VERBAL COMPREHENSION AFTER BRAIN DAMAGE

a psycholinguistic investigation

with special reference to cerebro-vascular accident

by

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Thesis submitted to the University of Newcastle upon Tyne

for the degree of Doctor of Philosophy, September 1976.

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ABSTRACT

A review of theory and practice in the examination of verbal comprehension in brain-damaged adults leads to the conclusion that this underdeveloped area of study can benefit from the application of theories from linguistics.

An experimental investigation of (principally) adults who had suffered cerebro-vascular accident applied, amongst other linguistic theories, the division of language into phonological, syntactic and semantic levels of organization. The main findings were:

a) Semantic abilities in speech and comprehension corresponded; syntactic abilities in speech corresponded with those in reading comprehension, but not aural comprehension; comprehension of phonemic distinctions corresponded with phonetic articulatory abilities, but not with degree of phonemic paraphasia. Tests of verbal comprehension which required simple manipulations of objects or tokens were contaminated by gesture dyspraxia. Functional comprehension was not a reliable predictor of results on linguistic tests.

b) Aphasic adults with left-brain damage experienced significantly more difficulties in comprehension when sequence was critical to the meaning of a word or sentence. At the syntactic level this occurred with reading as well as with aural input, indicating a central difficulty rather than one which is modality-specific. In aural comprehension, unlike all

types of control subjects including children, aphasic adults found sentences with reversible elements in surface structure harder than sentences in which reversible deep relations are not made explicit in surface structure sequence. Sequencing appears to be a significant influence on verbal comprehension after left-brain damage.

c) Right-brain-damaged adults who were not aphasic in speech, and who were familial right-handers, were selectively impaired in semantic comprehension. Semantic comprehension may be bilaterally represented in the brain, although comprehension at syntactic and phonological levels may depend principally on mechanisms lateralized to the left hemisphere.

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INTRODUCTION

When someone has a stroke, or cerebro-vascular accident, and particularly when that accident has occurred in the left cerebral hemisphere of the brain, one of the consequences may be a disturbance of language. The disturbance may take many forms; for convenience, and unless the disturbance is such that it appears to be limited to only one use of language (such as reading, or such as the organization of the movements of articulation for speech), these forms come under the rubric of 'aphasia'. (The term 'dysphasia' is sometimes used to describe all but complete loss of language, but following commoner practice aphasia is here used as a general term which includes dysphasia.)

The definition of aphasia must, on the one hand, include a strictly empirical feature: there must have been focal damage in the cerebrum. On the other hand, the definition must also refer to an abstract system, language, whose nature, and particularly whose psychological and neurological correlates, are as yet imperfectly understood. A working definition is that aphasia is a reduction, after focal brain damage, of available language, which affects all the modalities of language use, speech, hearing, reading and writing. But this leaves several unanswered questions: how is language not available? is the nature of this reduction one of timing or quality or quantity? must all the modalities be equally impaired? or indeed must all be impaired? does focal damage disrupt the language system in ways different from diffuse damage or normal fatigue? why does aphasia take such superficially different forms? and so on. The list of unanswered questions in aphasiology is long, and at the same time aphasia therapists are faced with a compelling need to search for answers to them, because people continue to become aphasic and to come to them for help.

The present investigation is an attempt to contribute to the study of aphasia by means of the application of some linguistic theories to the examination of disorders of verbal comprehension in people who have had a stroke. Other types of focal brain damage can precede aphasia: the reasons for limiting the experimental part of this investigation to people who have had a stroke will be given in Part Three, Section 1.1.

Because any exploration of aphasia based on linguistic theories is necessarily an examination of the psychological reality of those theories, it is a psycholinguistic exploration. However, no attempt has been made in the present investigation to correlate psycholinguistic phenomena with brain function, or with site of lesion other than in the most general sense of hemispheric side of lesion. Neurological information about the patients in the study was limited. They were known to have damage in the area of brain supplied by either the left or the right internal carotid arteries or their branches, and in a few cases further localizing information was available (see Part Three, Section 2). The investigation, therefore, is not 'neurolinguistic'. Except for the discussion of hemispheric differences, it falls into Van Buren's (1975) class of analyses of aphasia "as a functional concept apart from an anatomical substrate" rather than as "a problem of functional neuroanatomy" (page 35). One would hope that advances in our knowledge of brain function will be accompanied by advances in our ability to analyse the behaviour which follows disruptions of brain function; and it is with one aspect of this analysis that this investigation is concerned, the application of some linguistic theories to the examination of comprehension.

It is more usual for linguistic theories to be applied to the examination of utterances than to the comprehension of language. Broadbent (1964), McMahon (1973) and Jakobson (in press) recommended that a large number of samples of speech should be collected from aphasic adults and described and analysed according to linguistic principles. By now a fairly substantial body of studies shows that such advice has been taken to heart. Here are a few examples of different approaches to the linguistic analysis of aphasic utterances. Generative transformational grammar has provided a linguistic framework for Schuell, Shaw and Brewer (1969), Blumstein (1968, 1973), Myerson and Goodglass (1972), Schnitzer (1971). Crystal, Fletcher and Garman (1976) have used Quirk's Grammar of Contemporary English as the reference for their description of syntactic structure in deviant utterances. Martinet's interpretation of language as having different levels of 'articulation' or interfacings of hierarchical organization has provided another framework for the analysis of jargon utterances and jargon writing in aphasia (Lecours and Lhermitte 1969, Lecours and Rouillon in press). More elaborate protocols for the grammatical analysis of free speech samples, specifically tailored for computer processing, have been drawn up

(Gosse, Wachal and Spreen 1973, Wachal, Spreen and Gosse 1973): these are based on Fries' grammar and Wepman's classification of parts of speech. Because of this emphasis on the analysis of speech, the investigation of verbal comprehension in aphasia has not yet benefitted to a major extent from the application of modern linguistic theory. Indeed it has been under-investigated from any orientation, neurological, psychological or linguistic: as recently as 1974 Van Harskamp and Van Dongen described the investigation of verbal comprehension as a hiatus in aphasia research.

This is not to say that there are not many clinical procedures for the assessment of disorders of comprehension in aphasia. But they have, for the most part, been empirically-based, and have crystallised into routines which largely lack a formal theoretical framework. These well-beaten paths have long been trod by clinicians without any questioning of the basic assumptions which underlie them. Porch, for example, in 1967 commented that "the problem of constructing such a battery (for aphasia tests) is not so much one of selecting valid tasks, since these have been fairly well agreed on" (page 10), but that what was needed was a more sensitive and reliable system of scoring these agreed tasks. Some of these clinical procedures are described in Part One, Section 2.2.

In contrast, the few research studies of comprehension which have been undertaken so far, particularly those applying linguistic principles, have introduced new techniques of examination as well as new thinking. Most of all they have asked whether, rather than examining comprehension as distinct from and opposed to speech, we should be examining it as a central faculty which underlies and supports speech.

One of the main themes in aphasiology today is whether or not the superficially different behaviours of speaking and of listening to speech reflect the same underlying disorder or whether they are partially opposed. In fact, an investigation of verbal comprehension must include a definition of what the investigator includes in the term 'comprehension'. Many of these linguistic studies have been undertaken since the investigation to be reported here was initiated. There are now enough available to require a survey of work done to date, but as yet no such survey has been published. Consequently, what was first planned as an introductory background to the present report has been expanded into a separate 'Part One' to include a survey of some of these studies; the experimental work for the investigation forms Parts Two, Three and Four.

The studies described in Part One have not, for the most part, distinguished amongst the etiologies of aphasia, and this survey is therefore a general one rather than being restricted to aphasia after stroke.

Part One is divided into five sections. The first examines three orientations in interpretations of 'comprehension' in aphasia. The second gives an account of how, in practice, auditory comprehension is examined in clinics in patients who have been referred for examination for aphasia, and describes how the degree of the disorder in comprehension is measured. The other three sections are concerned with qualitative rather than quantitative examinations; firstly some clinical theories of qualitative distinctions in comprehension are described, then the linguistic theories which form the background to some of these investigations of qualitative distinctions, and finally some of these investigations themselves, are outlined.

Part Two reports on two preliminary experiments in the present investigation, and Parts Three and Four on the main experiment whose results are discussed under four headings; the appropriateness or otherwise of the measures which were used, the relationship of speech and comprehension, the results of the right-brain-damaged non-aphasic subjects, and the relationship of the comprehension disorder in aphasia to difficulties in processing sequence.

PART ONE   Comprehension in Aphasia: Review

PART ONE

Comprehension in aphasia: review

1. Theory

Three interpretations of 'comprehension' have been used in theories of aphasia: a modality-orientated interpretation, in which the behaviour of the reception of language is contrasted with the behaviour of its expression; a comprehension-as-central interpretation, in which comprehension is conceived of as representing an underlying knowledge of language unclouded by the motor difficulties of speech; and an interpretation of comprehension as a general cognitive ability which involves more than the medium of language. The labels whose connotations come closest to clarifying the distinctions are, perhaps, 'reception', 'language knowledge' and 'understanding'. These distinctions have sometimes been used as if they were different aspects or stages of comprehension which are disturbed in aphasia. For example Ombredane's (1951) account of the history of ideas on language disorders distinguishes three aspects of aphasia: the alteration of sensori-motor components, the degradation of symbolic aspects, and global 'psychic modification'. These three aspects seem broadly to correspond with these three distinctions in comprehension. However, in the present discussion, the three labels of reception, language knowledge and understanding are not meant to relate to either possible stages of processing or to different types of aphasias. They are used here to describe the different orientations of investigators, who have each tended to focus on one aspect and have paid less attention to the others.

1.1 Understanding

The discussion of whether or not aphasia implies a deficit in intellect is historically the oldest of these and dates from the sensualistic-spiritualistic controversies of the nineteenth century about the relationship between thought and language. According to the sensualistic concept, thinking occurs primarily in the sphere of language and on the base of words (Bay 1969); this necessarily implies that a disorder of language will result in a disorder of thought. From this theory, and from their own observations, several students of aphasia have seen the language disorder as indicative of a general cognitive deficit. Marie (1906, translated by Cole and Cole 1971) wrote "If for my part I were to give a definition of aphasia, the factor which I would be compelled to stress would be the diminution of intelligence" (page 54). He believed that there was a decrement particularly in those functions of intelligence which are produced by education or training, 'didactic processes', and cited the now famous case of the professional cook who, some years after becoming aphasic, shirred an egg by putting the butter on top instead of first melting it (an aberration which would nowadays be attributed to ideational apraxia rather than aphasia). Goldstein (1933, 1948) also perceived the essential disruption in aphasia as being all-pervasive; it is a loss in the ability to grasp the essential nature of a process, to differentiate 'figure' from 'ground', and to assume an abstract rather than concrete attitude. A modern proponent of the view that aphasia implies a general cognitive deficit is Bay (1964). Disordered conceptual thinking, an essential component of intelligence, lies at the root of aphasia. The true aphasia is the classic amnesic aphasia, in which the patient has difficulty in finding names but is free of the motor impairment which overlays some other aphasias, and this is not so much a language disorder as a disturbance of conceptual thought, of the faculty of establishing propositions.

The opposite view, the spiritualistic one, is that intellectual capacity which does not require the mediation of language for its use can be intact in aphasia. The intellectual deficits which undeniably are frequently observed in association with aphasia are attributed partly to additional disorders. Intelligence must be measured through some medium, and aphasic patients frequently have lesions which affect the use of these media; they may have difficulty in voluntarily coordinating responses (apraxia) or in recognising stimuli (agnosia). For the rest, by definition they have a deficit in one medium for the measurement of intelligence, language, and aphasic subjects must necessarily get lower scores on verbal scales of intelligence, particularly if delay is penalized.

However, there are four lines of evidence which can be adduced to support the thesis that intellect as a supposedly general or 'g' factor and apart from measured intelligence is not necessarily impaired in aphasia, and that consequently verbal comprehension can be examined independently of intellectual understanding:

1) there are several cases on record of aphasic adults with superior intelligence as evidenced by tasks which do not require language (Zangwill 1964, Van Harskamp in Lebrun and Hoops 1974, page 45, Goodglass in Lebrun and Hoops 1974, page 75); a substantial proportion of aphasics perform as

well as non-brain damaged subjects on non-verbal tests of intelligence (42% on Raven's Coloured Matrices according to Kertesz and McCabe 1975);

2) an anatomical location in the left brain has been suggested as the important structure for 'g' independent of its measuring media (Basso, De Renzi, Faglioni, Scotti and Spinnler 1973). One 'intellectual area' is situated in the retro-rolandic region of the right hemisphere and is medium-related. It is employed in visuo-spatial but not verbal skills, while the other in the left hemisphere does overlap the language area but is involved in non-verbal as well as verbal tasks. Basso and her colleagues suggest that "this left-sided region subserves a superordinate, intellectual ability, sharing many of the characteristics attributed to the 'g' factor by psychologists";

3) the acquisition of language by human babies is at least partially independent of intelligence (Lenneberg 1967). It has been proposed that, because the human child at an early stage of cognitive development learns to recognise from a degenerate sample of surface structures in the speech of those around him an abstract and universal system of deep structures, there must be an innate language-disposed mental structure (Chomsky 1968) or 'language-acquisition device' (McNeill 1966) which is species-specific. Whether this built-in capacity is purely linguistic or is cognitive in nature is arguable (Bever 1970). In favour of the argument

that it is cognitive are the observations that the cognitive abilities of human babies are more advanced than was once supposed (Bower 1974), and that intelligent chimpanzees can show considerable 'linguistic' abilities when these can be expressed by sign, button-pressing or by token manipulation (Gardner and Gardner 1969, Premack 1971, Rumbaugh, Von Glaserfeld, Warner, Pisani and Gill 1974). In favour of the argument that language is species-specific and requires a peculiar organization of the brain is the fact that despite the trained chimpanzee's ability to understand and create simple sentences and to devise new words, it seems so far that its syntactic skills are restricted to juxtaposition and sequence in surface structure. Moreover, despite superior auditory discrimination, mammals do not seem to learn the phonemic discriminations required for aural language (Kreindler and Fradis 1971), and the imitative vocal learning of birds never leads to the ability to recombine phonemes in an endless variety (Nottebohm 1975). Neither developmental nor animal studies have yet demolished the case for the separation of at least some aspects of language from intellect;

4) diffuse brain damage can result in intellectual impairment but still leave the victim able to perform relatively well on tests of verbal comprehension which are difficult for the aphasic. Generalized intellectual impairment is quite distinct from aphasia (Halpern 1971). In the condition

known as 'acute confusional state', after presumed bilateral brain damage, despite difficulties with articulation (dysarthria) and with naming, sometimes no verbal comprehension difficulties can be detected on clinical tests (Chédru and Geschwind 1972). The clinical tests which Chédru and Geschwind used were a test of "three orders using grammatical words similar to commands in the Token Test" (see Section 2.3.3) "and three complex questions using the passive form, the possessive and the comparative form".

Some facets of language are more clearly distinguishable from general cognitive operations than are others. Specifically a stronger case can be made for the specificity to language of phonological organization, and perhaps of syntactic organization, than of semantic (these terms are defined in Section 4.1). The partition between the semantic and the conceptual, if it exists, is thin. Goodglass (in Lebrun and Hoops 1974) concludes that although aphasic patients may be free from impairment in the logical approach to problem solving, they have a reduced ability to recover and use the elements which make up a total concept. Lhermitte, Derouesné and Lecours (1971) perhaps best summarise the majority opinion on this subject. They state that aphasia is not a consequence of reduction of intellect, nor does it bring in its train a lowering of efficiency in non-linguistic operations. There is an alteration of verbal thought in aphasia which may affect not only semantic systems but also the logical organization of thought, but non-linguistic deterioration must be attributed to changes in other physiological systems in which the left temporal-parietal region is involved.

The weight of evidence therefore suggests that some facets of verbal comprehension can be examined from a theoretical perspective in which comprehension does not need to be equated with intellectual understanding. It is also clear that when assessing verbal comprehension abilities in brain-damaged people we must include careful controls on the effects of additional complications of apraxia and agnosia on the media of measurement.

1.2 Modality-specific reception

The second interpretation of comprehension emphasises the medium of measurement, reception.

We receive language chiefly through two modalities, listening and reading, though it is also possible, of course, to receive it through sight of gesture (as in deaf sign language) or through touch (as in Braille). A disturbance exclusively, or primarily, in the modality of reading is given the name of alexia (or dyslexia), and is outside the main theme of this treatise, which centres on disruptions of what has been referred to as the primary language system of speaking and listening. However, the clarity of separation between alexia and aphasia is more one of classificatory convenience than of empirical fact. Some alexias are relatively 'pure' and are attributed to disconnection of the visual and language systems (Geschwind 1965) or to disruptions in a visual-language system itself (Luria's "optic aphasia", Marshall's "visual dyslexia", Hécaen's "pure alexia").

In these 'pure' alexias use of the motor-language system of writing is retained and provides the patient with a devious route for re-acquiring reading by tracing the printed words with his finger as if writing them. When disturbances of naming in speech are reported in association with such alexias (as they often are), they are attributed to agnosia, or to a failure to integrate percepts with concepts in long-term memory store. With other alexias the central language system itself is more clearly involved, even though the primary modalities of speaking and listening are much less impaired than the secondary ones of reading and writing, and the mistakes which are made in reading can be related to the linguistic rather than the visual nature of what is read (Marshall's syntactic-semantic dyslexia).

In the present investigation, however, disturbances of reading and writing are examined not in their own right but only as illustrative of the nature of the disorder in aphasia. In aphasia also, as in alexia and agraphia, the secondary language system is usually more impaired than the primary (perhaps because it is acquired later in life, if at all, and is less secure), but the primary language system is impaired enough to be clearly the centre of the disorder.

The contrasting of reception and expression in the primary language system is a deeply-rooted habit in aphasiology. Ever since Wernicke drew attention in 1874 to a kind of aphasia in which speech was fluent but comprehension was impaired, a double dissociation has been accepted by many aphasiologists between expression and reception. Some patients are said to have restricted non-fluent speech but good comprehension, and others to have unrestricted fluent speech but poor comprehension. The speech of these fluent speakers is, of course, not normal, but it is para-phasic rather than a-phasic, i.e. inappropriate speechsounds or inappropriate words are uttered rather than no or few words, and the quality of this abnormality can easily be missed in some patients. Geschwind (1974 page 290) comments that the error Wernicke pointed out 100 years ago is still a common one: "patients with fluent paraphasic syndromes are still often misdiagnosed as confused or psychotic".

It is not surprising, therefore, that descriptions of comprehension disorders in aphasia came somewhat later than descriptions of speech disorders. Geschwind credits Bastian in 1869 and Schmidt in 1871 with the first descriptions of aphasias with comprehension disturbances, but Wernicke was the first to attract attention to them, although he refers to "the rarity of such cases". His analysis was that the patient with this syndrome has lost the "sound images" of the names of objects and is thus neither capable of repeating nor understanding the spoken word. The patient has a large potential vocabulary, according to Wernicke, but his speech is aphasic because of the loss of its unconscious correction by the sound image; the errors consist in the ready confusion of words. Because of the way language is learned, all the modalities of listening, speaking, reading and writing are affected by this disturbance of auditory memory images, but the effect on the other modalities is essentially secondary to this primary deficit in the auditory modality. Wernicke located the site of the lesion of his new syndrome in the first temporal gyrus in an area which is now known by his name.

The fact that Wernicke considered comprehension difficulties to form a separate syndrome in aphasia, rather than being concealed in the kind of non-fluent aphasia Broca had described in 1861, has had a fundamental effect on interpretations of aphasia. For many years they have been dominated by this division into syndromes based on modality contrasts, despite repeated reminders through the years that the complete opposition of speech and comprehension disorders was unreal. If there are comprehension disorders in Wernicke's aphasia, Marie's famous equation, Broca's aphasia = Wernicke's aphasia + anarthria, should have been a reminder that comprehension disorders exist also in Broca's aphasia. Head, too, (1926) drew attention to the untenability of the assumption that reception is impaired independently of speech:

> "Although the defects produced by an organic lesion of the brain fall naturally into disorders of verbal formulation and defective recognition of meaning, we cannot divide the manifestations of aphasia according to these categories into two mutually exclusive groups. For the use of language as a whole is more or less affected ...." (page 547)

Yet one of the most influential modern classifications of aphasia, that developed by Geschwind, after Wernicke, which acts as the model for the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan 1972), is supported by a rationale which depends on contrasts of expression and comprehension. Syndromes are identified by the distribution of the labels 'intact', 'impaired' and 'limited', in a matrix headed by 'comprehension', 'spontaneous speech', 'repetition (i.e. imitative speech)' and 'naming'. To be identified as a Broca's aphasic a patient must have 'intact' comprehension but non-fluent speech (Green 1970). According to this, Broca's aphasia is essentially a disorder of expression, not of reception.

Another example of the reliance on the comforting pseudo-clarity of contrasts of the modalities comes from Weisenberg and McBride (1935). Theirs was the first study to use standardised tests with a relatively large number (over 60) of aphasic subjects; they, too, although they came to the conclusion that expressive aphasias are "language disorders which involve far more than verbal formulation and expression" (page 465), nevertheless described the terminology of 'expressive' and 'receptive' as "on the whole extremely satisfactory". They reconciled their findings with this terminology by introducing the modifier 'predominantly' in front of expressive and receptive. If aphasia is to be distinguished from dysarthria, from alexia and from agraphia, because all the modalities are impaired in aphasia (see the working definition on page 1) - and from such a list it could be inferred that <u>the</u> key modality of impairment in aphasia is <u>hearing</u> - it is rather surprising to find that the expressive-receptive dichotomy still has such a powerful appeal. 'Receptive aphasia' is particularly a misnomer; one searches the literature in vain for reports of a single aphasic patient who is impaired in auditory verbal comprehension and in reading but not (or even 'less') impaired in speech and writing. The rare patients with 'pure word deafness' (see Section 3.1.2) and normal speech read well. Nevertheless, in its many variants (motor-sensory, executive-impressive, encoding-decoding) the dichotomy still supports many practical summaries of an individual patient's disorder in hospital notes and in screening assessments. This modality-based terminology has survived the theorising which could have demolished it because the framework for the analysis and observation of aphasia has been itself almost entirely modality-based.

The headings in most aphasia tests group the sections by modality - 'auditory comprehension', 'visual', 'graphic', 'gestural' etc., and the patient is, therefore, most easily categorised by the section (the modality) which is most impaired.

At a time when behaviourism was dominant in Western psychology there was a strong appeal in such an apparently objective approach to the observation and assessment of aphasic disorders. Wepman and Jones' Language Modalities Test for Aphasia (1961) exemplifies this approach. Active proponents of the behaviourist approach today, Sidman and Mohr (Sidman, Stoddart, Mohr and Leicester 1971, Sidman 1971, Mohr and Sidman 1975) advocate that aphasia should be investigated through a rigorous cross matching of stimulus and response modalities using the same materials. However, if aphasia is conceived of as a central disorder, and not as a modality-based disorder of transmission like pure alexia or dysarthria, it would logically seem desirable to have some theoretical framework for the analysis of this central disorder which is independent of the peripheral limitations of the modalities of expression and reception.

One such framework is derived from linguistics, and is the one utilized in the present research. It is not the only possible one, however; another is outlined in Section 3.4, with the reasons why it was not practicable to use it in this particular study.

1.3 Language knowledge

The limitations inherent in the exclusively modality-orientated approach to the analysis of aphasia have brought about the third interpretation of comprehension as language knowledge. This knowledge is conceived of as being a specifically linguistic knowledge, distinct from other aspects of cognition; it also underlies all language processes rather than being primarily concerned with the reception of verbal signals.

Two recent developments have fostered this change in emphasis from reception to language knowledge.

The first is the recognition of the importance of social strategies and processes of interaction of verbal and non-verbal communication which are involved in comprehension through listening. Examination of 'reception' by asking the patient to perform an ad hoc series of actions is misleadingly simple; reception is interwoven with complicating factors, which speech, despite its being superficially the more demanding task, escapes. Comprehension, if defined as reception, needs the initiatory effort of another person, who provides something to comprehend: it is necessarily part of a communicatory act. Speech, in contrast, can be a spontaneous self-generated flow, which may not be intended as communicatory. In normal speakers it gives more direct evidence of language knowledge than does comprehension. But much of the speech produced by aphasic patients in therapy sessions is performative rather than informative in nature. When the patient names a list of objects (or describes a picture) he is not communicating the names to the therapist, who already knows them, but he is communicating to the therapist that he can (or cannot) utter the appropriate names; the communication is the act not the content. Verbal comprehension, on the other hand, is necessarily a part of an intended communication, a communication which (except in lists of words) is a composite of content, paralinguistics (i.e. intonation, voice quality, style, etc.), social expectancies, presuppositions and non-verbal support. Moreover, the raw material for the analysis of reception has no substance - only the stimulus material which the experimenter devised and the output which the subject produced. While speech can be recorded, transcribed, described and analysed, all that we can measure of reception is the response to the input, not the receptive process itself but the end product of a series of interacting processes of perception and integration expressed in some observable form such as moving an object, pointing to a picture, or speech. The more that acknowledgement is given to the complexity of these processes of perception, integration and execution and their interactions, the less satisfactory it becomes to say that we can make assessments of comprehension, if comprehension is conceived of as a one-sided affair, as reception. Measures of stimuli and responses have a spurious objectivity, but they are not measures of comprehension only. To find out what aphasic people comprehend, it turns out to be less complicated to try to access underlying language knowledge than to attempt to measure 'reception'.

Here, the second development, the application of linguistics to the study of aphasia, is opportune. Linguistic models of language (as opposed to psychological or psycholinguistic models) have often taken the form of representations of a central abstract system with minimal interest in the peripheral processes of access to this system by real-life speaker-hearers. The difference between speaking and listening is not of any material interest, and can be accommodated simply by reversing the direction of the arrows between the sub-components whose integration the model describes. Psychological theories such as the motor theory of speech perception (Liberman, Cooper, Shankweiler and Studdert-Kennedy 1967), analysis-by-synthesis (Miller, Pribram and Galanter 1960) or the theory of decoding-by-encoding (Trabasso 1972) equate the two processes of speech and comprehension explicitly, but they start from the premise that they are different. Linguistic theories seem to have equated them implicitly, without asking, at first at least, whether they may differ in important ways. It is not too difficult, against such a background, to think of language as being modality-free; and, for linguistics, the most convenient modality to choose for analysis (other things being equal) is speech. Hence the section on 'Linguistics and aphasia' in Osgood and Miron's account of an interdisciplinary conference on aphasia (1963) is entirely occupied with discussions of aphasic <u>speech</u>, starting from the viewpoint that:

> "Linguistics studies regularities within a language, that is, those rules which, when observed by the speakers of any language allow them to <u>produce</u> all the correct utterances of that language, and no incorrect ones ..... Linguistics can be thought of as a descriptive natural science whose raw data are the physical events (speech sounds) which constitute the messages exchanged among the speakers of any language" (pages 62-4) (my emphasis).

The first applications of linguistic models to aphasia therefore accessed the patient's language knowledge by analysing his utterances, and by asking him to perform operations like pronominalisation, the formation of sentences from verbs which require obligatory complements, the discussion of the relationships of words in sentences (e.g. Whitaker 1971, Penn 1974, Ulatowski and Richardson 1974). For patients whose difficulties in transmission in speech or reception are relatively minor, such procedures are useful, but there are more patients whose difficulties particularly in production make their speech an unreliable mirror of their language knowledge. Even to make the relatively simple judgement of degree of severity, Bay (in Lebrun and Hoops 1974, page 51) recommends examining not speech but comprehension:

> "The severity of aphasia should be assessed on the basis of receptive disorders.... expressive language does not permit a correct appraisal of the aphasic component because of possible confusions with dysarthria".

Hence the trend in the more recent linguistic studies to search for techniques for accessing the central language system without requiring speech. Weinreich's "model for essential linguistic components" (Osgood and Miron 1963, page 102) has a level labelled 'understanding' which underlies both input and output: it contains both grammatical understanding and semantic understanding, and:

> "would presumably involve some storage of a vocabulary of meaningful items against which the results of the grammatical analysis are checked during input, and from which items are submitted to grammatical organization during output".

Recent studies claim to have accessed this level; Von Stockert and Bader (in press), of their Sentence Order Test, write "our method enables us to examine linguistic capacities on precisely this level while avoiding the complexities of normal speech perception and expression"; Zurif and Caramazza (in press), having used a triadic comparison procedure to elicit links between words, claim: "we chose a task which circumvented the aphasic's problems in dealing with language as it unfolds in real-time".

Interest in aphasiology has thus been moving from observations of the opposition of speech and comprehension towards a search for commonalities between them, and a study of speech-free comprehension tasks as a purer measure of underlying language knowledge. Ironically enough, psycholinguistics as applied to that other field of special interest to the understanding of the nature of language, its acquisition in children, has been doing the opposite. Developmental psycholinguistics is a younger science than aphasiology and was gaining its momentum at a time when linguistic models took it for granted that speech and comprehension reflect the same competence. It was thus assumed that speech and comprehension were acquired in parallel, though with comprehension a step ahead of speech, as it was 'easier'. Now that a number of studies have indicated that in some respects speech anticipates comprehension (e.g. Clark, Hutcheson and Van Buren 1974, Chapman 1974, Chapman and Miller 1975), the interrelationships of speech and comprehension are seen to be more complicated than had hitherto been supposed (Bloom 1974). This is discussed in Part Four, Section 1.

The interpretation of comprehension which has been used in the present investigation is a compromise between reception and language knowledge. It is modality-orientated in that one purpose of the research has been to effect a comparison between measures of comprehension and measures of speech. In the main experiment, auditory comprehension has been assessed at the phonological level by using two different media of output, pointing to pictures, and indicating by nodding same-different judgements of printed words. At the syntactic level, auditory comprehension has been compared with comprehension of printed sentences, and output using gesture has been compared with output consisting of pointing to pictures. However, the purpose has not been primarily to compare modalities but to arrive at a better 'net' estimate of underlying language knowledge accessed by activities not requiring speech, so that this could be compared with language knowledge as evidenced in speech. In the main experiment, comprehension at the semantic level was tested (in one way) using a metalinguistic task of sorting printed words which were also spoken to obviate limitations of input modality. The intention here, too, was to access language knowledge, without requiring speech.

2. Practice

2.1 Recommendations in the assessment of comprehension

Whether we are guided by the second or the third interpretation of comprehension, there are a number of caveats of which to be aware when attempting to measure a specifically linguistic comprehension. There are, of course, a number of general prescriptions for the design of formal psychological tests (Nunnally 1970) and some which particularly apply to the design of formal tests of aphasia (summarised by Weigl 1966, Porch 1967, Benton 1967, McNeill and Prescott 1973). But there are also requirements which are not so much those of a test battery as such but which are specifically relevant to the assessment of linguistic comprehension in aphasia whether it be undertaken in the context of a standard test or informally; they are in fact requirements for the content of the material which is used for measurement and relate to only one aspect of formal test design, construct validity.

De Renzi and Vignolo (1962) list five features which a test should have if it is to be clinically useful in revealing receptive disorders: it should

1) be linguistically difficult;
2) be intellectually easy;
3) be short;
4) not exceed memory capacity at any (adult) age, and
5) not require special apparatus.

The particular nature of material which is at one and the same time intellectually simple but linguistically difficult they define as "lack of redundancy": there should be no extra-linguistic cues for comprehension from the situation or from the nature of the objects used, nor should there be duplication of linguistic cues within the sentence, but each word should be indispensible.

Carroll (1972) comments that tests of verbal comprehension, as used in educational measurement, tend to be significantly correlated with intelligence tests, even those of a non-verbal nature such as a figure analogies test. He questions whether it is possible "to distinguish 'pure' comprehension of language tests from processes of inference, deduction and problem solving that often accompany the reception of language tests" (page 3). He cites evidence from Davis, however, that factors of a truly linguistic comprehension (i.e. lexical knowledge, grammatical knowledge and the ability to locate facts in paragraphs) can be experimentally distinguished from an inferential factor requiring the examinee to go beyond the data given. Like children's tests, aphasia tests of verbal comprehension are not scrupulous in excluding factors of general knowledge or of inference beyond the data. The Boston Diagnostic Aphasia Examination (Goodglass and Kaplan 1972) includes amongst several such items, one about a hotel receptionist who insists that "all guests carrying their own fire escapes must pay in advance". Awareness of the worldly wisdom of the receptionist is not verbal comprehension, although it requires verbal comprehension to make it possible. One could, however, argue that it is useful to discover whether an individual aphasic patient has retained enough verbal comprehension to make such an inference possible (unfortunately a third of a class of speech students, despite their presumably good verbal comprehension, missed the implications of the hotel receptionist's dictum). But this illustrates a difficulty in assessing verbal comprehension in aphasia which does not occur with normal children. In the disordered adult, comprehension abilities are to be compared not with a standard obtained from developmental norms but with the adult's own pre-traumatic abilities which are (except in a few surgical cases) unknown. What one patient may have always found beyond his scope may represent a significant decrement for another man.

There are a number of factors which could have shaped the pre-traumatic linguistic skills of the aphasic adult, and which may therefore be inextricably involved with his present abilities. Froeschels (1970) suggests that an important influence is 'ideational type', i.e. whether the patient was more developed in optic or acoustic or motor-kinaesthetic skills. The motor-kinaesthetic type, for example, would rely on slight lip movements when doing mental arithmetic, and would be more severely affected by an aphasia in which articulation difficulties were prominent. Aylwin (1974) has recently shown that, with normal subjects, instructions to use visual, verbal or kinaesthetic 'imagery' significantly affects recall, indicating that there is therefore some validity in these distinctions. Educational level is another obvious factor, conspicuously obvious in facility in reading, but influential too in facility with oral language. But even at the same educational level, Day (1970) has suggested that some people operate more in terms of language than others: some are 'stimulus-bound', some 'language-bound'. Hunt, Lunneborg and Lewis (1975) have also shown that 'high-verbal' and 'low-verbal' students, all intelligent, are nevertheless consistently distinguishable by a range of cognitive tasks; for example, the high-verbal are more sensitive than the low-verbal to sequential order. The examination of verbal comprehension in children is aimed at finding out these differences as well as the educational level which the child has achieved. But what are we to conclude if an aphasic adult on testing is discovered to be 'low-verbal' - are we to conclude that he is an impaired 'high-verbal' or that he has always been a 'low-verbal'? With severely impaired patients it is only too obvious that they must be performing at a level which is grossly below their pre-traumatic abilities, but aphasia therapists often come across patients who are performing at a superficially adequate level yet who are painfully aware that they have not recovered their previous facility with language (a personal account of such a patient is that of Moss 1972). If a test designer designs for the 'lowest common denominator' in aphasic impairment of comprehension, he misses out on such aspects of lesser language decrement.

Cultural factors and local speech-community habits can also be reflected in scores on formal standard verbal comprehension tests. As the results of the present investigation show, non-brain-damaged subjects do not always make the same linguistic distinctions as text-book grammars (see Part Three, Section 7.1). There may be heated controversy between purists and sociolinguistic observers as to whether these local habits are 'bad' grammar or not: what cannot be disputed is that, with some aphasic patients, they are not indicative of a pathological deviancy. But identification of what is pathological and what is cultural in an individual patient is by no means obvious. For example, failure to distinguish between singular and plural versions of the auxiliary 'is/are' may be a normal feature of the speech of one community, but may also represent a pathological reduction (or regression) in the speech of a well-educated aphasic adult from that community.

For these reasons it is advisable, in examining linguistic comprehension in a patient, not only to make some estimate of the individual's pre-traumatic linguistic habits, but also to test out verbal comprehension measures with people from the same speech community, and to obtain approximate guidance about the influence of education through using the materials with children at various stages of schooling.

A factor which is of peculiar delicacy in the examination of verbal comprehension in aphasia is memory. Carroll (1972) suggests that, as soon as longer time-intervals than a few seconds are involved in the testing of comprehension, there is the possibility that we are studying memory processes along with, or in place of, comprehension processes. With normal adults and with older children, we can be reasonably sure that we are not compounding comprehension with short-term or immediate memory when we make sure that an auditory message does not have to be retained for more than three or four seconds, or when memory can be replenished by repetition, rehearsal or reading. Not so in aphasia. Storage of even two items requires a differentiation of traces, an ability to pass from one trace to another and sometimes to distinguish them by sequence which may be drastically reduced in aphasia. By definition, aphasia is a deficit in one kind of memory (long-term semantic memory), or probably more accurately in retrieval from that memory, but the essential nature of aphasia has also been characterised as a deficit in short-term memory. For Halpern, Darley and Brown (1973) a reduction in auditory retention span "appears to be a fundamental component of aphasia". Schuell, Jenkins and Jiminez-Pabon (1964) report an almost ubiquitous reduction in auditory verbal memory in aphasic patients. Even stronger claims about the relationship of aphasia and auditory memory for sequence (verbal and non-verbal) originated from Efron's (1963) findings (see Part Four, Section 3). It is, therefore, by no means certain whether memory can be isolated as distinct from language in aphasia as Carroll would suggest it must be with children. Memory processes cannot be assumed to be simply nuisance factors to be circumvented; their reduction may be central to the disorder in aphasia. Short-term memory, therefore, provides a useful framework through which to examine disordered verbal comprehension, and there are a number of questions which can be asked. Is the memory limitation in aphasia peculiar to the auditory modality? If it is, reading comprehension should reveal a superior span, other things being equal. Or is the memory limitation essentially one of language processing per se rather than of input modality? In this case reading and listening will show similar restrictions. Or perhaps the memory limitation in aphasia is just one instance of a reduced efficiency through damage to brain tissue? In this case it will affect all tasks whatever the nature and whatever the modality used. Or brain damage may have specific effects on memory depending on the site of the lesion, independently of an accompanying aphasia, as in temporal lobe excision (Milner 1968), frontal lesions (Konorski and Lawicka 1964), the Korsakoff syndrome (Lhermitte and Signoret 1972) or retrograde amnesia after head injury (Williams 1973, Baddeley 1973). In the present study, Part Four Section 3 examines one aspect of short-term memory whose disturbance has been particularly associated with the nature of the language disorder in aphasia, the ability to code and retain the sequence in which stimuli are received.

A final caveat needs to be made about the assessment of verbal comprehension in aphasia. However much the researcher may attempt to assess underlying linguistic knowledge and to reduce possible errors by duplicating input modalities and by simplifying the response required, it is still only the response which supplies the data for analysis. The expression of linguistic knowledge in aphasia is the end product of a number of complex processes, and the interaction of the organization needed for a non-verbal response with the linguistic system cannot be presumed to be negligible. The present investigation therefore monitors the effect of different kinds of responses on test scores. It is also, perhaps, timely to comment that when the input modality used is audition, a raised threshold for pure-tone hearing may account for difficulty in verbal comprehension.

2.2 The investigation of auditory comprehension in test batteries

For assessing disorders of speech in an individual, the recording of samples of conversational exchanges usually provides enough data for hypotheses to be formed about the nature of the disorder, which can then be tested with more structured material. For assessing auditory comprehension, on the other hand, such exchanges can be damningly unreliable. A judicious periodic yea or nay from the patient can give a totally misleading subjective impression that he is understanding the language content of the conversation rather than following the social rules of the situation. Similarly, a bizarre response may be as much an indication of speech being out of control as of failure to understand. To examine linguistic comprehension, therefore, it is necessary to rely almost entirely on structured situations and structured materials where the examiner has some control over the variables.

This section describes the established clinical procedures which are available to the investigator of auditory comprehension (reception) in aphasia. There are a few specialized whole tests which have been devised specifically for the examination of reception, and these are described in Section 2.3. But for the most part, reception is examined through sub-tests incorporated into larger test batteries which examine all the modalities.

These batteries can be distinguished by their aims. Firstly, there are the somewhat shorter batteries which take a small sample of behaviour from each modality as a preliminary assessment. They serve two purposes, firstly to establish whether or not a patient is aphasic, and secondly to indicate what abilities the patient has retained which can form the basis for early therapeutic work. These tests, for the most part, are not sufficiently rigorously standardised in presentation or design, nor sufficiently validated or reliable to meet the standards of the American Psychological Association, but they provide approximate routines through which behaviours can be scored as occurring or not occurring to supplement observational methods. Examples of such tests in English are, from the U.S.A., Halstead and Wepman's Screening for Aphasia, Eisenson's Examination for Aphasia, Sklar's Aphasia Scale, Schuell's Short Examination for Aphasia, Keenan and Brassell's Aphasia Language Performance Scales, Emerick's Appraisal of Language Disturbance; and, from Britain, Rochford and Williams' Measurement of Language Disorders, Butfield's Assessment and Case Recording of Aphasic Patients, and Whurr's Aphasia Screening Test. One outstanding such test from the U.S.A. which has been standardized and which is, therefore, reliable enough for test-retest comparisons and for inter-subject comparisons is the Porch Index of Communicative Ability (Porch 1967). In addition, many clinics follow their own unpublished (or published only in outline) procedures (see, for example, Leischner in Bonn 1974, Mohr and Sidman in Boston 1975, the Institute of Rehabilitation Medicine in New York as described in Needham and Swisher 1972, Sipos and Tägert in Hanover 1972).

Secondly, there is a range of batteries which claim to make a comprehensive examination of the assets and deficits of a patient diagnosed as aphasic. Though many clinics have developed their own procedures for this as well, there are a handful of published test batteries which have gained, or are gaining, some general currency for speakers of English (The Language Modalities Test for Aphasia 1961, from Chicago; the Minnesota Test for the Differential Diagnosis of Aphasia 1965; The Neurosensory Center Comprehensive Examination for Aphasia 1969, from Canada; the Queensland University Aphasia and Language Test 1972, from Australia; the Boston Diagnostic Aphasia Examination 1972). If one looks at these test batteries for a searching exploration of language knowledge, however, it is disappointing to find that they use largely the same tests, techniques and conceptualization of comprehension as do the shorter batteries. To illustrate this, the sections from these larger batteries which examine auditory comprehension are described below, together with two examples of this approach in other languages, French and Romanian.

2.2.1 <u>Language Modalities Test for Aphasia</u> (Wepman and Jones 1961)

This test is usually presented on filmstrip. Subtests are not grouped under modality headings, but the title of the test reflects its guiding principle, the examination of inter-relationships of behaviour amongst different combinations of input and output channels. Scoring is categorical, the categories used being derived partly from linguistic theory: pragmatic, semantic, syntactic, jargon and global. Subtests which assess auditory comprehension are those which ask the patient to:

1) Listen to a word, number or sentence and select the appropriate picture from a choice of four. (Auditory + visual modalities.)
2) Listen to a word or number and write it down. (Auditory + graphic modalities.)
3) Listen to a word, number or sentence and select the appropriate choice from four printed responses. (Auditory + visual-verbal.)
4) Listen to a word, number or sentence and repeat it. (Auditory + oral.)

Although the model of language used by Wepman and Jones distinguishes language 'integration' from language 'transmission', and defines aphasia as essentially a disorder of integration, nevertheless the factors which emerged from an analysis of data from 168 patients were interpreted mostly in terms of modality of transmission and of translation from stimuli in one medium to response in another (i.e. four main factors of translation from visual stimulus to oral response, from aural stimulus to oral response, from visual stimulus to graphic response, and from oral stimulus to graphic response). A fifth minor factor was interpreted as "an ability to comprehend language symbols", an ability which transcends the modality in which stimuli are presented.

Some acknowledgement was therefore made of 'language knowledge' as a central ability. It was noted that comprehension may be impaired when simple repetition is not. Moreover, age is represented in this comprehension factor; in older patients comprehension is more likely to be affected by brain damage. A final minor factor was defined by arithmetical scores and by educational level. An analysis of the variance in the data from 50 of the patients by Ross (described by Osgood and Miron 1963, page 119) confirmed that there were significant differences amongst subjects related to input and output modalities and to the translation from one medium to another.

An adaptation of this test into Hebrew has been undertaken (Bar David 1971), and a study using this adaptation is reported by Fredman (1975).

2.2.2 Minnesota Test for the Differential Diagnosis of Aphasia (Schuell 1965)

Schuell recognizes three aspects of auditory comprehension in this test: auditory discrimination, auditory recognition and auditory retention span. They are examined by the first nine subtests of the battery under the heading of 'auditory disturbances': the patient is asked to:

1) Listen to an object name, and point to the correct picture from a choice of six (e.g. cup, key, penny, spoon, comb and pencil). ("Recognition of common words".)
2) Listen to an object name and point to the correct picture from a choice of two whose names are phonemically close (e.g. goat and coat). ("Discrimination between paired words".)

3) Listen to the name of a letter of the alphabet and point to one out of five printed ones. ("Recognizing letters".)

4) Listen to two, and then three, names and then point to these objects in a picture. ("Identifying items named serially".)

5) Listen to a sentence, and indicate a yes/no response (e.g. Can anyone get a license to drive a car?). ("Understanding sentences".)

6) Listen to an instruction and execute it (e.g. close the box and ring the bell - from one to three objects are used with sentences of increasing length). ("Following directions".)

7) Listen to an anecdote and indicate yes/no to eight questions about it. ("Understanding a paragraph".)

8) Repeating digits (from 2 to 7).

9) Repeating sentences, of increasing length from one to three substantive items.

Digit repetition span and repetition of sentences are thus included amongst auditory disturbances, because of Schuell's emphasis on a reduction of auditory memory as a fundamental component of aphasia. The Battery then continues to examine "visual and reading disturbances", "speech and language disturbances", "visuomotor and writing disturbances" and "disturbances of numerical relations and arithmetic processes".

A British modification of this battery has been produced by Davies and Grunwell (1973) in which Americanisms have been changed. The battery has probably been the one most widely used in British clinics to date.

A factor analysis of scores on one of the earlier versions of the battery led Schuell to conclude that aphasia is a unitary phenomenon which differs in individuals in degree but not in quality. The superficial differences in 'aphasias' arise because simple aphasia is sometimes accompanied by one or more additional disorders, which are not themselves primarily aphasic according to Schuell's interpretation (visual, sensorimotor, emotional).

2.2.3 Neurosensory Center Comprehensive Examination for Aphasia (Spreen and Benton 1969)

This is an English language version of a test which it was intended to develop for international use, and for comparisons of aphasia in several languages (Benton 1969). The examination relies on the Token Test (see Section 2.3.3) and on recognition of objects by name for its formal assessment of auditory verbal comprehension. Actual objects are used (e.g. comb, padlock). It gives more emphasis than do other tests to the ability to name objects, testing these through the medium of touch as well as of sight. Some of the subtests assume a fair degree of auditory comprehension; the patient is asked to name as many items as he can in a minute which begin with the letter 'a' or 's' or 'f', and to combine heard words into a sentence.

(This test has been used to measure language development in children as well as aphasia (Gaddes and Crockett 1975).)

2.2.4 Queensland University Aphasia Test (1971) later described as Queensland University Aphasia and Language Test (Jordan and Tyrer 1972)

This test claims to provide for systematic testing of almost all the possible combinations of twelve channels of communication (i.e. the four inputs of auditory non-verbal perception, visual non-verbal perception, auditory verbal comprehension and reading combined with the three outputs of gesture, speech and writing). Only the combinations of auditory non-verbal perception with gesture and with writing are omitted. It is thus similar in approach to the Language Modalities Test for Aphasia. The variables which the authors consider important are carefully controlled; these are word frequency, number of syllables or letters, part of speech and structure of the choice which is offered. Auditory comprehension is tested through four sub-tests:

1) The examiner names an item and the subject points to one out of a choice of 10 pictures (e.g. show me 'the chair'). Variables controlled are word frequency, number of letters, number of syllables and part of speech.
2) The examiner speaks the name of five objects and the subject indicates by gesture which of the five names is the most appropriate for a picture (e.g. is this a dress, a friend, a coat, a box or a boat?). Variables controlled are phonetic or semantic relatedness, number of letters, number of syllables, part of speech.

3) The examiner speaks a sentence or a series of up to five sentences, and the subject selects one out of five pictures (e.g. which man is climbing the tall tree beside the fence?). The incorrect pictures illustrate a sentence which would differ by a key contrast of verb, noun, adjective or preposition. Variables controlled are word frequency, number of words, syllables and sentences, and part of speech in structure of choices offered.

4) A vocabulary test is given in which the examiner speaks one word and then five more words from which the subject acknowledges by gesture the word which is nearest in meaning to the test word. Variables controlled are word frequency, part of speech, number of syllables per word and per set of six words, structure of choice offered (i.e. antonym plus three other incorrect words).

2.2.5 Boston Diagnostic Aphasia Examination (Goodglass and Kaplan 1972)

One of the main aims of this test is to provide data whereby an individual patient can be classified by type of aphasia. Unlike the Language Modalities Test for Aphasia, the patient is classified on the basis of a profile derived from several test scores and ratings, rather than by categorical scoring of single test responses. The classification used is based on Geschwind's (1970) model (see Green 1970), and is achieved largely by contrasting the scores achieved on the auditory comprehension section with ratings derived from spontaneous and expository speech (expository speech being a description of a picture). Four tests examine auditory comprehension:

1) "Word discrimination". The examiner speaks a name, and the patient has to select the item from a choice of 18 items on a card. Six classes of words are distinguished; object names, action verbs, alphabet letters, colour names, shape names and numbers.
2) "Body part identification". The examiner speaks the name of a part of the body, or of a part of the body prefixed by "left" or "right", which the patient has to indicate on his own body (e.g. elbow, left cheek).
3) "Commands". The examiner speaks, singly, five commands for movements which the patient has to execute (e.g. make a fist. Put the watch on the other side of the pencil and turn over the card).
4) "Complex ideational material". The examiner speaks four pairs of sentences to which the patient indicates yes or no (e.g. is a hammer good for cutting wood?). Then the examiner reads aloud four anecdotes, followed by questions to which the patient indicates yes or no.

The test is unusual in distinguishing different categories of words in its auditory comprehension section, including the names of alphabet letters and numbers which some other tests measure under 'reading' or 'arithmetic'. It does not examine phonemic discrimination, but gives more emphasis to body part identification than do other tests.

An addendum to the test includes some 'psycholinguistic' tests which are similar to those suggested by Luria (see Section 2.4.2), but these are referred to as experimental and are not included in the test profiles for classification, nor have they been standardised.

The Boston Diagnostic Aphasia Examination is popular for research purposes where it is desired to have some reference for the classification of subjects by type of aphasia. A Canadian adaptation of this battery is known as the Western Aphasia Battery (Kertesz and Poole 1974).

2.2.6 <u>Examen de l'Aphasie</u> (Centre de Psychologie Appliqué 1965)

This is a popular standard test in France. It has seven sub-tests which examine 'oral comprehension':

1) The examiner speaks a name, which the patient identifies from pictures.
2) The examiner describes the use of an object, which the patient identifies from pictures.
3) The examiner speaks simple directions which the patient has to carry out (e.g. Open your mouth. Close the book in front of you.).
4) The examiner speaks a series of directions (two and three), which the patient has to carry out in series.
5) The examiner speaks an incomplete sentence, and then provides a multiple choice for the ending from which the patient has to select (e.g. I look with my eyes/hands/ears.).

6) The examiner speaks sentences and anecdotes, which contain absurdities, which the patient has to indicate he recognizes.

7) The examiner reads aloud a paragraph about which the patient is then asked questions.

Besides the pass-fail scoring on these items, qualitative scoring of disturbances of comprehension is recorded as blocking, phonemic confusions, semantic confusions, perseverations or anosagnosia (impairment of body-image as evidenced by demise of physical disability).

2.2.7 Quantitative Evaluation of Aphasic's Verbal Performance for Rehabilitation Purposes, Institute of Neurology and Psychiatry, Bucharest (Voinescu, Gheorghita, Dobrota, Bicescu 1971)

An index of decoding abilities is derived from three subtests:

1) "Single word decoding test", in which the patient has to recognise by name each of 10 objects, 10 pictures of objects and people, 10 verbs, 10 prepositions, 10 body parts and 5 colours.

2) "Tridimensional matrix test". This is a 48 item test which is derived from the first sections of the Token Test (see Section 2.3.3) but which does not examine the comprehension of prepositions etc. Each item consists of a three word 'matrix' of adjective plus adjective plus noun which identifies one of eight tokens. The tokens are of two shapes, colours and sizes.

3) "Complex command decoding test". The patient has to follow 10 spoken instructions to move objects and to move parts of his body. This subtest includes a version of Marie's three-paper test (see Section 2.3.1).

From the same centre in Bucharest, Kreindler and Fradis (1971) have described other specialized tests of which two are relevant to the examination of comprehension. The first is described as a "four-links test". It compares timed behaviour on the four possible combinations of non-verbal and verbal input with non-verbal and verbal output. A second test is described as a "notion test" and compares the time taken to find an object identical to a given one with the time taken to find an object which is similar in name but not identical in appearance (e.g. a differently shaped key). This latter test does not examine 'reception' but an ability to use semantic, or perhaps conceptual, information in categorization.

2.2.8 Comment

The formal tests have in common that they compare behaviour in the modalities and that the units of measurement are sentences, words and, sometimes, phonemes and paragraphs. They do not make the distinctions which have been proposed in linguistic theories of phonological distinctive features, semantic features nor of structure within sentences or within discourse (see Section 4.1). They are concerned with quantitative aspects of language like word frequency, number of syllables, sentence length. When distinctions are made by semantic categories, as in one test, it is a gross one such as between letter names and object names. When they make grammatical distinctions it is by parts of speech (sometimes in isolation) rather than by structure.

The organization of these test batteries reinforces the classical diagnostic distinction of aphasics into types in which either speech production is disturbed but comprehension is relatively intact, or comprehension is disturbed but speech production is relatively intact. Wagenaar, Snow and Prins (1975) consider that the clinical and experimental reports which suggest that aural comprehension is disturbed in all aphasics "cast doubt, not only on the traditional basis for classification, but also on the efficacy of traditional language-comprehension tests in the diagnostic process" (page 282).

2.3 The investigation of auditory comprehension in specialized tests

Test batteries which claim to make comprehensive investigations of the disorder in an individual patient must inevitably include measures of performances in the four language modalities. But what of the clinical tests which are free of this constraint, those which have been specifically devised to examine auditory verbal comprehension? If we look at the few examples of such clinical tests (excluding the research procedures to be described in Section 5), we find that they provide a quantitative assessment of auditory comprehension, rather than the qualitative analysis for which we might have hoped from this finer scale of investigation. Some research tests of qualitative distinctions in auditory comprehension have been incorporated into the assessments of the clinics from which they originated (e.g. the assessment used by Hécaen's Unité de Recherches Neuropsychologiques et

Neurolinguistiques in Paris incorporates a test of phonemic discrimination devised by Goldblum and Albert - see Section 5.1.3; and the clinic at Aachen incorporates tests of phonemic, semantic and discourse comprehension devised by Huber, Stachowiak, Kerschensteiner and Poeck (1975)). But the specialized tests of comprehension in common use are less selective: they provide a gross assessment of comprehension, not the qualitative analysis which might suggest the reasons for failure, rather than the fact of failure.

2.3.1 Marie's Three-Paper Test

One of the best-known, and oldest, is Marie's "Three paper test". First described in 1906 (Marie in Cole and Cole 1971), it has been consistently popular. It was one of the tests selected by Weisenberg and McBride (1935) for their psychological study of aphasia and is still used in Bucharest (Voinescu et al. 1971), in Paris (Examen Standard of the Unité de Recherches Neuropsychologiques et Neurolinguistiques) and in Bonn (Leischner 1974). Marie's original version went as follows:

> "Of the three unequal pieces of paper placed on this table, you will give me the largest one, you will crumple the middle-sized one and throw it down, and, as to the smallest, you will put it in your pocket".

Each version used by other clinics is slightly different (for example, in Paris the patient now has to "give me the little one, put the middle-sized one on your knees, throw away the big one"). This short test clearly makes no claims to be standardised, and the presentation varies as much as the content. It puts a substantial load on short-term memory, which must vary according to the speed of the examiner's delivery and the opportunity the patient has to rehearse (or perform) the gestures required at the same time as he listens. As De Renzi and Vignolo (1962) have pointed out, it is also informationally redundant. As Mohr and Sidman suggest (1975), ability to pass this test can show that a patient is not aphasic, but failure can be for many reasons.

2.3.2 Head's Hand-Eye-Ear Tests

These were part of a set of tests devised by Head (1926, Vol. 1 pages 149-160) to assess aphasia using only the most simple materials. He included the naming and recognition of common objects and colours and the reading and writing of three words (man, cat, dog), and the setting of a clock face to aural and written commands. The comprehension of numbers was examined through the 'coin-bowl' test in which the patient was asked either in speech or in writing to place one of four pennies into one of four bowls according to the appropriate number. The 'hand-eye-ear tests' are the best known of Head's tests; originally they included a modality comparison: the patient was first asked to imitate gestures in which the left or right hand touched the left or right ear or eye, then to execute these actions by copying them from drawings, then to execute them from oral commands and from written commands and finally to write down the actions performed by the examiner. The ability to perform ipsilateral actions could be compared with that to perform crossed actions and with that to recognize left-right relationships on someone else's body. The aural comprehension version is the most popular of these tests to survive, as for example in the Boston Diagnostic Aphasia Examination. But the use of body part names and left-right discrimination has been criticized. The tests may measure spatial abilities and body awareness which can be impaired independently of aphasia (Benson and Geschwind 1975). Moreover Wolf (1973) has reported that difficulties in left-right discrimination are relatively common in normal subjects: 17.5% of women doctors or doctors' wives have uncertainties about relating the words left and right to their own bodies.

2.3.3 The Token Test

Judging from accounts in published papers, this is fast becoming the most internationally popular test for aural comprehension in aphasia. Leischner (1974) reports, disapprovingly, that it is the principal means of assessing comprehension in many German clinics; it is so used in the Neurosensory Center Comprehensive Examination for Aphasia, and in the Bucharest test described above (in a modified version).

It was devised in Milan (De Renzi and Vignolo 1962) with the express purpose of detecting receptive disorders in patients in whom comprehension appeared to be unimpaired on standard clinical testing, even when the investigation had been "far more thorough than a routine clinical examination of aphasia". It has been extremely successful in this respect; through it, it has become clear that many 'motor aphasics' without apparent disorders in comprehension do in fact have difficulty in understanding language, and has stimulated research into the nature of these difficulties (see Part Three, Section 3.3.1).

The aims of its designers were that it should be short, require no special apparatus, should not tax memory or intellect, but should contain considerable difficulties on a linguistic level. The linguistic difficulties should be attributable not to complexity of structure, nor to low-frequency words, but to "lack of redundancy". There should be no extra-linguistic cues for comprehension from the situation, nor from the nature of the objects used. Nor should there be duplication of linguistic cues within the sentence: each word should be indispensible.

They used a set of twenty tokens "like those used in card games". They were of two shapes (circles and rectangles) of five colours (red, green, blue, yellow, white) and two sizes. The examiner speaks a sentence and the patient indicates comprehension by picking up or moving one or two tokens (or sometimes by touching several) according to the instruction. De Renzi and Vignolo did not prescribe an exact set of sentences for the first four parts of the test, but recommend that each part should contain ten sentences beginning with "pick up" or "take", although the exact execution of the activity named in the verb is not important in these parts. The essential content of the first set of sentences is a colour and a shape word, and of the second a colour, a shape and a size word, in each case identifying a single token. The third and fourth parts double these contents, and in each case two tokens have, therefore, to be identified. For the fifth and final part De Renzi and Vignolo prescribed twenty-one exact sentences. For these the patient needs to decode syntactic structure and grammatical particles. Locative prepositions, conditionals, relative conjunctions and adverbs are included, and the verb also varies significantly from "pick up" or "take" to "put" or "touch". Some research studies have recommended the use of only this last part of the test as being sufficient to reveal receptive disorders. The Token Test has been used as a standard of comparison in the present investigation, and some of these research studies and their findings are, therefore, reported in some detail in Part Three, Section 3.3.1.

2.3.4 Fingerle's Test for Receptive Aphasia

This test is not yet published (Denison personal communication 1975), but is included here as an example of how a formal test can set about the investigation of a patient who has essentially no speech. It has five sections:

1) The examination of general orientation and information (e.g. recognition of dates, familiar names and places).
2) The examination of sensory abilities (i.e. recognition and identification of sounds, tactile information, gesture, speech, the identification of missing parts and the matching of visual items).
3) The examination of comprehension of items which are of personal interest (e.g. preference for tea or coffee, hairstyles).
4) The examination of comprehension of numbers.
5) The examination of 'language comprehension' in general. This is tested by letter and word recognition, copying, spelling, recognition of grammatical acceptability in printed sentences (varied by part of speech as nouns, verbs, prepositions, pronouns, interrogative words and contractions), comprehension of a heard paragraph tested by four-choice answers, and comprehension of a paragraph by silent reading.

It is intended in all these subtests that the patient should indicate comprehension by pointing to a picture or by selecting a word from multiple choice; however, a number of patients spontaneously use speech to reply. It is thus possible to obtain a measure of the patient's spontaneous use of speech under circumstances where it is not 'compulsory' and where alternative adequate means of response are available. This has the incidental merit of consistently recording one functional level of availability of speech, which is different from the forced speech elicited in most tests. Denison (1971) reports that 16 out of 30 aphasic patients did not give any correct spoken responses to any test items, i.e. "they were unable to respond verbally to a specific item at a specific time" despite showing some evidence on other occasions of intelligible verbal expression. Somewhat contrarily, then, a significant contribution which this test of 'receptive' aphasia could make is the measurement of the functional level of availability of speech. Sections 1 and 3 on general and personal information showed least (although significant) impairment between aphasic and control subjects, suggesting that there may be functional levels of availability of comprehension as well as of speech. This theme is expanded in Section 3.4.

2.3.5 Comment

Specialized tests of auditory comprehension (like some of the subtests in the larger batteries) often rely on elaborative gesture as a means of indicating comprehension. They also do not acknowledge the importance of memory load in comprehension: the Token Test is claimed not to tax memory, but there is some evidence that it is in fact highly loaded with memory for sequence, verbal, visual and gestural

(Lesser 1976). For both of these reasons they provide estimates of a patient's language knowledge which are more contaminated than need be by difficulties of execution. In summary, they are efficient in detecting that there is a disorder, but not in revealing its nature.

2.4 The informal investigation of auditory comprehension

Two approaches will be described under this heading. In one, observations are made informally of the patient's comprehension in everyday circumstances but these observations are structured into a formal profile. In the other, a flexible approach is used with a repertoire of structured materials which can be drawn upon as is felt appropriate for the examination of an individual patient. In the latter case, in contrast to the previous tests described, the materials themselves are not specified but rather the principles by which they are to be selected.

2.4.1 Functional Communication Profile (Taylor 1965)

At the time of writing this assessment procedure appears to be unique in that it is based on informal judgement of functional performance not on test data. The information is derived from the assessor's own observation of the patient's behaviour and from relatives' accounts. As an assessment of functional behaviour it necessarily uses a modality framework for description. Fifteen items are used for the rating of 'understanding' (plus eight for reading); each is rated as normal, good, fair, poor or none:

1) Awareness of gross environmental sounds.
2) Awareness of emotional tone of voice.
3) Understanding of own name.

4) Awareness of speech.

5) Recognition of family names.

6) Recognition of names of familiar objects.

7) Understanding action verbs.

8) Understanding gestured directions.

9) Understanding verbal directions.

10) Understanding simple conversation with one person.

11) Understanding TV.

12) Understanding conversation with more than two people.

13) Understanding movies.

14) Understanding complicated verbal directions.

15) Understanding rapid complex conversation.

Although the ratings are avowedly subjective, reasonably good inter-assessor reliability has been reported, and the Profile is reportedly used in Scandinavia, as well as in New York where it originated (Reinvang 1969).

2.4.2 Investigation of 'receptive speech' (Luria 1970)

The flexible approach to the examination of the disorder in the individual patient has been used by several investigators, as a supplement to, or sometimes instead of, formal testing using published material (see for example Penn 1974, Ulatowska and Richardson 1974). It is easier to relate the material to the special interests, and special difficulties, of the individual patient. The investigator has certain qualitative distinctions in mind, and draws on a repertoire of short informal adjustable tasks to explore the quality of the disorder. The best-known proponent of this method is Luria. For Luria, comprehension is not only the reception of signals; it includes the underlying knowledge which is characterized as 'inner speech'. His examination of 'receptive speech', as outlined in his book on traumatic aphasia based on studies of war-injured soldiers, examines the qualitative distinctions which can be related to the three main 'decoding' syndromes he describes of acoustic-agnostic, acoustic-amnesic and semantic aphasia. Luria considers that the aphasic deficit in one of these syndromes (acoustic-agnostic) is secondary to a disability in phonemic discrimination (a position which has, however, been refuted by Blumstein, Goodglass and Baker 1973 and by Naeser 1974). Luria's examination, like the Boston Diagnostic Examination for Aphasia, is therefore designed with the purpose of placing the patient into a syndrome; but unlike the American test the syndrome is identified not by comparison of performances in modalities, but by qualitative differences within one modality. Luria's examination is also novel in that it relates as much to the dynamics of the disorder as to its state. He is interested in the effect of the rate at which tasks are presented, in the amount of information which can be coped with at certain speeds and in the stability of various aspects of comprehension as a function of time. Luria's system of investigation is receiving increasing interest from the West, and a version of his tests has recently been published in Denmark (Christiensen 1975).

Luria distinguishes four aspects of comprehension:

1) Phonemic hearing, the recognition of meaningful combinations of distinctive features.

2) The comprehension of word meaning, particularly as regards the breadth and stability of meaning.

3) The comprehension of grammatical relationships amongst words.

4) The awareness of the 'concrete' setting in which speech is heard and of the intentions of the speaker.

The two last aspects are classed by Luria as the predicative aspects of language comprehension, in contrast to the nominative (2) and the phonemic (1). These aspects bear a close relationship to the divisions made by many linguists into the phonological, semantic, syntactic and sociolinguistic aspects of language. Perhaps because of the relative youth of the patients with whom he worked out his investigation, and the selectivity of their head injuries, some of Luria's investigations of comprehension require the patient to speak and assume a fair ability to understand instructions and to perform metalinguistic tasks. Luria categorises his measures of reception under three headings, phonemic hearing, word comprehension and grammatical structure:

A. <u>Phonemic hearing</u>

1. Discrimination of disjunctive and opposite phonemes ("disjunctive" contrast by more than one distinctive feature, "opposite" by one).

   a) The patient is asked to repeat, write, or point out from a list which syllable he hears, e.g.

      ba-sa   pa - ba   pa - pa
      ba-ra-ma   ba - pa - ba

   b) The patient is conditioned to raise his hand every time he hears "ba" and not when he hears "ra" (disjunctive); he is then tested with an oppositional contrast "pa".

   c) The investigator varies the pitch of the two syllables, to test whether discrimination is aided.

   d) The investigator varies the rate of presentation, or introduces extraneous stumuli, or asks the patient to perform his task after delay.

e) The patient is asked to detect incorrect pronunciation in a list of words in which some are correct, some incorrect, e.g. ging king.

f) Patients who can speak are asked to name several words beginning with the same letter.

2. The patient is asked to indicate how many sounds there are in a word, e.g. cat

and then to do this with external speech blocked by holding the tongue between the teeth.

3. The patient is asked to name the letters in a word in a different order. If he can only name them in the standard order, it is deduced that intonational images are preserved but not their precise phonetic-articulatory context.

4. The patient is asked to synthesize individual sounds into syllables and words. This is also tested without external speech (writing or multiple-choice), and both with and without allowing the patient to watch lip movements.

B. <u>Word comprehension</u>

1. Preservation of nominative function is examined in the following ways. The investigator speaks the names of objects, the patient points, explains or mimes their use. The items are contrasted by being in sight or not, being common or rarer (cheekbone, finger-nail) or by having repeated syllables. The investigator notes whether the patient points without repeating the name himself. The recognition of words in isolation is compared with their recognition when used in meaningful sentences.

2. Stability of nominative function is tested in the following ways.

a) The word is used repeatedly, e.g. the investigator names several objects many times in random sequence, such as
eye - ear - nose - ear - nose - eye - ear ....
and the patient points to the items. If meanings are not stable the patient will begin to make errors after three or four trials.

b) The amount of information to be retained is varied, e.g. two or three items are named together and the patient points at them after hearing all the names.

c) Retention span is tested, with delays of varying length before the patient points to one or two items.

3. The structure of word meanings is examined in the following ways.

a) The patient is asked to define words, e.g. "liquid", "transport" and to explain metaphors, e.g. "an iron hand", "green fingers".

b) The patient is asked to point out objects (pictures) belonging to a category, e.g. "vehicle", "building". If the patient points out one type of vehicle only - such as cars only, not lorries - it indicates a constriction of word meaning. If the patient points out objects such as "stove" and "furniture" for "building" it indicates a loss of categorical meaning.

C. Grammatical structure

1. Simple forms (these are case suffixes in Russian, but prepositions in English). The patient is first asked to point out pairs of objects in the same order as the investigator has named them (e.g. key, comb) and is then given a sentence which includes both words (e.g. "with the key, point to the comb"). The investigator then reverses the instruction ("point to the key with the comb") - the patient with such sentences has to inhibit the tendency to pick up the first named object.

2. Attributive constructions, e.g. "mother's daughter", "father of the brother". The patient is asked to point in a picture to the mother and to the daughter and then to point to the mother's daughter. He is asked to explain the difference. The investigator speaks two phrases such as "the wife of the sister" and "the sister of the wife" and is asked which is nonsense.

3. Locative prepositions.
The patient is asked to draw (or put) "a circle under a triangle", "a triangle under a circle" or given a triple instruction "draw a circle under a triangle and above a cross" or "place the pen to the right of the key and to the left of the comb".

4. Comparatives.
The patient is asked to indicate which is correct "An elephant is larger than a fly" "A fly is larger than an elephant".
The investigator provides two papers of different colours and asks "Which is lighter....darker....less light....less dark?"
The investigator provides three coloured circles and asks "Which circle is larger than the red one and smaller than the blue one?"

5. Inverted constructions.
The patient is asked to choose the correct one from "The earth is illuminated by the sun" "The sun is illuminated by the earth".
He is asked to answer questions such as these: "I ate after I chopped the wood - what did I do first?" "Peter struck John - who was the victim?"

6. Conflicting instructions.
"If it is night now put a cross in the white square; if it is day now put a cross in the black square". "Tap twice when I tap once, tap once when I tap twice".

7. Complex grammatical constructions.
Conjoined sentences are compared with complex (embedded) sentences, e.g. "Father and mother went to the theatre but the old nurse and the children stayed at home", with "The woman who worked at the factory came to the school where Dora studied to give a talk". The patient is given the sentence for silent reading and then asked to answer questions about who left, who stayed at home, who gave the talk, where the talk was given, etc. The task is given with the sentence removed or with it left in front of the patient, to assess whether failure is due to memory or difficulty in recognising grammatical relationships.

8. Comprehension of fables.
This tests the ability to grasp general meaning. The patient is asked to repeat the story, explain the underlying meaning and to tell the moral.

2.4.3 Comment

In Luria's investigation, and in Schuell's, but in no other published clinical test which has achieved wide currency, we find a systematic exploration of some qualitative distinctions within comprehension (in Luria's case it is distinctions amongst phonemic, lexical and grammatical comprehension; in Schuell's case amongst auditory discrimination (phonemic), auditory recognition (semantic), and auditory retention span). In other formal investigations there is a partial acknowledgement (often more incidental than systematic) of some facets of these qualitative distinctions. One variable which influences retrieval from the lexicon is singled out, word frequency: one aspect of grammatical comprehension, the distinction by parts of speech; and retention span is acknowledged in the majority of tests by making the items within a subtest increase in length (Porch, 1967, has pointed out, however, that this distorts scores for patients who take some time to adjust to the requirements of a subtest). But acknowledgement of these facets in the test batteries does not amount to an examination of systematic qualitative distinctions in comprehension as distinct from differences of degree. From the linguist's point of view it is such possible qualitative distinctions which are of interest, and these are discussed in the next section.

3. Qualitative distinctions

The first qualitative distinction to be made in disorders of verbal comprehension was between a type of disorder now known as either word-deafness or as auditory agnosia for speech and impairment of referential meaning. It is a distinction which Wernicke did not make: in fact he described the second impairment in terms of the first. But an early description by Bastian (1869 cited by Goldstein 1974) acknowledges different origins for disorders of comprehension:

> "In certain of the severe cases of aphasia .... it is distinctly stated that the patient either did not gather all or with difficulty and imperfectly the import of words when he was spoken to, though he could be made to understand with the utmost readiness by means of signs and gestures. Must we not suppose that in such a condition either the communication of the afferent fibres with the auditory perceptive centres is cut off, or that this centre itself, in which the sounds of words are habitually discriminated and associated with the things to which they refer is more or less injured?"

From Bastian's account we can distinguish three components in auditory comprehension: the relaying of acoustic information to perceptive centres for its analysis, the discrimination of word-sounds, and the association of words with their meaning. The first component is auditory perception, which need not be verbal, the second is the component which is disturbed in auditory agnosia for speech, the third is the component which is disturbed in 'Wernicke's aphasia' as it is sometimes now defined.

3.1 Three kinds of impairment in auditory comprehension

3.1.1 Auditory perception and agnosia

Auditory perception is now recognized as implicating many diverse abilities. Martin and Martin (1973) distinguish three levels of organization in hearing: the transformation of acoustic energy into activity in the auditory nerve, the discrimination amongst sounds along several parameters (time, periodicity, frequency, loudness, direction), and the recognition and identification of sounds. The deaf person is impaired at the first level, but there can be impairment at the second level which affects hearing more subtly; Martin and Martin report "a wide range of auditory skills for different individuals, even within a relatively homogenous group" of sixth form schoolboys, without intercorrelations in ability to perform different tasks of discrimination of frequency, duration and rhythmic pattern. A deficit at the third level of perception is subsumed under the general name of 'agnosia'. Here, too, further subcategorizations must be made.

A distinction which Hirsh (1959) makes at this third level is between simple recognition and identification, and comprehension defined as recognition sustained over a long period of time. This dynamic factor is often ignored in analyses of comprehension disorders, although there are frequent clinical reports of patients who can comprehend if given sufficient time, while others apparently cannot sustain recognition long enough to comprehend. One of the earliest (1843) personal accounts of an aphasia was given by a professor of physiology who acquired a transient language disorder at the age of 52, Lordat. Bay (1969) considers his disorder may have been a transient bulbar paresis with hysterical components; nevertheless Lordat describes, as well as his speech impediment, a disorder of comprehension which is specifically related to timing:

> "I was no longer able to grasp the ideas of others for the very amnesia that prevented me from speaking made me incapable of understanding the sounds I heard not quickly enough to grasp their meaning. Inwardly I felt the same as ever."

Nielsen (1946, page 69) identified Lordat's disorder as sensory aphasia. A more recent account of timing difficulties in comprehension is by Albert and Bear (1974).

Agnosias are said to be selective by sensory modality (auditory, visual, tactile). Within auditory agnosia, selective disorders have been described for music (Wertheim and Botez 1961), for meaningful sounds (Spinnler and Vignolo 1966, Albert, Sparks, Von Stockert and Sax 1972), and for speech. Selective agnosias for music and for speech can be reconciled with current theories about the separation of music and speech in the cerebral hemispheres (Kimura 1973)(although amusia has been reported after left hemisphere damage as in Wertheim and Botez' patient, and Gardner (1975) suggests that music is bilaterally represented). It also seems that acoustic processing and phonetic processing in speech perception can be experimentally distinguished by dichotic listening and electroencephalographic recordings (Wood 1973). But recognition of meaningful sounds seems to bridge the border between the acoustic and the verbal, and its nature has been the subject of some dispute.

Albert et al. (1972) defined auditory agnosia as an inability to associate sounds such as a telephone bell, a siren or animal cries with their referents, despite good pure-tone hearing, and concluded that it involves a central auditory processing mechanism which is different from the one involved in treating linguistic inputs. It is examined by asking the subject to select a picture to match a sound which he hears. The incorrect pictures illustrate sounds which are acoustically similar or ones which would be produced by sources in the same semantic category as the heard sound (e.g. a different kind of bell from a telephone bell, or a different kind of animal). Vignolo (1969) suggests that right hemisphere damage can impair acoustic discrimination (Martin and Martin's level two), as evidenced by selection of the pictures for acoustically similar sounds, while left hemisphere damage can affect semantic identification (Martin and Martin's level three) as evidenced by selection of incorrect semantic choices. In contrast Albert, Benson, Goldblum and Hécaen (1971) report a correlation between acoustic-type errors and left hemisphere anterior lesions, and between semantic-type errors and posterior lesions in either hemisphere. Albert et al. consider it possible to dissociate 'semantic' meaningfulness from language. They consider, with Kimura, that the right hemisphere predominates for non-verbal sounds whether meaningful or not. Not surprisingly auditory agnosia is frequently associated with bilateral temporal damage (Mills 1891, Lhermitte, Chain, Escourelle, Ducarne, Pillon and Chédru 1971, Jerger, Weikers, Sharbrough and Jerger in Lebrun and Hoops 1974). Auditory agnosia according to Albert et al. (1972) is an inability to associate a perceived non-verbal sound with its meaning not simply because it cannot be associated with its name, but rather because the correspondence between the perceived sound and its sensory or motor associations cannot be established. Yamadori and Albert (1971) have proposed a "step-wise series of neuropsychological processes dealing differentially with the perception of meaningful non-word sounds and word-sounds, each of which has word-meaning attached at a different level."

3.1.2 Agnosia for speech

Agnosia for speech or pure word-deafness is an inability to associate verbal sounds with meaning, although pure-tone hearing and recognition of other non-verbal sounds is retained. On a test for auditory agnosia for meaningful sounds such as that just described, the patient would not be expected to make errors, either acoustic or semantic, provided the input was non-verbal. His difficulty is exclusively in recognising auditory verbal sounds, and consequently, though he would be able to match the sound of a telephone bell with a picture of a telephone, he would not be able to match either with the spoken word 'telephone'. Reading, writing and speech, however, should be normal. As the disorder is thus limited to one modality (at least in the syndrome as theoretically detailed), some authorities do not regard it as an aphasia (just as they exclude pure alexia and dysarthria). Others do include it amongst their classifications of aphasias on these grounds: firstly auditory comprehension has a primacy amongst the modalities of language use, and impairment in this modality therefore warrants attention as aphasic, where other selective impairments do not; and secondly (and consequently) in actual fact there are always secondary effects on the other modalities of language. Marie (1906) went so far as to describe the syndrome of 'pure' word-deafness as a "simple myth". Luria (1964) refers to it as "very rare" and "so-called pure verbal deafness". A more recent survey calls the syndrome "rare" (Hécaen and Goldblum 1972). Goldstein (1974), however, has reviewed a number of cases in the literature which approximate to this syndrome, and which evidenced a selective difficulty in perceiving speech despite normal or nearly-normal hearing for pure-tones. Naeser has examined one such patient (1974) and compared her results on tests of auditory comprehension with those of Wernicke's aphasics. In contrast to them she was more impaired on a test of phoneme discrimination which required same-different judgement of spoken words than she was on a test which required the same minimally distinguished pairs of words to be matched with a picture. Phoneme discrimination appeared to be less impaired for phonemes of longer duration and for those which may be less lateralized to the dominant hemisphere (Studdert-Kennedy and Shankweiler 1970), i.e. fricatives and vowels. Although described as an example of pure word-deafness, Naeser's patient initially presented as a 'jargon' aphasic, with impaired repetition, comprehension, and dyslexia and dysgraphia. (Mohr and Sidman 1975 also report that "the rarer cases of pure word deafness usually are considered initially to reflect central, or Wernicke's, aphasia".) By the time of testing, however, reading and writing were unimpaired and speech output was 'normal' but with an altered melody with fast crescendo-like phrases. Despite her inability to comprehend speech, this patient could discriminate between English and other languages.

Whether or not pure word deafness can exist in isolation without other impairment of language, the descriptions of its nature are identical with those that have been proposed for 'auditory imperception' as a component of aphasia.

The nature of word-deafness has been characterized in several ways. Conrad (1954) has described it as an inability to detach auditory Gestalten from their background. According to Klein and Harper (1956) it can incorporate a disability in sequencing acoustic stimuli; speech is heard as a continuous hum without rhythm. Albert and Bear (1974) agree that time-sense is impaired in word-deafness but also single out another quality besides sequence, temporal resolution. They offered a neuroanatomical explanation for one case of word-deafness. They deduced that there was a subcortical lesion in the left temporal lobe which disconnected Wernicke's area from inputs to this lobe, although the pathways along the corpus callosum which linked left and right temporal lobes were relatively well preserved. They suggested that linguistic inputs had to be relayed to the left temporal lobe via the right temporal lobe instead of directly, thus slowing down the process and resulting in the patient's not being able to understand speech at a normal rate. An alternative hypothesis was that the linguistic processing occurred in the right hemisphere itself, and was therefore less efficient as the right hemisphere lacks the specialization of the left for temporal resolution and sequencing. Schuell et al (1964) have commented on similar timing difficulties in aphasia. This auditory imperception was described as a "marked on-off effect, as if the signal were not received". Wepman (1972) has also commented on this phenomenon in aphasia as of fluctuating inattention. Luria and Karasseva (1968) refer to a similar phenomenon - a loss of auditory speech memory due to a heightening of auditory speech-trace inhibition, but suggest that there need not be any disturbance of the acoustic analysis of speech sounds as such. Salvatore (1972), interpreting imperception in a slightly different way from Schuell and her colleagues, as temporary forgetfulness of the task, claimed that transitory imperception in aphasics did not occur in a visual non-verbal task. The task was to select a match for a figure from four choices: the matches involved colour, size, shape, rotation, spatial organization, missing parts and figure ground discrimination. A baseline probe item (matching of a horizontal line) inserted in the test was always performed without error, although there were several errors in test items themselves. Salvatore concludes that the aphasic's errors are not due to a switching off of attention.

It seems as if imperception as a component of the language deficit in aphasia is the same as in its (theoretically) isolated occurrence in agnosia for speech: it is peculiar to the auditory medium, and it is probably not an absolute deficit but fluctuates at different moments of time. Luria's explanation (1970 page 127) of the basic deficit in sensory or acoustic-agnostic aphasia as a disturbance of auditory analysis and synthesis is that it is due to an instability of the phonemic component or 'auditory image' of words, rather than of a semantic component. Words can potentially be perceived correctly and their meanings recognized but the auditory image fluctuates: there is instability of audio-verbal traces (Luria 1973). Rinnert and Whitaker (1973) interpret this as a defect of short-term auditory memory.

3.1.3 Impairment in relating verbal input to meaning

In agnosia for speech, whether it is conceived of as a distinct syndrome, or as a type of sensory aphasia, or as a component in aphasia per se (if aphasia is conceptualized as unidimensional), the disturbance is essentially at the level of speech-sounds. Word meanings as such need not be disrupted, as evidenced by the reportedly normal speech of some people with pure word deafness. This is not necessarily so in the third kind of impairment which Bastian's early account anticipated, a disorder in relating verbal input to its reference. It is unambiguously classed as an aphasia, specifically as sensory or Wernicke's aphasia ('sensory' not in this case having the same meaning as in the syndrome described by Luria as acoustic-agnostic), or in an extreme form as sensory transcortical aphasia. Naeser (1974) describes it as "impaired phonemic-semantic association ability". Weisenberg and McBride (1935) distinguished receptive disturbances more marked in the appreciation of meaning from those more marked in appreciation of speech sounds, and commented (page 63) on the irregularity in the relationship between the two processes in individual patients. Goldstein (1948 page 226) explains the semantic paraphasias (use of words associated in meaning instead of the exact word) in the speech of Wernicke's (or in his terms "central") aphasics as being secondary to this kind of auditory impairment:

> "the sound complex may be sufficiently precise to awaken a realm of ideas to which the idea belongs without being precise enough to awaken the individual idea which belongs especially to the presented word" (page 226).
>
> "The patient may not .... be able to perceive the word so well that he is able to understand it or repeat it, but sufficiently enough so that the sphere of meaning to which it belongs is elicited and the patient may summon up another word belonging to this sphere" (page 91).

Conrad (1954), having defined pure word deafness as an inability to separate auditory figure from background, defined sensory aphasia as a disorder in the reception of auditory Gestalten as the carriers of signification. Weigl and Bierwisch (1970) also distinguish the identification of phonemic or graphemic structure in the processing of incoming words from a second subcomponent, the summoning up of meaning. The results of each of these operations, they say, have to be stored in short term memory. They give an illustration from alexia of the separation of retention of graphemic structure from meaning. An alexic patient had been asked to read some words but had failed; on hearing a word spoken he realized that it was one of these words. He thus demonstrated retention of graphemic structure, when meaning could be accessed through a less damaged modality, hearing, though it could not be linked with meaning through the damaged modality of reading. Weigl and Bierwisch considered that phonemic or graphemic short term storage of this nature is limited to three words or to a few letters or syllables.

According to Albert and Hécaen (1972) "auditory and semantic processing can be distinguished and may have separate anatomical localizations" in the brain. Some phonemic processing takes place in the left frontal lobe, while semantic processing is a temporal lobe function. "Final integration of acoustic inputs to arrive at full auditory comprehension seems to involve, in addition to primary phonemic and semantic processing in diverse areas of the left cerebral hemisphere, an element of sensory-motor integration plus a capacity to maintain and utilize sequential aspects of an acoustic input".

Luria's (1970) second syndrome in which disorders of decoding are primary, acoustic-amnesic aphasia, is described as a defect in the permanent memory of the sound structure of words (according to Rinnert and Whitaker (1973) a defect in long term memory, rather than short term as in acoustic-agnostic aphasia). In physiological terms Luria (1973 page 144) interprets it as "a pathologically increased inhibitability of the audio-verbal traces". When the lesion extends into the posterior zones of the left temporal region, there is a disturbance both in naming and in evoking visual images for heard words, as the link between the "auditory and visual analysers" is disturbed. Sound and meaning are thus separated.

An extreme form of dissociation of verbal input from meaning is that described by Geschwind and Kaplan (1962) as "isolation of the speech area". Goodglass and Kaplan (1972) and Von Stockert (1974) identify it with the syndrome of transcortical sensory aphasia. Von Stockert says of it that "the phonemic structure is understood but meaning is not". The bidirectional separation of the speech-sound system and the meaning system is deduced because the patient, unable to understand speech or to speak meaningfully, readily echoes back utterances and can complete automatic-phrase jingles. Nielson (1946) also described these features in transcortical sensory aphasia: "the patient can repeat what he hears without understanding it" (page 32).

3.2 Qualitative distinctions which may not be specific to the auditory modality

Bastian's comments about comprehension difficulties, probably the earliest in the scientific study of aphasia, have thus been endorsed by modern studies of two aspects of difficulty in understanding speech - breakdowns either at the level of speech sounds or in relating these sounds to meaning. They do not, however, exhaust the possibilities for the qualitative analysis of comprehension disorders. We have already commented that Schuell singled out reduced auditory retention span as a significant factor and this will be discussed in detail in Section 3 of Part Four. In 1953 she commented that the correlation between comprehension impairment and improvement following therapy "depends less upon the degree of impairment than upon the kind of receptive difficulty present. Thus it appears that receptive language disturbances do not constitute an entity" (page 176). She distinguished two kinds of receptive disturbances. The first is "a fundamental break-down of symbolic processes" with poor prognosis for recovery: the second is "an impairment of the ability to evoke or recall sound sequences utilized in language", and the prognosis for recovery is favourable. Both these kinds of 'receptive' disorders seem to transcend the specific input of modality, hearing, and appear to be breakdowns at a more central level. Agnosia for speech is defined as being modality specific; a failure in phonemic-semantic links may be interpreted in the same way, although, because of the close relationship between phonemic and graphemic coding, and because the break in the link may be bidirectional, it is more commonly interpreted as a disorder affecting all modalities; but a breakdown in the meaning system itself must have repercussions on all modalities.

Some examinations of comprehension disorders have, therefore, approached the problem indirectly. They have classified those patients who appeared to have comprehension disorders, not on the basis of theoretical concepts of qualitative distinctions in comprehension, but by their observed behaviour in speech, and then secondarily proposed distinctions in comprehension. A more recent approach is the study of comprehension deficits in those patients who have traditionally been classed as 'motor' aphasics with 'good' comprehension. These two approaches are described in the next two sections.

3.2.1 The 'impaired comprehension' syndromes

A modern classification of 'Wernicke's aphasias' (i.e. aphasias in which there is a marked deficit in comprehension) distinguishes four forms through features of their production of speech. These four forms are characterized, respectively, by predominantly semantic paraphasia, by semantic jargon, by phonemic paraphasia and by phonemic jargon (Huber, Stachiowiak, Kerschensteiner and Poeck 1975). But the best known analyses of the 'sensory' syndromes have been made by Luria and by Hécaen and his colleagues.

Two of the 'decoding' syndromes which Luria described have already been discussed (acoustic-agnosia and acoustic-amnesia). Their names reflect their links with the auditory modality. The name of the third syndrome Luria described amongst the receptive disorders, semantic aphasia, indicates that the disability is more central - hence Jakobson's (1964) suggestion that the translation 'decoding' was more appropriate than 'sensory' or 'receptive'. The essential difficulty in semantic aphasia is in organizing the separate components of language into a coherent unity. Luria locates the site of lesion in the parietal or temporo-parietal areas of the left brain; hence this difficulty in simultaneous synthesis can be traced in other aspects of behaviour besides language (for example construction and calculation). In language two deficits may be distinguished. Because of the complex system of ties and interrelationships contained within each word, there is a disturbance of lexical meaning. Secondly because of the similarly complex system of ties and interrelationships between words when they are used in syntactic units or sentences, there is a disturbance of grammar. Luria stresses that syntactic relationships are not simply a matter of sequence, but that they require simultaneous synthesis of systems of connections of meaning, of and beyond the meaning of individual words. The aspects of grammar in which the semantic aphasic's disorder may be most sensitively displayed are case forms and auxiliary words such as conjunctions and prepositions. Luria's examination of grammatical disorders in 'receptive speech', already described, shows how this disorder may be examined through, for example, possessive constructions like 'father's brother', 'brother's father'. In semantic aphasia the acoustic structure of speech is preserved, and there is not the alienation of meaning from phonemic structure of the word which is proposed in acoustic aphasias, but "the patient proves to be unable to perceive those complex relations into which the logico-grammatical system of language places separate concepts" (Luria 1964, page 157).

Hécaen and Goldblum (1972) have proposed a threefold classification of the sensory aphasias which partially overlaps with Luria's. The first type is called "sensory aphasia with predominant verbal deafness", and appears to correspond with Luria's acoustic-agnostic aphasia. Speech is characterized by paraphasias (incorrect words) and neologisms (new words), but nevertheless the general theme of a discourse can be maintained. Repetition of a heard utterance is impossible whether the utterance is meaningful or not. Phonemic discrimination, as assessed either by word discrimination or by picture selection, is impossible. In contrast reading comprehension and writing are relatively good. The second type is described as "sensory aphasia with predominant comprehension difficulty": although it partly corresponds to acoustic-amnesic aphasia, Hécaen's account draws attention to disorders of speech which seem to be much severer than those described by Luria (1970 page 140) in nine illustrative cases of his syndrome. According to Hécaen speech is stereotyped and disjointed with incomplete phrases, numerous paraphasias and "glissements" of meaning. The content of the discourse is not pursued. Words can be repeated after being heard, but nonsense items not so easily. Longer items are easier to repeat than shorter ones where the informational content is not supported by a phrase structure. Phonemic discrimination is adequate, but following of either aural or printed directions is poor. While spontaneous writing is characterized by many paraphasias, writing from dictation is better. The third type is peculiar to Hécaen's classification, "sensory aphasia with attentional disorganization". Speech is extremely disjointed and intelligibility is consequently poor. Speech is characterized by perseverations and reiterations and by echolalic responses to other people's words. Sentences are not completed, due to distractability, but the syntactic structure of phrases is maintained, though not their semantic selection restrictions. Aural comprehension, though impaired, appears to be superior to comprehension through reading. Repetition of heard utterances is satisfactory. In some respects this disorder, as evidenced in speech, resembles that described in syndromes in two other classifications. The echolalic tendencies are characteristic of transcortical sensory aphasia, and both these and the inability to pass from one item of discourse to another are features of what Luria classes as a motor syndrome, dynamic aphasia after frontal lesions.

Over ten years of observations in his clinic, Hécaen reports finding twenty-five clear-cut examples of these three sensory syndromes, nine with type one, eleven with type two and five with type three. An analysis of their speech characteristics (Dubois, Hécaen, Cunin, Daumas, Lerville-Anger and Marcie 1970) confirmed that they differed objectively on speech, as well as on the sensory aspects of the disorder. Types one and two differed according to the quality of paraphasia (substitutions or neologisms), while type three was distinguished from both by superior syntactic 'depth' as measured by the average or maximum number of right branchings in a sentence (Yngve 1960).

The attentional disorder Hécaen describes reminds one of the comments of Schuell, Wepman and others of disorders of fluctuation of attention in aphasia. They appear, however, to be attributing it to an auditory imperception primarily affecting phonemic perception, rather than to a failure to maintain attention to larger units of language. Wepman's comments also imply that it is a characteristic feature of aphasia rather than being peculiar to one type. From Hécaen's description it would appear that the patient with this disorder cannot maintain the semantic content of what he hears or of what he would wish to say long enough to hold his attention to either task. It is possible to interpret this in a different way, as will be done in Section 4.

The differential analysis of syndromes has, thus, added more qualitative distinctions in verbal comprehension to our list from Bastian; these are a disturbance of word meaning as such, a disturbance in logico-grammatical relations, and an attentional disorder. We can also add to the list a reduction in short term auditory memory which appears to be of a different nature from an attentional disorder as such.

3.2.2 The 'good comprehension' syndromes

One of the merits of the Token Test has been that it has forcibly drawn attention to something which had been half acknowledged but dismissed from mind as it was not compatible with systems of classification which contrast comprehension and speech: patients previously classed as having 'motor' disorders with good comprehension were discovered to have deficits on this test of auditory comprehension. On the results of the Token Test it proved impossible to distinguish the non-fluent from the fluent aphasic (Poeck, Kerschensteiner and Hartje 1972). Needham and Swisher (1972) also reported that correlations of Token Test scores with ratings of comprehension on the Functional Communication Profile were not significant. It appears, then, that the Token Test accessed some level of difficulty in comprehension in non-fluent aphasics which had previously escaped notice in clinical observation. Naeser (1974) reports that three "anterior plus comprehension deficit patients" had lower Token Test scores than three Wernicke's aphasics, although they made fewer errors on a test of matching words to pictures to assess phonemic discrimination, and showed no impairment at all on a word-word matching test of phonemic discrimination. She tentatively suggests that the deficit may be "decreased verbal retention or something not yet identified yet qualitatively different from the Wernicke's comprehension deficit".

In their examination of dimensions of auditory language comprehension in aphasia, Goodglass, Gleason and Hyde (1970) included three types of aphasic patients in whom comprehension is usually described as good (Broca's, conduction, and anomic aphasics) as well as two in whom comprehension is described as impaired (global and Wernicke's aphasics). The four dimensions of comprehension they examined were breadth of vocabulary, sequential pointing span, comprehension of directional prepositions and recognition of correct grammatical usage of prepositions. They found that global patients were by far the most severely impaired on all measures of comprehension. Broca patients had poor sequence spans, but appeared to understand the sentences with prepositions well. The Wernicke patients were most impaired on the recognition of correct grammatical usage of prepositions. When a covariance adjustment was made for general comprehension level, it was found that the anomic patients were relatively more impaired on recognition of vocabulary than any other group except the global patients. Like the Broca patients, conduction aphasics had reduced sequential pointing span, but relatively good vocabulary: they could be distinguished from them, however, on a discriminant analysis function characterised by low scores on directional prepositions and high scores on recognition of appropriate grammatical usage. Goodglass and his colleagues concluded that auditory comprehension is multi-dimensional, and that in some respects comprehension shows the same pattern of deficit as does speech in the different types of aphasia. Anomic patients show a difficulty in comprehending nouns which mirrors their difficulty in speech. On the other hand, Broca's aphasics, with few prepositions in speech, understand prepositions well. Nevertheless the examination showed one similarity between the speech and comprehension of these aphasics; their reduced spans of utterance, strings of connected words of three or fewer, were matched by a reduced span of sequence in comprehension.

Luria's opinions about comprehension deficits in motor aphasias, as voiced in 1970, were that "in some cases severe impairment of expressive speech may produce a secondary disturbance of word comprehension" (page 312). Because "speech hearing is a complete systemic function which is based upon the coordinated activity of auditory and articulatory structures of the cortex" (page 111) patients with severe afferent motor aphasia may have difficulty in the immediate recognition of words. Similarly patients with efferent motor aphasia may show a severe effect on the process of primary word identification if external speech is suppressed by pressure applied to the tongue. The limitations of word comprehension in motor syndromes, Luria suggests (1966a page 380), "require further study, and the suggestion, most probably true, that a disturbance of the motor aspect of speech must inevitably affect its receptor aspect also must be subjected to further analysis". In the encoding as well as in the decoding aphasias, therefore, the principle deficit in comprehension recognized by Luria at this time was thus a disturbance of phonemic recognition, in keeping with his emphasis on articulatory disturbances in speech as the prominent feature of efferent and afferent motor aphasias. In 'frontal' and 'frontotemporal' syndromes he also describes (1966a page 381) a disorder in comprehension due to perseveration of the meaning of one word extinguishing the meaning of a following one.

Recently, however, more emphasis has been put on the agrammatic nature of the speech of motor aphasics, particularly of Broca's or efferent motor aphasics, and consequently the examination of comprehension in such patients has focussed on disorders of grammar. Luria, on the other hand, has clearly attributed some disorders of grammar in comprehension to semantic aphasia, whose anatomical site of lesion in the 'language area' of the brain is about as far removed from that of a Broca's aphasia as it could be. Luria's opinions on disturbances of grammatical comprehension as expressed in a recent paper (1975) are, therefore, particularly interesting. Luria compared the performance of patients with semantic aphasia after parietal lesions, with that of patients who were non-fluent after anterior lesions, on tests of syntagmatic and paradigmatic comprehension. Syntagmatic features are ones which depend on contextual organization (e.g. agreement between subject and verb). Paradigmatic features are ones which depend on selection from a simultaneous choice. Paradigmatic comprehension was measured by tests of logico-grammatical relationships such as have been described already in Section 2.4.2 (reversible possessives and relationships between two objects expressed through locative prepositions). Syntagmatic comprehension was measured by asking the subjects to make judgements about sentences with superfluous and incorrect syntactic inflections. Luria reports a double dissociation. Patients with semantic aphasia failed on the paradigmatic tests and succeeded on the syntagmatic; patients with non-fluent aphasia failed on the syntagmatic tests and succeeded on the paradigmatic. In this recent expression of his views, it seems that for Luria disorders of comprehension of grammatical speech in motor aphasia are essentially in its contextual syntagmatic organization and not in logical relationships as such. Conceivably the infill of the sentence with grammatical words and inflections occurs at a later stage of organization than the allocation of relationships. Without making this distinction between syntagmatic and paradigmatic aspects of syntax, other investigators have recently reported disorders in syntactic comprehension to be associated with agrammatic speech. Lexical knowledge seems to be less disturbed than syntactic in agrammatism. But there is some dispute as to whether or not there may be impairment of grammatical comprehension also in Wernicke type aphasias, even though speech shows retention of grammatical structure. Some of these recent studies are discussed in Section 5.

3.3 Summary

A list of some qualitative differences which have been proposed in disorders of comprehension in aphasia, up to the present time, goes as follows:

agnosia for speech, attributable to a disorder in either

a) the elementary analysis of speech sounds

b) the phonemic recognition of such sounds

a dissociation of speech sounds from meaning

a disorder in word-meaning itself (which can also be differentiated as being a widening or a narrowing of meaning - see Section 5)

a disturbance of the simultaneous synthesis of relations amongst words in a sentence

a disturbance of recognition of agreement of syntactic inflections in sentence structure auditory imperception due to on-off switching of reception of signals

a reduction in (short-term) auditory memory (particularly for sequencing)

a failure of attention.

It is evident that some aspects of linguistic theory are pertinent to some of these distinctions, particularly the description of language in terms of levels of phonological, syntactic and lexical-semantic organization. Section 4 defines these terms and describes some nicer distinctions which have been made within each level and which have been applied in research into aphasia. But before this, one tentative addition will be made to the list above which introduces a dimension not yet developed to any extent in linguistic theory.

3.4 Functional levels of availability

The above distinctions in comprehension in aphasia are either by linguistic levels or by the dynamics of retention span and attention. The additional dimension to be proposed is by functional levels of availability. These are not functional levels in the sense applied by Halliday (1973, 1975) to children's acquisition of language, such as the instrumental or 'I want' function or the regulatory or 'do as I tell you' function. They are, rather, developed from two concepts from neuropathology, a reduction in availability as opposed to loss of a skill, and apraxia.

Aphasia was originally conceived of by some observers as a loss of language; for example, Wernicke attributed the disorder in patients with poor comprehension to a "loss of sound-images". Most recent models of language no longer assume all-or-none physical representations in the brain of units of language such as words. For example, Morton's (1970) 'logogen' model conceives of word-genesis-elements as achieving threshold for realisation as a word from a build-up of influences such as input from listening or reading, contextual effects, frequency of use, cognitive long-term store effects and so on. It is easy to relate to such a concept the notion that aphasia is not a loss of words but a reduction in their availability because the threshold for realization is now higher. Apparent fluctuations in availability would occur if one influence were more resistant than others and circumstances sometimes favoured it. Oldfield (1966) succinctly argued the case for aphasia as a reduction in availability of language rather than as a loss, partly on the evidence that sometimes and under some conditions aphasics showed resources of language which they did not under others. Howes (1964) similarly showed that the potential vocabulary of aphasic subjects is still enormous, as in normal speakers, although aphasics tend to use the more frequent words proportionately even more frequently than do normal speakers. Discussions of whether or not aphasia is a loss of 'linguistic competence' or of performance only are variants on this theme (see Part Four Section 1.1).

The condition of apraxia, first described by Liepmann as "the incapacity for purposive movement of the limbs despite retained mobility", is now well documented (Geschwind 1967). Involuntary spontaneous movement appropriate to the context of a situation is unimpaired, but when the patient attempts to perform the same actions out of context, it seems that the programming of the performance cannot be voluntarily reconstituted. As well as apraxia of limb movement it is now recognised that there can be apraxia for mouth and face movements (bucco-facial or oral apraxia), and that there can be a specific apraxia for mouth and face movements for the purpose of speech (verbal apraxia or apraxia of speech). Although these apraxias may occur together, apraxia of speech can be evident without oral apraxia (Darley 1968). Thus the distinction is not only between automatic and voluntary movement, but also by the purpose for which the voluntary movement is required. In apraxia of speech movement schemae for muscles for non-speech activities may be able to be summoned up at will (e.g. pressing together and parting of the lips, raising and lowering of the tongue tip), whereas these same schemae cannot voluntarily be summoned for speech (for 'p' or 't'). Organization for speech therefore seems to operate at a different level from organization for non-speech movements (hence the plausibility of its being controlled by one cerebral hemisphere, while movements of the same muscles for other purposes are under bilateral control). Nonetheless the distinction between the automatic and the voluntary applies to speech as well as to non-verbal activity. Darley (1968) writes:

> "There is evident discrepancy between certain speech performances and others. Just as in a non-language apraxia, we find a discrepancy here between volitional performance and reflex performance. We may hear a patient comment upon his poor performance in saying certain words after us, and as he comments he is fairly fluent and his articulation is fairly good. He may be able to recite numbers or days of the week and produce such reactive expressions as greetings or curses fluently and with good articulation, but when his set is different in trying to produce a particular word, even though it is an easy one, he may have much trouble" (page 9).

A combination of this idea of dissociation between the automatic and the voluntary in speech and the idea of reduction in availability of a central word store leads to the proposal that this dissociation may apply to the central language system as well as just to coordination for speech. Baillarger and Jackson, in the late nineteenth century, were the first to draw attention to the dissociation of the automatic and the voluntary in uses of language. Jackson (Taylor 1958) wrote "the more voluntary uses of language are more or less profoundly altered, while its more automatic uses are not only preserved but even liberated". This was, Jackson suggested (page 133), because automatic language is initiated by the right hemisphere, while the left initiates voluntary propositional language. Having observed that "the left half of the brain is that by which we speak, for damage of it makes us speechless, the right is the half by which we receive propositions", Jackson adds the footnote that "the essential difference is not that betwixt the internal and external use of words, for speech may be internal; we can speak and constantly are speaking, to ourselves. The difference is in, or corresponds to, the voluntary and automatic use of words." (Taylor 1958 page 132.) Hence we sometimes find even in severely non-fluent speakers preservation of swearing and reactive speech such as "yes", "no", "I can't", "sorry". The much-quoted example of the dissociation between the automatic and the purposive is of the patient who said "No, doctor, I can't say no". Jackson describes a woman who, for the six months before she died, said only "Yes, but you know", except when she saw a child nearly falling and cried "Take care". On Tyneside, where 'aye' rather than 'yes' is often used to show agreement, it is not uncommon to find an aphasic patient who freely uses 'aye' appropriately, but who is incapable of producing the same phonetic realization to name his own eye. This is not the same distinction as has been commented on by Gardner and Zurif (1975) between the reading of 'bee' and 'be' (or '2 bee oar knot 2 bee' and 'to be or not to be'), where the critical distinction is by part of speech (i.e. substantive words are available, grammatical are not). Rather it is a difference in availability related to the purpose for which the utterance is required: 'aye' is spontaneous, 'eye' is an elicited and self-conscious task. The variability in performance which Oldfield comments on in aphasia may thus be partly attributable to the difference in the functions for which the utterance is required. Jackson proposed, not all-or-none automatic speech, but degrees of ejaculative utterances, depending on the degree of emotion aroused - 'non-speech' swearing, inferior speech and 'real speech' (page 178) such as "How is Alice getting on?" It is a common observation that patients often find it easier to utter a word to complete a given phrase (where the choice is restricted and semi-automatic) than they do to utter the same word to label an object. The first task is assisted partly by the syntactic context, but it is clearly not only a matter of the context restricting the area of search for a word: the area of search is even more restricted when a specific object has to be named. The difference is rather that one task is semi-automatic and the other forced. One of the main principles of therapy is to make use of these semi-automatic abilities to lead the patient back into the voluntary uses of language (Vignolo 1964).

Wepman (1976) currently puts forward an extreme proposal for therapy, that certain patients should not be treated by direct methods, but that intervention should be directed at stimulating thought and therefore indirectly supplying the content for language. He describes a patient who had reached a low plateau of recovery after therapy which had previously consisted of linguistic verbally directed effort aimed at improving word usage, but who began to speak spontaneously without word-finding difficulty after two weeks of 'thought-stimulation therapy' in which he was never asked in any way for the voluntary elicitation of verbal expression. The key to this new approach, Wepman proposes, is that the patient should think about other things than how to express himself. Such an approach implies that easier access to the automatic and incidental operates at all levels of speech rather than only in the motor organization of articulation or in pre-patterned articulatory chunks such as swear-words or clichés.

The emphasis given by Goldstein and Scheerer (1941) to the concrete nature of behaviour in brain-damaged people also implies an all-pervasiveness in this reliance on the real needs of a situation and this inability to instigate a behaviour synthetically. Amongst the conscious and volitional modes of behaviour for which an abstract attitude is required is the detachment of the ego from the outer world or from inner experiences. For example, a patient with a right hemiplegia can find it impossible to repeat the sentence "I can write well with my right hand", not because of articulatory or linguistic difficulties but because the sentence is not true.

The question is whether or not the dissociation of the automatic and the purposive is such as to apply to language knowledge as accessed by comprehension of speech, or whether, like apraxia, it is essentially a disorder of execution, of speech.

Zurif and Caramazza (in press) state that there are multiple levels of language knowledge (including the linguist's ability to articulate his knowledge of rules). Anyone who sets out to examine verbal comprehension in aphasia is unlikely to ask for articulation of knowledge of the rules of language, but he may well ask the patient to make metalinguistic judgements about the acceptability of semantically anomalous or agrammatic sentences. At a less artificial level the patient may be asked to recognize an utterance as being appropriate for a situation or a picture. But often another level of comprehension is also being tested, the ability to understand the test instructions (unless these are entirely non-verbal). One can imagine a situation where the examiner says "Point to the picture which shows 'The man is pointing to the picture'". Is it inevitable that a patient who could do the first part of the task must be able to do the second? If the patient were to point to an incorrect picture, he would be failing on the formal task but showing comprehension of the incidental task instructions. When aided by situational and non-verbal clues an automatic level of linguistic comprehension may be available to the patient when a metalinguistic self-conscious level is not. But it could still be a linguistic comprehension, not a reaction solely to situational cues. Brain (1964) has drawn attention to the fact that "the signification of words, as well as being influenced by syntactic context is influenced by the 'context of interest' that is the attention paid to the objects which surround the speaker and the listener". In 1946 Nielsen commented (page 19) that patients could fail to respond to instructions because they were couched in an unusual manner, "For example if the patient is told 'put your finger on your nose' he may fail entirely, not because he cannot do it but because it is an unusual proposition. If we take another course and ask 'Have you a nose?' he will say 'Yes'. Then we ask 'Where is it?' and he will immediately put his finger on it to show us. The stimulus thus reaches his 'eupractic' area by a two-stage but much easier route". Despite these speculations, there seems at present to be no evidence to show whether or not functional use is influential on lingustic comprehension, as distinct from the linguistic structure of the material.

In the present investigation it was originally intended to compare the 'automatic' verbal comprehension of the subjects with their results on formal tests. A pilot study was begun in which subjects' comprehension was to be assessed in natural situations in their own homes for comparison with clinic scores. The assessment was to be based on a set of sentences each introduced naturally in to the conversation on a visit to the patient at home, but without clues from accompanying non-verbal gesture, so that the patient's comprehension would be based on the interaction of situation and language. Examples of the sentences were "Where do I put my coat?", "We need a newspaper", "Turn over a new page", "Where's the bathroom?". Unfortunately the study proved impracticable for the present investigation because of the need to explain to helpful relatives that their intervention was unwanted. Because the relatives were also being used as control subjects for the formal tests, and were also being asked to fill in a questionnaire, it became too complicated to establish a third situation with them in which they must avoid participating in the conversation. Rather than jeopardize the whole scheme by losing the relatives' cooperation as control subjects, it was decided to rely on their answers to the questionnaire for an opinion about how far the patient's disorder in verbal comprehension affected functional conversational exchanges at home.

In the formal clinical tests, the verbal instructions were supplemented by visual and gestural information in the manner described in Part Three Section 3.5.

4. Linguistic themes

4.1 Levels of description

The main linguistic notion applied in this study is that of different levels or planes of description in language. Although some linguists distinguish several levels (Lamb's stratificational grammar, 1966, proposes six strata for English), and some (the Prague school) consider the notion of separate levels as being a misleading if convenient reduction of complexity, it is common practice to divide language up into three levels for the purposes of description: the system of sounds, phonology, the system of word arrangement and groupings in sentences, syntax, and the system of meaning, semantics. When these levels are used in research into aphasia, the hypothesis is being tested that they are psychologically valid levels of organization as well as levels of description devised to make the linguist's job more manageable. Distinguishable levels of processing have also been proposed in the study of memory (Craik and Lockhart 1962): they also imply that we have the capacity to analyse verbal information in different ways such as phonemic and semantic.

For practical convenience in the study of aphasia, subdivisions can be made within these linguistic levels. Phonological descriptions can be made at the phonetic or phonemic sublevels. (Historically the study of phonetics preceded the linguistic concept of phonemic organization to be described below; and in some linguistic terminologies 'phonology' refers only to the later study of phonemics.) Syntactic descriptions sometimes focus on structure or groupings, sometimes on morphemics, the realization of this structure through classes of words and their inflections. Within semantics (in addition to the philosophical study of semantics as the relationship of word meaning to the concepts or objects outside language), there are two kinds of descriptions: some are in terms of the meaning relations amongst individual words in the vocabulary or lexicon, others are in terms of the meaning relations amongst words in sentences (this study is sometimes called semotactics, or syntactic-semantics).

4.1.1 <u>Phonology</u>

Phonetic descriptions are in terms of the elementary acoustic and articulatory components of speech sounds which are essentially independent of meaning. Phonemic descriptions, on the other hand, apply the concept of an abstract system of 'phonemes' or contrasts of sounds which are capable of changing meaning in words. Each abstract 'phoneme' has phonetic variants in its actual realisation in speech which do not change meaning (allophones). Languages have their individual systems of up to some fifty phonemes; although related languages show overlap of their systems, the boundaries of what is a phonetic contrast (non-meaningful) and a phonemic contrast (meaningful) do not always coincide.

For instance, aspiration of stop consonants is a phonetic feature in English, a phonemic feature in Hindi.

The phonetic-phonemic distinction has been fruitfully applied in the description of aphasic speech and in distinguishing aphasic syndromes. Some Broca's aphasics are said to evidence 'phonetic disintegration' (Alajouanine, Ombredane and Durand 1939 as interpreted by Lecours and Lhermitte 1976, Poncet, Degos, Deloche and Lecours 1972), an articulatory failure to realise phonemes with the correct precision needed of tongue and mouth movements. On the other hand, the kind of fluent speech which is characterised by literal (phonemic) paraphasias shows intact phonetic realization of each phoneme but misplanning of the patterning of phonemes in a word or combination of words. The unit which becomes distorted in speech in the articulatory 'phonetic' syndrome is the phoneme; in the paraphasic 'phonemic' syndrome it is the word. Unfortunately this neat differentiation of phonetic and phonemic deviations is complicated by two facts. Firstly, deviations which may be articulatory in nature can distort the realization of the phoneme in such a way that it is realized as a different phoneme. Secondly, Broca's aphasia (unlike dysarthria) seems to be characterised by true phonemic disorders of patterning as well as phonetic distortions. In practice, then, 'phonetic disintegration' includes phonemic paraphasias, although phonemic paraphasias can occur without phonetic disintegration.

The mispatternings of phoneme sequences in literal paraphasias almost always maintain the rules of combination of phonemes allowable in the speaker's native language ('morpheme structure rules' - Lightner

1971), even though the aberrations of patterning may be so gross as to produce neologisms which cannot be related to a target word (Blumstein 1973, Lecours and Caplan 1975). Phonemic paraphasias are therefore thought to be indicative, not of a disintegration of the phonemic system, but of difficulty in programming its evocation.

Prosody (intonation, stress, juncture) is sometimes included within phonology, as describing the system of sounds in 'suprasegmental' units, i.e. units larger than single phones.

Phonology in comprehension has been studied chiefly at the phonemic sublevel. Of the fifteen investigations outlined in Section 5, eleven are of phonemic discrimination, one of phonetic discrimination, and three of comprehension of prosodic features.

4.1.2 Syntax

At the syntactic level, descriptions of aphasic comprehension at the sublevel of morphemics preceded those in terms of larger units of structure. Morphological descriptions use two kinds of units: 'grammatical' words (Lyons 1969) such as prepositions, articles, verb auxiliaries, conjunctions; and inflections, the suffixes added to words to determine their grammatical significance, such as the possessive inflection ' -'s ' or the verb tense inflection ' -ed '. Grammatical words are one kind of 'free' morpheme, while inflections are 'bound' in that they do not occur in isolation. The justification for classing both together is that many languages use inflections to denote relationships that other languages expand into separate grammatical words. Descriptions of aphasic syndromes associate reduction in or preservation of the use of inflections with similar behaviour with grammatical words.

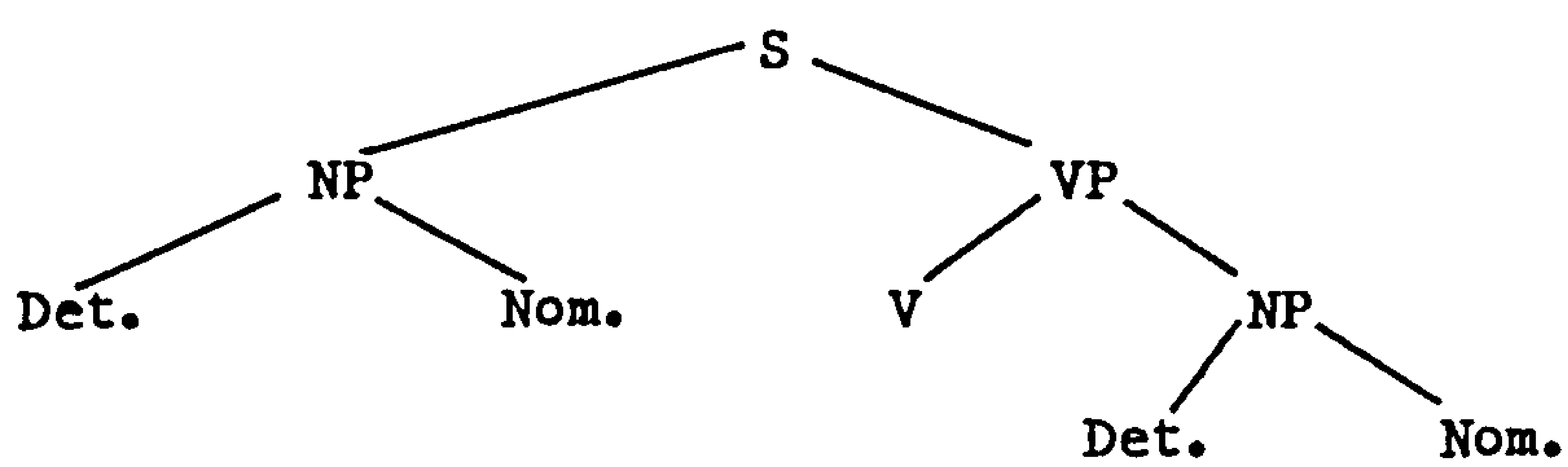
However, one study (already described in Section 3.2.3 - Goodglass et al. 1970) has shown that comprehension of one kind of grammatical word, prepositions, can be good despite agrammation in speech, while other studies have shown that recognition of some inflections by agrammatic patients can be poor (Goodglass 1968). It is therefore not unlikely that there may be a dissociation of comprehension of grammatical words and of inflections. However, it is probable that the differences relate to factors like stress, informational content, emotional content, and phonological saliency (Goodglass's 'stress-saliency' hypothesis 1968) rather than to syntactic differences as such. The two classes of 'grammatical words' and 'inflections' are too heterogenous to be valid psychological units for aphasia and their exact correspondence in severity in impairment cannot be expected.

Another approach, therefore, has been to study the hierarchy of difficulty of inflections themselves, and it is reported that this hierarchy is consistent irrespective of clinical type of aphasia (Goodglass 1968). The verb inflection for the third person singular 's' proved to be more difficult than the possessive 's' which in turn was more difficult than the noun plural 's'. Jakobson (1964, in press) explains this rank of difficulty because of the size of the organizational unit involved. The plural form is one word which implies no syntactic sequence, the possessive implies a phrase ('John's dream') while the verb-third-person implies the clause level of organization in language with a subject and predicate. Such observations lead naturally to the analyses of syntactic comprehension in aphasia in terms of larger units of structure than morphemes or combinations of free and bound morphemes as words.

Structure has sometimes been described in terms of traditional grammar (e.g. as subject, verb, object). It has also sometimes been described in terms of phrase-structure grammars, which use re-write rules to show the hierarchical or tree-like structure which underlies a surface string. For example (for a simple transitive sentence):

$$S \rightarrow NP + VP$$
$$VP \rightarrow V + NP$$
$$NP \rightarrow Det. + Nom.$$

where S = sentence, NP = nominal phrase, VP = verb phrase, Det. = determiner, Nom. = nominal. The tree-structure of the same example would be represented as:



The hypothesis has been tested that, in agrammatism, breaks in the higher constituents of sentences (as between NP and VP) should be harder to bridge than breaks in the lower constituents (as between determiner and nominal) (Von Stockert 1972, 1974, Zurif and Caramazza in press).

Some descriptions of disturbances of comprehension in aphasia have also drawn on transformational generative grammar which proposes, in addition to such phrase re-write rules, transformational rules. Transformations imply two levels of syntactic structure, a deep or base one and a surface one which is the product of the transformations. There can be different surface realizations of an identical base structure, depending on which transformations have been applied. For example the same base structure may be realized in an active form as

'The union is calling out the miners' or in a passive form as 'The miners are being called out by the union'. There can also be identical surface structures which relate to different base structures. Chomsky's classic example is 'John is easy to please' and 'John is eager to please'. Both have the same surface structure, but their underlying base structures differ. In the first case John is in the passive role, as object in deep structure, although subject in surface structure; in the second case John is in the active role as subject in both deep and surface structures.

There is some dispute as to whether these base structures are syntactic or whether they are better conceived of as being deep semantic relations. Standard transformational theory (Chomsky 1965) has it that they are syntactic; the relationships denoted in them can be expressed for example in the grammatical terms of subject and object roles. A modification by Fillmore (1968) proposes that these roles are those of agent, instrument, receiver etc., all of which can appear in surface syntax as the subject; but by analogy with the cases of inflected languages these roles are still described as syntactic. Advocates of 'generative semantics' (McCawley 1968, Lakoff 1971), which contrasts with the generative syntax of standard transformational grammar, hold that deep relationships are semantic ones and there is no need to postulate their duplication in a separate level of deep structure which is syntactic rather than semantic. This dispute about theory has practical implications for aphasia, because of the dissociation between syntactic and semantic disorders which has been proposed (Whitaker 1971, Buckingham, Avakian-Whitaker and Whitaker 1975). If deep relations are semantic, recognition of them should be preserved in syntactic disorders and disturbed in semantic disorders. If they are syntactic the opposite would be predicted. Whatever their theoretical status, deep relations or base structure seem to be close to the 'logico-grammatical relations' Luria describes as being disturbed in semantic aphasia, while the disturbance in the motor aphasias would appear to be at a surface structure level. In the present investigation, however, a comparison is made between comprehension of deep relations which are not made explicit in surface structure and comprehension of subject-object relations which are revealed through surface structure. In these terms 'logico-grammatical relations' such as the possessive and linking of two nouns by a locative preposition are surface structure features in that it is word order and morphological features and not word meaning that make them explicit.

In Section 5, fifteen studies, over the last decade, of comprehension in aphasia at the syntactic level are outlined; six of them have examined (primarily) grammatical words and/or inflections; nine have examined (primarily) phrase structure.

4.1.3 Semantics

Although comprehension of the semantics of sentences and of connected discourse has been studied in aphasia, for example using selection restrictions (Whitaker 1971, Bliss 1971) and interpretation of metaphors in episodes (Huber, Stachowiak, Kerschensteiner and Poeck 1975) most of the experimental investigations of semantics in aphasia have used the single word as the unit of analysis. They have studied lexical semantics, rather than syntactico-semantics. The examination of meaning has presented even more problems to grammarians than has the formulation of descriptions of syntax. Several dimensions of lexical meaning have been proposed. Leech (1974) for example lists seven: conceptual, connotative, stylistic, affective, reflected, collocative and thematic. The majority of studies of lexical meaning in aphasia have been of denotative meaning (approximately what Leech describes as conceptual). This has been defined as having two aspects: reference, concerning the relationship of the word with the object or event it describes, and sense, concerning the interrelationships amongst words such as synonymy and antonymy. But a few studies have examined connotative meaning in aphasia, connotative in this case being defined as the emotional or affective aspects of meaning, though other definitions would include in connotative meaning all those residual aspects of meaning which are not a part of the dictionary definition. As used in aphasia research, connotative meaning has been measured by versions of Osgood's Semantic Differential, a technique which asks subjects to rate words on their affective values (usually on three seven-point scales, as good to bad, strong to weak and active to passive). Osgood and Miron (1963) report some speculations about whether or not connotative meaning should be spared or impaired in aphasia: is it more 'abstract' than denotative meaning and therefore more vulnerable; is it more 'basic' and primitive and therefore less vulnerable or is it an essential part of meaning interdependent with denotative meaning and therefore necessarily impaired to the same degree? Two studies of connotative meaning in aphasia are outlined in Section 5. The uncertainty of their conclusions reflects the uncertainty of the definition of what connotative meaning is, and of what the figural version of the Semantic Differential (Osgood 1960) which they both used actually measures.

The examination of denotative meaning in aphasia requires some model of how such meaning is organized in the lexicon. Some of the proposals about the form this may take are outlined in Section 4.2.3.

4.2 Some linguistic theories which have been applied in research into comprehension in aphasia

4.2.1 Distinctive features

The term 'distinctive features' relates primarily to phonology (although there have been secondary applications to semantics). Following the proposals of the Prague School, phonemes are conceived of as being bundles of more elemental features through which one phoneme contrasts with another (a phoneme therefore 'exists' only in terms of contrasts of these features). In the phonological theories of the 1950's, distinctive features were related to acoustic criteria which could be specified from a spectrogram. They were binary contrasts of sonority (vocalic/non-vocalic, consonantal/non-consonantal, nasal/oral, compact/diffuse, abrupt/continuant, strident/mellow, checked/unchecked, voice/voiceless) of protensity (tense/lax) and of tonality (grave/acute, flat/plain, sharp/non-sharp). These contrasts have been modified in generative phonology (Chomsky and Halle 1968) and include features directly related to human articulation rather than to physical acoustics. Besides the major class features of sonorant/non-sonorant, vocalic/non-vocalic, etc., there are articulatory cavity features (coronal/non-coronal, anterior/non-anterior etc.), features of manner of articulation (continuant/non-continuant, tense/lax etc.) and source features (voice/voiceless, strident/mellow etc.).

It is this latter formulation of distinctive features which has been applied to the investigation of aphasic speech in the U.S.A. by Blumstein (1973) and by Martin and Rigrodsky (1974). In France, however, schemes of distinctive features based entirely on articulation have been used (Lecours and Lhermitte 1969, 1972), in which distances between phonemes are measured by the number and distance of the articulatory movements (including those of the larynx) which are required.

For the investigation of auditory phonemic discrimination, the protocols which have been used have not been as elaborate as for speech. A simple schema of distinctive features has been used for some of the English consonants which distinguishes manner of articulation (stop, fricative, nasal), place of articulation (labial, alveolar, velar) and presence or absence of voicing. Walsh (1974) has argued that a schema such as this (the one he proposes is somewhat more elaborate) is of more practical use in the description of speech disorders than the distinctive features of generative phonology.

Some investigations of comprehension have either not specified the criterion by which they were measuring phonemic similarity, or have used an empirical method of determining discriminability, by employing sets of words which normal subjects had confused when they heard them against a noisy background.

4.2.2 Markedness

Markedness is another concept which originated in phonology and which has been applied to semantics (as well as to syntax). In the present investigation it has only been applied at the semantic level.

The concept is of binary pairs, one of which is more basic than the other (the unmarked member), the other one being marked by some additional feature (the marked member). At the semantic level the concept of markedness has been applied particularly to scalar adjectives of degree. Unmarked adjectives can be used in a neutral sense without implying a polarized value. For instance, we can say "How old is that baby?" without implying the anomaly of the baby's being an elderly person. If we use the marked member of the pair 'young' in a sentence like "And how young did that actress say she was?" we are implying a judgement value that would not have been there if we had used the word 'old'. Similar pairs are deep/shallow, wide/narrow, tall/short, big/small, and many others. Clark and Card (1969), Clark and Chase (1972, 1974) have also applied the markedness distinction to pairs of prepositions: 'above' is said to be unmarked and 'below' marked. Developmental studies have supported the psychological validity of the distinction; unmarked terms tend to be acquired before their marked pair and children appear to pass through a stage of acquisition where both terms are interpreted as having the base unmarked value (Wales and Campbell 1970; Eilers, Oller and Ellington 1974) and to have more difficulty learning nonsense syllable equivalents of the marked pole of a dimension (Klatzky, Clark and Macken 1973). Studies measuring reaction times with normal adults show faster reactions to unmarked than to marked terms (Clark and Card 1969, Carpenter 1974).

4.2.3 The organization of the lexicon

Of the possible descriptions of the way meaning is organized in the lexicon, there are four principle ones which have been used in aphasia research. These are, firstly, association networks of words, secondly semantic categories, thirdly semantic fields around individual words, and fourthly, semantic features.

Meaning, or to be more precise meaningfulness, has been defined in terms of the number of associations a word produces (Noble's 'M'). Associations are defined empirically; the starting point for this concept of organization is not linguistic theory, although linguistic analyses have been made of the empirically collected data. Subjects are asked to give one word which springs quickly to mind for a given word; or sometimes chains of several words are elicited for one word. Sets of association norms have been established. The original intention was to gain information about the mental status or personality of the subject. But more recently interest has grown in the use of this method as a way of exploring the nature of relationships within the lexicon, rather than individual differences between subjects. Kiss (1968, 1973) has collected an associative thesaurus by getting students to give an associate to each of a hundred words, then taking these responses and getting more students to give responses to them, and so on for four times in total. From these responses he was able to build up a network of associations, and using flow-graph theory, to derive mathematical formulae from which to predict the probability of one word's being given as an associate of another. Association networks built up in this way are unidirectional: there is not equal probability of a response in turn eliciting the original stimulus. Word association network models offer some advantages for aphasiology because, being empirically based, they are subject to all the influences which affect the lexicon in natural languages - influences of grammatical class, visual associations, operativity, knowledge of the world, clang similarities, contextual associations from juxtaposition in phrases - besides the influences which come under a strict definition of semantics. Rinnert and Whitaker (1973) found that the misnamings of aphasic patients could best be characterized as being similar to the word associations of normal people; out of 217 examples of semantic confusions, 180 were ones in which the target and error word were paired in word association norms. Semantic integrity in comprehension has therefore been examined by asking patients to select a word from amongst those associates which are the most frequently given for it in word association norms.

Semantic categories are defined by Lehrer (1974) as "a group of words closely related in meaning often subsumed under a general term" (page 1). She uses the term 'semantic field', while in aphasiology it is practical to make a distinction between the terms 'category' and 'field' in which her definition for field is apter for category. Categories which have been well studied because of their modest size and the ease with which inter-cultural comparisons can be made are colour terms (e.g. Berlin and Kay 1969) and kinship terms (e.g. Greenberg 1966), while detailed studies have been made of larger categories within one language, for example verbs of motion (Miller 1972), and cookery terms and terms for containers (Lehrer 1969, 1970). Lehrer concludes that most categories (fields) are not closed well-defined sets; there are peripheral terms which some people would include in a category, others exclude. Lexical categories do not seem to be systematically arranged in patterns of oppositions and differences, but in a multiplicity of ways, and there are frequently gaps in them (for example we have a term for dead bodies which are human - 'corpse' - or animal - 'carcass' - but not vegetable). Some sets of words are not appropriate for analysing by interrelationships at all, because the relationships amongst them are so diffuse ('even', 'only'); others have a very simple linear structure (cardinal numbers, alphabet letters). Lexical 'field' theory appears to capture some realities about how language is organized: it explains some syntactic regularities in that, for example, the members of the category of 'manner-of-speaking' verbs can all be used parenthetically, can be interpreted as reports of assertion, have nominal direct objects cognate with the verb etc.; and it gives insight into how meanings can be dynamically extended (for instance into how a novel phrase like 'warm war' or 'his politics are pink' would be readily interpretable).

Applications of lexical field or category theory to the study of comprehension in aphasia have so far been conservative. Goodglass, Klein, Carey and Jones (1966) used seven categories, alphabet letters, numbers, colours, body parts, geometric forms, actions and the very wide category of 'objects' to examine whether or not semantic categories are selectively disturbed in aphasias of different types. The major differences in difficulty of the categories could be partly explained in terms of the phonological distinctiveness of an item within its category, and the range of the category from which the selection was to be made (an enormous one for object names). There was some difference between Broca's and Wernicke's aphasics; the former had relatively low scores on letters and geometric forms, the latter on body parts. Goodglass and his colleagues speculate that the word-finding system may be subdivided anatomically according to the psychological nature of different word categories. In the same vein Yamadori and Albert (1973) have reported findings from a patient who appeared to have a word-category aphasia specific to body parts and room objects. Weinstein (1964, Weinstein and Keller 1963) described misnamings in non-aphasic right brain damaged patients which appeared to be principally of terms related to hospitals and illness. In contrast Orgass, Poeck, Kerschensteiner (1974), comparing the comprehension by aphasics of body-part and object names, found a high correlation between them: "a selective comprehension deficit for body-parts could not be demonstrated. The same was true for understanding of colour names".

The third model of how the lexicon may be organized uses the term semantic field to denote, not a category, but the physiological links any single word has with others around it. It is thus somewhat similar to the idea of associations, but the imagery used is not one of a network but of a graded zone of meaning around a word. Moreover the links are of meaning, not of contextual syntagmatic relationships (such as 'go + home'). The evidence for the validity of this concept of organization was collected in experiments like those of Luria and Vinogradova (1959). Using conditioned responses to an aversive stimulus, they demonstrated that responses to a word generalized to responses to other words within its semantic field. They were also able to demonstrate that the field had a central area and a peripheral one: responses conditioned to the aversive shock could be distinguished from orienting responses (scalp blood vessels contract in the one case, dilate in the other), and it was found that words in the centre of the semantic field of the word which had been the subject of the original conditioning produced an aversive reaction like the word itself, while those which were peripheral produced only the orienting response. To words outside the field there was no response. This model, with its implication of spreading areas of neural excitation on the arousal of a substantive word, fits in with recent findings by Meyer, Schvaneveldt and Ruddy (1972). Meyer and his colleagues measured the time people took to recognise a word as English rather than nonsense, and found that recognition was faster if an associated word had already been alerted (e.g. faster for 'nurse' if 'doctor' had just been recognised). It was also found that this effect held even if other pairs of words had intervened; the activation of associates of one word persisted, and Meyer suggests that 'spreading excitation' is a better description of such an effect than activation of links, which would have been broken by intervening words.

From data from aphasics, Goodglass and Baker (in press) suggest that the semantic field of a concept can exist with or without the availability of the name for it. As possible structures for a field they included the word's superordinate terms, an attribute, a coordinate, a function associate (i.e. an associated activity), and functional context (e.g. the place where the object the word names might be found). Clang (rhyming) words did not seem to have a place in the field, or at least this place was not revealed by the particular task they chose, although Luria had reported some generalization of conditioning to phonologically similar words. Goodglass did agree that the semantic field appeared to be graded.

A simpler application of the notion of semantic fields was made by Lhermitte, Derouesné and Lecours (1971), and has been used in the present investigation. This makes a single empirical division between words which are central in the field and words which are peripheral.

The notion of semantic fields has had a practical use in therapy. Weigl (1970) reports that words in a semantic field have been used to 'deblock' the central word which was not available to the patient.

The last proposal to be discussed here for the specification of semantic interrelationships amongst words is componential analysis. This conceives of the meaning of words as being built up from elemental components or features (some theorists like Weinreich see these components as themselves being words and the realization of the bundle of components as a single word or as a phrase being in principle the same). There are systematic relationships amongst words which can be expressed in terms of universal features. These features are usually described in terms of binary oppositions - e.g. ± physical object, ± living thing, ± animal, ± human. But there are also features which cannot be classified so systematically, but which specify the exact meaning of a particular word. These 'residual', although distinguishing features, are the ones which are the first to be cancelled out by negation. For example, if we are told that someone is not a husband, we assume that he is not married rather than that the speaker is not referring to a man, + married being a residual feature and + human a basic one (Miller 1969). In addition to these basic and residual features there is an even less structured penumbra of meaning for each word which includes all the subsidiary information which would not appear in a dictionary definition, factual subsidiary information, personal experiences, emotional associations, etc. The basic features can plausibly be arranged hierarchically, and it has even been proposed that residual features can be so arranged: differences in verification times have been attributed to the distances to be searched between nodes in the hierarchy (Collins and Quillian 1969). An experiment is described in Section 5 which has applied the notion of semantic features to the analysis of disorders of semantic comprehension in aphasia and which has used both a hierarchical cluster analysis of the data, in accord with this proposal, and a multidimensional scaling analysis.

Componential analysis does not account for conceptual relationships amongst terms such as between 'come' and 'go', or between 'buy' and 'sell', although it lends itself to phyletic taxonomies. Palmer (1976) is of the opinion that it "raises far too many difficulties to be at all workable". The complexity of semantic organization is such that at the present time the empirical quality of association network and semantic field studies, and the delimitation of areas of theorizing to categories would seem to have advantages. Moreover, meaning in the lexicon is distinguished from meaning at an abstract conceptual cognitive level by its interaction with some kind of phonological and grammatical form, and heuristic methods, by including these 'impurities', seem more likely to lead to psychologically valid models than do those derived from abstract linguistic theorising.

5. Investigations of comprehension applying linguistic levels

The examples of recent research into aphasic comprehension which are summarised below are restricted to those where more than one subject has been studied, and where the method has not relied on the subjects' speech for answers, but some technique has been employed which could have enabled people with severe disorders in expression to be included. Following the outlines of the individual investigations, the implications of their findings at each linguistic level will be summarised.

The following tabular form is used:

Date	Language	Author(s)	Number of brain-damaged subjects + number of adult non-brain-damaged control subjects, where reported	Communication channels used

A. Focus of investigation

B. Main findings.

5.1 Investigations at the phonological level

5.1.1 Prosodic

1969	English (American)	Fink	10 + 20	Tape-recorded auditory input; Yes/no decision

A. Perception of intonation in aphasia. Three tests used a synthesised sentence 'see you soon' with different tonal patterns. Subjects had to identify them as question or statement, or choose from a pair.

B. Some aphasics were not capable of responding normally to intonation patterns; but older normal subjects also had difficulties similar to the aphasics. Evaluation of a single item was more difficult than deciding between two items.

1970	Rumanian	Mihaeilescu, Botez, Kreindler	10	Live auditory input; response was to demonstrate use of object, or point

A. Recognition of correct and incorrect stress in multisyllabic nouns. Measures used in scoring were latency and adequacy of gesture used.

B. Mis-stressed words are identified by aphasics as if they are correctly stressed. If subjects echoed a word they corrected any incorrect stress pattern. Aphasics, like normal subjects, draw on an existing stock of neural aggregates which the heard word stimulates, regardless of a distorted stress pattern.

1972	English (American)	Blumstein, Goodglass	17 + 13	Tape-recorded auditory input; picture-choice response

A. Recognition of stress as an index of meaning. Twenty-five pairs of words were contrasted in meaning by position of stress: in twenty, the contrast was between a compound noun and a noun phrase (e.g. whítecap/whíte cap), and in five between a verb and a noun (e.g. convíct/cónvict).

B. Comprehension of stress as a distinguisher of meaning was preserved, regardless of type of aphasia.

5.1.2 Phonetic

1971	English (American)	Mostofsky, Van den Bossche, Sheinkopf, Noyes	29 + 20	Computer-synthesised speech for auditory input; response was choosing two out of three as more similar (method of triads)

A. Examination of auditory impairment in terms of perception of magnitude of stimuli. Five versions of a prose passage were presented (undistorted, vocoded, reversed, time expanded, time compressed).

B. Multidimensional scaling analysis showed that the judgements of the aphasics were located differently in the multidimensional space from the controls. Severely impaired aphasics were poorer at distinguishing clear and distorted speech than control subjects were at making discriminations within types of distorted speech. "Aphasics experience an auditory deficit ... which causes them to perceive speech as more similar to distorted speech than do normals".

5.1.3 Phonemic

1964	French	Alajouanine, Lhermitte, Ledoux, Renaud, Vignolo	19	Live auditory input etc.; picture choice response etc.

A. (Part of an investigation of phonemic and semantic components in jargon aphasia). An examination of phonemic discrimination in patients with marked literal paraphasia in speech. Several tests were used, including recognition of a word, indicated by choice from five pictures representing phonemically similar words (e.g. gant, paon, gland, dent, banc); recognition of whether or not words were correct or contained literal paraphasias when spoken by examiner; recognition of words recorded against a background of 'pi, pa, pi, pa'; delayed auditory feedback; repetition; sensori-motor transpositions.

B. Although auditory comprehension as measured on clinical tests was good in these patients, they showed impairment in phonemic discrimination (mean percentages of errors on test one was 5.5%, on test two 22.5%, on test three 27%). The errors they made on test two were mostly in accepting a word with literal paraphasia as correct, rather than in not identifying it. The conclusion was that there is a sensori-motor, auditory-phonatory factor which supports phonemic evocation, and that this is a functionally separate system from semantic integration.

1969	English (S. African)	Levinsohn	7 + 6	Live auditory input; picture choice

A. A comparison of phonemic disturbances in perception and production. Test of phonemic discrimination used four pictures for phonemically similar words (e.g. bowl, bail, ball, bull) (Hutton, Curry and Armstrong test). Patients' phonemic abilities in speech were assessed from spontaneous speech and from naming of words contrasted by consonants (e.g. pea, bee) or vowels (e.g. shed, shared).

B. All patients but one showed errors common to perception and production, such as breakdown in front-back contrast or substitution of one phoneme for another. The results were interpreted as corroborating Schuell's claim that auditory impairment is basic to aphasic difficulties.

1968	Italian	Pizzamiglio, Parisi, Appicciafuoco	100 + 40	Tape recorded auditory input; picture choice

A. (Part of an investigation of phonemic, syntactic and semantic comprehension in aphasia). The test of phonemic discrimination used sets of four words (pictured) which had been confused by normal subjects when heard against a background of white noise.

B. Aphasics were significantly impaired, but 21 out of the 60 aphasics scored above the cut-off point for the normal control subjects (13 of these were classed as amnesic, 8 as Broca's aphasics). There was a .80 correlation with the clinical rating for comprehension in general. Pictures for words which were considered to be phonemically close were chosen in error more frequently than those which were considered to be more distant.

1971	English (American)	Carpenter, Rutherford	25 + 10	Tape recorded auditory input; same-different choice.

A. Twenty pairs of words were used which were phonologically identical except for one acoustic distinctive feature (referred to as 'Discrimination of Acoustic Cues Test'). Some cues were spectral (e.g. as between /g/ and /b/ in 'fig'/'fib'), others were of onset time for voicing (e.g. 'hit'/'hid').

B. Success or failure on this test did not always match success or failure on a clinical test of auditory comprehension (the Boston Diagnostic Aphasia Examination was used). "There is a group whose comprehension problems may be related more to a specific type of auditory perceptual deficit than to a symbolic or higher level deficit". Although all the aphasic subjects had an auditory retention span of at least three digits, discrimination of temporal cues was more difficult than discrimination of spectral cues.

1971	English (American)	Aten, Johns Darley	10 + 10	Tape recorded auditory input; pictures pointed to in sequence

A. An examination of retention of auditory sequences in patients with apraxia of speech. 190 sequences of two or three monosyllabic words (consonant, vowel, consonant) were presented, with one second intervals. The subject had four pictures from which to point in sequence to the two or three named items. The words were 'minimally varied', i.e. by one phoneme in initial, medial or final position.

B. In the three word sequences, some patients with apraxia of speech as their main presenting syndrome were unable to retain the consonant distinctions for the second and third words. It was concluded that they had a reduced auditory retention span.

1972	French	Goldblum, Albert	75 + 14	Tape recorded auditory input; picture-choice

A. An examination of phonemic discrimination in 'sensory', 'motor' and 'mixed' aphasics. The 'phonemic distance' amongst the sets of four words was one phoneme (in 10 test items) or more than one (in 8 test items) (e.g. 'choux, loup, roue, houx' or 'patinette, mobylette, clarinette, midinette').

B. 'Sensory' aphasics were more impaired than 'motor' or 'mixed'. Two types of sensory aphasics could be distinguished. Those with 'predominant verbal deafness' made errors primarily on the one-phoneme-distance items; those with 'predominant comprehension difficulty' made as many errors on both kinds of items.

1973	English (American)	Blumstein, Goodglass, Baker	13	Tape recorded auditory input; same-different decision

A. An examination of three aspects of phonological comprehension - phonemic discrimination, syllable discrimination, phoneme order discrimination. Seventy-two pairs of mono- and bi-syllabic words were used, contrasted by stop consonants which varied by place of articulation and/or in voicing (e.g. pen/den; super/suitor);

eight pairs of words had contrasting unstressed syllables (e.g. describe/prescribe); eight pairs of words had reversed phonemes (e.g. main/name, scotty/stocky). Similar nonsense syllables were also used.

B. All dimensions of phonological processing were impaired. All the aphasics perceived the real words better than the nonsense syllables. Wernicke's aphasics were not as impaired as 'anterior plus comprehension' patients or as 'posterior residual' patients, suggesting that disturbances of phonemic hearing are not limited to patients with temporal lobe damage. For Wernicke's aphasics, voicing was easier to discriminate than place of articulation, perhaps because the timing component of voice onset is acoustic rather than phonetic, and the patient's impairment is not one of auditory processing but is linguistic in nature. The disturbance of phonemic hearing is not sufficient to account for the comprehension deficit in Wernicke's aphasia, as Luria has implied.

1973	French	Consoli	12 + 5	Live auditory input; same-different decision

A. An examination of discrimination of (nonsense) syllables contrasted by initial consonants on the stem '-rin'. The initial contrast varied by manner (stop/fricative) by place or by voicing, and by number of distinctive features employed in the contrast.

B. Factor analysis showed principal factors of number of distinctive features employed, and of presence of voicing in the initial consonant of the second syllable heard, and a third factor related to the temporal sequence of movements which changed the place of articulation. As there were fewest errors when the first syllable had a voiceless consonant and the second syllable had a voiced consonant, it was suggested that perception was characterised by a degradation of the first sound heard, or possibly by a masking effect of the second comparable sound. There were fewer errors on discriminating voicing than on discriminating place (but this did not reach significance), and place errors were more frequent when the distance between the places of articulation were shorter than when it was longer (i.e. between bilabial and velar). There were more errors on discriminating velars than on other places. The subjects made more errors with different syllables than they did with pairs of syllables which were the same.

1974	French (Swiss)	Assal	62 + 20	Tape recorded auditory input; picture choice (time limit of five seconds)

A. An examination of the relationship of phonemic discrimination abilities to site of lesion. Two series of twenty monosyllabic words were used, with a choice of four pictures for each. The pictures represented words in which the initial phoneme varied (distinctive feature theory was not applied).

B. There was a tendency for poor results to be associated with left anterior lesions; poor results were obtained from three of the 22 people tested who had right brain damage; in these three the damage was in the parietal-temporal-occipital area.

1974	English (American)	Naeser	13	Tape recorded auditory input; picture choice compared with same-different decision

A. A comparison of phonemic discrimination assessed by responses on a same-different decision task and assessed by a picture selection task. Subjects were also given the Token Test. Both the phonemic tests used the same words, 24 consonant-vowel-consonant word pairs, contrasted by initial or final consonant and by one or two distinctive features (voice, place, manner). Picture choice was binary.

B. The three tasks seemed to be assessing distinct abilities: there was no significant quantitative relationship between phoneme discrimination assessed by same-different decision and phoneme discrimination assessed by picture choice and comprehension as measured by the Token Test. On the same-different test all subjects made more errors when the words differed by only one distinctive feature, but on the picture test Wernicke's aphasics made almost as many errors with two distinctive features as with one, unlike the other subjects. The order of difficulty of the distinctive features on the same-different test was place, voice, manner, and on the picture test place, manner, voice. There was no difference in difficulty between initial and final consonants. The hypothesis was put forward that there are three kinds of comprehension deficit: word deafness, which is characterised by a deficit in phonemic discrimination; the Wernicke type of disorder, in which phonemic discrimination is adequate but there is an impairment in the ability to associate the phonemic pattern with meaning; and the type of comprehension deficit which the Token Test detects, which is perhaps related to decreased verbal retention.

1975	Italian	Gainotti, Caltogirone, Ibba	133 + 120	Live auditory input; picture choice

A. A test of Alajouanine et al's hypothesis that the auditory-phonatory functional system is separate from semantic integration. The test used was a 'Verbal Sound and Meaning Discrimination Test', with 20 words spoken by the examiner, and for each, a choice of six pictures representing the correct word, one word phonemically similar, one from the same semantic category and three unrelated words.

B. Broca's aphasics (in this case diagnosed only from speech, and therefore including 'global' aphasics) were as impaired as were Wernicke's aphasics. Phonemic-type errors of discrimination were relatively more common in patients with phonemic jargon, mixed phonemic and semantic jargon or Broca's aphasia than they were in patients with semantic jargon, but the association between errors in phonemic discrimination and phonemic errors in speech was less convincing than the striking association of semantic errors in speech with errors in semantic discrimination.

5.1.4 Summary

From the studies summarized above, the following points emerge:

1) As a group aphasics show a deficit in segmental phonemic discrimination but not in using for comprehension the suprasegmental features of stress and, perhaps, intonation.
2) Where the linguistic model of distinctive features has been applied, in English and in French, it appears to be valid; but although, in general, place seems to be harder to discriminate than voice, one study has suggested that discrimination of the time of onset of voicing near the end of a word is particularly difficult.
3) The phonological level can be disturbed at least partly independently of the semantic level, suggesting that these levels have a neuropsychological reality as well as being convenient levels of linguistic description. Nevertheless, meaning facilitates phonemic discrimination: nonsense syllables are always more difficult than words. Even more strongly than normal subjects, aphasics relate their percepts to existing word forms, and notice distortions less well.

4) There appears to be some correspondence between phonological errors in speech and in comprehension.

5) The deficit in phonemic discrimination is not generally thought to be severe enough to explain the deficit in auditory comprehension in Wernicke's aphasia.

6) People with Wernicke's aphasia tend to make as many errors on the grosser contrasts of more than one distinctive feature as they do on the finer contrasts of one distinctive feature.

7) Disturbances of phonemic hearing can occur with anterior as well as with temporal lesions. In patients with apraxia of speech (anterior lesions?) there may be a reduced retention span for phonemic discrimination. There may be degrading effects, or masking effects of a second sound which is phonemically close to a preceding sound (even though other sounds in the syllable or word and a pause have intervened).

5.2 Investigations at the syntactic level

5.2.1 Morphemic (and mixed)

1968	English (American)	Fodor (reported in Goodglass)	33	Live auditory input; picture choice

A. Test of ability to discriminate contrasts of tense (past, present), plural (is/are, verb inflection '-s' without noun inflection) and subject-object order in active and passive voice. Examiner spoke both contrasting sentences; subjects were asked to speak the sentences and to choose from two pictures the one for each sentence after hearing the examiner repeat it.

B. The order of difficulty of the contrasts was (virtually) the same in aphasic and non-aphasic brain-damaged subjects, in non-fluent as in fluent aphasics, and in production as in perception. The passive and the verb inflection '-s' as the only clue to plural/ singular were difficult, while the active sentences and verb tense were easier.

1968	Italian	Pizzamiglio, Parisi, Appicciafuoco (also Parisi & Pizzamiglio 1970)	59 + 20 (+ 60 children)	Live auditory input; picture choice

A. (Part of an investigation of phonological, syntactic and semantic comprehension.) The ability to discriminate between twenty syntactic contrasts was tested, with four examples of each. Eight of the contrasts were of locative prepositions, others were of verb tense, plurality marked by noun and verb, noun gender, reflexive, negative, possessive pronoun, active, passive, subordinate phrase, and direct and indirect object.

B. Aphasics were significantly impaired, and results correlated with clinical tests. No brain damaged control subject (left or right brain damaged) made more than ten errors. The rank order of difficulty of the items was similar for all types of aphasics and for 3 to 6 year old children.

1969	English (American)	Doktor Taylor	12 + 12	Live auditory input; picture choice (slides)

A. Test of discrimination of ten syntactic contrasts: plurals (is/are, noun, verb inflection, possessive pronouns), negative, tense (past, present, future), pronoun gender, active and passive sentences, direct and indirect object with and without 'to'. Both reaction times and error rates were used as scores.

B. Aphasics made significantly more errors than normal subjects, and showed a different hierarchy of difficulty. The hierarchy shown by the aphasics was similar to that shown in a previously reported test for children - the most marked difference being that aphasics found the passive harder and children the past tense harder. The hardest contrasts for the aphasics were of direct and indirect object without 'to', and verb plurality as indicated by inflection, while the easiest contrasts were of male/female pronoun in the subject form, and negatives. It was suggested that the hierarchy showed an interaction of at least three factors: the number of transformations in the history of the sentences, the level at which the choice has to be made (phrase level or word level) and the clarity with which the surface structure makes the deep structure explicit (e.g. inclusion of 'to' before the indirect object).

1970	English	Goodglass, Gleason, Hyde	52 + 12 (+ 44 children)	Live auditory input; picture choice, and decision of preference

A. An examination of different aspects of auditory comprehension in four types of aphasics, Broca's, Wernicke's, anomic and conduction aphasics. Besides a vocabulary test and a test of pointing-span for names of objects, subjects were given two tests of prepositions.

In one, 24 sentences were used with contrasts of directional or locative prepositions (e.g. behind, over, under), and the subject was asked to choose a picture (e.g. show me the girl behind the car). In the other the contrasts were between prepositions expressing idiomatic or grammatical relations other than location (e.g. waiting for, in Japanese), and the subject had to indicate which he thought more suitable in a given pair of sentences.

B. Except on the vocabulary tests, the aphasics performed at a level rather below that of 7 year old children. The directional and locative prepositions test did not show significant differences amongst the types of aphasias, but the preposition preference test was done worst by the Wernicke's aphasics.

1974	English (American)	Smith	5 + 5	Live auditory input; reponse was movement of objects, or arrangement of written words

A. A test for the comprehension of prepositions. There were two versions, both using ten objects (cup, key, book, bowl, ribbon, coin, nail, pencil, comb, ring). In the first version the subject had to arrange the objects according to instructions (e.g. put the coin in the bowl); in the second the subject had to arrange written words into sentences to describe displays of the objects. In this second version the subject was given either the exact words for the sentence, or those plus three superfluous words. The first test was scored as plus if more objects than relationships were correctly indicated, and as minus if more relationships than objects were correctly indicated. The prepositions tested were: on, under, in, beside, with, and, by, or, from, before, after, over, in front of, behind, off, about, only, upside-down, next to.

B. On the first test there appeared to be no consistent order of difficulty for the prepositions, but there were fewer errors when only one object had to be manipulated. Three non-fluent aphasics had more difficulty with relationships than with selection of correct objects, while this situation was reversed with a patient with anomic speech. In the second test, the addition of superfluous words made the test so difficult that two patients gave up. Without the superfluous words, three of the patients still produced no correct sentences, although the sequences they produced were not random; in two patients the majority of their errors were reversals of the nouns.

In preparation	English (American)	Zurif, Green, Caramazza, Goodenough	6 + 3 (15 + 5)	Printed words as input; method of triads

A. An examination of sensitivity to articles and possessive pronouns in patients with Broca's aphasia or 'anterior plus comprehension' aphasia. Three types of sentences were used, from which patients had to link two words out of every possible combination of three words. In the first type of sentence there were either two articles or two pronouns (e.g. The dog chased a cat/My dog chased their cat). In the second type, the definite article prevented the sentence from being ambiguous (He hates the burning rubbish; She loves the flying kites). In the third type, the preposition 'to' was contrasted with the preposition 'by' in a passive construction (Gifts were given to John/Gifts were given by John).

B. The Broca's aphasics (rated on the Boston test as having satisfactory comprehension) were more sensitive to grammatical words that encode semantic relations (i.e. pronouns and prepositions) than they were to articles, with minimal difference between pronouns and prepositions. But the patients with comprehension difficulties and anterior lesions were no more successful in marking a noun phrase with pronouns than they were with articles, and they were also insensitive to the preposition-noun link. Retention of the basic semantic roles which noun-phrase constituents can assume was shown by the Broca patients' awareness of 'to' and 'by'; but it was queried whether or not this is retained by the 'anterior plus comprehension' patients.

In preparation	English (American)	Goodenough, Zurif, Weintraub, Von Stockert	(details not at present available)

A. A test of whether articles hinder or help aphasics in the specification of a referent. Subjects were shown an array of three figures such as a white circle, a black circle and a black square, and were instructed either (appropriately) to 'press the white one' or (deductively) to 'press <u>the</u> black one'). Reaction time was measured.

B. Like normal subjects anomic patients showed longer latencies in responding to the latter kind of instruction; they restructured the situation to infer 'press the black circle' i.e. the black one of the two circles. Broca's aphasics, in contrast, showed no difference in latencies in the two conditions, and it was concluded that they are relatively incapable of understanding the article's modulating role in a sentence.

5.2.2 Structure

1968	English (American)	Levy, Taylor	12 * 12	Printed sentences as input; picture verification (slides)

A. A test of comprehension of sentences differing in transformational complexity. Four picture slides depicted a boy kicking a girl or vice versa in every left-right combination. Eight slides showed printed active, passive, negative and negative-passive sentences describing the pictures. All 32 combinations of pictures and sentences were presented, always with the sentence first. Reaction times for reading and for verification were recorded, as were errors.

B. The aphasics were impaired on all the scores in comparison with the control subjects. The order of difficulty, as measured by error scores, was different in aphasics and normal subjects. The order of difficulty for the aphasics was: negatives > passives > negative-passives > actives. For the normal subjects it was: negative passives > negatives > passives and actives. The aphasic subjects' comprehension of passives, negatives and negative passives under these circumstances was described as being only slightly better than chance. The results were interpreted to mean that aphasics' difficulties are related to the application of optional rather than 'base' transformations.

1969	English (American)	Shewan (also Shewan Canter 1971)	27 + 9	Live auditory input; picture choice

A. An examination of the influence of sentence length, syntactic complexity and word frequency on comprehension. Six examples of each of seven kinds of sentences were spoken: length was of 7, 11 or 15 syllables, syntactic complexity varied through active, negative, passive and negative passive; word frequency was high or low (less than 24 per million). Responses were scored for accuracy and for speed (within 3 seconds, up to 10 seconds, more than 11 seconds).

B. The aphasics were significantly impaired. The patterns of impairment were similar in all types of aphasia, and were similar to those of normal subjects. Syntactic complexity presented more difficulty than either sentence length or word frequency. Scores for length of sentences correctly understood did not correlate with the patients' digit spans; and the correlation between severity rating in speech and scores on this comprehension test was not significant. The conclusion was that "receptive deficits for sentences differ only along a quantitative dimension" and cannot be used as a basis for classifying aphasias.

1972	English (American)	Von Stockert	2	Printed words as input; response was arranging words into a sentence

A. A comparison of two patients (one with Broca's aphasia, one with Wernicke's) on the ability to re-order sentences which had been cut up into three parts, either at constituent boundaries (e.g. The girl/from Boston/is pretty) or within constituents (e.g. The/girl from/Boston is pretty). The 48 sentences were either simple declaratives (e.g. The young lady opened the door), sentences with embeddings (as above), questions (e.g. When did your father go?) or imperatives (e.g. Sing a song for your mother!).

B. On the simple declaratives, the Wernicke's aphasic, although alexic on clinical testing, arranged the split sentences at better than chance, particularly when they had been cut within constituents. The Broca's aphasic was also more successful with sentences which had been split within constituents rather than between: with the latter he tended to juxtapose the two noun phrases and then add the verb. The Wernicke's aphasic thus showed retention of some syntactic ability, despite an inability to read substantive words; while the Broca's aphasic, able to read substantive items, showed a reduction in syntactic abilities. "Syntax and lexical semantics are treated separately on a certain level in the process of comprehension of written material".

1972	English (American)	Zurif Caramazza Myerson	3 (+ 4 see Zurif and Caramazza, in press)	Printed words as input; method of triads

A. An examination of whether the syntactic judgements of Broca's aphasics show the same underlying phrase structures as do those of normal subjects. After reading a complete sentence, subjects were given combinations of three words from the sentence and asked to pair the two words most linked. There were ten kinds of sentences, with five examples of each: declarative, intransitive and transitive, direct plus indirect object, yes-no question, WH question with 'be', WH question with auxiliary and pronoun, embedded sentence, passive, comparative and future.

B. A hierarchical clustering analysis showed that from normal subjects cluster hierarchies could be derived which on the whole corresponded to phrase structure as predicted by theory. The aphasic subjects, although providing consistent clusters, showed a different structure, linking substantive words together and grammatical words together. When grammatical words were semantically important (as the possessive pronoun in 'Where are my shoes?') the aphasics were more able to link them with a substantive word, than when their semantic content was low.

1975	English (American)	Gardner, Denes, Zurif	31 + 20	Live auditory input or printed sentences as input; response was decision between pairs of sentences or marking with cross

A. A comparison of recognition of violation of syntactic rules and of semantic rules (selection restriction). For 100 pairs of spoken sentences, subjects had to indicate correctness, or (printed version) to mark errors with a cross. Some examples just obscured meaning, others were factually incorrect (e.g. The dog was bitten by the man).

B. Aphasics, both those with anterior and those with posterior lesions, found semantic violations easier to detect than syntactic (e.g. John sat on him chair). Errors were least often detected in semantically anomalous passive sentences. Different types of syntactic errors were of different difficulties for anterior and posterior patients: anterior aphasics were most insensitive to errors of number and of word order.
There was a tendency for anterior patients to find the reading version harder and the posterior patients the auditory version harder.

1975	French	Kremin Goldblum	44	Printed words as input; response was arranging words into sentence, or sorting by category

A. An examination of four aspects of syntactic comprehension. Test one used Von Stockert's methodology of cutting up sentences at or within constituents, and also cut them up as single words; sentences were simple declaratives, intransitive sentences with an adverbial phrase, transitive sentences with an adverbial phrase, 'be' sentences with adverbial phrase, negative and passive sentences. Test two used the same material but grammatical words were omitted, and in some of them the infinitive form of the verb was substituted for the inflected form. In test three, single words had to be sorted into categories as nouns, verbs, adjectives, articles, pronouns or conjunctions. In test four, a root morpheme was shown to the subject with a series of ten suffixes and the subject was asked to decide whether each composite word was acceptable; only two of the ten suffixes were correct, the others being endings appropriate to other languages or syntactically unacceptable. The aphasic subjects were also given a clinical assessment of speech, naming, picture sequencing etc.

B. Two kinds of strategies were observed in 13 of the aphasic patients, by which they could be divided into a group of 8 and a group of 5. The first group (whose clinical ratings described them as 'sensory' or 'mixed') were better on test one with grammatical words included, than on test two with grammatical words omitted; in test three, they were more impaired on sorting substantive words into categories than grammatical words; they were more impaired on test four than were the other group. The second group (whose clinical ratings described them as 'motor' or 'mixed') fared better on test two than on test one in which they used a strategy of clustering substantive and grammatical words separately; on test three they were able to categorize substantive words better than grammatical; on clinical tests they were worse at repetition but better at naming than the other group. But this second group had not appeared agrammatic in spontaneous speech, although they were impaired on a formal 'sentence generation' test. It seemed that "the defect of comprehension can exist at the receptive level without showing a similar disorder at the expressive level", and that "the greater fragility of comprehension of written material may expose specific deficits which would not appear in aural material". The results were interpreted as supporting the claim that there can be a central dissociation of syntactic and semantic aspects of language.

In press	German	Von Stockert Bader	30	Printed words as input; response was arranging them into sentences

A. A modification of the Sentence Order Test described above. Three kinds of sentences were used: firstly ten simple declaratives, secondly ten sentences in which syntactic information (inflections) clashed with semantic information, thirdly ten 'sentences' in which syntactic information was supplied with nonsense material. In this version of the S.O.T. all sentences were cut at constituent boundaries.

B. Wernicke's aphasics achieved 80% success on test one with the simple declaratives, and 73% success on test three, while in test two for 74% of the sentences they arranged the words according to syntactic information, disregarding the conflicting semantic information. Broca's aphasics had a 75% success rate on test one, typical errors being to put subject and object first and verb at the end; they either refused to undertake test three or produced random results; on test two, 52% of the sentences were arranged according to the lexical sense, with syntactic information disregarded, 11% were arranged according to the syntactic information, and 33% showed errors of order in that the object preceded the subject with the verb at the end. Of the ten global aphasics examined, eight followed the Wernicke pattern, preferring syntactic information to lexical, and two followed the opposite Broca pattern; no patient performed entirely at random. From the results overall it was concluded that in Broca's aphasia the prominent deficit is a loss of grammatical capacity, which can be detected in these tests even when spontaneous speech shows almost complete recovery of grammar; and in Wernicke's aphasia the prominent deficit is a disturbance at the lexical-semantic level, the paragrammatism which occurs in speech being not primarily a grammatical disorder, but a lexical-semantic one.

In press	English (American)	Zurif Caramazza	6 (15 + 5 in later study, see Caramazza and Zurif, in press)	Live auditory input; picture choice

A. An examination of the role of semantic content in syntactic comprehension. Three kinds of centre-embedded sentences were used: ones that were not reversible (e.g. The apple that the boy is eating is red), ones that were reversible and plausible (e.g. The boy that the girl is chasing is tall) and ones that were improbably reversible (e.g. The dog that the boy is patting is fat). There were also, for comparison, simpler 'filler' sentences (e.g. The boy is eating the red apple). The subject was given a choice of two pictures. The incorrect picture could be one of four kinds; it could show the sentence with an incorrect adjective, or an incorrect verb, or both, or could show the subject and object reversed.

B. All the aphasics found the 'filler' sentences easiest, and made fewer errors of choice when the incorrect picture differed in both adjective and verb. They were more likely to choose a picture showing an incorrect adjective than an incorrect verb. Most errors of all were made when the alternative picture showed the subject and object reversed: with the improbable sentences only 50% were correctly identified when the choice showed the more plausible alternative; with the reversible plausible sentences 64% were correct; and with the non-reversible 74% were correct. "Agrammatism appears to reflect a true language limitation. Such sensitivity to structure as is shown in comprehension seems to be heavily reliant upon either lexical or general semantic constraints". One posterior patient was included in the sample, and it was provisionally stated that "at this point neither anterior nor posterior patients appear to be able to compute syntactic relations independently from semantic content".

5.2.3 Summary

From the above accounts, the following points emerge:

1) There appear to be two interacting trends in syntactic comprehension: one is related to a hierarchy of difficulty of morphemic inflections, grammatical words and structural (transformational) complexity which probably applies to all aphasic subjects as it does to normal adults and children. The other is related to the separation of syntactic and lexical-semantic abilities according to type of aphasia. Some patients show relative preservation of syntactic comprehension and others of lexical-semantic comprehension, with corresponding reduction of lexical-semantic or syntactic abilities respectively. But some syntactic features are relatively well understood even by those with reduced syntactic comprehension: these are the syntactic features

which encode semantic relations, such as prepositions, and which on the whole are amongst the easiest in the hierarchy. There is a difference in difficulty for prepositions, but it seems to be related to the number of referents involved and to the number of actions required in the test.

2) There is, moreover, some uncertainty about the degree to which syntactic comprehension can be preserved when lexical-semantic comprehension is impaired, as in Wernicke's aphasia. Syntactic comprehension in such an aphasia may be limited to simple declarative sentences. On the whole, all kinds of aphasics (like normal subjects) tend to notice violations of semantic constraints more than violations of syntactic constraints, although Wernicke's aphasics are readier to accept (leave uncorrected) semantic violations than are Broca's aphasics.

3) These syntactic investigations leave some uncertainty about the nature of global aphasia. Some investigators interpret their findings to mean that it is a gross reduction in both syntactic and semantic ability, even involving deep subject-object relations: others suggest that it conceals two types in which syntactic <u>or</u> semantic abilities are more impaired.

4) The agrammatism shown in the speech of Broca's aphasics appears to be a central reduction of language which applies to comprehension as well as speech, according to these experimental studies. It appears that agrammatism can be exposed on formal clinical tests using reading when it is not evident in conversational speech, suggesting that the spontaneous use of syntactic structures in speech recovers

before formal application of syntactic knowledge in tests of comprehension under experimental conditions.

5) There is some suggestion that syntactic disorders are revealed more clearly in Broca's aphasia by tests using reading, while syntactic (?) disorders are revealed more in Wernicke's aphasia by tests using listening.

5.3 Investigations of comprehension at the semantic level

The following examples of studies of semantic comprehension in aphasia do not include any which primarily have examined performance on standard vocabulary tests, but only those which have attempted to characterize the nature of disturbances in the organization of interrelationships amongst words.

5.3.1 Connotative

1971	English (American)	Mostofsky Van den Bossche Scheinkopf, Noyes	28 + 20	Live auditory input; response was choice of figure

A. A test of retention of connotative meaning using a figural non-verbal version of the Semantic Differential. Subjects were asked to choose for twenty concepts (e.g. good, strong, fast) which of twelve visual alternatives they preferred (e.g. arrows pointing up or down).

B. Aphasics showed more consistency amongst themselves and more agreement with the preferences of normal control subjects than did patients with right brain damage who were not aphasic. It was concluded that word-finding difficulty in aphasia was not correlated with impairment in recognition of connotative meaning.

1973	English (American)	Gardner, Denes	42 + 10	Live auditory input; picture choice and figure choice

A. A comparison of retention of connotative and denotative meaning. The test of denotative meaning used 17 items, for which patients had to select pictures. The test of connotative meaning used 10 of these items again (concrete nouns) plus 11 common adjectives appropriate for these nouns, and 10 abstract nouns which corresponded to these adjectives. The subject was shown 14 pairs of 'expressive lines' or figures, and asked to select which member of the pair was more appropriate for the word.

B. There were significant correlations amongst scores on the denotation test, the connotation test and comprehension scores on the Boston Test. However, "sensitivity to connotation was shown to be relatively robust under conditions of brain-damage". There was no difference between nouns and adjectives on the connotation test. Anterior patients fared better than posterior or global patients on both tests, and posterior better than global on the denotative test but not on the connotative test. People with right brain damage sometimes refused to do the connotation test, saying that the figures were meaningless.

5.3.2 Denotative

5.3.2.1 Categories

1964	French	Alajouanine Lhermitte, Ledoux, Renaud, Vignolo	5	Live auditory input; picture choice

A. (Part of the study described in Section 5.2.3.) Ten sets of five pictures were shown to the subjects illustrating words from the same semantic category. The categories were food, writing materials, furniture, toilet materials, cutlery, smoking, clothes, sewing materials, farm animals and bicycle parts. An example of the choice of words is (for food) butter, cheese, bread, chocolate, meat.

B. Aphasics characterised by semantic jargon in speech made 18% errors, almost three times as many as did patients whose speech was characterised by phonemic jargon. There is a regression of semantic values in comprehension as there is in speech, although it is evidenced to a lesser degree.

1966	English (American)	Goodglass, Klein, Carey, Jones	135	Live auditory input; picture choice

A. A comparison of comprehension and naming of items in different semantic categories. The categories were alphabet letters, numbers, colours, body parts, geometric shapes, actions and objects. For body parts the subject was asked to indicate recognition by pointing to his own body; for other categories the pictures from the Boston Test were used. Scores were weighted for speed of response.

B. There was a dissociation between the ability to name and to show recognition of words in the same semantic category. "The operation of producing language is in surprising measure independent of understanding it even when the same lexical content is involved", but the difference can be explained in terms of phonological distinctiveness and information theory: letters and colours were hard to decode but easy to name, while objects, actions and numbers were easy to decode but hard to name. Clinical types of aphasia could be distinguished in that, in comprehension, Broca patients had relatively low scores on letters and on geometric forms, while Wernicke patients had relatively low scores on body parts. But the types were not as clearly distinguished in comprehension as in speech. "It seems compelling to recognize the anomic component of fluent aphasia as a specific deficit which is qualitatively different from the retardation and failures in word-finding which are found in nearly all aphasics."

1971	Rumanian	Kreindler, Gheorghita, Voinescu	50	Live auditory input; response was pointing to token

A. An adaptation of the Token Test (Tridimensional Matrix Test) to test comprehension of colour, size and shape words. An abstract version using tokens was compared with two concrete versions using drawings of flowers and houses (in one 'intermediate' concrete version these were referred to as plants and dwellings).

B. A fifth of the subjects could not proceed with the test, as they could not recognise by name, singly, either the colours, shapes or sizes. There was significant difference in the difficulty of the three categories: shape > colour > size (which conforms to word frequency in Rumanian). There were more errors on the abstract version than on the concrete versions.

1974	German	Orgass, Poeck, Kerschensteiner	45	Live auditory input; pointing to diagram, own body, pictures

A. A test for selective impairment in comprehension of body parts. Subjects were asked to point out 25 named items on a diagram of a man and on their own body, and were also given a test of identifying 50 items from pictures where the incorrect choices were semantically similar or phonemically similar.

B. There was no evidence for selective impairment of body parts; the scores for body parts and for object names (and for colour names from a previous experiment) correlated highly. It was suggested that word frequency is a more important variable than semantic category.

1974	English (American)	Gardner	61 + 10	Written symbols as input; selection from three spoken words, or naming, as response

A. A test of recognition of different categories of symbols (verbal and non-verbal). The 11 categories were numbers, alphabet letters, colours, animals, punctuation marks, objects, number signs, faces, printed words, typographically distinct words, and miscellaneous items.

B. Recognition and naming of symbols was impaired across the board in aphasic patients and showed the same relative order of difficulty as in normal subjects. Posterior patients were significantly more impaired than anterior patients on recognition.

5.3.2.2 Word associates and semantic fields

1968	Italian	Pizzamiglio Parisi Appicciafuoco	59 + 20	Live auditory input; picture choice

A. (Part of an examination of phonological, syntactic and semantic comprehension.) For thirty words the subject had to choose one of four pictures each representing a close semantic associate of the word, as judged from the degree of overlapping in word association responses from normal subjects.

B. Only 3 out of 36 aphasics scored above the cut-off level of 3 errors established by the control subjects. Incorrect choices were most frequently of the closest associate.

1971	French	Lhermitte Derouesné Lecours	50 + 120	Printed words as input; response was sorting them into classes

A. An examination of the disturbances of organization of semantic fields. Patients were asked to classify twelve words according to whether they were semantically close, semantically remote, or unrelated to a head word. There were ten head words: for each, four words had to be placed in each class of semantic distance. In a second (polysemic) test seven words had to be classified into one of two classes, as being possible meanings of a homonym or not. There were ten homonyms. The acceptability of the classes was empirically established from control subjects of different educational backgrounds. Severely impaired and intellectually impaired aphasics were excluded.

B. All the aphasics but one showed a 'semantic deficit', i.e. had more difficulty than control subjects of the same educational level. Errors on the monosemic test were characterised as being either 'hierarchization' errors (misclassifications of semantically close and remote words) or as 'widening or narrowing' errors (misclassifications of remote and unrelated words). By including results from the polysemic test, widening and narrowing errors could by distinguished. These three types of errors were relatable to three types of aphasic disturbance, which, however, did not coincide exactly with conventional classifications. Amnesic aphasics made high errors (though the sample was small) suggesting that amnesic aphasia is not just an unavailability of words for speech but that "one might view amnesic aphasia more or less as an isolated form of the semantic deficit also displayed by other aphasic subjects".

In press	English (American)	Goodglass Baker	48 + 16	Tape recorded auditory input; response was pressing a bulb

A. An examination of the structure of semantic fields in aphasia. Sixteen picturable nouns each with six associates and seven unrelated words were heard on tape, while the subject looked at the printed noun and a picture of the object it represented. As soon as the subject heard a word he felt was at all related to the picture he had to press a bulb. Before the test the subject was asked to name the word, so that his naming ability could be compared with his responses on the associate recognition task. The associates were a superordinate, a coordinate, an attribute, an associated activity, an associated place and a clang associate. The words were either of low or of high frequency. The subjects had been classed as high or low comprehension on the Boston Test.

B. There were very few false responses to unrelated words, and few responses to clang associates. Word frequency had only a limited effect. High-comprehension aphasics showed the same latency pattern as did the control subjects: fast reactions to the identity word, the superordinate, the associated place and the attribute, but slower to associated activity words and to coordinates. (These were inferred to be peripheral in the semantic field.) Low-comprehension aphasics in contrast accepted coordinates more readily as being associated but not place associates; but they did recognise the identical word as quickly and as accurately as the other subjects did, showing that they were attending to the task. For low-comprehension aphasics (but not for high) error rates on comprehension were markedly related to naming ability: there were 50% more errors on words which had not been named. It was concluded that anomic aphasics are particularly impaired in the structure of their semantic fields.

5.3.2.3 <u>Features</u>

1974	English (American)	Zurif Caramazza Myerson, Galvin	10 + 5	Printed words as input; method of triads

A. An examination of semantic features as a model for aphasic disturbances of semantics. Twelve words were used which were likely to be classed on the basis of general semantic features into + human (mother, wife, cook, partner, knight, husband) and - human (shark, trout, dog, tiger, turtle, crocodile). The words could also be classed according to residual features (e.g. married), systematic interlexical relations (e.g. species membership) and referential knowledge (e.g. ferocity).

B. A hierarchical cluster analysis and a multidimensional scaling analysis both gave acceptable results. The anterior aphasics retained the general semantic feature ± human (though they classed 'dog' with humans), but they clustered animal terms mostly by affective and situational implications, whereas control subjects had clustered them by species membership. With the posterior aphasics even the ± human feature was lost; there was no evidence of a hierarchical structure, and they often paired words on the basis of how they could be fitted together in a copula sentence rather than on their semantic relatedness. It was concluded that posterior aphasics show a serious reduction in semantic organization, while, in anterior aphasics, semantic organization, although retaining some structure, emphasises extralinguistic information and concrete situations.

5.3.2.4 Discourse

1975	German	Huber, Stachiowik, Kerschensteiner, Poeck	95 + 19	Live auditory input; picture choice

A. A test for the comprehension of connected discourse. It consists of 25 stories each with a set of five pictures. It investigates knowledge of pronominal coreference and of idiomatic comments whose precise interpretation depends on a preceding sentence. The examiner tells the story consisting of six sentences including an idiomatic one (e.g. "He's following in his father's footsteps") and then asks "Which picture shows the situation he's in?" Three of the incorrect pictures show the wrong subject, verb or verb complement, while the fourth incorrect picture shows a literal interpretation of the idiom. Two types of idiom were used, ones in which the incorrect picture could represent a possible answer to the question asked (e.g., as in the example above, "He's following in his father's footsteps") and another where the semantic link was only via the idiom (e.g. "He's a fish out of water").

B. The overall performance of the aphasics was not poorer than that of right brain damaged or normal controls. All subjects were three times as likely to choose the literal picture for the idiom when it was semantically related as when it was remote. It was suggested that aphasics are helped in comprehension by the greater redundancy of connected texts.

5.3.3 Summary

The following points are extracted from the survey above:

1) Connotative meaning (defined as including situational and other subsidiary meaning, as well as affective meaning) is probably better preserved in aphasia than the more structured aspects of meaning.

2) Patients with posterior lesions, and with anomia and semantic paraphasia in speech, show greater disorganization of the lexicon than do patients with anterior lesions. Even in the relatively circumscribed syndrome of anomia there is probably a major disturbance of semantic organization. It is disputed whether or not this disturbance is qualitatively different from, or is a more severe degree of, the lexical-semantic difficulties which almost all aphasics have.

3) There is conflicting evidence about whether or not different categories of words may be differentially impaired by different sites of lesions. But discrepancies between speech and comprehension in semantic categories can be accounted for by behavioural circumstances without necessarily implying a central dissociation.

4) All the models of lexical-semantic organization so far used seem to be compatible with the results which have been found. The complexity of semantic organization is such that they may all catch some facet of it.

5) As a group aphasics may be relatively better at understanding connected discourse than they are at understanding single lexical items.

6. Conclusion: Experimental Plan

Of the studies outlined in Section 5 some sixteen or so were available at the time the present investigation was initiated in 1971. From them it appeared that the framework of the linguistic levels was a promising one through which to investigate verbal comprehension after brain damage and that these levels could show some degree of autonomy in impairment. (The later studies have tended to reinforce this impression.) For practical application in therapy, therefore, some system of examining these different language levels in patients' comprehension seemed desirable.

The investigation was not intended to develop and standardise a set of clinical tests, but to use experimental material to study some of the linguistic and extra-linguistic variables which must influence the development of such tests.

The experimental investigation, reported in Parts Two, Three and Four, was undertaken in three stages:

1) A preliminary experiment was aimed at (i) testing the practicality of using picture materials as a medium for examining verbal comprehension, and (ii) generating hypotheses about what variables would be influential in further studies. The experiment was based on the three tests in Italian outlined in Section 5.
2) A second preliminary experiment was aimed at (i) testing whether or not one of the main hypotheses derived from the first experiment was worth further examination,

i.e. that aphasic patients make more errors in syntactic comprehension when sentences contain reversible elements than when they do not contain such elements, and (ii) testing whether, in picture-sentence matching tests of syntactic comprehension, the arrangement of the figures in the pictures influences results, so that, if necessary, this variable could be controlled in further material.

3) A main experiment tested the hypotheses generated from the preliminary work. Because of the circumstances under which the investigation had to be carried out, it was decided to include a number of areas of study in one major experiment rather than to conduct a series of minor experiments. The principal areas investigated were:

   (i) The extent to which measures of verbal comprehension access a central knowledge of language, as inferred from (a) the relationship of the experimental linguistic tasks to other measures of verbal and non-verbal comprehension, (b) the effect on scores of the input medium used and the complexity of the gestural response required, and (c) the relationship of scores on verbal comprehension to measures of speech.

   (ii) The influence on aphasic comprehension of the necessity for material to be processed sequentially.

   (iii) The deficits in verbal comprehension of people with right brain damage who had not been diagnosed as aphasic.

The two preliminary experiments are described in Part Two. Part Three gives an account of the main experiment and its results concerning (i)(a) and (i)(b). The theoretical background to (i)(c), (ii) and (iii) requires some discussion, and the accounts given in Part Four of the results of the main experiment pertinent to these three areas are, therefore, each introduced by a survey of the relevant background.

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PART TWO

Experimental: two preliminary experiments

1. The first preliminary experiment: an English version of three Italian tests of verbal comprehension of aphasia

The experimental work for this investigation of comprehension after stroke began in 1971 with the adaptation into English of three tests of comprehension which had been devised in Italian (Pizzamiglio and Appicciafuoco 1967, Pizzamiglio, Parisi and Appicciafuoco 1968). These were part of the first (published) study to apply the concept of three linguistic levels to the examination of comprehension in aphasia. They all used sets of pictures from which the patient has to make a choice to match a spoken word or sentence. First reported in English at a conference at Ohio, details of these tests became available somewhat later in international journals and a book (Pizzamiglio and Parisi 1970, Parisi and Pizzamiglio 1970, Pizzamiglio and Appicciafuoco 1971). Professor Pizzamiglio kindly supplied copies of the Italian tests. When the English versions had been produced and the data collected from the subjects, the Sub-Department of Speech of this university invited Professor Pizzamiglio to Newcastle, through the British Council, providing an opportunity for the results to be discussed, in person, with him.

Part of this experiment was undertaken in cooperation with Alan Coupar, a postgraduate student in the Department of Psychological Medicine, University of Newcastle upon Tyne, whose particular interest was to examine the effect of frontal leucotomy on language comprehension.

The following account is an expansion of a published report of the experiment (Lesser 1974).

1.1 Aim

The aim was to test the practicality and validity of the method used in the Italian tests by duplicating them as nearly as possible in English versions, using exact translations with the same pictures, or, where this was not possible, similar techniques in devising the tests. It was hypothesised that the English versions would prove as satisfactory as the Italian in distinguishing aphasic and non-aphasic subjects, and that they would correlate significantly with existing English-language aphasia tests. As it was not possible to match the Italian and English groups of subjects, it was not expected that the two versions would produce similar results in absolute terms, but that they would show a similar relative order of difficulty. It was also expected that the experiment would generate hypotheses about what variables would be important in the further study of verbal comprehension.

1.2 Subjects

Four groups of adult subjects were used; fifteen subjects with unilateral left-hemisphere damage (LBD) and aphasia following cerebrovascular accident; fifteen subjects with unilateral right brain damage (RBD) without clinically diagnosed aphasia following cerebrovascular accident; nine subjects who had undergone bilateral frontal leucotomies (BFL); and fifteen non-brain-damaged subjects (NBD).

All subjects were in the age range 33-65 and were without abnormal hearing loss or clinically evident visual agnosia. The groups were equated for age and years of schooling (Table 1); each of the groups of fifteen included eleven people who had left full-time education at or below the age of 15.

Table 1

Mean Ages and Years of Schooling of All Groups

Years	LBD	RBD	BFL	NBD
Age	51.47 s.d. 9.46	54.60 s.d. 7.28	51.67 s.d. 5.27	53.93 s.d. 8.33
Schooling	10.27 s.d. 1.98	9.67 s.d. 1.50	9.33 s.d. 0.87	9.67 s.d. 1.50

These three groups each included eight women and seven men; the leucotomised group four women and five men. No patient was tested until at least two months after the stroke or trauma; the LBD aphasic group was tested at from three months to seven years after the stroke, the RBD group from two months to four years and the leucotomised group from two and a half months to eight years after the operation. The aphasic patients had all been referred as outpatients for speech therapy at the Royal Victoria Infirmary, Newcastle. The first fifteen patients eligible by the criteria previously indicated were used for testing. The aphasic group was accordingly not selected for diagnostic categories as had been the Italian group. In the aphasic group eleven patients had been judged on their clinical performance, including executive speech, to have predominantly anterior lesions, one to have a predominantly posterior lesion and three to have anterior-posterior lesions. The language disabilities of three patients, one of whom had already returned to part-time paid employment, were rated by the speech therapist as mild, five patients were rated as moderate, seven as severe. Eight of the aphasics had right-sided hemiplegias; the remainder had had no motor disability or had now recovered functional use of arm and leg. The right-brain-damaged group had all had left hemiplegia, from which four had made a virtually complete recovery. Seven were hospitalised for lack of adequate home accommodation; only two had returned to paid employment. Seven of the leucotomised group had been operated on following chronic depression, two following obsessional neurosis. Two had returned to paid employment (one at a lower status than before the operation); one was permanently hospitalized and one attended hospital as a day patient. The operation had involved undercutting Brodmann's areas 9 and 10 in both frontal lobes through burr holes in the skull made approximately 2 cms anterior to the coronal suture (Coupar 1972). The patients had no known additional brain damage. Four patients had reported speech difficulties post-operatively, notably 'slurring', syllable reversals and word-finding inaccuracies particularly with people's names. The final group of subjects, the fifteen non-brain-damaged normal controls, was formed mainly of spouses of the aphasic patients and factory employees; six in this group were in paid employment.

In order to make a comparison of the order of difficulty of syntactic contrasts in aphasic breakdown and in language acquisition, the Syntax Test was also given to a group of children, as had been the Italian test. The group of English children consisted of three boys and three girls in each age group 4-4.11, 5-5.11, and 6-6.11; all attended an infants' school in a mixed working class and middle class district.

1.3 Test measures

Each adult subject was given the three new tests and four commonly used clinical tests of auditory comprehension: the Token Test in the version used in the Neurosensory Center Comprehensive Examination for Aphasia (Spreen and Benton 1969), the Wepman Auditory Discrimination test (Wepman 1958), the Auditory Verbal Comprehension (Oral Sentences) Section of the Eisenson Examining for Aphasia test (1954) and the Auditory Comprehension subtest number six of Schuell's (1957) Short Examination for Aphasia. In the Wepman Test the subject has to indicate whether 40 pairs of words are the same or different; only the 30 pairs which are in fact different are scored. In the Eisenson sub-test the subject selects from a choice of four words the appropriate answer to each of ten simple questions. In the Schuell sub-test the subject is asked in sentences of increasing length to perform ten actions using a set of objects. Each subject was also given the Raven's Standard Progressive Matrices (Raven 1958) with a 20-minute time limit, and the English Picture Vocabulary Test 3, age 11 to 18+ (EPVT) (Brimer and Dunn 1968). The Raven's Matrices were used to make an approximate assessment of intellectual functioning. These last two tests and the Token Test were also used in the main experiment: details of the previous applications of these three tests are given in Part Three, Sections 3.2.1 and 3.2.2.

Scoring on all tests was pass/fail, except in the new tests and in the Token Test. In the latter, a score of one was given per item of information responded to in each sentence. In the new tests the same method of scoring was used as in the Italian tests, 1 for a correct choice elicited without repetition, $\frac{1}{2}$ for a correct choice made after two or more requests for repetition. All tests were presented individually. The tests were given to the aphasic patients over several sessions to avoid fatigue, and during clinical visits for speech therapy. The majority of the RBD were tested in two sessions at the hospital and the leucotomised were tested in one session each at the hospital. Six of the RBD and eleven of the NBD were tested in single sessions in their own homes.

Except for the aphasics where testing was spread over several sessions, the order of presentation was Syntax Test, Semantic Test, Phonological Test, Wepman Test, Token Test, Eisenson and Schuell sub-tests, EPVT and Raven's Matrices.

1.3.1 The English Semantic Test

The English material drew chiefly upon recently published norms of word association in a British population (Miller 1970) supplemented by American norms (Keppel and Strand 1970). Enough published British data was not available to make complete indices of associative overlapping as in the Italian, where one of the indices described by Marshall and Cofer (1963) had been used; a simpler scheme was therefore employed. Each of thirty stimulus words was illustrated together with its three most frequent associations. Fourteen of these stimulus words were 'bidirectional', i.e. they overlapped strongly with one of their associates in that when these associates had themselves been given as stimuli in the preparation of the original norms they had in turn produced the original stimulus words.

Ten stimulus items were of a frequency of from 11 to 45 per million in the Thorndike-Lorge count (Thorndike and Lorge 1944), and the remaining twenty appeared in the thousand most common words. Twenty of the stimulus words were most commonly interpretable as nouns, ten as verbs or adjectives. Eleven of the items included distractor words which were 'contiguous' rather than 'substitutive' (Ervin-Tripp 1970) e.g. 'walking' '-stick'.

The pictures were simple black on white line drawings, which had been judged as appropriate for the words they illustrated by twelve normal people. The pictures were on the whole simpler and less detailed than those in the Italian version. They were presented four on a page of A4 size, 21 cms by 30 cms, and were separated by space rather than dividing lines. The correct picture occurred eight times in a top or bottom right quadrant and seven times in a top or bottom left quadrant: the order was randomised.

The stimulus words were spoken by the examiner and the rate of presentation was adjusted to the rate of response. Two unscored trial items were presented first. The instructions and list of items are given in Appendix A.

1.3.2 The English Phonological Test

This test used materials from Black and Haagen's Multiple-Choice Intelligibility Test (Black 1957, Black and Haagen 1963), the original source upon which material for the Italian test had been modelled (Pizzamiglio and Massa 1968). The stimulus words were taken from lists which had been read out to service personnel against a background of white noise. The distractor words were the three words most commonly mistaken for the stimulus by Black's subjects. Due to the requirement that all four words in each set from this list had to be easily picturable and common, only twenty sets plus two pre-test sets were prepared; this test was therefore shorter than the Italian, which had 28 items. The stimulus and distractor words were all of a frequency of at least seven per million on the Thorndike-Lorge count. Nine of the stimulus words were of AA or A frequency (100+ or 50+ occurrences per million). Every stimulus word except one had at least one of its accompanying distractor words of higher or equal frequency and, in all but three cases, at least one of lower frequency. A typical set was 'sit, six, sift, sick'. Eighteen of the word sets were monosyllabic, two bisyllabic. In the Italian test 24 word sets were bisyllabic and three trisyllabic. Phonological patterns differ greatly between the two languages (Migliorini and Griffith 1966), and all the Italian test words end in a final syllabic vowel. In the English test four of the stimulus words were verbs ('torn, carve, scorch, sit'), five were interpretable as verbs or nouns ('heat, end, lock, bite, sleep') and the remaining eleven were pictured only as nouns. Italian makes a more precise difference between substantives and verbs (Agard and Di Pietro 1965a); for example, the syntactically ambiguous English word 'sleep' would be in Italian either 'dormita' (substantive) or a part of the verb 'dormire', and, similarly, the gerund 'mangiando' ('eating') is a substantive and not a verb, where both possibilities are open in the English translation.

The stimulus words were recorded on tape, so that the subject heard each word twice spoken first by a man then by a woman. There was an interval of 15 seconds before the next stimulus word was given.

If the subject needed more time the tape was stopped until he was ready to continue, and a $\frac{1}{2}$ score was given if he then selected the correct item. The word was not repeated. The picture format was the same as in the Semantic Test. The instructions and items are given in Appendix A.

1.3.3 The English Syntax Test

For this test it was possible to use substantially the same material as the Italian with a direct translation into English using the same pictures and the same order of presentation of the items. A few minor changes were made. Two items using the reflexive/non-reflexive contrast could not be satisfactorily translated; 'The girl is brushing herself' and 'The man is shaving him' were substituted for 'La bambina si pettina (The girl is combing herself)' and 'Il papà si metto il cappello (The father puts on his hat)'.

To maintain internal consistency, sentences were used as stimuli throughout, although the Italians had used non-sentences for seven items (e.g. 'Sedie' was presented in the English version as 'It's the chairs'). For ease of analysis where the Italian had presented six plural contrasts and only two between/beside contrasts, the English version maintained a consistent pattern of four examples of each of twenty contrasts. The English version thus contained four new pictures (two for the reflexive and two for the between/beside contrast). There was also a minor change in one picture. Pre-testing showed that the picture for 'He has been running' was ambiguous and footsteps were added to make interpretation easier.

In translating, the progressive tense form was used intuitively where it seemed conversationally more natural, except in longer sentences, e.g. 'Il ragazzo ha corso' was translated as 'The boy has been running', and 'Il gatto che sta sulla sedia salta sul topo' as 'The cat which is on the chair jumps on the mouse'. English more consistently than Italian uses a tense which relates the past to a present moment of time, e.g. 'The boy has been running' compared to 'The boy was running' or 'The boy ran'. As pictures show a static moment of time the use of this imperfect-present tense was judged preferable to the straight imperfect or perfect past tense.

The 80 pairs of pictures were presented on cards of 4 inches by 5 inches. The instructions and items are given in Appendix A.

1.4 Results

The mean results for each group on each test are presented in Table 2. (Because the large number of comparisons to be made increased the likelihood of a type one error, the significance level was set at .01.)

Analysis of variance (Table 3) showed that performances between groups were significantly different from performances within groups at $p < .001$ in the Syntax, Semantic, Token and Schuell tests, and at $p < .01$ in the Phonological, Wepman and EPVT. The differences amongst groups on the Eisenson sub-test and Raven's Matrices did not reach a .01 level of probability. An analysis of covariance partialling out the effects of the two conventional measures of intelligence and educational level (EPVT and Raven's Matrices) did not affect the

Table 2

Mean scores and standard deviations

on all tests for each group

Tests	LBD	RBD	BFL	NBD
Syntax max. = 80	64.90 s.d. 6.12	76.03 s.d. 4.95	77.72 s.d. 1.80	78.07 s.d. 0.94
Semantic max. = 30	24.73 s.d. 4.00	27.03 s.d. 2.21	28.33 s.d. 1.50	29.23 s.d. 1.18
Phonological max. = 20	16.50 s.d. 2.25	18.06 s.d. 1.94	19.22 s.d. 1.30	18.80 s.d. 0.86
Token max. = 163	112.40 s.d. 36.70	158.60 s.d. 3.64	158.11 s.d. 4.70	160.33 s.d. 3.04
Wepman max. = 30	23.27 s.d. 5.18	28.07 s.d. 1.75	25.78 s.d. 5.26	27.67 s.d. 2.79
Schuell sub-test max. = 10	8.07 s.d. 1.87	9.80 s.d. 0.41	9.89 s.d. 0.33	10.00 s.d. 0.00
Eisenson sub-test max. = 10	9.40 s.d. 0.80	9.93 s.d. 0.10	9.89 s.d. 0.10	10.00 s.d. 0.00
EPVT max. = 48	31.40 s.d. 7.35	28.60 s.d. 12.69	37.33 s.d. 6.18	40.73 s.d. 5.40
Raven's Matrices max. = 60	22.67 s.d. 7.98	21.47 s.d. 11.87	26.33 s.d. 7.92	32.47 s.d. 9.52

significance of any of the F-ratios except for the Semantic Test, which was reduced from $p < .001$ to $p < .01$ (Table 3).

Table 3

Analyses of Variance and Covariance

Test	F-Ratios	
	Analysis of Variance	Analysis of Covariance controlling for EPVT & Raven's
Syntax	31.29 **	28.67 **
Semantic	8.36 **	5.07 *
Phonological	6.40 *	5.15 *
Token	20.43 **	18.52 **
Wepman	4.79 *	4.71 *
Schuell	11.68 **	10.30 **
Eisenson	4.14	3.45
EPVT	5.89 *	-
Raven's Matrices	3.94	-

* $p < .01$

** $p < .001$

Mann-Whitney U-tests for comparisons between groups on the tests which showed differences (Table 4) confirmed that the Syntax and Token Tests and Schuell sub-test discriminated excellently between aphasic and all non-aphasic groups, none of the inter-control group ratios being significant. The Phonological Test discriminated satisfactorily

Table 4

Mann-Whitney U-Tests of

Differences between Groups

Test	LBD v. NBD	LBD v. RBD	LBD v. BFL	RBD v. NBD	RBD v. BFL	BFL v. NBD
Syntax	0.5**	17.5**	1.5**	90.5	59.0	62.5
Semantic	28.5**	80.0	30.0	35.5**	41.5	31.0
Phonological	43.5*	67.0	22.5*	93.0	38.5	44.5
Token	17.0**	21.5**	14.0**	76.0	67.0	43.5
Wepman	55.5*	52.5*	43.5	111.0	64.5	65.0
Schuell	22.5**	33.0**	17.0**	90.0	63.5	60.0
EPVT	33.0**	102.0	33.5	40.5	36.5	38.0

* $p < .01$

** $p < .001$

(one-tailed test except for RBD v. BFL)

between the LBD and the NBD and BFL, but only at $p < .05$ between LBD and RBD. The Semantic Test, however, did not satisfactorily distinguish aphasic from non-aphasic groups. In this test both the LBD aphasic and the RBD groups scored significantly below NBD scores ($p < .01$) and the LBD aphasic and the RBD were not significantly different.

Pearson product-moment correlations were computed for the test scores; there were significantly high correlations amongst all the aphasia tests (Table 5). The highest correlations were between the

Syntax and Token Tests (0.84) and the Syntax and Semantic Tests (0.80). The correlation coefficients for the three new tests with the Token Test were all significant at $p < .001$.

Table 5

Pearson Correlation Coefficients between Tests

	Semantic	Phono-logical	Token	Wepman	Schuell	Eisen-son	EPVT	Raven's
Syntax	0.80**	0.59**	0.84**	0.48**	0.75**	0.52**	0.38*	0.28
Semantic		0.52**	0.69**	0.40*	0.66**	0.53**	0.46**	0.40
Phono-logical			0.47**	0.28	0.30	0.40*	0.48**	0.48**
Token				0.56**	0.70**	0.52**	0.27	0.26
Wepman					0.35*	0.41*	0.17	0.06
Schuell						0.63**	0.17	0.17
Eisen-son							0.23	0.18
EPVT								0.56**

Partial Correlation Coefficients between Tests,

Controlling for Effect of EPVT and Raven's Matrices

	Semantic	Phono-logical	Token	Wepman	Schuell	Eisen-son
Syntax	0.76**	0.50**	0.83**	0.46**	0.75**	0.48**
Semantic		0.35*	0.65**	0.39*	0.67**	0.50**
Phono-logical			0.39*	0.26	0.25	0.33*
Token				0.55**	0.69**	0.48**
Wepman					0.33*	0.39*
Schuell						0.61**

* $p < .01$

** $p < .001$

1.5 Discussion

1.5.1 Group Performances

The leucotomised group did not perform significantly differently from the normal group or from the RBD group on any tests, although they performed better than normal on the Phonological Test but achieved a poor score on the Wepman Test, a finding which suggests that these two tests are not measuring the same skill. Lasting gross dysphasic symptoms have rarely been reported after frontal leucotomy (Freeman and Watts 1942, Mettler 1952); Milner (1964) has reported reduced word fluency after left frontal lobectomy, and Luria and Homskaya (1964) a disturbance in the efficacy of their own speech to regulate their motor reactions in patients with frontal lobe lesions. Petrie (1952) reports a loss in accuracy of word definitions after frontal leucotomy. Some impairment in a task like the present Semantic Test might have been expected, and indeed the leucotomised group showed more impairment on this task than on other aphasic tests, though the difference from normal performance did not reach significance.

The RBD group was not significantly different from the leucotomised on any tests. It differed significantly from normal, however, on two language tests, the Semantic Test and EPVT, and also on Raven's Matrices ($U = 44.5$, $p < .01$). In the two latter tests the RBD group scored lower even than the aphasics. An impaired performance on Raven's Matrices is not unexpected (see Part Three, Section 3.2.1), but the poor EPVT results are unusual. The EPVT results are depressed by two very low scorers, but nevertheless seven of the fifteen RBD scored below the mean for aphasics. The mean RBD score was at the 21 %ile. The poor results of the RBD on the Semantic Test are discussed in Section 1.5.3.

The NBD had been expected to score perfectly or nearly perfectly on all aphasia tests. In fact, no normal control subject achieved a perfect score on the Syntax Test, only four made no errors on the Token Test and on the Wepman Test, only three on the Phonological Test (chiefly due to one unsatisfactory item) and only nine on the Semantic Test. The Schuell and Eisenson sub-tests presented no difficulties at all. The mean group performance on Raven's Matrices was at the 41 %ile (but it should be borne in mind that a 20 minute time limit was imposed) and the mean EPVT score was at the 63 %ile.

The LBD aphasic group had the lowest scores on all tests except EPVT and Raven's Matrices. Their results are discussed in detail under the different test headings.

1.5.2 Comparison of English and Italian results

In all the three new tests the English LBD aphasics achieved higher mean scores than the Italian, suggesting that either the English sample was less severely impaired or that the English tests are intrinsically easier. The performance of the English control groups, however, was in general inferior to the Italian, indicating that the former is the more likely explanation. The English results confirmed the correlation of the new tests with existing aphasia tests, and the discriminativity of the Syntax and Phonological Tests; but due chiefly to the poor performance of two RBD subjects in the English group, satisfactory cut-off points for aphasic and non-aphasic performance were not obtained for the Syntax and Phonological Tests. Both these subjects were long-term hospital residents and scored low on all tests involving picture material, though well on the Wepman, Schuell and Eisenson Tests.

The major discrepancy between the English and Italian results is the failure of the English Semantic Test to distinguish satisfactorily between aphasic and RBD performance. All three brain-damaged groups showed some trend towards impairment on this test. The English and Italian brain-damaged groups were not comparable in that half the Italian brain-damaged control subjects were patients with left brain damage but without aphasia, who, it may be presumed, had suffered less cerebral damage. From their scores on the two tests which are not usually used for aphasia diagnosis, EPVT and Raven's Matrices, the English RBD group would seem to have been more intellectually impaired than the LBD aphasic group. It is thus highly probable that the sample of RBD patients used as control subjects in the English study had suffered more brain damage than had the Italian control group.

Detailed comparisons of the Italian and English results are included in the discussion below on each test.

1.5.3 <u>The Semantic Test</u>

An examination of the individual items in the Semantic Test showed no clear trends in the variables which had been monitored. In only five of the twenty-three errors made on items with contiguous choices available did aphasic subjects choose the contiguous word ('knob' for 'door', 'pipe' for 'stove', 'cloth' for 'table' and 'bone' for 'shoulder'). Six of the items on which the aphasic group made no errors or one error were of low frequency on the Thorndike-Lorge count, while four were of high frequency. On the fourteen 'bidirectional' items, of the 44 errors made, only 15 were by choosing the strongly associated word.

Several explanations for the unexpected selective deficit of the RBD on the English Semantic Test were considered. Firstly, the semantic impairment appeared to be associated with poor vocabulary in the group as a whole, although the educational level of all the subject groups was equivalent. However, if frequency in the language is taken as a measure of difficulty of vocabulary, the Semantic Test should have been at least as easy as the Phonological. Secondly, a general cognitive deficit attributable to brain damage could not account for the apparent selectivity of the deficit to the semantic rather than the syntactic or phonological level. Thirdly, an obvious candidate for poor results from a group with right brain-damage on tests where pictures are used is some difficulty in interpreting picture material. This could not be ruled out completely, but again the selectivity of the deficit to one kind of picture test could not be explained. Fourthly, there is some evidence that after right brain damage a left visual field neglect may persist even when there is no frank hemianopia (Oxbury, Campbell and Oxbury 1974). Both the Semantic and the Phonological Tests required the scanning of four pictures including two placed on the left. However, examination of the results showed no bias towards left sided neglect in the errors, and had any such factor been important it would have operated in the Phonological Test as well as in the Semantic. Fifthly, the possibility of some covert left brain damage in the RBD could not be excluded, particularly in a population of this age and with a history of vascular disease. However, the RBD were not aphasic in speech, nor were they aphasic in comprehension according to the test which is usually used to examine subtle defects in verbal comprehension, the Token Test. (Good scores on the Token Test are not incompatible with poor scores on a test of semantic discrimination, if they are in fact examining different abilities as is argued in Part Four, Section 2). Sixthly, only a small number of subjects had been tested, and they may by chance have been atypical in their lateralization of language; their handedness was not known. But, again, right brain damage had apparently not interfered with speech. Overall, therefore, the selective semantic deficit of the RBD could not be immediately dismissed as an artefact of the particular experiment, and further research was indicated into this possibility of a selective linguistic deficit.

1.5.4 <u>The Phonological Test</u>

There was one unsatisfactory item: 11 of the 18 mistakes made by the NBD were on choosing 'run' instead of the correct 'rum', and on this item all the brain-damaged groups made fewer effors than the NBD. The test was also undiscriminating in respect of nine items on which the LBD aphasics made no errors. There was a low correlation between the Phonological Test and the Wepman Test, in line with Naeser's (1974) findings and her proposal that sound-sound matching requires a different ability from sound-meaning matching as tested in selecting a picture for a word. The Wepman test did not significantly separate the LBD from the leucotomised; it has been criticised for its tendencies towards a response bias (Vellutino, Desetto and Steger 1972) and it requires a sustained attentiveness to the metalinguistic task of discriminating 'same' and 'different', an ability which may be a general cognitive one as much as peculiarly linguistic.

There was some trend for the LBD subjects to have most difficulty in making discriminations on the Phonological Test which depended on syllable-final contrasts. Of the nine low error items, six had syllable initial contrasts; of the four items on which five or more errors were made, three had syllable final contrasts, and one a syllable initial contrast of three stops and a fricative (till, pill, kill, fill). However, reliable inferences could not be drawn from the data; because of the empirical nature of Black's material the contrasts were not systematically balanced, and no theoretical rationale related to word position or number of distinctive features had been employed.

1.5.5 The Syntax Test

Like the Italian, the English Syntax Test was highly successful in discriminating between aphasic and euphasic groups.

The results of the NBD group were examined to discover whether any item or picture had presented difficulties. At least ten of the fifteen NBD subjects made the correct choice for each item. However, five of them chose the picture of a girl drinking rather than stretching out her hand to take a glass for 'The girl will have a drink'. Four subjects chose a picture of a boy up in a tree for 'The boy is under the tree', perhaps because in the alternative the boy is not quite positioned under the tree. These pictures from the original Italian test could be redrawn to make interpretation easier. Four subjects had difficulty with 'The boy shows the cat to the dog' and two with 'The boy points out his family to his friend'. Both illustrate the direct/ indirect object contrast (B), the most difficult contrast for the RBD and BFL, the Italian aphasic group and the English children (Table 6). The other two pictures illustrating contrast B were selected without error by the NBD, 'The boy brings the cat to the mouse' and 'The shepherd takes the lamb from the sheep'. Two subjects pointed out, in the pictures for 'This is his car' (a family group or a single man beside a car), that in either picture it could be his car, and chose the family group.

Table 6

Syntax Test: Rank Order of Difficulty of the Twenty Contrasts

Contrast Type	Italian Children	English Children	Italian Aphasics	English LBD Aphasics	English RBD	English BFL	English NBD
A	7	3½	4	1	6	7	8½
B	2	1	1	4	1	1	1
C	10	10	6	16½	6	n.e.	n.e.
D	13	16	17	13	6	n.e.	n.e.
E	20	16	13	13	n.e.	3½	3
F	1	3½	11	7	10	7	n.e.
G	18	18	20	16½	n.e.	n.e.	n.e.
H	19	19½	19	18	n.e.	n.e.	n.e.
I	8	11½	7	10	14½	n.e.	n.e.
J	17	19½	15	19½	14½	n.e.	8½
K	16	9	14	19½	10	n.e.	8½
L	5	2	3	7	2	7	8½
M	4	6	5	3	3	2	2
N	9	14	10	10	14½	n.e.	8½
O	6	6	2	2	10	7	8½
P	3	8	8½	10	4	3½	4
Q	14	11½	16	13	10	n.e.	n.e.
R	15	16	18	15	14½	n.e.	n.e.
S	11	6	8½	5	n.e.	n.e.	8½
T	12	13	12	7	10	7	8½

1 is the most difficult item and 20 the easiest item. n.e., no errors.

Contrast types: A reversible subject-verb-object; B direct/indirect object; C reflexive/non-reflexive; D behind/in front of; E on-in/under; F from object and to object; G near/away from; H in/out of; I from/to; J affirmative/negative; K gender; L Present/past tense; M present/future tense; N behind/beside; O reversible passive; P his/their; Q singular/plural; R up/down; S embedded phrase attached to subject/object; T between/beside.

The RBD group made a total of 55 errors on 16 of the contrasts; the BFL group made 25 (pro-rated for the size of the group) on 9 of the contrasts; the LBD aphasic group made 173 errors over all 20 of the contrasts; the group of 18 4-6 year old children made 277 (pro-rated) over all 20 contrasts. It should be noted that as the items all present a binary choice it is possible to achieve a 50% score by random guessing, and the scores of two of the children suggested that this is what they were doing.

The rank order of difficulty of the 20 contrasts correlated significantly for all groups, Italian and English, adult and children (Table 7).

Table 7

Syntax Test: Kendall Correlation Coefficients between groups for rank order of difficulty of the twenty contrasts

	Italian Aphasics	English RBD	English Leucotomised	English NBD	English Children	Italian Children
English Aphasics	0.59**	0.34	0.51**	0.34	0.61**	0.55**
RBD		1.00	0.50**	0.30	0.58**	
Leucotomised			1.00	0.72**	0.47*	
NBD				1.00	0.33	
Italian Aphasics					0.68**	0.60**

* $p < .01$

** $p < .001$

There were, however, some discrepancies between the languages. The reflexive contrast, C, was much easier for the English aphasic group ($16\frac{1}{2}$ in rank order) than for the Italian (6th) though of similar difficulty for the English RBD group; both English and Italian children found the reflexive of medium difficulty (10th). The easiest contrasts for the English aphasics were gender and the negative/affirmative; these were 14th and 15th for Italian aphasics and 9th and 20th for English children.

Although the significant correlation between adult and children's difficulties appears to support one aspect of Jakobson's (1968, 1971) hypothesis that language breakdown mirrors in reverse language acquisition, when the results are further analysed according to the underlying nature of the syntactic contrasts some distinctions can be made between adult aphasic and child performance.

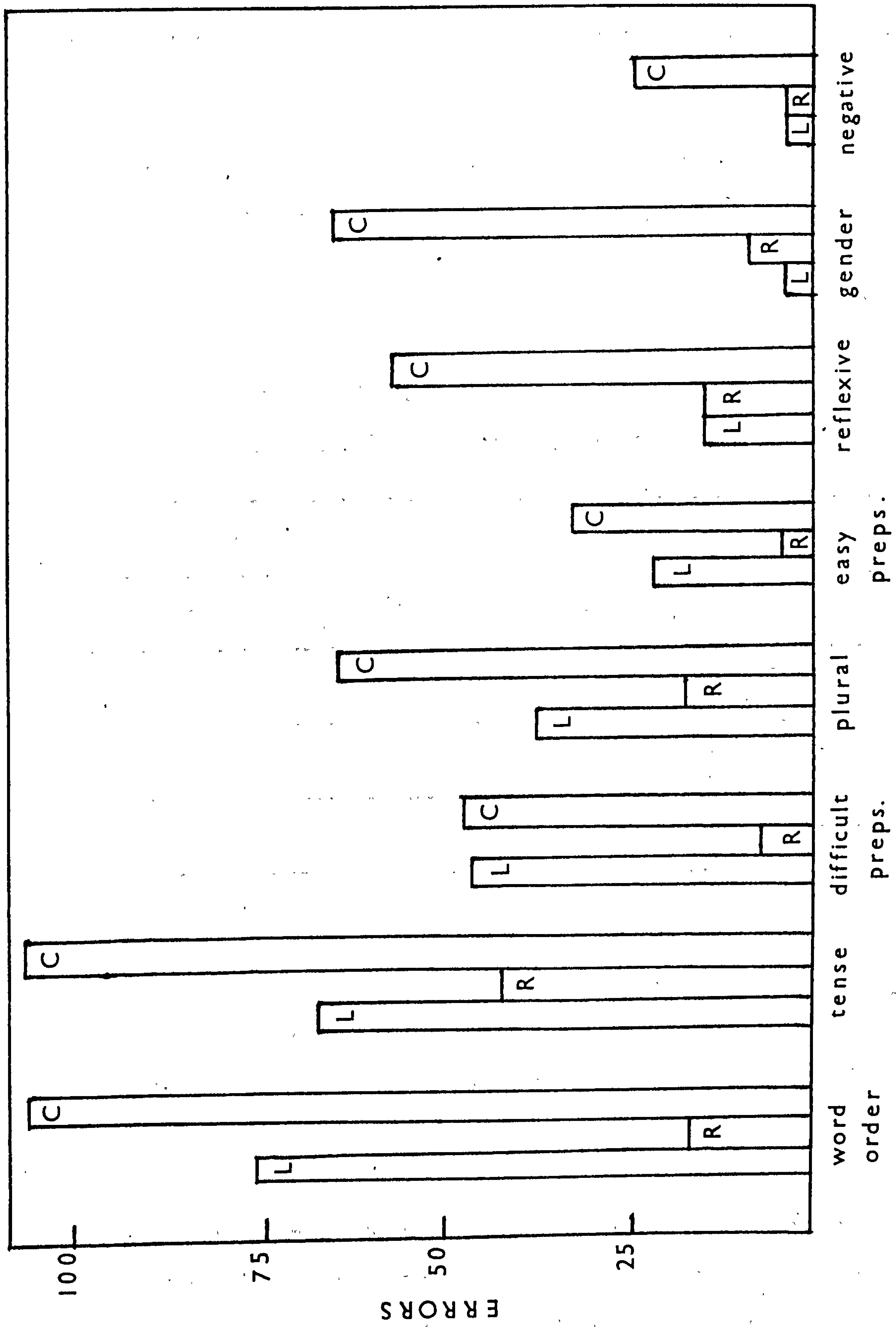
In five of the 20 contrasts the deep structure of the sentence is critically related to the surface order of words, i.e. contrasts A, B, F, O and S. Illustrations of these contrasts are: A, The lorry hits the train/The train hits the lorry; B, The boy brings the cat to the mouse/The boy brings the mouse to the cat; F, The dog is going from the tree to the house/The dog is going from the house to the tree; O, The bicycle is being followed by the car/The car is being followed by the bicycle; S, The guard who has the rifle stops the robber/The guard stops the robber who has the rifle. In the remaining contrasts the order of the words is not so critical; the distinction rests upon the presence or absence of a morphemic feature. In two contrasts the feature is a tense marker: M, The boy is drawing/The boy will draw; L, The boy is bathing/The boy has been bathing. In two contrasts the feature is the plural marker: Q, It's the chairs/It's the chair; P, This is his mother/This is their mother. Other markers are the negative (contrast J) and the reflexive (C). The gender contrast K (The grandmother is telling a story/The grandfather is telling a story) was included to match the Italian version; but it might be considered that the feature ± masculine is more properly a semantic feature than a syntactic one in English. The remaining eight contrasts are pairs of locative prepositions. The most difficult of these, contrast I, The bird is flying from the tree/The bird is flying to the tree, involves a temporal order which has something in common with the critical word order contrasts. The other prepositional contrasts relate to static space (G, The dog is near/away from the fire; D, The cat is behind/in front of the tree; H, The flowers are in/outside the vase; N, The tree is behind/beside the house; T, The lamp is beside/between the table and chair). The aphasic subjects' results divided the preposition contrasts into two groups, 'difficult' with nine or more errors (I, N, T) and 'easy' with six or fewer errors (D, E, G, H, R). 'Behind' and 'beside' (contrast N) are similar enough in sound to account for some aphasic errors; and 'between' (contrast T) would seem to be a more difficult concept as it implies three rather than two relational positions. The implication of sequential order may account for the difficulty of contrast I.

The English children found the tense contrasts as difficult as the word order contrasts (pro-rated 107 errors each). The RBD adult group found tense by far the most difficult contrast - the only contrast in which a syntactic feature of verbs is critical. The RBD found word order a relatively easy contrast to appreciate, while both aphasics and children found it hard. Discriminating affirmative and negative was easy for everybody. Aphasic and child performance can be distinguished, at this level of analysis, by the disproportionate difficulty for the aphasics in the word order contrasts, by the fact that male/female and singular/plural were still relatively difficult discriminations for the children to make, by the children's difficulty with reflexives and by the greater difference in the aphasic group between 'difficult' and 'easy' prepositions (Figure 1).

An analysis of the rank order of difficulty of the eight grouped types of contrasts (Kendall's) showed aphasic and child performance not to be significantly correlated ($t = 0.44$, $p = .06$) and aphasic and RBD not to be significantly correlated ($t = 0.40$, $p = .08$), while the performance of children and RBD was significantly correlated ($t = 0.69$, $p = .008$). There seem to be enough differences in the order of difficulty of the types of grouped contrasts to make for hesitation in accepting Jakobson's hypothesis.

The English aphasics' results on the Syntax Test are also out of line with those of the control groups in that, while the direct/indirect object contrast B was by far the most difficult of the word order contrasts for all control groups, the aphasics had even more difficulty with contrast A, short reversible active subject-verb-object sentences (19 errors as against 16). In fact, unexpectedly they made more errors on simple reversible active than reversible passive sentences. Moreover, sentences with subordinate clauses (contrast S) were easier for aphasics than simple contrast A sentences (13 errors as against 19), although children found them fairly difficult (6th). This shows that it was not the greater length of the sentences which made word-order contrasts difficult for aphasics. It also suggests that syntactic impairment in

Part two Figure 1.



SYNTAX TEST: NUMBER OF ERRORS ON GROUPED TYPES OF CONTRASTS

Key: L left-brain-damaged R right-brain-damaged C children aphasia is not related in any simple way to the number of transformations a kernel sentence is presumed to have undergone before surface structure realisation.

An examination of individual performances showed that this difficulty with word-order was not consistent amongst all the aphasics (Table 8).

Table 8

Syntax Test: Individual Performances of the Aphasics on Four Types of Grouped Contrasts

Contrast Type	High error (over 33%)	Medium error	Low error (1 or no errors)
Word order	a, c, m, r, u, v, y	b, d, e, j	g, n, o, p
Tense	e, j	a, b, c, d, m, t, v	g, n, o, p, u, y
Plural	a, p	b, t	c, d, e, g, j, m, n, o, u, v, y
Difficult Prepositions	a, c, r	b, e, u, v, y	d, g, j, m, n, o, p

Individual aphasics coded by alphabet letters a to y

On this test random guessing could give a correct score of 50%. An error incidence of 33% or more was therefore classed as a high error incidence, and of 12½% or under (i.e. one or no errors) as low. By these criteria most of the aphasics fall into two groups: those with errors at a consistent level on all contrasts and those with inconsistent errors. Three patients scored consistently low errors and one consistently medium. Those with contrasting performances scored either consistently high on word-order errors and low on tense and plural contrasts, or high on tense contrasts, low on plural, and medium on word-order contrasts, or high on plural and low on all others. There was, therefore, some suggestion that, in different patients, either word order or tense or plurality could present peculiar difficulties. Those who found word order difficult also tended to have highest errors on difficult prepositions.

The syntax scores did not match the clinician's rating of degree of impairment which was based on production of speech as well as comprehension. The three patients with consistently few errors were rated as moderately impaired, while two of the three mildly impaired patients made high errors on one contrast, the other showing medium difficulty on all tasks. All severely impaired patients, however, made high errors on at least one contrast.

1.5.6 The comparison tests

This study gave additional confirmation of the Token Test's ability to distinguish aphasic and euphasic populations. The test just failed to reach a significant correlation with intelligence, as measured by Raven's Matrices, but did correlate at $p < .05$ with the vocabulary test.

The ten-item, multiple-choice subtest from the Eisenson battery was not discriminating enough to show up deficits in comprehension in most of the aphasic subjects, while the Schuell sub-test, which requires a gesture response, was more successful in this respect. The Wepman test did not discriminate between the LBD aphasic group and the leucotomised.

1.5.7 Individual differences on the three new tests

Table 9 shows that five of the aphasic subjects maintained the same level of performance on each of the three new tests. No subject was a high scorer in one test and a low scorer in another test, not a surprising finding in view of the high correlations amongst the tests, and endorsing the apparently unitary nature of aphasic disorder when examined at this general level and in this sample of patients. Within the variability of performance amongst tests which did occur, the Phonological Test showed the greatest discrepancy. Three patients scored better on this test than on the other two tests and two worse. Two patients scored better on the Syntax Test than on the others; one scored worse. One scored better on the Semantic Test than on the others; one scored worse. Table 9 also shows that of the five who scored at the same level over all three tests, only two were consistent scorers on the various types of contrasts within the Syntax Test. This lends some support to the belief that the three tests and the types of contrast within the Syntax Test are differentially examining distinguishable language skills.

1.6 Summary and conclusions

The picture selection technique appeared to be a practical method of examining comprehension in English, which could be used with the great majority of aphasic patients, however limited their powers of expression.

The results indicated that the Syntax Test was the best of the tests in differentiating aphasic from euphasic and that it also provided

Table 9

Inter-test comparisons:

Individual Performances of Aphasics

Individual Aphasic	Syntax Test	Semantic Test	Phonological Test	Consistency amongst the 3 new tests	Consistency within Syntax Test
a	l	l	med.	-	-
b	med.	med.	med.	+	+
c	l	l	med.	-	-
d	med.	h	med.	-	-
e	med.	l	med.	-	-
g	h	med.	med.	-	+
j	med.	med.	h	-	-
m	med.	h	h	-	-
n	h	h	h	+	+
o	h	med.	med.	-	+
p	med.	med.	l	-	-
r	l	l	l	+	-
u	med.	med.	med.	+	-
v	med.	med.	l	-	-
y	med.	med.	med.	+	-

h = high score (> 1 standard deviation above mean)

med. = medium score (within 1 standard deviation of mean)

l = low score (> 1 standard deviation below mean)

\+ = consistent performance

\- = inconsistent performance

diagnostic guidance for individual patients. An examination of grouped types of syntactic difficulties showed significant differences between aphasic breakdown and acquisition in children, in contradiction to Jakobson's hypothesis. The Syntax Test, with its 80 items, was long and could take up to 30 minutes with the severely impaired patients; it also seemed to be disproportionately loaded with prepositional contrasts which did not present difficulties to this sample of patients.

The Phonological Test distinguished aphasic from euphasic fairly satisfactorily but it was considered that it could be improved to provide more diagnostic information. In particular, distinctive features and position of contrast in the word should be controlled.

The Semantic Test did not significantly separate the left-brain-damaged aphasic group from the right-brain-damaged euphasic group, although it distinguished both from the normal group. There was a trend towards impairment on the Semantic Test (and on vocabulary) in the leucotomised group, but this did not quite reach the 1% probability level which was set for this study.

The majority of the aphasic subjects were differentially impaired on one or other of the three new tests. There were also signs of differential impairment within syntax, in that, for some, more errors were made on items where the order of the words was critical, while others found the other types of contrast more difficult.

Four areas of further exploration were delimited by the results of this first preliminary experiment.

1) An examination of the possible selective disturbance of semantic comprehension in the right-brain-damaged who had not been diagnosed as aphasic. A number of control measures would need to be incorporated into a further experiment. All picture tests should use a binary choice of top or bottom to reduce possible scanning difficulties. A measure of impairment in visual-interpretive abilities should be included. Semantic knowledge should be tested both with and without pictures. The handedness of the subjects should be ascertained.

2) An examination of the relationship of difficulty in comprehension at the syntactic level to difficulty in discriminating and processing sequence. A comparison of reversible and non-reversible sentences and words should be made; the size of the unit (phoneme, morpheme, word) at which such a difficulty might occur should be ascertained, and the relationship of such verbal sequencing to non-verbal sequencing should be explored.

3) As the results from the right-brain-damaged suggested a partial independence of speech and auditory comprehension, in that the discrimination of semantic meaning in single words could apparently be significantly impaired without producing noticeable effects on syntactic-semantic organization in speech, a comparison should be made of ratings of disorders in speech at the different linguistic levels with ratings or rankings of comprehension.

4) An extension of the technique to include reading input as well as hearing, and to include more elaborate gesture as well as the simple pointing response, would enable a check to be

made on the dependence of the results on the specific combination of input and output used in this preliminary experiment.

2. The second preliminary experiment: picture and word order in aphasic and normal subjects

2.1 Aims

This second experiment had two purposes:

1) to check on the implication from the first experiment that aphasic patients have difficulties in comprehending word order in sentences, and to ascertain whether this represents a qualitative difference from comprehension in normal subjects. It seemed desirable to check on this possible impairment in view of Goodglass' (1968) comment on comprehension in aphasia that "the best retained signal of grammatical relationships is word order, as illustrated by the subject-object sequence, in the active voice" (page 194).

2) to discover whether the arrangement of the items in the pictures had a significant effect on the results. It was hypothesized that pictures in which the left-right arrangement of the actor and acted-upon corresponded with the left-right order of subject and object in the sentence would facilitate comprehension in aphasic patients, and would result in faster matching times for normal subjects. Carpenter and Just (1975) have suggested that, when a sentence is matched with a picture, constituents from the mental representation of the sentence are

serially compared with the corresponding constituents of the picture representation. Moeser (1975) has also found that subjects judging the acceptability of 'sentences' in an artificial language make fewer errors when they are given their test sentences in the left-right sequence which had been used in teaching the visual symbols for the words. These studies imply that, if pictures are perceptually congruent with sentences, a picture-sentence match should be facilitated. There is other evidence besides Moeser's (reviewed by White 1969) for a left-right preference by Western adults in reporting verbally on visual material displayed bilaterally without a stable fixation point. Although the sentences in this experiment were to be presented aurally, it therefore seemed possible that the temporal sequence of the sentence would correspond to a left-right scanning of the pictures under pressure of time in a reaction time experiment, or that such a strategy would assist an aphasic subject.

2.2 Subjects

To check on the universality of word-order difficulties in aphasia, and to avoid bias in the selection of subjects, it was decided to examine all the eligible patients attending one hospital speech clinic during two weeks, regardless of the etiology of the aphasia.

All the adult aphasic outpatients attending the speech therapy clinic of Newcastle General Hospital during a period of two weeks were used as subjects, except for those who did not meet certain requirements (age under 70, not deaf, not less than ten weeks after the onset of the aphasia, and able to pass a screening test of picture recognition by name). Of the 24 eligible patients, 18 were men, six women, age range 28 to 67. Two had had head injuries, one a cerebral abscess, and twenty-one had had cerebro-vascular accidents. Ten academics (five men and five women), age range 22 to 46, were used as normal adults.

2.3. Test materials

The task required all subjects to choose one of two pictures to match a heard sentence. A set of 48 sentences was devised in order to create a hierarchy of difficulty, to check whether results from normal and aphasic subjects would show the same rank order. Each was illustrated by two drawings, one showing the correct interpretation of the sentence, the other the incorrect minimal contrast being investigated. Forty of the sentences were reversible, and the incorrect contrast showed subject and object reversed. The eight sentences which were not reversible used for their contrasts the semantic feature of ± markedness ('more' contrasted with 'less' or 'fewer').

The markedness contrast was also used in half of the reversible sentences. These contained the pairs of comparatives 'bigger-smaller', 'longer-shorter', 'higher-lower', 'wider-narrower', 'fatter-thinner'. The other twenty reversible sentences were simple actives and passives. Examples of all the types of sentences are given in Table 10. (For the full list of sentences, and pictures, see Appendix B). The predicted rank for difficulty of these sentences, taking into account all effects of reversibility, markedness, sentence length and number of transformations, was that in the table, the first being easiest.

Table 10

Picture-Word-Order Test: Examples of sentence types in predicted rank order of difficulty

Non-reversible unmarked comparative:	This jug has more water
Non-reversible marked comparative:	This bottle has less milk (for a 'mass' noun)
	This chair has fewer cushions (for a 'count' noun)
Reversible active:	The Indian drags the soldier
Reversible passive:	The girl is led by the dog
Reversible unmarked comparative:	The flower is bigger than the leaf
Reversible marked comparative:	The stick is shorter than the tree

To give approximately the same pictorial content for each type of sentence, the illustrations for the non-reversible sentences included a superfluous second item.

Half the number of pictures for each type of reversible sentence showed the subject and object from left to right in the same order as they were named in the sentence (i.e. picture and sentence were congruent); half showed them in the opposite positions.

An attempt was made to control the influence of semantic variables as Sinclair and Ferreiro's (1970) study indicated that the particular verbs used in tests of the passive influenced comprehension. The verbs were chosen from restricted sets: six of them had implications of relative position ('pull, push, follow, lead, drag, chase'), six had implications of directed aggression ('shoot, kill, bite, frighten, hit, wet') and two were neutral verbs ('watch' and its stative 'see').

There were equal numbers of top and bottom positions for the correct choice for each type of contrast, and a random order of presentation was used with the proviso that there were no sentences of the same type adjacent.

2.4 Method

The task was given individually. The normal subjects saw the two pictures on a slide projected from a Carousel projector at eye level to give a dimension of approximately 18" x 25". They heard a recorded sentence at the end of which the picture was projected in synchrony with the activation of an SE Timer Counter (SM 200 Mk 2). The timer stopped when the subject moved a toggle switch up or down to point to the picture chosen. Reaction times were measured to the nearest millisecond. The test items were preceded by ten practice items. Timing the picture choice after the sentence had been heard minimized the effect of different sentence lengths (five or seven words).

The aphasic subjects heard the sentence spoken live while they looked at the two pictures on a 6" x $8\frac{1}{4}$" card. They were allowed unlimited time to point to their choice, and the sentence was repeated if necessary. There was an initial practice with four pairs of pictures. The scoring system used was in terms of errors and repeats needed. One error point was scored for an incorrect choice for an item; self-corrections were not penalised, but if a repetition was requested an additional half error point was scored. The maximum error score possible on any set of five reversible sentences was therefore $7\frac{1}{2}$ (5 incorrect choices after repetition of the sentence).

2.5 Results

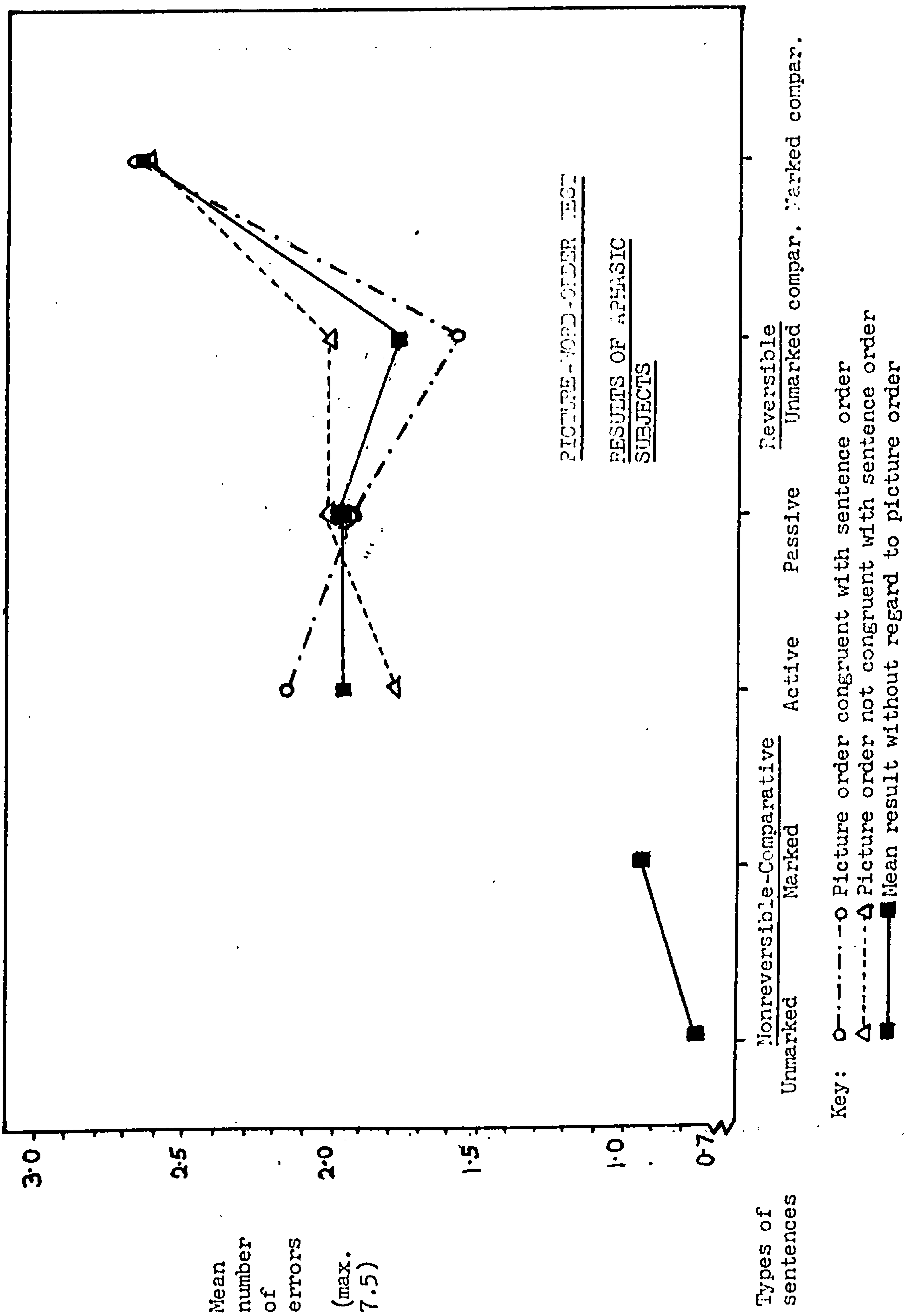
The results are shown in Table 11 and graphically in Figures 2 and 3. The normal subjects had a total error proportion of under 4% of the total number of items; in the analysis of the reaction time data, times for an individual's mean for a type of contrast were used with the few false decisions excluded. Only one aphasic subject made no errors. In the aphasics' data, error scores from the non-reversible sentences were adjusted to compensate for the fact that there were only four examples of each type of non-reversible sentences.

Table 11

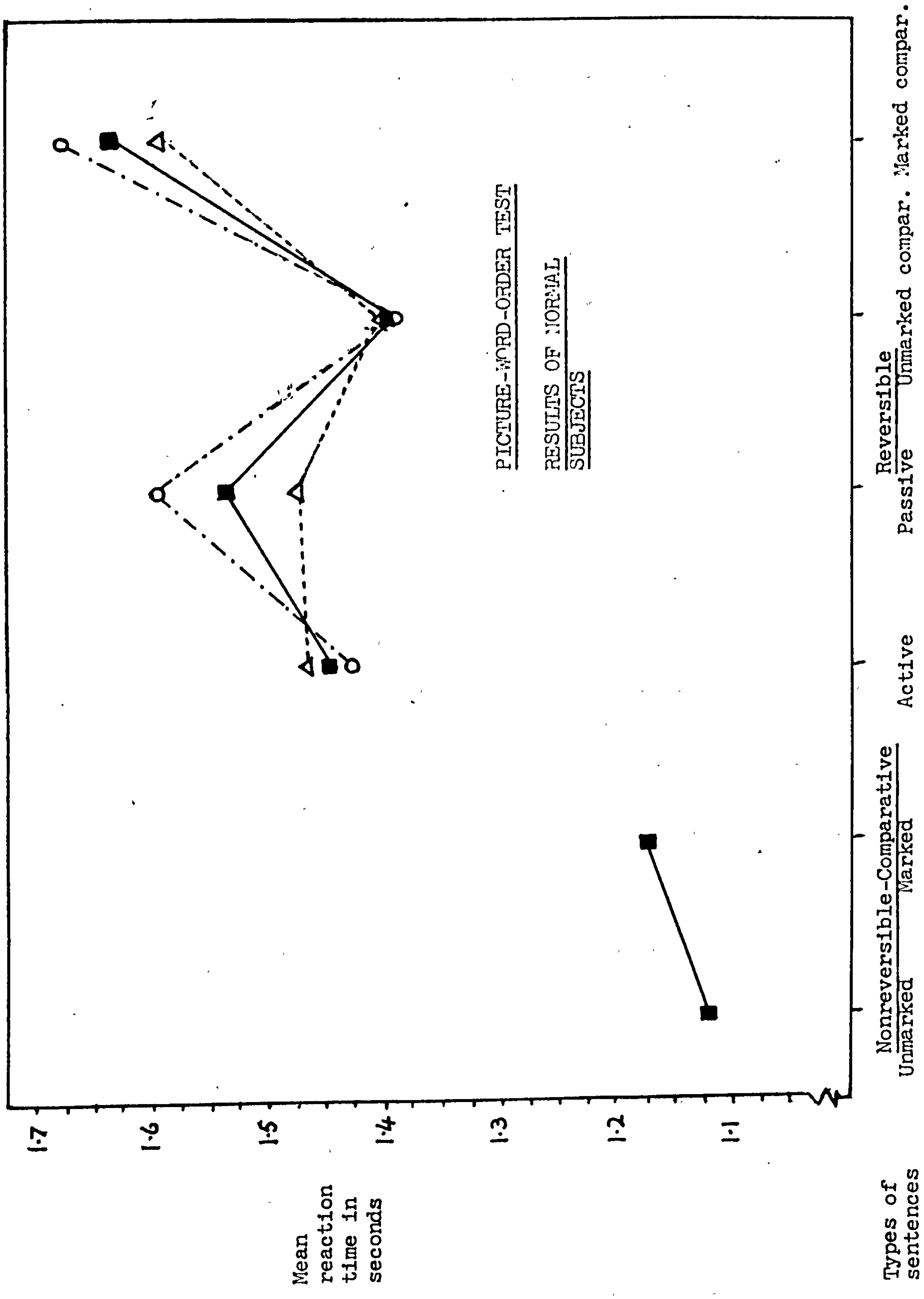
Picture-Word-Order Test: Results

Sentence Types	Aphasic Subjects mean no. of errors (maximum 7.5)	Normal Subjects mean reaction time (in seconds)
Non-reversible unmarked comparative	0.757	1.115
Non-reversible marked comparative	0.935	1.176
Reversible active		
Picture congruent	2.174	1.431
Picture not congruent	1.783	1.465
Reversible passive		
Picture congruent	1.913	1.595
Picture not congruent	2.022	1.482
Reversible unmarked comparative		
Picture congruent	1.543	1.394
Picture not congruent	2.043	1.406
Reversible marked comparative		
Picture congruent	2.696	1.676
Picture not congruent	2.652	1.600

Part two Figure 2.



Part two Figure 3.



Key: see Figure 2 page 178

Both groups of subjects showed approximately the same rank order of difficulty with the different types of sentences. This was the predicted order apart from the unmarked comparative sentences which proved easier than the simple actives. A second discrepancy from the prediction was that the aphasic subjects did not make more errors on passive sentences than on active.

Dunnett's t statistic for a control compared with other means (Winer 1970) was used in comparing results from the reversible sentences with those from the control set of non-reversible sentences. For both normal and aphasic subjects all the types of reversible sentences were significantly harder than the non-reversible (Table 12).

Table 12

Dunnett's t statistics for comparison of reversible sentences with non-reversible 'control' sentences

Type of reversible sentence	Normal subjects	Aphasic subjects
Unmarked comparatives	3.68**	3.04*
Actives	3.82**	3.62**
Passives	4.62**	3.59**
Marked comparatives	5.99**	5.85**

* $p < .01$

** $p < .005$

To measure the effect of picture congruence on the reversible sentences, three-way analyses of variance were used on each of the groups' data separately. The three independent variables tested were 'complexity' (i.e. passive or marked versus active or unmarked), 'adjectival' (i.e. comparative sentences versus simple active and passive) and 'picture congruence' (i.e. pictures representing left-right sentence order versus the opposite). The analyses showed that congruence had a negligible effect on the results of either group (normal subjects $F = 0.21$, $p = .65$, aphasic subjects $F = 0.01$, $p = .90$). With both groups there was a significant main effect of complexity (normal subjects $F = 6.69$, $p < .02$; aphasic subjects $F = 4.97$, $p < .03$). The main effect of adjectival did not reach a .05 significance level in either group. With the aphasic, but not with the normal, subjects there was a significant interaction between adjectival and complexity ($F = 4.73$, $p < .03$), i.e. marked comparatives were harder than passives. The analysis was repeated on data transformed to a closer approximation to a normal distribution (log transform for reaction times, $\sqrt{\text{score} + \frac{1}{2}}$ for error scores). The significance of the results was not affected.

2.6 Discussion

Reversible sentences were significantly harder than non-reversible sentences for both groups of subjects under conditions where a similar choice had to be made. In fact, as it turned out, some normal subjects reported using a strategy of verification instead of choice. However, such a strategy could have reduced the reaction times only for reversible sentences: for the non-reversible sentences it was necessary to make a choice from both pictures rather than to make a true-false decision based on one picture (e.g. 'This bottle has more milk' ensures that both pictures have to be compared).

Picture congruence did not have a significant effect on the results of either group of subjects, and would therefore not need to be controlled in the preparation of further test materials. Even given unlimited time the aphasic subjects apparently did not use an iconic strategy to help them with any verbal sequencing difficulties.

The findings underline the importance of semantic and heuristic factors rather than of syntactic and algorithmic factors (Anderson and Bower 1973, Fodor, Bever and Garrett 1974) in comprehension in both normal and pathologically disordered subjects. Firstly, reversibility, which depends on the semantic factor of plausibility, had a dominating effect. Secondly, the next most influential factor was another semantic one, markedness. Thirdly, the unmarked comparative reversible sentences, despite their presumed syntactic complexity, were understood by both groups of subjects more easily than predicted. According to Fodor et al (1974), the "syntax of the comparative is in fact enormously complicated" (page 92). Yet these data showed that this kind of sentence is more easily understood than a simple active sentence unless it is complicated by both the additional semantic factors of markedness and reversibility. Fourthly, for the aphasics, the difference in difficulty between the syntax of the active sentences and that of the passive sentences was negligible, in contrast to the major difference between the two kinds of comparative sentences, where the distinction was semantic. On the ten marked comparative sentences, out of the 23 patients fourteen made five or more errors (with repetitions not penalised), a level compatible with chance guessing, and even in some cases (2 patients with 8 errors) with a tendency to misinterpret the marked as being unmarked. On the ten unmarked comparative sentences, on the other hand, only two patients made five errors with one patient making six.

However, the hypothesis of heuristic semantic comprehension needs to be qualified for short sentences such as were used in this experiment. No normal subject reported using a strategy which would have speeded up reaction times to reversible sentences, i.e. processing only the minimal information necessary to make the choice. The majority of the reversible sentences were 'pseudo-transitive', i.e. they did not require a compulsory object, and in order to make the correct choice it was only necessary to recognise the first three or four words, e.g. 'The soldier shoots'. The results suggest, however, that with short sentences of these types the whole sentence was processed regardless of whether it contained information redundant to the task or not. With reversible sentences it is only under such circumstances that syntactic decoding of subject and object roles would be necessary.

From the equal difficulty for aphasics of active and passive sentences, however, it might appear that syntactic transformational factors were less influential on aphasics' comprehension than they were on the normal subjects'. The finding that the reversible active sentences were approximately as difficult for aphasics as were reversible passive sentences agrees with that in the first preliminary experiment. It does not, however, agree with reports in the literature that passives are harder for English-speaking aphasics (Goodglass 1968, Levy and Taylor 1968, Doktor and Taylor 1969). It seems unlikely that there was any material difference in plausibility between active and passive sentences which could account for this unexpected finding in the two preliminary experiments of the present investigation. The experiments reported in the literature used agrammatic subjects or patients who could pass a "concept identification task" concerned with actor and acted-upon relationships, as well as screening tasks, whereas the present experiment used a virtually unselected group of aphasics: this may have contributed to the difference in the results, particularly if semantic factors were more important than syntactic, as has been suggested. It would be desirable to test whether or not this finding of equivalent difficulty with reversible passive and active sentences would be repeated with another set of sentences and another group of aphasic subjects.

Despite Goodglass' comment that word order is the best retained signal of grammatical relationships, the present experiment indicated that aphasics have some difficulty in actually processing this order (although, if they do process it satisfactorily, its significance in distinguishing subject and object may still be retained as Goodglass opined); consequently the inclusion of a study of sequencing difficulties in the main experiment would be justified.

Except for the passive sentences, and taking into consideration the different conditions and methods, the similarity of the results from the normal and aphasic subjects is striking. It suggests that the difficulty aphasics may have in processing sequence in language, although superficially appearing as a qualitative impairment in that the aphasic misinterprets sentences, is a pathological exaggeration of distinctions in normal comprehension which can be observed under experimental conditions. Where the patterns do diverge, it may, speculatively, be attributed to a greater reliance in the aphasics on semantic rather than syntactic factors in comprehension.

2.7 Summary and conclusions

1) A group of aphasic patients (all those attending a speech therapy clinic, with minimal selection) made significantly more errors in understanding reversible sentences of different types than non-reversible sentences. The hypothesis that such patients have some difficulty in comprehending word sequence in a syntactic context was supported. The difficulty seemed to reflect an inherent rank order of difficulty of sentences which was, in most respects, the same for aphasic and for normal subjects.

2) The hypothesis that congruence of picture and sentence arrangement would assist comprehension was not supported.

3) The semantic feature of markedness was more influential on comprehension than the syntactic feature of transformational complexity (i.e. the transformations presumed to underlie the passive and the comparative).

Further investigation in the main experiment of the nature of a possible deficit in verbal sequencing in syntactic comprehension in aphasia was, therefore, indicated.

PART THREE Experimental: the main experiment

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PART THREE

Experimental: the main experiment

1. Aims

1) The main experiment was an elaboration of the first preliminary experiment, incorporating the four extensions described in Part Two Section 1.6. Its principle aim was the differential analysis of comprehension, after brain damage from stroke, by the three linguistic levels of phonology, syntax and lexical-semantic organization. At the syntactic and lexical-semantic levels test measures were to use two media of input, hearing and reading (input at the phonological level being necessarily only auditory). At the syntactic level two main output media were to be compared (pointing and manipulating objects), and two different kinds of responses were to be required also at the other two levels (pointing and same-different decision or word sorting), to check on how far the results reflected central abilities. Other measures of verbal and non-verbal comprehension would also be used as control measures.

2) Although the analysis was to be made in a structured way requiring a semi-artificial use of language (see Part One, Section 3.4), and it was to have a restricted range from the phonemic to short sentences (i.e. it was to exclude phonetic discrimination and comprehension of discourse), an assessment was to be attempted of the relevance of the test

findings to everyday living. Relatives of patients were to be given a questionnaire through which functional comprehension at home could be ascertained.

3) The investigation was to focus on three aspects:

   a) the relationship of results on the comprehension tasks at the linguistic levels to measures of linguistic abilities shown in speech, in order to examine by this means, as well as by variation of input media and mechanics of gestural response, how far test measures access central language knowledge;

   b) the possibility of a deficit in lexical-semantic comprehension in patients whose speech is not overtly aphasic after right brain damage;

   c) the relationship of impairment in verbal comprehension in left brain-damaged aphasic patients to difficulty in processing temporal sequence.

1.1 Stroke

The investigation was specifically restricted to patients who had suffered a stroke*, and some explanation of this restriction is required. Research studies have often not differentiated amongst the different causes of aphasia, and it is not uncommon to find that

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* In accordance with current medical practice, the layman's term 'stroke' will be used in preference to the more cumbersome 'cerebrovascular accident'. The term 'brain damage' is used in the literal sense of damage to the brain, and does not imply any specialist distinction between head injury by external trauma and internal brain pathology.

amongst the subjects some have had a stroke, some neoplastic growths, some abscesses, some head-injuries which had damaged the skull as well as the brain ('open-head trauma') and some closed-head injuries.

It is not certain whether or not different causes per se result in different types of aphasia, although each etiology is characteristically associated with different types of patient. For example, patients who are aphasic after externally inflicted head injury are typically younger than patients who have had a stroke (although stroke can occur in children), and the lesion is not progressive as it may be in some cases of neoplastic invasion, nor is it recurrent as in some types of stroke. Writing after the 1914-18 war of soldiers with aphasia after gun-shot wounds, Head (1926) compares them with patients with stroke:

> "They were euphoric rather than depressed, and in every way contrasted profoundly with the state of the aphasic met with in civilian practice. Moreover, with gunshot wounds of the head the symptoms tend to clear up to a considerable extent, provided there are no secondary complications, even though the effect produced by the initial impact of the bullet may have been extremely severe ... whereas in civilian practice any change in the clinical manifestation is usually in an opposite direction. Even if the vascular lesion is stationary, the symptoms rarely disappear, whilst in most cases the condition of the patient gradually deteriorates. There is still another difference between the results produced by gunshot injuries of the head and those vascular lesions which are usually responsible for disorders of speech in the old. The missile strikes the skull from without, and even if it penetrates the brain, tends to cause the greatest damage on the surface. Vascular lesions on the other hand destroy the substance of the brain where the fibres are diverging or converging on their path to or from the cortical centres; a small haemorrhage may in consequence be followed by a profound and wide-spread disturbance of function. But structural changes produced by a local injury to the external surface of the skull not only cause less severe and extensive manifestations of cerebral injury, but give greater opportunity for the appearance of loss of function in more specific forms". (Vol. 1, pages 146-7.)

Consequently, some classifications of aphasia (e.g. Luria 1970) have been based primarily on observations of men whose brains have been damaged by gunshot wounds; it has often been assumed that the types of aphasia distinguished are essentially the same for all causes, if factors of age, extent of lesion, status of lesion and the health of the remaining tissue in the ipsilateral and contralateral hemisphere are equated. Typically, sex is not considered to be an important factor (Gardner 1975 page 46) though this may be primarily for the practical reason that the majority of studies have been exclusively or primarily of men (see Lake and Bryden's 1976 review of sex differences in hemispheric asymmetry for arguments why the possible influence of sex on aphasia should not be neglected).

However, there are some indications that the quality of the aphasia from different causes may be different, though whether it is secondary to the different types of patient rather than to the different cause is a matter of speculation. Heilman, Safran and Geschwind (1971) found that a sample of patients who were aphasic after closed head trauma displayed either Wernicke's or amnesic aphasia: there were none with motor aphasia. Green (1969) comments that phonetic cues are helpful to patients with (Luria's) semantic aphasia "if the damage is due only to tumor, not to vascular disease. Just why this difference should obtain is not wholly clear". (Page 40.) Geschwind (1974) reviewing Luria's book on traumatic aphasia, comments that certain syndromes do not appear in it: "Since he is primarily considering wounds produced by missiles, some of the clinical pictures which cannot be produced in this way, but which can result from occlusion of blood vessels, are absent" (page 502). Geschwind exemplifies this with pure word-deafness, pure alexia without agraphia, the syndrome of the "isolated speech area" and the callosal disconnection syndrome. The cause of the aphasia is also acknowledged by most authorities as a significant influence on recovery (Butfield and Zangwill 1946, Wepman 1972, Halpern 1972, Darley 1975). Benton (1970) recommends that in further research into the consequences of brain damage, etiologies should not be mixed.

In this present state of uncertainty, it would therefore seem to be wise to restrict an experimental investigation into aphasia, which already has compounding variables aplenty, to patients who share a common etiology.

Under peacetime conditions, stroke is the most frequent cause of aphasia (Report of the Geriatrics Committee Working Group on Strokes 1974, Sarno 1975), and except in specialized units patients with this etiology are the most readily accessible subjects for research and the most likely to be recipients of any benefits derived from research. However, it would be a mistake to imply that by selecting only stroke patients we can obtain a homogenous sample. There are different causes of aphasia within the syndrome of stroke.

One broad distinction is that between cerebro-vascular accidents caused by blocking of arteries and those caused by bursting of arteries. Within the first category, the blocking may be due to lodgement of a free circulating embolus (originating, for example, in heart spasm), or to the lodgement in a narrowed artery of a freed thrombus or fatty deposit, or to the accumulation of thrombotic plaque finally sealing an artery. Even within the same etiology of blocking, therefore, the health of the brain tissue may vary; in both of the latter conditions, blocking may be accompanied by generalized arteriosclerotic degeneration. Within the second category, haemorrhages may be distinguished in their effect by their location relative to the brain and its membranes or meninges. Subdural haematomas are accumulations of blood which may exert pressure on the brain. Subarachnoid haemorrhages usually bleed into the ventricles. Other haemorrhages occur in the brain tissue itself. Haemorrhages are sometimes attributed to abnormalities in the structure of the artery walls, resulting in weak places which balloon out into aneurysms: consequently they tend to occur in a population which is on average younger than that whose strokes are attributed to arteriosclerotic degeneration. They are also more often followed by surgical intervention than are the first category of stroke. Surgery, however, can also initiate a blocking type of stroke in endarterectomy, when the carotid artery in the neck is opened to peel away a thrombotic portion (though whether such tragic strokes are a consequence of dislodgement of thrombus or to intracranial haemorrhage adjacent to an already infarcted zone is open to doubt - see Freed 1975).

Unfortunately, although these different causes of stroke are known, it is not always possible with present-day techniques to diagnose which type has occurred in an individual patient (Oxbury 1975). Smith, Champoux, Leri, London and Muraski (1972) comment that several neuropathological and arteriographic studies

> "have clearly demonstrated the limited validity of clinical diagnosis and localizations of intra-cranial occlusions, differentiations between haemorrhages versus nonhaemorrhagic or embolic stroke and even between vascular and nonvascular causes of stroke" (page 94).

(Nonvascular causes of stroke include infections.) The development of new instruments such as the EMI tomographic head scanner (Kreel 1975), and techniques for measuring cerebral blood flow (Gustafson, Hagberg and Ingvar 1976) may partially remedy this situation as regards localization. For the time being, however, it is more common to find strokes classified only by those symptoms which can be objectively verified.

It is possible to make a reliable distinction between vascular accidents which have occurred in the region of the brain supplied by the left or right carotid arteries and those in the region supplied by the vertebral-basilar artery. Aphasia is almost invariably associated with carotid-territory stroke, and more frequently with damage in the branch of the carotid called the middle cerebral artery than with that called the anterior cerebral artery (which may tend to result in a specific type of aphasia, see Rubens 1975) or with that called the posterior cerebral artery (which may result in alexia, see Benson and Geschwind 1969). The significant lesion is also more likely to be cortical than subcortical, although speech depends on cortico-subcortical connections (Penfield and Roberts 1959) and a "withering of the language mechanism" has been reported after exclusively subcortical lesions (Brown 1974).

A second practical distinction which can be made reliably is by the stage of completion of the stroke. There may be a series of minor transientischaemic attacks, impending stroke or completed stroke. A long-lasting aphasia is associated with completed stroke.

Thus, although aphasic patients who share a common etiology of stroke may all have in common a completed stroke in left carotid artery territory, perhaps even specifically in the area supplied by the middle cerebral branch of the carotid artery, this apparent homogeneity masks a wide range of differences in location and in type of lesion. However, because at present neurological science cannot reliably index these differences in individual patients, we have an empirical justification for grouping together as research subjects patients whose aphasia is a consequence of stroke.

2. Subjects

The subjects for the main experiment were 90 adults and 425 children from Tyneside, and 212 children from Surrey. Sixty-four of the adults had had strokes.

There were 40 left brain-damaged patients (20 men and 20 women); all had been diagnosed by a doctor and speech therapist as aphasic and had been referred to a speech therapy clinic. The maximum age was 68. Of the aphasic patients originally seen three were excluded from the final sample on grounds of doubt about the laterality of the lesion. One man was to have had an extensive neurological examination, as he had no unilateral signs on preliminary examination. However, he made such a good physical recovery (although still aphasic) that this examination was not undertaken, and there was therefore no confirmation of the side of lesion. Two women were also excluded after being tested because conversations with relatives suggested that there might have been a transient ischaemic attack in the right hemisphere some years before.

One woman was also excluded as she had a greater hearing loss than was acceptable (see Section 3.1.1) and three more aphasics because of doubtful visual acuity (see Section 3.1.2). These seven subjects were replaced.

There were more aphasic men available than women, and, in order to obtain the desired number for women, two severely aphasic women were included who had been discharged from speech therapy as no longer likely to make improvement with treatment. The remaining aphasic subjects were all still under the supervision of the speech therapists, though one had not yet had therapy or a full assessment due to an ambulance strike. Because the sample of women aphasics represented all those available in the area at that particular time, and because the selection of aphasic men could be more eclectic and may have been unwittingly biassed, a comparison of results between the sexes was not attempted with the left brain-damaged. The women included four under 40 years old, though this was the age of the youngest man. The difference in availability between the sexes presumably reflects the reported higher incidence of strokes in men than in women below the age of 60 (Matsumoto, Whisnant, Kurland and Okazaki 1973; Held 1975).

Twenty-three of the aphasics had had strokes which were thought to be occlusive; seven were diagnosed as having had a cerebral haemorrhage (in three of these it was specified as subarachnoid). Two men had acquired aphasia following left endartectomy (removal of an atheromous area on the carotid artery). A differential diagnosis had not been proposed in the remaining cases. One man had had an embolic stroke and later a subdural haematoma after a fall for which surgery had been required; a further complication after surgery had required the removal of an area of diseased skull bone, which was not replaced.

Three of the men had had a university education, and four of the women had stayed at school till 16. The remaining aphasics had left school at age 15 or under. The distribution by socio-economic class was approximately that to be expected from the General Census of 1971 (see Susser and Watson 1971), i.e. Class I (higher professional) 2.72%, Class II (lower professional) 14.83%, Class III (skilled) 47.74%, Class IV (semi-skilled) 22.05% and Class V (unskilled) 4.57%.

Two of the subjects were of mixed handedness (see Section 2.1), three were right handed but had a left handed near relative, and the remaining 35 were right handed without a familial left hander.

Six of the subjects were reported to have right visual field defects, and in a further seven a visual field defect had been suspected initially but had resolved later. Only three had not had a hemiparesis; of the others three were reliant on wheelchairs at the time of testing, eight were able to walk with stick or tripod, eighteen walked unaided but with a limp, and in the remaining eight the initial hemiparesis had resolved although subjective weaknesses were reported. In every case of paresis except one, weakness in the upper limb was greater than in the lower limb, a symptom compatible with damage in the area of the middle rather than the anterior cerebral artery.

In order to match the control group of non-brain-damaged subjects with the aphasic group, near relatives of the patients were asked to participate. By taking people of the same socio-economic class, usually of the same educational level and in particular people who had shared the same linguistic habits in the same speech community for several years, it was hoped to obtain a control group whose overall performance would represent as nearly as possible that of the aphasics before they had suffered their strokes.

The groups had also to be matched for age, and the normal age disparity between husband and wife caused some difficulty. With an upper age limit of 68, one of the husbands had to be excluded; two young wives of the professional class aphasic patients were also not asked to be control subjects, so as not to lower the mean age of the control group or to overweight it by the professional classes. Six of the aphasics were unmarried, widowed or divorced; in one case a sister acted as a control subject. Two of the aphasics were married to each other. To raise the average age of the control group, the father of one young aphasic woman was asked to be a control subject instead of her husband. One aphasic woman's husband was not available as he travelled away from home frequently. Two spouses had greater hearing losses than were considered acceptable (see Section 3.1.1) and one wife poorer visual acuity (see Section 3.1.2). One wife refused to go through the tests. The control group also included the wife of the man and the husband of one of the women who were later excluded from the study on neurological grounds. Also in the control group were two men, a former miner and carpenter, who had advanced muscular dystrophy and were residential in a long-stay hospital where two of the aphasic women were living. The final group of control subjects thus comprised 11 men and 11 women who were close relatives of the aphasic subjects, plus 2 spouses of excluded subjects, plus the two hospitalized men. The possibility of unconscious bias in the selection of a control group was thus reduced to a minimum.

Most of the control subjects were not the kind of person who readily volunteers to be an experimental subject for mental tests. They co-operated because of their desire to help their relatives.

One of the non-brain-damaged group was a diplomat, two had remained at school till age 17, and the remaining 23 had left school at age 15 or under. One was known to have high blood pressure and to have had a heart attack, but apart from this no medical information was available and the absence of brain damage was taken on trust. One was left handed, one ambidextrous, five were right handed with a left handed relative, and the others were right handed without a known left handed relative.

To obtain the group of 24 right brain-damaged non-aphasic subjects, approximately two thousand records from two years were searched in the Physiotherapy Departments of the Royal Victoria Infirmary and Newcastle General Hospital to find people who had had treatment for left hemiplegia following cerebrovascular accident. Patients were excluded when there was any report of aphasia (but not of slurred speech in the few days after the stroke), when there was known bilateral damage, when the hemiparesis was suspected of being hysterical, when it was associated with a lesion in basilar artery territory, and when some degree of dementia was suspected. This left 11 eligible women, one of whom was living at the same long stay hospital as 4 of the aphasic and control subjects. These 11 women were asked if they would be subjects, and all agreed. The twelfth right brain-damaged woman was the sister of an aphasic patient. There was more choice with the right brain-damaged men, and those 12 who lived nearest were asked to co-operate. There were no refusals. One of the men was a graduate; one woman was illiterate. Twenty-one of the group had left school at age 15 or under.

In fourteen of the right brain-damaged, the stroke was thought to have been occlusive, and in three haemorrhagic. Two were in wheel-chairs, six walked with a stick or tripod, four walked without assistance but with a limp, and in eleven there had been an apparently complete recovery from hemiparesis. One woman had had no hemiparesis but a left sided sensory loss.

By obtaining patients through physiotherapy records, the selection was biassed towards those who had lesions in the pre-Rolandic area of the brain. However, the severity of motor symptoms was roughly comparable in both the brain-damaged groups, although only two of the right brain-damaged were reported to have visual field defects with one other doubtful. There was a (significant at $p < .05$) difference in the number of months that had elapsed since the onset of the stroke in the two brain-damaged groups (see Section 7.1, Table 15); however, the number of months post onset did not correlate significantly with any of the test scores in the right brain-damaged, and with only three of the test measures in the left brain-damaged (see Section 7.3, Tables 26 and 27). No brain-damaged patient was tested till at least two months after the stroke.

Because there was little risk of bias which might have affected the selection of men and women for the right brain-damaged, it was considered legitimate to make comparisons between the sexes for this group (see Part Four, Section 2.8).

Comparative data for the three groups of subjects are summarised in the following tables 1 to 4.

Table 1

Personal details: non-brain-damaged subjects

	age	school leaving age	handedness	hearing	job
NM1	32	15	R	--	Driver (brewery)
NM2	37	17	F	--	Draughtsman
NM3	49	14	F	36.7	Shipyard welder
NM4	53	14	F	30.0	Joiner*
NM5	54	14	R	20.0	Miner*
NM6	55	14	R	--	Plumber
NM7	59	14	R	--	Furnaceman
NM8	61	14	F	11.7	Miner
NM9	62	14	R	11.7	Cleaner
NM10	63	17	A	21.7	Director
NM11	64	14	R	21.7	Driver (bakery)
NM12	68	13	L	21.7	Miner
NM13	68	14	R	20.0	Mechanic
NM14	68	23	R	--	Parks superintendent

	age	school leaving age	handedness	hearing	job
NF1	39	15	R	--	Punch card operator
NF2	42	14	R	--	Canteen assistant
NF3	43	14	R	--	Dancer
NF4	44	15	R	8.3	Shop assistant
NF5	53	14	R	25.0	Factory packer
NF6	53	14	R	--	Dry cleaner
NF7	56	13	R	15.0	Catering manageress
NF8	56	14	F	11.7	Shorthand typist
NF9	58	14	R	--	Shop assistant
NF10	60	14	R	--	Home help
NF11	61	14	R	40.0	Cook
NF12	62	14	F	18.3	Housewife (husband mechanic)

* with advanced muscular dystrophy, dependent on wheelchair.

KEY (all tables)

Handedness: L left handed, A mixed, F right handed with familial left hander, R right handed without familial left hander.

Type of stroke: O occlusive, H haemorrhage, E following endartectomy, U unknown.

Degree of hemiplegia: A absent, R recovered, L limp, S stick or tripod used, W wheelchair.

Visual field: D defect persisting, R recovered.

Hearing: average threshold in dB for three speech frequencies in better ear (500, 1,000, 2,000 c.p.s.).

Table 2

Personal and medical details:

Left brain-damaged subjects - men

	age	school leaving age	handedness	hearing	job	months after stroke	type of stroke	degree of hemiplegia	visual field defect	localization within hemisphere
LM1	40	15	A	3.3	Clerk	15	O	L	R	fronto-temporo-parietal (also later surgery for removal of bone)
LM2	42	14	R	13.3	Machinist (mining)	45	O	L	-	
LM3	44	14	R	25.0	Tamping (B.R.) machine op.	14	U	L	-	
LM4	44	15	F	3.3	Policeman	4	O	W	-	
LM5	44	21	R	10.0	Engineer (manager)	28	H	L	-	
LM6	50	22	R	16.7	Further ed'n Head of dept.	18	O	R	-	
LM7	50	14	R	15.0	Local gov't. officer	17	O	L	-	mid-temporal
LM8	53	14	R	16.7	Manager (tool co.)	4	E	A	R	parietal
LM9	55	15	R	16.7	Marketing executive	26	E	L	-	
LM10	56	14	R	18.3	Baker	68	O	L	-	
LM11	56	14	R	25.0	Signwriter	2	O	R	-	
LM12	57	14	R	21.7	Slotter	22	O	A	-	ascending fronto-parietal branch of mid. cer. art.
LM13	57	14	F	6.7	Motor engineer	4	O	L	-	
LM14	59	15	R	16.7	Salesman supervisor	33	O	L	-	
LM15	62	22	R	5.0	Executive	29	H	S	-	
LM16	62	14	R	8.3	Sales rep.	22	O	S	-	
LM17	66	14	R	25.0	Miner	75	O	S	-	
LM18	66	14	R	16.7	Mechanic (bus maint.)	3	U	R	-	
LM19	68	14	R	13.3	Blacksmith (mining)	7	U	R	-	
LM20	68	14	R	16.7	Weighing clerk (mining)	4	U	R	R	

Table 3

Personal and medical details:

Left brain-damaged subjects - women

	age	school leaving age	handedness	hearing	job	months after stroke	type of stroke	degree of hemiplegia	visual field defect	localization within hemisphere
LF1	26	15	R	6.7	Telephonist	5	O	A	R	angular gyrus
LF2	36	15	A	16.7	Insurance club collector	5	H	R	-	mid. cer. art. aneurysm
LF3	38	16	R	10.0	Shop assistant	27	O	R	-	temporal
LF4	39	15	R	15.0	Textile factory worker	15	H	L	D	post. com. art. aneurysm
LF5	43	14	R	13.3	Housewife (husband engineer)	33	O	L	D	
LF6	47	14	R	15.0	Cleaner	31	O	S	R	
LF7	50	14	R	18.3	Housewife (husband bricklayer)	8	O	L	R	fronto-temporo-parietal
LF8	54	14	R	20.0	Housewife (husband joiner)	59	O	L	D	
LF9	56	14	R	23.3	Bakery manageress	11	H	L	D	post. cer. art. aneurysm
LF10	56	14	R	16.7	Cleaner	21	O	S	-	
LF11	57	14	R	10.0	Accounts clerk	6	O	S	-	
LF12	58	14	R	16.7	Cleaner	34	H	L	-	
LF13	58	14	R	13.3	Housewife (husband miner)	3	H	W	D	internal capsule
LF14	60	16	R	15.0	Statistician	15	O	L	-	fronto-temporal
LF15	62	16	R	31.7	Secretary	41	O	S	-	
LF16	64	16	R	28.3	Housewife (husband parks sup.)	5	O	S	-	
LF17	64	14	R	18.3	Civil servant	4	U	R	R	
LF18	64	14	R	15.0	Farm worker	8	U	L	-	
LF19	65	14	F	40.0	Domestic help	4	U	L	-	
LF20	68	14	R	36.7	Not known	47	U	W	D	

Table 4

Personal and medical details:

Right brain-damaged subjects

	age	school leaving age	handedness	hearing	job	months since stroke	type of stroke	degree of hemiplegia	visual field defect	slurred speech reported at time of stroke	localization within hemisphere
MEN											
RM1	37	15	F	--	Local gov't officer	22	O	R	-	no	frontal and temporal?
RM2	45	14	R	13.3	Fitter	82	O	S	D	yes	
RM3	47	14	R	13.3	Shipyard welder	19	U	R	-	yes	
RM4	50	14	A	10.0	Caretaker	23	U	R	-	no	
RM5	50	14	R	8.3	Fitter	135	O	L	-	yes	
RM6	53	14	R	25.0	Labourer	24	O	R	-	yes	internal capsule
RM7	60	14	F	30.0	Electrician	16	U	S	-	yes	
RM8	63	15	F	28.3	Master hairdresser	36	O	L	-	yes	
RM9	63	22	R	25.0	Office manager	23	O	S	-	no	(also a right frontal skull fracture 13 years previous to stroke)
RM10	64	15	R	--	Catering manager	5	U	L	-	no	
RM11	64	14	R	16.7	Coachwork painter	21	O	S	?	yes	
RM12	66	14	R	21.7	Signwriter	29	O	R	-	no	
WOMEN											
RF1	30	15	F	25.0	Telephonist	12	U	R	-	yes	
RF2	47	14	R	--	Shop assistant	32	O	R	-	yes	fronto-temporo-parietal
RF3	53	16	F	20.0	Civil Servant	54	H	R	-	yes	internal capsule
RF4	53	14	R	33.3	Barmaid	38	O	S	-	yes	
RF5	57	14	R	33.3	Bakeress	13	O	A	-	yes	sensory part of internal capsule
RF6	57	14	R	26.7	Shop assistant	66	O	W	-	yes	
RF7	59	14	R	26.7	Canteen assistant	96	H	W	D	no	aneurysm clipped on rt. anterior communicating artery
RF8	60	14	A	18.3	Factory worker	28	U	R	-	no	
RF9	61	14	R	25.0	Cleaner	3	U	L	-	no	
RF10	62	14	R	16.7	Factory worker	21	O	R	-	no	
RF11	65	18	F	30.0	Teacher	27	H	S	-	no	
RF12	67	14	R	30.0	Tailoress	78	O	R	-	no	

For two of the tests, children were also used as subjects. A preliminary study was undertaken with 212 children from a school in Surrey aged 8 to 11. The school was in a middle and working class district. For the purposes of comparison with the Tyneside adults in the main experiment, 425 children aged 7 to 11 from two junior schools in Newcastle were tested; both schools were in predominantly working class districts, one in the east end and one in the west end of the city, and were thus from the same speech communities as the majority of the adult subjects in the study. In the preparation of the test materials a panel of adults and children was used. These were middle class, and as the results eventually showed, the test material presented more difficulty to the control subjects in the study than had been expected from the preparatory work. However, this was not entirely disadvantageous; it meant that the control subjects maintained more interest in the tasks than they would have if they had been without any difficulty for them.

2.1 Handedness

People described as left handers are more likely than right handers to suffer aphasia following a unilateral brain lesion (Gloning, Gloning, Haub and Quatember 1969) and are more likely to recover from it quickly (Subirana 1958). Left handers are consequently sometimes considered to show a different pattern of cerebral lateralization of language from right handers (Beaumont 1974) which may be characterized by a greater diffuseness of 'functional units'. In a group of 44 left handed or mixed handed people, the Wada test showed speech to be represented in the right hemisphere in 20% and in both hemispheres in 16% (Milner, Branch and Rasmussen 1964), though this population may not have been typical. It has been suggested that a degree of bilateral representation of language is the rule in the non-dextral individual (Levy 1974a, Zangwill 1975). It is somewhat misleading to think of handedness as being dichotomous: Annett (1967) has shown that there is a continuum of degrees of preference between consistent right and consistent left handers with some 30% of adults and children having mixed hand preference. There may also be a genetic bias in handedness (Levy 1974a, Zangwill 1975). Zurif and Bryden (1969) and Hécaen and Sauget (1971) have suggested that the degree of lateralization of functions is linked with familial handedness. In confirmation of this McKeever, Van Deventer and Suberi (1973) found that a significant right visual field superiority for recognition of sequenced letters could only be demonstrated in right handed students who had no near left handed relatives. Lake and Bryden (1976), however, consider the evidence for the relationship of language lateralization and familial sinistrality to be inconclusive.

As one of the concerns of the present research was the possibility of some representation of language in the right hemisphere, it was pertinent to obtain some estimate of the handedness of the subjects. This presents some problems with people who are hemiplegic; direct testing of handedness is obviously inappropriate, and so in fact are some of the items on a standard questionnaire designed for students such as the Edinburgh Inventory (Oldfield 1971). For example, recall of which hand is used uppermost on a broom handle may require rehearsal of the gesture. White and Ashton (1976), through a factor analysis of answers to the Edinburgh Inventory, have suggested that there is a second factor involved in addition to handedness, which involves 'mental imagery'. Handedness was therefore assessed in the following way; the patient (or in some cases the spouse where the patient was too aphasic) was asked if he had been left handed before the stroke, and specifically if he would have used his left or right hand for writing, for holding a knife when eating, for cutting with scissors, for throwing a ball, or for "anything at all like that". The patient was also asked if anyone in the family was at all left handed for anything. He was considered to have a familial tendency if a parent, sibling, aunt, uncle or child was left handed (provided that in the case of children the spouse had no familial tendency to left handedness).

Annett (1973) reported that of 41 families attending a pediatric outpatient clinic, 44% had at least one member with strong sinistral tendencies. In the present sample of 88 families (treating husband and wife as of different genotype, and excluding the sister and father from the NBD) there was a lower proportion, 20 families. (With husband and wife treated as same family, there were 70 families in all, with 20 with sinistral tendencies.) Three factors may have contributed to this lower figure: a worse memory in an older population for relatives who were left handed, a greater tendency for left handers to have been encouraged to behave as right handers, and the fact that a brain-damaged population selected as being either aphasic after left brain damage or non-aphasic after right brain damage may have been biassed towards people with stronger lateralization of functions in the brain, and therefore including fewer familial 'mixed' handers.

3. Tests and measures

Three kinds of tests and measures were required:

1) Ones on which to screen subjects for possible exclusion from the sample because of disabilities in hearing and visual acuity.

2) Standard psychological and clinical tests of brain damage, against which to compare the results of the experimental tasks. These tests should give an estimate of intellect, vocabulary, auditory verbal comprehension as customarily assessed, memory for sequences, praxis, and visual-interpretive abilities. Independent assessments of the aphasic patients' abilities should also be obtained from their speech therapists and relatives.

3) The experimental tests of verbal comprehension at the three linguistic levels, and a method for eliciting and analysing a sample of speech and writing, so that the centrality of the language disorder could be assessed.

3.1 Screening tests

3.1.1 Hearing

The subjects were screened for pure-tone hearing, so that any patients whose comprehension deficit could be attributable to inadequate hearing could be excluded. It was therefore necessary to establish what degree of hearing loss could be considered acceptable.

Three principal influences on hearing loss are relevant to the kind of population sampled here, and therefore to the decision as to what degree of hearing loss was acceptable: presbycusis, or deterioration of hearing with age, affecting the high frequencies more than the low, exposure to noise, and pathological deterioration. These three influences may, in fact, not be as distinct from each other as they at first appear. It has been suggested that presbycusis may be attributable to arterio-sclerotic degeneration in addition to noise trauma (Nober 1966). Indeed, arteriosclerotic degeneration may itself be attributable to noise trauma: Rosen (1970) reports that noise-exposed animals can develop aortic atherosclerosis, and that a tribe in the south east of the Sudan which had startlingly better hearing than the Americans who were examined at the Wisconsin State Fair had much better cardiovascular health. There is also a slight association of hearing loss with cigarette smoking (Siegelaub, Friedman, Adour and Seltzer 1974), and hearing loss is greater in the lower social classes than in the higher (Heron and Chown 1967). The association of hearing loss with exposure to industrial noise is well documented. According to Hinchcliffe and Littler (1960) coal miners in South Wales had a low and a high tone frequency loss in addition to that attributable to presbycusis, and it was related to the number of years they had spent at the face. Because of greater exposure to noise, older men are said to have more hearing loss than older women. Hinchcliffe (1959) examined people living in Dumfriesshire (Annandale) and found significantly higher thresholds for hearing in older men than in women, but only at 2,000 to 8,000 cycles per second. However, Kell, Pearson and Taylor (1970) consider that there may be other influences than noise exposure which affect the sexes differently: even in an isolated, relatively noise-free community, Westray in the Orkneys, men had greater deterioration of hearing at 2,000 c.p.s. From these reports some degree of hearing loss at all frequencies might be expected in a sample of people in their fifties and sixties in an industrial community like Tyneside, with an even greater loss at the higher frequencies and particularly in men.

There are also reasons to expect that these losses may be greater in patients who have had a stroke. Karlin, Hirschenfang, Miller and Rich (1963) have reported a hearing threshold in hemiplegic patients which was an average of 10.3 dB higher than the standard for their equivalent age group. Street (1957) was of the opinion that hearing loss was a concomitant of the lesions which produce aphasia. Terr, Goetzinger and Rousey (1958) found no difference between the right and the left brain damaged but that both groups had a significant mean loss in both ears at all frequencies, although there were wide individual variations. There have been some suggestions that hearing loss can be detected more often in people with right brain damage than in those with left brain damage. Karp, Belmont and Birch (1969) reported that in a right brain-damaged group age 55 to 75, the left ear had a significantly higher threshold for hearing than in controls, but the right ear did not. They suggest that "unilateral cerebral damage can result in contralateral threshold changes in audition as well as in somesthesic and visual sensibility". Both Miller (1960) and Karlin et al (1963) report a higher incidence of sensorineural deficits affecting the speech frequency ranges (500-2,000 c.p.s.) in left hemiplegics (i.e. with right brain damage) than in right hemiplegics.

It appears that, although aphasics as a group may evidence a hearing loss for pure tones, this loss is not causally related to aphasia. Schuell (reported by Smith et al 1972) considered that the defects in auditory processing in aphasia were high level ones and that hearing itself could be intact. Smith's own study concluded that "the hearing losses were not significantly related to and apparently did not determine the nature and degree of aphasic disorders". Testing of pure tone hearing in aphasics is, therefore, useful as a screening measure to exclude those patients whose problems in comprehension may be partly attributable to a hearing loss, rather than as providing information relevant to the aphasia itself. A recent review by Noble (1973) of comparisons of pure tone audiometry with speech-test audiometry shows that even in normal subjects speech hearing and pure tone hearing measures produce conflicting results: Noble suggests that measures of everyday functional hearing are required in addition to formal audiometry.

There can be problems in testing the pure tone hearing of aphasics. In a study by Ludlow and Swisher (1971), 9% of aphasics could not be reliably tested at every frequency. However, their problems were not entirely due to comprehension difficulties: 39% of those who responded appropriately were rated on the Functional Communication Profile as having as much difficulty in comprehension as those who did not respond appropriately. The main problems were 'behaviour problems', for example, poor eye contact, negativism, fatigability, lability. For this special study hearing was tested by an audiologist in a booth, and the unfamiliarity may have enhanced the behaviour problems. Smith et al's report of a long interdisciplinary study at their own clinic makes no mention of any such difficulties.

There are several methods for testing hearing which can be used in aphasia clinics (see Oyer and Beasley 1973, Van Gelder 1974 for reviews). For the present purposes a simple screening procedure was used. Ludlow and Swisher advocate the 'descending method' of testing hearing, in which bursts of pure tones are given at 5 dB drops of intensity until the patient ceases to respond. However, Carhart and Jerger (1959) reported that the descending and ascending and combined methods of testing give approximately the same results and strongly recommend that the ascending method specified in the Hughson-Westlake technique should be used as standard in all clinical testing. With this method the subject is first given a tone intense enough to be heard, some 30 dB above his anticipated threshold, in order to orientate him to the frequency; his approximate threshold is thus established by reducing the intensity by 15 dB steps. The pure tone is then presented at 10-15 dB below this threshold and in ascending 5 dB steps. Each tonal burst lasts 1-2 seconds and must be followed by a silent interval of at least 3 seconds. The ascending procedure should be repeated 3 or more times to establish the threshold at each frequency.

For the present investigation, this ascending method was used, with the simplification that the approximate threshold was guessed rather than ascertained by reducing the intensity. The ascending method tends, if anything, to overestimate a hearing loss (Ward 1965). A portable Amplivox 115 audiometer was used, and air conduction hearing was tested at 1,000-8,000 and then 500-125 c.p.s. This order of presentation is that recommended by Burns (1968).

Following Harris' recommendations (Glorig 1965) the average of hearing loss at 500, 1,000 and 2,000 c.p.s. was taken to be critical for speech. Davis and Kranz (1965) suggest that impairment of hearing may be considered to begin at a level of 26 dB (International Standard) and that amplification is not needed until a 41 dB level or more. Smith et al (1972) described losses of 16-25 dB as "minimal", of 26-40 as "mild" and of 41-55 as "moderate" and of 56-70 as "moderately severe, 71-90 as severe and of over 90 dB as "profound". When allowance is made for the change in 1965 from American Standards to International Standards (requiring an average addition of 11 dB to the American Standard for each frequency - see Nober 1966), this agrees with Karlin et al's (1963) description of a loss of 16-30 dB as slight. In view of the reasons reviewed earlier why some degree of hearing loss was anticipated and the fact that aphasia is expected to be relatively independent of hearing loss up to a certain point, it was therefore decided for the present investigation to take a hearing level of 40 dB in either ear as acceptable, but to exclude subjects with a greater loss.

It was originally intended to test the hearing only of the aphasics so that people whose auditory comprehension difficulties could be attributed to hearing loss could be excluded. However, after the study had begun, it became clear that a number of patients, particularly women, did indeed have greater hearing loss as measured in this way than the standard age presbycusis curves show, and that normative data would be useful. At this point, to examine the representativeness of this hearing loss in the aphasic women, the control and right brain-damaged subjects whose assessment had not been completed were also given hearing tests. Fifteen of the NBD and 21 of the RBD were tested, and within this sample there was apparently a slightly greater hearing loss than in the LBD (though this may have been because they were tested in less favourable conditions at home). Two possible NBD and one possible LBD subjects had a hearing threshold of over 40 dB, and were excluded from the experimental subjects.

To estimate the everyday functional hearing of the aphasic patients, an item about this was included in the questionnaire given to relatives.

3.1.2 Visual acuity and visual interpretation

Screening for visual acuity was combined with a test of visual-interpretive ability which was needed to assess the degree to which scores on the picture tests were influenced by such ability. Although it would be appropriate to describe this test also under Section 3.3, for convenience, as it included a screening measure, it is described here. A test was adapted from Warrington and Taylor (1973), which uses photographs of objects seen from unconventional but common view-points. Of four measures of visual perceptive difficulties which they used - the other three were figure-ground discrimination, recognition of enlarged drawings of small objects, recognition of fragmented drawings - this was the only one on which people with right brain-damage (particularly parietal) were impaired and people with left brain-damage were not. This effect was maintained even when scores weighted for age were used. Warrington and Taylor suggest that the deficit in people with right posterior damage can be attributed, not to the hypothesised first stage of perception, the structuring of forms into a gestalt, but to a failure in classification, the mechanism whereby two or more stimulus inputs are allocated to the same class. From its impairment in right and not left brain damage, they conclude that this ability "must function independently of verbal hypotheses".

Of Warrington and Taylor's subjects, as described in Taylor and Warrington (1973), fewer than half of those with left brain damage were aphasic, and it was therefore necessary to make some modifications to their test for the present investigation. The objects to be photographed were chosen so that their use could be demonstrated by gesture, or so that they could be pointed to in the room, if the patient could not name them. Ten objects were photographed (milk jug, hammer, cup, beer bottle, light bulb, hand-brush, tennis racket, knife, typewriter and teapot) from both conventional and unconventional viewpoints. The unconventional viewpoints were showed first to the subjects, for all the ten items, followed by the conventional viewpoints (see illustrations in Appendix C). Warrington and Taylor reported that the error rate for recognition of the conventional viewpoints was very low in all groups: for the present investigation the second part of the test was therefore used as a screening test. Anybody who made any errors on this second part of the test was excluded as having doubtful visual acuity. In the event, four potential subjects had to be excluded on these grounds, one NBD and three LBD. In one or two cases with the LBD, when the patient was severely aphasic and was also unable to indicate recognition through gesture due to apraxia, recognition had to be assessed by giving the patient a multiple choice of names.

This test also provided a measure of naming ability and material for the analysis of misnamings and circumlocutions (see Part Four, Section 1).

3.2 Standard tests

3.2.1 Raven's Standard Progressive Matrices

This test was used to obtain an estimate of the subjects' intellectual status as in the first preliminary experiment.

The Progressive Matrices test (Raven 1958, originally published in 1938) was described by its author as a test of "innate educative ability". It consists of 60 designs from each of which a part has been removed. Each design consists of nine patterns (in matrix form), eight arranged according to a system which has to be inferred in order to select the correct ninth one from a multiple choice set out below the incomplete matrix. The sixty designs are arranged in five sets, each with a different theme (set A continuous patterns, set B analogies, set C progressive changes, set D permutations, set E resolution of figures into constituent parts). Four versions of the test are available: a solid version for children, a coloured version for less able adults, the standard version and an advanced version.

For the standard version test-retest reliability coefficients for normal adults have been reported ranging from .79 to .93 (Burke 1958). The guide to the Standard Progressive Matrices (Raven 1960) provides age-related norms; lower scores are likely to contain a higher proportion of random guesses and therefore to be less reliable than higher scores. A subject with a total score of 17 or less is expected to get no more than one item correct from the two last sets; curtailing the test should, therefore, not materially affect his score.

At least two studies have presented the standard version with a time limit (Vernon 1949, Heron and Chown 1967), and occupational and age norms are thus available for this condition. Vernon's time limit was 20 minutes, Heron and Chown's 40 minutes, but they recorded the score reached after 20 minutes. As they included women in their sample, unlike Vernon, their 20 minute norms are relevant to the present investigation, and are given below.

Table 5

Heron and Chown's norms for 20 minute

Raven's Standard Progressive Matrices

	Age:	30-9	40-9	50-9	60-9	70-9
75%ile men		48.0	42.9	40.8	36.0	29.3
women		43.5	42.8	38.5	35.5	26.0
50%ile men		41.3	37.5	35.2	28.3	21.5
women		38.5	36.5	31.0	29.5	18.5
25%ile men		37.0	31.6	31.9	22.7	14.8
women		29.5	27.5	24.5	22.5	14.0

Mean scores vary not only with age (Savage 1973) but also with occupational group and educational level, psychiatric status, and presence of diffuse cerebral damage (Kendrick and Post 1967) as well as with lateralized brain damage. Factor analyses have raised doubts about whether the test does provide the "almost pure measure of 'g'" which Spearman, Vernon and Vincent have suggested it did (Burke 1958). Factors which have been identified in various studies include memory, a "complex non-verbal practical factor unrelated to verbal intelligence" (Tizard, O'Connor and Crawford 1950, page 900), "mental energy", "induction", "spatial factor", "hypothesis verification", "perceptual speed" and "concept formation". For use with unilaterally brain-damaged subjects, the significant question is whether or not the test relies so much on visuo-spatial perception, that it provides a misleading assessment of intellect, or, as Raven described it, "immediate capacities for observation and clear thinking", with subjects who have right brain damage. Luria (1966a, page 365) recommends the use of the tests in Set A for measuring visual perceptive ability after brain damage, while Colonna and Faglioni (1966) described the whole test as having a 15% saturation in a spatial factor. Zaidel and Sperry (1973) report that the right hemisphere, in 'split-brain' patients with severance of the corpus callosum, finds the test easier than does the left (a modified version was used in which the hands had to identify the missing part by touch). Studies which have reported impairment on Raven's Matrices after right hemisphere damage include those by Piercy and Smyth (1962), Archibald, Wepman and Jones (1967), Russo and Vignolo (1967) and Costa (1976). Smith (1969) reported markedly subnormal scores on the coloured version in three patients with right hemispherectomy, but a normal score in a left hemispherectomized patient. Archibald and Wepman (1968) noted that in the relatively infrequent cases where unilateral right brain damage is accompanied by a frank aphasia, there is a significant reduction on Raven's Matrices scores.

However, there is also a body of evidence which shows that left brain damage can depress scores on the test as much as can right brain damage. Several studies have reported no overall significant difference between the left and the right brain damaged (Costa and Vaughan 1962, De Renzi and Faglioni 1965, Colonna and Faglioni 1966) while others have reported somewhat lower scores after left brain damage (Meyer and Jones 1957 in patients operated on due to epilepsy, Arrigoni and De Renzi 1964).

Amongst those with left brain damage the effect of aphasia is also disputed. As a group, aphasics have been reported as scoring significantly worse than euphasics by Colonna and Faglioni (1966) and by Luteijn (Lebrun and Hoops 1974, page 40). Van Dongen (Lebrun and Hoops 1974, page 59), however, reported a mean I.Q. equivalent of 93.5 with 18 aphasics and a slightly lower one of 92.4 with 18 matched euphasic left brain damaged. There have been reports of severely aphasic individuals achieving average, indeed superior scores (Kinsbourne and Warrington 1963, Zangwill 1964, Smith et al 1972). Welmar and Lanser (Lebrun and Hoops 1974, page 47) report that 30% of the aphasics they tested scored in the high range, with 20% in the normal range. A number of studies have suggested that the major cause of poor scores on the Raven's Matrices is not aphasia but constructional apraxia associated with parietal lesions (Piercy and Smyth 1962, Arrigoni and De Renzi 1964, Zangwill 1964, Van Harskamp in Lebrun and Hoops 1974, page 41). However, the possibility that the test also draws on verbal skills cannot be excluded. Archibald et al (1967), for example, found that talking aphasics achieved higher scores than non-talkers; Costa and Vaughan (1962) reported that Raven's Matrices scores correlated more highly with the Mill Hill Vocabulary Scale than with "other visual spatial tests".

Despite these reservations, Raven's Matrices seems to be the most convenient test at present available for making a relatively quick overall assessment of intellectual ability in brain damaged patients.

For the present investigation, the instructions given by Raven (1956 edition) were slightly modified and shortened for the more handicapped patients; if the patient made the wrong choice on the first item he was corrected with an explanation.

3.2.2 English Picture Vocabulary Test

This test is a modified anglicized version of the American Peabody Picture Vocabulary Test aimed at measuring levels of listening vocabulary in children. The task is to indicate one of four pictures in response to a spoken word. The distractor items are frequently not semantically associated with the correct word and the rationale for their selection is not made clear. The items were derived by presenting 3,885 words whose meanings could be pictorially represented to 360 subjects aged 2 to 18, and items were then placed at the age level where 40-60% of the appropriate age group passed them. Tests for four age groups and a composite one are now available: the version used in the present investigation was number 3 (EPVT 3), for the age range 11 to 18+. Test-retest reliability is reported as averaging .91.

EPVT 3 contains 48 items which range in difficulty from 'reel' to 'orifice'. Standardized scores are reported (Brimer and Dunn 1968) derived from 1,508 subjects age over 18 who were engaged in full-time or part-time education. The table below gives the percentiles for raw scores which are pertinent to the present investigation.

Table 6

EPVT norms

Raw score	Percentile
38.5	50
31.0	25
23.0	10
18/19	5
10/12	1

Although no studies of the EPVT 3 with adult aphasics seem to have been reported, there are several of the Peabody test on which it was based. Goodglass et al (1970) reported that even global aphasic subjects scored on average better than 8 year old children, while conduction aphasics had a mean score slightly superior to normal adults. Perry and Boswell (1967) found that although the mean score of an aphasic group was below that of a control group, 24% of the aphasics achieved scores above the normal mean. It would seem that impairment of vocabulary (as measured on such a test) is not a necessary feature of aphasia. In normal people, in contrast to Raven's Matrices scores, vocabulary scores hold up well despite advancing age (Heron and Chown 1967), and are related not to age but to social class. Comparing young patients with traumatic aphasia with a group 20 years older with aphasia after stroke, Smith et al (1972) report similar levels of vocabulary as measured by the Peabody Picture Vocabulary Test: good vocabulary comprehension tends to be associated with absence of hemiplegia and sensory defects rather than with youth.

The use of the EPVT and other vocabulary tests, with subnormal populations has been questioned (Wheldall and Jeffree 1974) but primarily on the grounds that they tend to be misused as estimates of general ability. Wheldall and Jeffree comment that the order of difficulty of the items is not necessarily the same as that derived from normal subjects. Sefer (1973) makes a similar comment à propos of an aphasic patient who scored at under the 1%ile in the Ammons Full Range Vocabulary Test: he had difficulty with words such as 'fear' and 'bed' but not with 'mastication' and 'centigrade'. In the present investigation it was also noted that many patients had a disproportionate difficulty with the first two items (reel, wrath) in comparison with words such as 'talon', 'rodent', 'senile', which are supposedly more difficult. As there is a cut-off point for the test, which is not completed if more than five items in any run of eight are failed, one must have some reservations about the use of this test with aphasic patients as a principal means of assessing auditory comprehension. It was included in the present investigation so that the correlation of the experimental tests with vocabulary level could be measured.

To facilitate recognition, a black cardboard mask was used to isolate the four pictures from which the word was to be identified.

3.3 Clinical tests of brain damage

3.3.1 The Token Test

The Token Test (TT) is probably the most widely used 'quick' test of auditory verbal comprehension in aphasia. The original version (De Renzi and Vignolo 1962) has already been described in Section 2.3.3 of Part One. Some of the many research studies which have been undertaken of it, and modifications of it, since then are listed in Table 7.

Table 7 Research studies of the Token Test

	Language	SUBJECTS LBD aphasic	LBD non-aphasic	RBD	NBD	Children	Modification	Scoring
Orgass & Poeck 1966	German	26	------49-----		66	15		Weighted
Boller & Vignolo 1966	Italian	34	26	30	31	-	'Pick up'→ 'touch'	Pass-fail
Boller 1968	Italian	-	27	37	20	-		Pass-fail
Swisher & Sarno 1969	English	11	-	16	11	-	Random scatter, 'touch'	Pass-fail
Spellacy & Spreen 1969	English	67	------37-----		-	-	Short form, squares	Pass-fail & weighted
Poeck et al 1972	German	33	-	-	-	-		Pass-fail
Sipos & Tägert 1972	German	-----28------		28	31			Pass-fail
Needham & Swisher 1972	English	25	-	-	-	-		Pass-fail
Whitaker & Noll 1972	English	-	-	-	-	252	Squares, 'touch'	
Van Dongen & Van Harskamp 1972	Dutch	27	------59-----		46	-		Pass-fail
Poeck et al 1973	German	41	------56-----		-	-		
Hartje et al 1973	German	57	27	31	-	-		Pass-fail
McNeill & Prescott 1973	English		(not reported)				Squares, extended	15 point qualitative
Wertz et al 1973	English		(not reported)				Squares	
Poeck et al 1974	German	100	37	42	-	-		Pass-fail

(The table does not include studies in which it has been used solely as a control test for comparison with other measures.)

These researches have confirmed that the TT satisfactorily distinguishes aphasic from non-aphasic with an accuracy of from 84% to 91% (Boller and Vignolo 1966, Orgass and Poeck 1966, Spellacy and Spreen 1969, Swisher and Sarno 1969, Van Dongen and Van Harskamp 1972, Hartje, Kerschensteiner, Poeck and Orgass 1973). A confirmation that this is partly attributable to lack of redundancy, as De Renzi and Vignolo suggested, is derived from Swisher and Sarno's observation that the test is harder in English which has fewer inflections than Italian or German.

Some studies endorse the inventors' claim that test performance is independent of intellectual ability (Orgass and Poeck 1966, Boller and Vignolo 1966), while others have found a significant correlation with intelligence scores in aphasics (Poeck, Hartje, Kerschensteiner, Orgass 1973) or in control subjects (Van Dongen and Van Harskamp 1972). In adults the correlation with age is not significant (Orgass and Poeck 1966, Swisher and Sarno 1969, Poeck et al 1973) but the test discriminates different levels of ability with age in children (Orgass and Poeck 1966, Whitaker and Noll 1972, Wertz, Wangler, Rosenbek and Lemme 1973). TT ratings have correlated with clinical ratings of overall severity (Orgass and Poeck 1966, Swisher and Sarno 1969) but not with functional ratings (Needham and Swisher 1972).

Modifications which have been made are a change in terminology from 'rectangles' to 'squares' and from 'pick-up' to 'touch', and a random instead of ordered presentation of tokens. The test has been shortened to its sixteen most discriminating items (Spellacy and Spreen 1969), to a selection of items from each part (Spreen and Benton 1969) and to the final section only (Sipos and Trägert 1972) which correlates at over .9 with the complete test. Less abstract versions have been developed (the Tri-dimensional Matrix described in Section 5.3.2.1 of Part One) or are being developed (Pizzamiglio, personal communication). Another substantial revision is that proposed by McNeil and Prescott (1974) which uses standardised materials and presentation, a balanced number of occurrences of each type of word, extensions of the last section and a 15-point scoring scale similar to that used in the Porch Index of Communicative Ability (Porch 1967). The relative merits of pass-fail and of weighted scoring (one point per item correctly interpreted within a sentence) have also been investigated (Spellacy and Spreen 1969).

The results of using the test with aphasics have been illuminating. The type of aphasia, according to conventional classifications, seemsto make little difference to scores. Non-fluent aphasics are no less impaired in comprehension as assessed by this test than are the fluent (Poeck et al 1972), and they show a similar rank order of difficulty of items in the last section (Poeck, Orgass, Kerschensteiner and Hartje 1974). Naeser (1974) suggests that the Token Test particularly catches the comprehension difficulties experienced by Broca's aphasics. The divorce of TT results from the particularities of a speech disorder is supported by evidence that people who are not aphasic despite left brain damage make a significant number of errors on the test (Boller 1968).

Slight impairment has been reported after right brain damage, but attributed to difficulties in visual scanning (Swisher and Sarno 1969). Zaidel (in press, a) has used a technique he has devised for prolonging presentation of an image to one visual field (Zaidel 1975) to examine the different capacities on the TT of the right and the left hemispheres in split-brain and hemispherectomised patients. He concludes that the right hemisphere makes no specific contribution to normal TT performance: as a separated hemisphere it failed to process sequential and semantically context-free information "despite having an adequate auditory vocabulary of about the level of an 11 year old as measured through the Ammons and Peabody picture vocabulary tests" (Zaidel in press, b).

Besides being incorporated into test batteries, the TT has been used in therapy as a training procedure to assist recovery of comprehension (Holland and Sonderman 1974, West 1973).

Just what qualities make the TT difficult for aphasics has been the subject of discussion. Leischner (1974), criticising its adoption in clinics as the prime means of assessing auditory comprehension, describes it as "too polyvalent and artificial, influenced by attention, concentration, fatigue, difficulty in differentiation amongst similar tasks, optic gnostic disturbances". Tallal (1975) considers that the main difficulty in the TT in children with developmental dysphasia may be not so much linguistic as a defect in rapid analysis. Nevertheless, at least three studies have attempted a qualitative analysis of errors on its last section based on the linguistic characteristics of the sentences (Whitaker and Noll 1972, Poeck et al 1974, Wertz et al 1973).

Whitaker and Noll's analysis (of children's errors) relates the difficulty of items in the last section to the implicit cases associated with the different verbs used. For example, 'touch' is particularly difficult because the implicit instrumental case ('with your hand') is negated in a sentence such as 'touch the red square with the green circle'. The difficulty of eight sentences can be attributed, they suggest, to this shift from an implicit to an overt instrumental case. The other two studies had some reservations about endorsing Whitaker and Noll's analysis or applying it to results from aphasics: order of difficulty in normal children and aphasic adults only partially coincided.

For the present investigation the version used was Spreen and Benton's, with a random scatter of tokens for all except the last section. Weighted scoring was used.

3.3.2 Verbal and non-verbal sequencing

Several measures were used in order to assess ability to register and execute sequences, both verbal and non-verbal. These are listed in the table below.

Table 8

Sequencing tasks

Non-verbal tasks	Verbal tasks
Hand gesture imitation Tapping Pointing to designated objects (visual) Arranging a series of pictures	Pointing to named objects Arranging a sequence of months Arranging a sequence of words into a sentence Automatic serial speech Sections of the phonological and syntactic tests

The hand gesture and tapping tasks were adapted from Luria (1970 page 267, 275). Luria describes his fist-palm-side test as a test of the ability to shift from one motor pattern to another, and, as such, being sensitive to the premotor lesions which are associated with Broca's or efferent motor aphasia. The patient imitates the examiner's action in positioning his hand in different orientations on the table, the hand being placed either flat with palm down, flat with side down or fist-shaped with palm down. Luria considers that imitation of tapping rhythms is disturbed by both premotor and temporal lobe lesions because of sensory perseveration in the first and acoustic disturbances in the second. In the present investigation the number of actions or 'dot dash' taps the patient could imitate in sequence was scored. Each of the 'memory for sequences' tasks (see Appendix C) began with the execution of one action and increased up to five or eight the number of actions to be imitated in a set sequence. There were two examples at each length. Testing stopped after two consecutive failures. The score was the maximum sequence correctly copied in both examples, with a half point scored if only one example had been correctly copied. In all cases imitation was immediate. A pencil was used for the tapping task, to make a noise on a hard surface, and the subject watched the action as well as hearing the noise.

For the two pointing tasks (visual sequencing and verbal sequencing), adaptations were used of Albert's sequencing test (Albert, Goldblum, Benson and Hécaen 1971, Albert 1972a, b). To lessen scanning difficulties the number of objects was reduced from 20 to 10. The objects were selected for their familiarity, for their visual distinctiveness from each other in material, colour and shape, and for their linguistic distinctiveness in semantic category and in the phonological pattern of their names. So that they could be attached to a circular board of 27 cms diameter, and thus be presented in fixed positions and conveniently rotated while still keeping their relative positions, the objects chosen were all fairly flat and small. The verbal test was given first. The objects were named singly by the investigator to check whether or not the patient could recognise them by name. Unless the patient had virtually no speech, he was also asked to name them, thus providing a measure of naming ability in addition to that derived from the photo test. The patient was then asked to point to increasing numbers of objects in a set sequence (as described above). Live voice was used with intervals of approximately 1.5 seconds between items, and with rising intonation on each name except the last one in the sequence, so as not to cue chunking in recall. Albert's test used a tape recorded voice, but live voice was preferred in the present investigation as minimizing perceptual difficulties. A recent experiment (Green and Boller 1974) seems to have justified this decision by showing that aphasics have more difficulty with tape recorded instructions than they have with live voice, even when they cannot see the instructor.

Following this 'verbal' section, the patient was then asked to imitate the investigator's pointing to sequences of objects. As a check on the amount of internalized verbalization used in such an apparently visuo-spatial task, an additional task was given. In this the investigator rotated the board after pointing and before the subject pointed. Under this condition most control subjects acknowledged that they were covertly naming the objects. Scores were lower in all the subject groups in this condition, indicating that in the unrotated task the visuo-spatial image was assisting performance, and it was concluded that the unrotated task could provide a valid measure of non-verbal sequencing abilities.

Albert reported that right-, left- and non-brain-damaged groups did not differ significantly on his visual (unrotated) task, but that on the verbal task the left-brain-damaged were significantly worse than the non-brain-damaged. Within the left-brain-damaged group, those without aphasia performed at approximately the same level as the right-brain-damaged. Amongst the aphasics 'anterior' ones did rather better than 'posterior' ones and 'mixed' were most impaired. Albert infers that the neurological basis of left cerebral dominance for language is the organization of neurones to carry out the specific function of maintaining and utilizing the sequential aspects of verbal acoustic inputs. He considered the sequencing test to be a more efficient discriminator of aphasic from euphasic than the TT. Goodglass et al (1970) included a simple test of auditory verbal memory for sequence in their examination of comprehension difficulties and (in contrast to Albert) reported that Broca's aphasics (anterior) were particularly impaired in this respect.

The sequencing tasks of arranging pictures, months and sentences were also used to elicit speech and are described in Section 3.5.5.1.

3.3.3 Praxis

An estimate was required of the patients' abilities in using gesture voluntarily to see to what extent difficulties on linguistic tasks could be attributed to the mechanics of execution. Although the hand sequencing task based on Luria's provided some indication, it was not necessarily of the same kind of difficulty as the patient experiences in co-ordinating meaningful gesture. Failure to perform actions to command is not infrequent in aphasia, and it is sometimes difficult to decide whether the failure is in verbal comprehension or in the organization of the response, gesture dyspraxia. Goodglass and Kaplan (1963) concluded that failure to execute spoken commands cannot be entirely accounted for by poor comprehension in aphasia; when the influence of auditory comprehension was controlled in their study, they found that pantomimic-gestural ability was not related to the severity of aphasia. Geschwind (1967) suggested that people with left brain damage and a right hemiparesis experience difficulty in executing commands with their left hands because a lesion in the left hemisphere has interrupted the pathway from the left language and motor association cortices to the right motor association cortex which is needed to transfer the 'instruction' for execution to the left hand. These patients can, however, recognize visually the correct movements if a series is demonstrated to them to choose from. A lesion in the left arcuate fasciculus does not impair the spontaneous motor organization controlled by the left motor association cortex, but it does disconnect it from the auditory verbal system, thus affecting the execution of commands to a spoken order.

Kaplan and Imamura (unpublished) have designed a test to measure type and degree of dyspraxia. The battery distinguishes praxis as being 'bucco-facial', 'intransitive gesture', 'hand to body', 'hand away from body', 'lower limb movements' and 'whole body movements'.

There is some evidence that whole body movements are mediated by different (non-pyramidal) pathways from limb movements, and are therefore usually not impaired in aphasias. For the present investigation, two items were therefore selected from each category except for whole body movements. Behaviour was noted according to the qualitative categories recommended in the battery (see Appendix C), but, for the purpose of analysis, behaviour on the six activities with the hand was summarized as being free of dyspraxia, showing some degree of dyspraxia or showing conspicuous dyspraxia.

3.4 Independent assessments of the aphasic patients

3.4.1 Clinic

No one standard aphasia battery is universally used by the two Speech Clinics which the aphasic patients were attending, and it was therefore not possible to make direct comparisons amongst the patients from test results obtained independently of the research investigation. Consequently, a form was prepared which the speech therapist in charge of the patient was asked to fill in (see Appendix C). It provided for a rating on a five-point scale of abilities in twenty aspects of language in all four modalities, plus an overall rating of effectiveness in communication.

3.4.2 Home

A questionnaire was also devised for the husbands and wives of the brain-damaged patients (RBD and LBD). It was prepared in four forms, two for each sex, one of these forms containing two extra pages relevant to the language disorder of the LBD which was omitted from the form for the RBD (pages SA3 and 4). Much of the questionnaire was concerned with an interest outside the present investigation, the relationship of the course of recovery to the amount of social stimulation to which the aphasic patients were exposed, and the RBD were included to discover whether or not a physical handicap without a speech disorder were less socially limiting than a language disorder with or without a physical handicap. A copy of the form of the questionnaire given to the wives of the aphasic men is included in Appendix C.

The section of the questionnaire which is of relevance to the present investigation is pages S1 and 2, which were used with both the LBD and RBD. The purpose was to derive an estimate of the functional communicative abilities of the patients for comparison with the formal research results. The questionnaire first aimed to remind the spouse about the patient's language abilities before the stroke, and then asked specific questions about certain functional abilities of the patient in speaking and writing. A guarded approach was used to ask the relatives about what the patient could understand in language, because of possible defensive reactions to implications of intellectual deficiency: the question about understanding speech was preceded by a question about hearing.

The questionnaire was approved by the Medical Ethics Committee of the Newcastle University Hospitals, and by the three Local Medical Committees in the area from which the patients were drawn. Individual permission to administer the questionnaire to each patient was also obtained from the hospital consultant and/or the general practitioner responsible for each case.

Completed questionnaires were obtained for 47 of the 64 patients in the study. Of the others, 15 had no spouse who could answer the questions, one wife (excluded from the study as a control subject on the grounds of impaired visual acuity) did not complete the questionnaire appropriately, and one wife refused.

3.5 Experimental tests and measures

Before the linguistic tests were prepared, a decision had to be made about the measure of word frequency to be used. In the absence of a comprehensive count of the frequencies of words in modern spoken British English, the choice is at present from a number of American counts, all of them with some disadvantages. Howes' (1966) corpus was spoken words, but the number of subjects was limited (41 students and patients) and there are some intuitively unacceptable findings (for example, the words 'environment', 'electronics' and 'myelogram' are credited with a higher frequency than 'fat' and 'alive'). A modern computerised count (Kučera and Francis 1967) uses spaces between printed words as a delimiter of what constitutes an item, thus giving separate frequencies for such words as 'walk', 'walks', 'walked', and 'walking'. The older count by Thorndike and Lorge (1944) gives the joint frequency of such words classed together, and is therefore easier to use as a measure of frequency of 'lexemes' rather than of words identified as collections of alphabet letters. For present purposes it was therefore decided to use the Thorndike-Lorge count despite its disadvantages.

3.5.1 Phonological test

Several changes were made in the design of the test from that used in the first preliminary experiment.

1) The choice was binary, not from four items, to reduce scanning difficulties, and to make it comparable with the other picture tests.

2) Distinctive feature theory (in a simplified form - see Part One, Section 4.2.1) was applied in the selection of items for the test. The contrasts were always of only one distinctive feature, which several studies have shown to be more difficult than contrasts of more than one distinctive feature. There were equal numbers of contrasts of voice, place of articulation and manner of articulation (manner including contrasts of stop, fricative, lateral and nasal). Consonant clusters were also included, and vowels.

3) In order to compare errors on items where sequence confusions were possible (syntagmatic items) with those on items where such confusions were not (paradigmatic items), there were equal numbers of paradigmatic and syntagmatic contrasts. A third kind of item was also included, the contrast between presence and absence of a sound (omission items).

4) For the paradigmatic and omission items there were equal numbers of contrasts in initial, medial and final position in the word. For the syntagmatic items there were equal

numbers of contrasts where initial and final consonants might be confused. With the syntagmatic items which used clusters, half had the reversal possible in final position in the word, and half between initial and final position.

5) All stimulus words or their uninflected roots were of AA or A frequency on the Thorndike-Lorge count except one. The more frequent word of a pair was always given as the stimulus word.

6) The test was given in two versions: one in which the subject heard the tape recorded word and then pointed to the picture, and another in which he had to indicate whether a printed word was the one he heard or not.

Table 9 shows how these requirements were met.

In addition to these contrasts at the phonological level, eight extra items were included to test whether syntagmatic reversal difficulties occurred across word boundaries as well as within them. In four items the initial phonemes or clusters from two words could be transposed to give a meaningful contrast (e.g. 'key and toffee'/'tea and coffee'). This part of the test was given only with the picture-selection response. The instructions and stimulus words (see Appendix C) were recorded on magnetic tape in the investigator's voice on a Ferrograph recorder by the Language Laboratory of the University. They were spoken once each with pause between them of five seconds. For item nine ('ask') the short Northern /a/ was used, so that the alternative contrast was 'axe', not 'arcs' (although both possibilities were acknowledged in the picture). The tape was played to subjects in the clinic

Table 9 Phonological Test: Types of Contrasts

Stimulus word	(frequency)	Alternative word	(frequency)	Position in word			Distinctive Feature			Type			Category			
				Initial	Medial	Final	Voice	Place	Manner	Para.	Syntag.	Om.	Vowel	Cons.	Cluster	Syll.
Bark	A	Park	A	x			x			x				x		
Patting	A	Packing	30		x			x		x				x		
Cars	AA	Card	AA			x			x	x				x		
Gate	AA	Date	AA	x				x		x				x		
Fitting	AA	Fishing	AA		x				x	x				x		
Log	A	Lock	A			x	x			x				x		
Bill	AA	Mill	A	x					x	x				x		
Writing	AA	Riding	AA		x		x			x				x		
Map	A	Mat	18			x		x		x				x		
Ship	AA	Sheep	A		x					x			x			
Pull	AA	Pool	34		x					x			x			
Bag	AA	Beg	A		x					x			x			
Tired	AA	Diet	27	x		x	x				x			x		
Cat	AA	Tack	9	x		x		x			x			x		
Nail	A	Lane	32	x		x			x		x			x		
Tending	A	Denting	3	x	x		x				x			x		
Tackle	A	Cattle	14	x	x			x			x			x		
Daily	AA	Lady	AA	x	x				x		x			x		
Nets	A	Nest	A			x					x				x	
Ask	AA	Axe (Arcs)	35 (9)			x					x				x	
Whips	41	Wisp	4			x					x				x	
Tops	AA	Stop	AA	x		x					x				x	
Talks	AA	Stalk	27	x		x					x				x	
Spot	AA	Pots	47	x		x					x				x	
Year	AA	Ear	A	x								x		x		
Drive	AA	Dive	21		x							x		x	x	
Teeth	A	Tea	A			x						x		x		
Appeal	A	Peel	12	x								x	x			x
Support	AA	Sport	A		x							x	x			x
Summer	AA	Sum	A			x						x	x			x

either on a Ferrograph recorder or on a Uher 4000 Report-L which was used for all subjects who were seen at home. The volume control was adjusted each time to suit the comfort of the individual subject. After the picture version had been given the tape was rewound and replayed for the printed version. For the picture version there were equal numbers of correct choices in top and bottom positions (as for all the picture tests) for syntagmatic, paradigmatic and omission contrasts. The order of top and bottom choice within these categories was random.

The subject saw the pictures (or printed word) before and during hearing the word on the tape. No words were repeated. In a few instances with the LBD the tape had to be stopped to give a longer pause before the choice was made. The test was presented in book format, using cards ringed together of A6 size, with the pictures on the right hand side opposite a blank page. For the printed version, four words to a page were printed in 24 point Century Schoolbook capitals (Letraset).

3.5.2 Syntactic Tests

The revision of the measure of comprehension at the syntactic level made several changes. It was principally measured in three forms: with auditory input and pointing to a picture as a response, with printed sentences as input and pointing to a picture as a response, and with auditory input and with manipulation of objects as a response.

3.5.2.1 With picture choice

The changes made from the test in the first preliminary experiment were these:

1) There were equal numbers of sentences in which word order was critical to meaning and in which word order was not critical to meaning.

2) There were, in addition, a set of sentences which examined 'deep relationships'. In these subject-object relationships had to be inferred from knowledge of word meaning and not from word sequence made explicit in the surface structure of the sentences (see Part One Section 4.1.2). These sentences have a theoretical transformational derivation from two underlying structures (for example, 'The shop is cheap to buy' is said to be derived from the two underlying sentences 'Someone buys the shop' and 'The shop is cheap'). They were therefore paired with 'surface structure' sentences which were also theoretically derived from two sentences, such as 'It's the patient (whom) the doctor visits'. These latter kinds of sentences were included amongst those in which word order is critical to meaning. These three sets of sentences will be labelled henceforth as WOC (word order critical), ONC (order not critical) and DR (deep relations).

3) The three sets of sentences were of approximately the same mean length, although the heterogenity of the items within each set meant that individual items must differ considerably in length. The measure of length used was number of syllables. No sentence contained more than three nouns. All the contrasts were expressed in terms of complete sentences (unlike the original Italian version).

4) The WOC items included sentences where the order of single word insertion was critical (e.g. The boy kicks the girl), where phrase order was critical (e.g. The man with the hat meets the lady), and where clause order was critical (e.g. He put his coat on before he chopped the tree). Phrase order was also examined with noun phrases consisting of head noun and single modifier (e.g. It's a big bed for a little man).

5) The contrast was dependent on one feature only: there was no duplication of clues as in the Italian test and the English version of it. In the ONC sentences, recognition of plurality markers in verbs was examined by using them in agreement with nouns which have (or can have) the same realization in the plural as in the singular (sheep, salmon, fish, deer). To examine recognition of plurality in pronouns, a singular pronoun was paired with a plural auxiliary verb (e.g. his hands are ...) and vice versa (their skin is ...) so that the feature of singularity or plurality in the pronoun was not assisted by any other clue. Similarly the plural pronoun as the object of the sentence was paired with a singular subject and verb (e.g. The rider is watching them from the hill). These comments apply to the aural version; in the reading version the alternative easier contrast was employed (their hands are ... his skin is ...).

6) The test was shorter than the Italian Test (64 items). Some contrasts were omitted which the first preliminary experiment had indicated did not contribute significantly to the

difficulty of the test (reflexives, negatives, gender and some 'easy' prepositions - in, out, up, down, near, far). All the prepositions retained were those which necessarily implied transitive relations, whereas the omitted ones were those which can be transitive (e.g. He's gone out, she looks up). The beside/behind contrast was omitted for two reasons: it is prone to phonological confusion, and one realization of the contrast (behind) allows for word order misinterpretation, while the other (beside) does not. The behind/in front of contrast was retained. The pictures which illustrated the prepositional contrasts used a constant perspective of the subject's viewpoint, and not as sometimes in the preliminary experiment the viewpoint of one of the figures in the picture. For example, 'The donkey is behind the shed' was illustrated from the viewpoint of the experimental subject, whereas in the Italian test such items were sometimes illustrated by left-right position.

7) Different lexical items were used in the revised sentences from those in either of the two preliminary experiments as a check on the use of the test as a measure of syntactic rather than lexical comprehension.

8) Although the second preliminary experiment had indicated that the relative position of the figures in the pictures was not important, the precaution was taken of having equal numbers of pictures which were congruent with sentence order and which were not.

9) Besides the main selection of items by the three types of sentences WOC, ONC and DR, a number of subsidiary contrasts were employed: 'before/after' in a WOC and an ONC context; singular and plural contrast realized as + the verb inflection '-'s' and as an auxiliary verb 'is/are'; contrasts amongst various pronominal forms; contrasts between the indirect object with and without 'to'; between simple active and passive sentences and their topicalized versions with 'it's'; and between unmarked and marked adjectives. The intention in making these subsidiary contrasts was to check on the generality of possible types of difficulty: for example, if a patient had particular difficulties in understanding pronominalization per se, it would be reflected in poor recognition of pronoun contrasts regardless of whether they were of plurality, gender or possessiveness. Difficulty with only one might suggest that the confusion could be for other reasons, for example phonological confusion between 'he' and 'she'. Similarly, if difficulty was found with one kind of verb plural and not another, the difficulty could not simply be with the feature of verb plurality as such.

However, caution would be needed in interpreting the results. With a binary choice, a 50% rate can be achieved with random guessing, and with results from aural and reading versions combined there were only four examples of each exact prescribed type of sentence, although these types could be clustered into larger groups (e.g. pronouns, tense, plurality, topicalized) with more examples of each. For this part of the present investigation the main concern was to test the hypothesis that WOC sentences would be more difficult than ONC sentences or DR sentences, and having a number of various sub-types within the main sets enabled the generality of the hypothesized difficulty of surface structure sequence to be examined. Table 10 lists the types of sentences used (see Appendix C for test sheet order and instructions).

To permit examination of aural and reading input, two versions of the Syntax Picture-choice test were prepared, A and B. Subjects were given either A1 (aural) and B2 (reading), or B1 (aural) and A2 (reading). The reading versions used the same pictures as the aural, but the alternative sentence was given: it was printed in 24 point upper and lower case Century Schoolbook, on the left hand page opposite to the pair of pictures. The printing was always arranged to occupy two lines in the middle of the page. The format was the same as that described for the Phonological Test, with equal numbers of correct top or bottom choices for the three main types of sentences, WOC, ONC and DR, but the book size was A5, twice that of the Phonological Test, as the pictures included more figures.

With the aural version, the subject saw the picture before and while he heard the sentence and was given unlimited time to make his choice; the sentence was repeated without penalty in the score (unlike the preliminary experiments) if the subject indicated he wished it to be, thus minimizing inflation of error scores due to mishearing. With the reading version no assistance was given to subjects; a note was made of whether the subject read silently or aloud and in the latter case of any misreadings.

Table 10

Syntax tests (picture-choice): Types of contrasts

	Example
Word order critical (WOC)	(Reversible words and phrases underlined)
Simple active	The boy lifts the girl
Topicalized active (with subject topicalized)	It's the jug fills the pan
Topicalized active (with object topicalized)	It's the doctor the patient visits
Simple passive	The car is crushed by the rock
Topicalized passive	It's the girl the boy is splashed by
Direct/indirect object with 'to'	The man points out his friend to his wife
Direct/indirect object without 'to'	The teacher shows the class the lady
Modifying phrase	The man waves to the woman with the dog
Modifying adjectives	It's a tall man for a little wife
Comparative	The parcel is smaller than the box
Possessive	The secretary's boss smokes
From-to/To-from	She walks from the door to the bin
In front of/behind	The book is in front of the 'phone
Before/after	She sweeps before she shops
Order not critical (ONC)	(Critical words underlined)
Pronoun plurality - subject	He would like to go out for a walk
Pronoun plurality - object	The rider is watching them from the hill
Pronoun plurality - possessive	Their hair is very curly
Pronoun gender - subject	She is looking at a magazine
Pronoun gender - object	The shopkeeper is serving him
Pronoun gender - possessive	His umbrella is open
Verb plurality - inflection	The sheep follow the farmer
Verb plurality - is/are	The fish is swimming away from the net
Verb tense - present/past	The boy has hurt his foot
Verb tense - present/future	The cup will fall off the table
On/under (not reversible)	The parcel is on the bed
From/to (not reversible)	The lady is walking to the bus stop
Between/beside	The traffic warden is beside the cars
Before/after (not reversible)	He lights the fire before breakfast
Deep relations (DR)	The doctor wonders/advises what to take

The aural versions of the Syntax Test were also given to the schoolchildren. Results were obtained for 117 Surrey children from version A, and 119 children for version B. Seventy-five of these children took both versions, thus permitting a paired-test comparison of the two versions. To establish the rank order of difficulty at different age levels for the Tyneside community, 425 children from Tyneside were given version A. It was predicted that children would find the DR sentences relatively difficult. Chomsky (1969) reported that distinctions of deep subject-object relations may not be acquired by some children even by age 11 (for example, between 'Tell him what to feed the doll' and 'Ask him what to feed the doll' - in the first, he feeds the doll, in the second you do). The contrast between 'tell' and 'ask' was also incorporated into the present syntactic test.

Group presentation was used for the children, with the pictures projected from slides on to a screen. The children were provided with forms on which they were asked to encircle the word 'top' or 'bottom' in a numbered square for the picture they thought was correct for the sentence (see Appendix C). The number of the sentence was spoken before the sentence, and each sentence was repeated. Reminders were given about position of the sentence on the form. If a child could not make a choice during the pause allowed, he was instructed to cross out the whole square so that he did not lose his place. These omissions were scored as errors. With the Surrey children a teacher constantly checked that the less able children were marking the correct place on the form; with the Tyneside children five forms for the younger children had to be rejected because the child had lost track of the place.

3.5.2.2 With manipulation of objects as response

Most of the contrasts examined in the Syntax Picture-choice Tests were repeated in a test which required a more complicated response than pointing to a picture, manipulation of toy figures to enact the sentence. This test (to be referred to as the Syntax Gesture test) also included some of the features from the final section of the TT. The toy figures were chosen so that their names were phonologically distinct, and because they were lexical items which had been used in the picture tests - car, sheep, horse, woman, farmer, box. The patients were first asked to recognise the figures singly by name, both aurally and from printed cards, and were asked to name them themselves (unless they had gross difficulties with speech). The investigator demonstrated how the figures could be moved (using only one hand, as this would be necessary for hemiplegic patients) to illustrate the spoken sentence.

As with the picture tests, there was a balanced design of items which depended on critical word order and items which did not. But because for every WOC sentence all features, including non-order, had to be decoded for correct execution of the action, some sentences included WOC and ONC items (Table 11).

In the set of 28 sentences, 33 ONC features could be scored and 22 WOC features, making for easy adjustment of the scores to compare type of feature in the analysis. Up to four features were included in each sentence; these are indicated by dashes on the sentence list (see Appendix C), the features themselves being indicated by block capitals in the sentences. Some words and structures (e.g. with 'between') were

Table 11

Syntax Gesture Test - Types of contrasts

	Number of examples	Category
Features derived from the syntax picture tests		
Simple active (reversible)	2	2 WOC
Simple passive (reversible	2	2 WOC
Topicalized active (reversible	1	1 WOC
Topicalized passive (reversible)	1	1 WOC
Direct/indirect object with 'to'	1	1 WOC
Direct/indirect object without 'to'	1	1 WOC
Possessive	2	2 WOC
Comparative	2	2 WOC + 2 ONC
Pronoun - subject	3	3 ONC
Pronoun - object	3	3 ONC
Pronoun - possessive	2	2 ONC
Verb plurality - inflection	2	2 ONC
Verb plurality - is/are	2	2 ONC
Verb tense - past	1	1 ONC
Verb tense - future	1	1 ONC
From-to/To-from	1	1 WOC + 1 ONC
In front of/behind	2	2 WOC + 1 ONC
From/to	2	1 WOC + 2 ONC
On/under	2	2 ONC
Between/beside	2	2 WOC + 2 ONC
Before/after	2	2 WOC
Features derived from the Token Test		
With	1	1 WOC + 1 ONC
And	1	1 ONC
Or	1	1 ONC
Away from	1	1 ONC
If	1	1 ONC
Except	1	1 ONC
Instead	1	1 ONC
Together	1	1 ONC
Adverb (slowly, quickly)	1	1 WOC
Negative	1	1 ONC

capable of either a WOC type or an ONC type of error. Two scores were derived from this test. One was based on pass-fail scoring of each sentence, giving a maximum of 28. The other, for analysis in Part Four Section 3, was based on the number of WOC and ONC features interpreted.

As with the picture test in the aural version, the investigator spoke the sentence with normal intonation and clear articulation, and sitting in a position where aphasic subjects could watch mouth movements. No feedback was given about the correctness or otherwise of the actions, and the sentence was repeated without penalty in the scoring if requested or if no response was made to the first utterance.

3.5.2.3 With arrangement of printed sentence as a response

A further measure of syntactic ability which, like one of the Syntax Picture tests, depended on the ability to read, was derived from a sentence arrangement task. It was included for its relevance for verbal sequencing, and not primarily as a measure through which linguistic levels would be compared. Although this did not require speech, it was included for practical convenience under the 'expression in speech and writing' tasks (see Appendix C). Six short sentences were printed in 24 point Century Schoolbook capitals, and each cut up into five parts. The sentences were ones which had been used in the picture tests and each was accompanied by the appropriate picture to give meaning to the reconstruction of the sentence. The cuts for the most part separated the sentence into single words or noun phrases with determiner, but in two sentences constituent boundaries were not breached ('man has', 'hit by'). Three sentences were WOC, i.e. allowed for arrangement into a sentence which would have been semantically and syntactically acceptable but which was not apt for the picture (a reversible active, passive and comparative sentence). The other three sentences were selected from the ONC list. For comparison of ability to sequence the five syntactically related words or pairs of words with five serially related words, patients were also asked to arrange in order five printed cards on which were written five months (also in 24 point Century Schoolbook capitals). As it was expected that this task would be relatively easy, even for severely handicapped patients, its difficulty was increased by selecting months which were not adjacent in sequence.

These two tasks were only given to the LBD aphasic subjects.

3.5.3 Semantic tests

In a sense every verbal task in the investigation programme necessarily depended on recognition of meaning, and therefore involved the semantic level of language (one possible exception is some parts of the reading Word Recognition test to be described in Section 3.5.4, for which decisions could have been based on a visual gestalt without meaning necessarily having to be involved). Selecting a picture to match a word or a sentence requires that meaning must be associated with form. The criterion for distinguishing the tests by the three linguistic levels was that, at the phonological level the unit of contrast was the phoneme within a word, at the syntactic level the unit of contrast was an inflection, a grammatical word or sentence structure, and at the semantic level a substantive word.

Two approaches were used to examine knowledge of lexical meaning: a picture choice test using binary choice to match the phonological and syntactic tests, and (to by-pass possible difficulties with pictorial material particularly in the RBD) a sorting test with printed words.

3.5.3.1 With picture choice

The picture-choice test used the presence or absence of the indefinite article, 'a', in order to make contrasts of lexical meaning which were of different levels of subtlety. At the most subtle level the article distinguished between the count and mass meanings of a lexical item, for example between the count meaning of 'lamb' as an animal like bullock and pig and its mass meaning as a meat like beef and pork. Even in these subtle cases there is sufficient change of meaning to make a major change in the pictorial referent with which such a contrast is illustrated. Lamb as a meat is visually and conceptually distinct from lamb as an animal (a distinctiveness which is great enough to make animal-lover not synonymous with vegetarian). Although the key to the contrast is a grammatical word, and thus at first glance such a contrast may seem to fall under our definition for the syntactic level of organization, the contrast itself lies in the two meanings of the substantive word; other grammatical words, as used in the syntactic tests, do not change the meaning of the substantive words which follow them (e.g. with 'in/under the table', 'table' has a constant meaning). Plural inflections duplicate (or multiply) the referents but do not change their inherent meaning. The use of the indefinite article in this test is also different from the use of the definite article in the test by Goodenough et al (in preparation) described in Part One Section 5.2.1; the definite article does not change the referent's meaning (but identifies the referent deictically), while the indefinite article in the present test does produce a change of meaning.

A slightly easier discrimination to make than one which rests entirely upon the distinction between count and mass, is one in which word meanings, though etymologically derived from the same root, have diverged and become polysemic (e.g. 'change' as money, and 'a change' of clothes). Easier still should be words which have been derived from different roots (e.g. 'cricket' the game and 'a cricket' the insect - fortuitous homonyms according to Kooij's (1971) definition). Discrimination might be expected to be still easier when in addition to the divergence of meaning there is a divergence of syntactic class and root derivation (e.g. 'mine' as a possessive pronoun, and 'a mine' for coal). Discrimination could plausibly be facilitated even more when the two words, although still homophonic, are not homographs ('made' and 'a maid').

To 32 items exemplifying these different hypothetical levels of difficulty were added a 'control' set of 8 items in which the same phonemic realization /ə/, 'a', was an inherent constituent of word meaning (e.g. in contrasting pairs of words such as 'loud' and 'allowed' and 'greed' and 'agreed'). In these last items the discrimination depended only on the presence or absence of an initial syllabic vowel in the word and was therefore by our definition phonological. As the test was presented only in an aural version, a large number of failures on these control items would have suggested that the subject was not succeeding in listening for the critical presence or absence of 'a'. A means of including items in which an initial syllabic /ə/, 'a', could make a semantic contrast integral to the word instead of a fortuitous phonological contrast would have been to use the prefix 'a-' which negates the sense of the stem word (as in a-phasic). Unfortunately, such words are of too low a frequency and too difficult to illustrate to be suitable for a test such as this. Table 12 lists the different hypothetical levels of difficulty of the 40 items.

Table 12

Indefinite Article test - Types of contrasts

Category	Items
A count/mass distinction only	45 lamb, A cloth, 41 straw, 11 tomato, AA paper, AA fish, AA glass, AA wood
B meaning diverged from common root	AA change, 16 plaster, AA board, AA game
C common root, but different syntactic usage	AA sweet, 13 fawn, 27 lemon, AA home
D different root	A corn, 46 copper, AA race, 14 cricket
E different root, and different spelling	AA peace/AA piece, A flour/AA flower, AA night/AA knight, A hair/18 hare
F different root, different syntactic usage, same spelling	AA back, AA mine, AA last, 7 grating
G different root, different syntactic usage, different spelling	AA made/A maid, A thrown/43 throne, A bare/AA bear, AA none/9 nun
H incorporated in word, same spelling	AA cross/AA across, 3 greed/AA agreed, AA mount/AA amount, 9 tacking/A attacking
I incorporated in word, different spelling	39 peers/AA appears, AA sending/29 ascending, 7 frayed/AA afraid, A loud/AA allowed

(The figures and letters above the items indicate frequency on the Thorndike Lorge count.)

For the 24 homographic pairs the word frequency, as measured in counts of printed words, is the same for each member of the pair. Because of the nature of the material, the pairs in which spelling differed were not equated for frequency.

For 20 of the 40 items a sentence formula was used which began with 'it's'; for the others the formula began with a referential pronoun. The 'a' was present in half the sentences and was omitted in the other half. (See Appendix C for the list of sentences.) The test was preceded by a practice session using six items with feedback and discussion, to key the subject in for listening for the significant 'a'; for the first two of these items both pictures in the contrast were named and described, and the subject was then asked to make his choice when the sentence for one of the pictures was repeated (see instructions, Appendix C).

When the indefinite article test was to be used as a 'pure' semantic measure, for purposes of comparison of the linguistic levels, it was rescored with some items omitted. These were the eight 'control' items (Types H and I) for which the contrast was phonological, and the eight Type F and G items, in both of which types the distinction of different roots in the words was reinforced by a distinction in syntactic usage.

To obtain age-related levels of difficulty on the test, it was also given to the schoolchildren from Surrey and Tyneside. With adults and with children the same methods of presentation were followed as with the syntactic test. As the pairs of pictures were usually more divergent from each other with this test than they were in the syntactic test, colour was used with many items to draw attention to the critical feature in each picture; care was taken to use the same colour for each member of the picture pair. Unlimited time, repetitions and self-corrections were allowed, with no penalty in the score.

3.5.3.2 With sorting of printed words as response

The second measure of ability to make semantic discriminations was an adaptation of the test used by Lhermitte et al (1971), also reported in Derouesné and Lecours (1972); it has been outlined in Part One Section 5.3.2.2. It is based on the theory that for a given word other words may be either central, peripheral or completely unrelated to its semantic field. The task is to sort twelve words into these three classes for a head word (using a forced choice of four words to each category).

For the present investigation a total of 21 head words each with their twelve subsidiary words was tested on the panel; ten of the head words were free translations of the French words, while others were included because they have been used in experiments in semantic memory or have a theoretical rationale. For the subsidiary words it was intended to apply a systematic set of relationships; the relationships proposed were those of superordination, subordination, co-ordination, human use, associated activity, identification through the senses, and unique semantic association (such as 'acorn' for 'oak'). However, in the amendments which had to be made following thecomments of the panel, this theoretical structure had to be abandoned and a more empirical framework substituted. The guiding reference for this was Kiss's associative network (Kiss 1973), which is empirically based on the 8,400 different word associations of over 9,000 British students. Dr. Kiss was kind enough to supply computer printouts of both the forward and inverse associations for the head words, together with the frequency with which such associated words were given. When a word had to be substituted for one which the panel did not find acceptable as being central to the semantic field of a given head word, it was chosen from those which appeared in both the forward and inverse associations of the head word. Words in the periphery of the field were those appearing with lower frequency in one association list. Words outside the semantic field did not appear at all in the list. By trial and error a set of seven words with their subsidiary words was derived on which there was general (but not universal) agreement from the panel on their placement. Four of them were based on the French items (fire, teach, cloth, oak) in free translation; three were based on semantic theories. For 'canary' Collins and Quillian's (1969) experiments, for example, suggest that 'bird', 'yellow' and 'sings' should be closely associated in nodal distance, with 'skin' and 'legs' more distant. For 'father' the construct of shared features in kinship terms suggests that 'mother' and 'son' should be closer than 'niece' and 'cousin'. For 'cook' Lehrer (1969) has proposed four main categories of 'boil', 'fry', 'grill', 'bake'. The list of words with instructions is given in Appendix C.

To make the test instructions as little dependent as could be on verbal comprehension, a board was used which was divided into three sections, with cross lines indicating where words should be placed. The section on the left was white and was headed by a tick; that in the middle was grey and was headed by a question mark; that on the right was black and was headed by a cross. The test words were printed on cards in 24 point upper case Century Schoolbook and the head word was distinguished by two bars. It was put at the top of the board, above the tick, with the twelve words set out in the order given on the test sheet below the board, arranged in three lines of four words long. The words were read out by the investigator as they were set out, and re-read again if the patient indicated he wished it. The head word was repeated also. Unlimited time was allowed and there were set prompts to encourage the patients. When all the words had been put on the board, the subject was asked if he was happy with that, and was allowed to make any changes he wished. A strategy which had been noted during the preparation of the test with the panel was the sorting out first of the irrelevant words, and during the experimental sessions a note was made of whether or not the subject adopted this or any other strategy.

Lhermitte et al included in their examination of semantic fields a test of recognition of the multiple meanings of homonyms. They used the results from this test to distinguish between 'widening' and 'narrowing' of a semantic field, thus implicitly accepting that semantic fields include a phonological component of word shape. This assumption is, perhaps, somewhat questionable; it implies, to take an example from their test, that the homonym 'article' and 'loi' (law), 'magasin' (shop), 'grammaire' (grammar) and 'journal' (newspaper) share a common sense, not simply access to the same phonological shape of 'article'. Legal, portable, indefinite and factual articles have diverged widely from their common etymological root. When distinguishing linguistic levels it is useful to make a conceptual distinction between lexical field and semantic field; the semantic field concerns abstract relationships of meaning, whereas the lexical field concerns relationships amongst words which, because by definition they have form, must include phonological and/or graphemic components (and probably syntactic components as well). By describing the different meanings of their homonyms as being at 'the centre of the field', Lhermitte and his colleagues give a prominence to the phonological shape of the head word in their fields which indicates that they were thinking in terms of lexical fields, with their phonological 'impurities' rather than entirely of abstract relationships of meaning. The suggestion that there is an abstract level of semantic meaning which is divorced from phonological shape, in that one meaning of a homonym does not necessarily link with another meaning of it, is not just a linguistic convenience to maintain the theory of different levels of organization. There is some empirical evidence in support of it. Goodglass and Baker (in press) found that clang associations were not responded to as having anything to do with the meaning of a word; they concluded that a semantic field exists without a name being realisable in phonological form. When clang alliterative associations are given in word association tests, there is typically a semantic or syntagmatic link as well as the phonological one (Deese 1962, Carter 1969). Luria and Vinogradova (1959), examining the generalising of conditioned responses in semantic fields, reported that "words not having a sense link with the critical word and bearing only a superficial phonetic resemblance to this word (Russian examples given) did not provoke a vascular reaction", thereby indicating clearly that, in a normal subject, they are not included in the actual system of sense links. There is therefore some justification for treating this homonym test as distinct from the semantic field test, and for not expecting it to show the same type of semantic disruption.

The Indefinite Article test also used polysemes and homonyms, in order to assess semantic discriminations, but in a different way. In the one case two meanings are activated by the pictures and the subject has to make a choice between them: in the other one graphemic form is presented which, presumably, activates a dominant meaning. The subject then has to cancel out this meaning, and seek alternative meanings. Where the new meanings are semantically linked with the first polysemic one aroused there may be a generalization of the activation which facilitates the recognition of this meaning. On the other hand, where the new meaning is not close (as, for example, when the subject, having thought of 'box' in connection with sport, has to move to thinking of 'box' as a shrub - or as with fortuitous homonyms) a fresh link with the graphemic form has to be made for which the already activated meaning of the homonym may be a block. To some extent, therefore, the French homonym test measures an ability to change set, to cancel out one train of associations and substitute another for it, establishing a fresh link with the surface graphemic form. From many observations of aphasia (e.g. Goldstein 1936, page 361, Diamond, Epstein and Bender 1969) we might expect this ability to be impaired.

A version of the homonym test was therefore included in the present investigation, not as part of the examination of semantic fields, but to measure the subjects' capacities to cancel out one graphemic-semantic link and to create another.

From prior testing, six homonyms of AA or A frequency were selected, whose range of meanings varied from four to seven, the criterion for a distinct meaning being whether or not it appeared under a separate entry or sub-section in the Oxford English Dictionary (Murray, Bradley, Craigie and Onions 1933). To identify each of these meanings a key word was selected from the dictionary definitions, and each homonym was presented with seven words from which to select possible meanings, (so that in one case all the words were acceptable).

There were two weaknesses in this test. One was that there was a bias towards correct responses (30:12) which meant that the undiscriminating achieved a spurious level of success. The other was that it was dependent on verbalized instructions. Although a board was used, divided into two columns headed by a tick and a cross, the criterion for division of the words in two categories could not be inferred as easily from the nature of the words as in the semantic field test. The test sheet with its instructions is given in Appendix C.

3.5.4 Reading

Although the Semantic Field and Homonym tests were both presented with the words read out for the subject, as well as being available for silent reading, the tests did presuppose some capacity for recognition of meaning from single printed substantive words. (The Semantic Field test was not, in fact, given to the RBD subject who had never learned to read or write: she was also not asked to take the reading version of the Syntax Picture test nor the Word Recognition test described in the present section.) It therefore seemed necessary to check the degree to which this minimal reading skill was retained. In order to be informative about even the most severely impaired aphasic subjects, the test had to be easy to perform. Based on an idea from Hécaen, Goldblum and Kremin (personal communication), a test was devised in which the subject was only required to indicate whether or not a printed word was a 'real' word or not. Words, however, can be recognized as acceptable words on the basis of their visual gestalt without their meaning being recognized (Gibson and Guinet 1971). The test was therefore designed to make it likely that semantic and syntactic information would be processed as well.

Six root morphemes were printed singly on cards in 24 point Century Schoolbook lower case. Accompanying each were 12 suffixes and the patient was shown each combination of root plus suffix and asked to indicate whether it was a real word or not. Of the 60 suffixes 30 were correct and 30 incorrect, the number of correct suffixes for each root varying from three to six.

The incorrect suffixes were of three types. Ten were not English (e.g. -erez, -vol), and it was expected that if the patient had any reading ability at all these words would be identified as not acceptable. Ten were acceptable English suffixes or syntactic inflections for the (probable) syntactic class of the root morpheme, but did not happen to be appropriate for this particular example; while the remaining ten were not acceptable English suffixes or inflections for that class (Quirk, Greenbaum, Leech and Svartvik 1972 page 993). For example, 'beauti-' is a noun stem: nouns may be converted to adjectives by a number of suffixes (e.g. -less, -ful, -ic), or modified as nouns by other suffixes (-let, -ess, -ery). They may not be combined with suffixes which are 'de-verbal' or 'de-adjectival' (e.g. -ation, -able, -ive, -ous) unless the noun is also a possible verb or adjective. A number of suffixes in isolation are, of course, ambiguous e.g. '-er' could be a de-nominal or de-verbal suffix or be a comparative inflection for an adjective. The three stems employed in the test which were free rather than bound morphemes were also syntactically ambivalent:

two could be verb or noun ('cart', 'act') while one was most likely to be interpreted as an adjective ('slow'). Of the bound morphemes two were likely to be thought of as verb stems ('admir-' and 'div-') and one as a noun stem ('beauti-'). If patients were sensitive to syntactic information, it was predicted that they would make more errors on the items which were acceptable to the presumed syntactic class of the stem, than they would on the suffixes which would not form a syntactically acceptable combination. For instance, 'beautiless' should be incorrectly accepted more often than 'beautiable'.

Another measure was built into the test materials. Besides a change of syntactic class, half of the stem morphemes were open to a change of semantic meaning. These were the alternative items 'div-', 'cart-' and 'act-', and in each case three transformations of meaning were possible. 'Div-' could be combined as 'diver' etc., 'divine' and 'divide', each from distinct semantic categories. 'Cart-' could lead to 'carter' etc., 'carton' and 'cartoon'. 'Act-' could lead to 'active', 'actual' and 'actors'. In the first two cases the change of meaning would be reflected in changes in stress and in the phonemic realization of the vowel, and a strategy of reading aloud would not help the subject. This measure of ability to recognize different semantic potentials in stem morphemes provided a control test for the test of homonym recognition described in 3.5.3.2. The list of words, with instructions is given in Appendix C.

3.5.5 <u>Expression</u>

3.5.5.1 <u>Speech</u>

A graded series of tasks was used in order to elicit samples of speech from the aphasic patients so that some information could be obtained from even the most handicapped patients:

1) automatic serial speech (the months of the year). This was elicited immediately after the patient had been asked to arrange five months on printed cards in the correct order, but the cards were removed before the patient began to speak.

2) Naming

(a) of drawings of a boy and a girl

(b) of the six toy figures used in the syntax gesture test

(c) of the ten household objects used in the memory for sequences task

(d) of the ten photographed objects used in the visual screening and interpretation test.

3) Descriptive sentences:

(a) six sentences each describing a picture taken from the syntax picture tests

(b) seven sentences describing actions taken from the syntax gesture test.

4) Connected sentences: a description of the episode illustrated in a set of five pictures which had to be arranged into a meaningful sequence.

5) Repetition of sentences was also included in the tasks, as ability to repeat is a diagnostic criterion in some classifications of aphasia (Green 1969, Goodglass and Kaplan

1972), although some aphasiologists have doubted its value (e.g. Brown 1975). Ten sentences taken from the syntax gesture test were spoken for immediate repetition by the patient.

The purpose of the first four graded tasks was to ascertain the severity of the disorder in expression in speech and to provide material for the analysis of the speech deficits by linguistic levels. The rating scales and methods used for this are described in Part Four Section 1.2. The RBD and NBD were only asked to perform tasks 2(d), 3 and 4, as the other tasks were too simple. An estimate was thus obtained from these control subjects of the complexity of the sentences and story which the LBD might have been expected to produce before the stroke. The speech was recorded on magnetic tape on the portable Uher recorder described earlier. Transcriptions of the stories are in Appendix D.

3.5.5.2 Writing

A sample of writing was also elicited from each subject, including the RBD and NBD. It was obtained in order to check on whether or not the LBD were able to reveal in writing an ability superior to that in speech at any linguistic level. Again the samples from the euphasic subjects served to establish a realistic norm of what could have been expected. The writing tasks were also graded:

1) Automatic writing - own name.
2) Date.
3) Two short names (boy, girl) immediately after having seen them in print.

4) Six sentences describing pictures: these sentences had immediately before been arranged in print and read out.

5) Three sentences describing actions, without any prior model.

Besides the grading of difficulty of the tasks, the amount of help which was offered was also graded. In condition 5 no help was offered, and this task could not be attempted by some of the LBD. In conditions 3 and 4 stages of help were offered as needed. The task was first attempted with the printed words removed. If the patient failed to start or to continue writing, the investigator spoke the next word. If he still failed, the word on the card was presented again for him to copy. If it was thus established that the patient was unable to write intelligibly without a model to copy, he was not asked to do any more writing, thus minimizing stress and delays. The writing samples obtained are in Appendix E.

4. Experimental design

The nineteen procedures in the programme of investigation were divided into three blocks: those concerned with assessing any aspect of semantic comprehension; those concerned with any aspect involving sequencing, including syntax and phonology; and the screening and control measures. The tasks included under each heading are listed in Table 13 below.

Table 13

Experimental design: blocks

Semantic block	Semantic Field
	Indefinite Article
	Word Recognition in reading
	Homonyms
	EPVT
Sequence block	Syntax Picture-choice (aural or read)
	Syntax Gesture
	Syntax Picture-choice (read or aural)
	Phonological
	Memory for sequences
	Expression in speech and writing (sentences)
	'Self' sequencing, i.e. picture sequence, months, story, praxis
Control block	Token Test
	Audiometry
	Photographs
	Raven's Matrices (20 minutes)

Plus questionnaire and clinical assessment.

Half of the subjects in each group were given the 'semantic' block first and half the 'sequence' block first. The control tests were fitted in in a standard order with the NBD and the RBD, who were seen at home in two or three sessions, but not with the LBD who were seen in many sessions at the hospitals or at home, and for some of whom the Syntax Picture tests (reading and aural), the Semantic Field test and the Word Recognition reading test had/each to be given in two sessions.

Having some 'free-floating' control tests allowed for some flexibility with the LBD if an ambulance was delayed. With the RBD and the NBD the TT was given first, as a reassurance that the tasks would be simple, followed by either the 'semantic' or the 'sequence' block in the order listed. The semantic block was followed by the photo test, which provided a diversion for the subjects. In the sequence block the tape recorder set up for the phonological test was rewound during the memory tasks, so that it was ready for recording of the expression tasks, including the story. Raven's Matrices was given at the end, so that while the subject was filling in the form the investigator could rewind the tape recorder, and make any necessary notes. Audiometry was fitted in during the first or second visit, depending on the availability of the machine. The questionnaire, and handedness, were discussed at the end of the first session, and the questionnaire left at home for completion and collection on the second visit.

Within the 'sequence' block, half of the subjects in each group received an aural version of the syntax picture-choice test first, and half were given a reading version first. Furthermore, half of each of these subjects received version A first and half version B first (in the aural or reading forms as appropriate). There were therefore three conditions to be used as factors in the analysis of the effect of the experimental design: the block given first, the input modality given first, and the particular combination of A and B versions.

Table 14 shows how the subjects in the three groups were allocated to the three different conditions. There were equal numbers of men and women in each condition, except for the two extra NBD men. Subjects were allotted to the slots as they became available, though some adjustments had to be made when subjects failed screening tests, or when an LBD subject became unexpectedly first available in the clinic at a time when only one set of materials was to hand.

Table 14

Experimental design - Allocation of subjects

NBD

	Sequencing block first		Semantic block first	
Aural first	NM6 NM12 NM2 (NM1)	NF3 NF12 NF6	NM8 (NM4) NM5 NM11	NF4 NF11 NF9
Reading first	NM13 NM3 NM14	NF2 NF7 NF5	NF7 NM9 NM10	NF1 NF8 NF10

RBD

	Sequencing block first		Semantic block first	
Aural first	RM5 RM10 RM7	RF11 RF7 RF10	RM12 RM2 RM8	RF6 RF12 RF9
Reading first	RM4 RM1 RM3	RF4 RF8 RF3	RM6 RM11 RM9	RF2 RF1 RF5

LBD

	Sequencing block first		Semantic block first	
Aural first	LM4 LM7 LM17 LM10 LM15	LF6 LF8 LF1 LF4 LF17	LM5 LM16 LM11 LM12 LM18	LF2 LF10 LF19 LF7 LF9
Reading first	LM2 LM20 LM13 LM14 LM19	LF5 LF11 LF14 LF3 LF16	LM1 LM3 LM6 LM8 LM9	LF13 LF15 LF12 LF18 LF20

Subjects receiving version B in the aural syntax picture test are underlined.

(The two NBD who were excluded from the analysis of variance are bracketed.)

5. Method of analysis

The analyses to be used were of three kinds:

1) For inferential statistics, with two exceptions, non-parametric tests were to be used for the data from adults as these do not require the data to be normally distributed nor the variances between groups or between tests to be the same (although requiring the distributions to be of identical shape). The exceptions were the discriminant analyses used in Part Four Section 1, and the analysis of covariance used in Part Four Section 2. These were used in order to test and extend the less powerful non-parametric procedures also employed. The probability level to be accepted as significant was set at .01 where the number of tests to be used was such that a .05 probability level would make a Type One error likely (i.e. rejection of the null hypothesis when this was inappropriate). Where directional predictions were made one-tailed tests were used; where they were not, as indicated in the text two-tailed tests were used.

2) Descriptive statistics would be used to provide two indices:

(a) an index of the relative difficulty of each task, derived from the number of subjects scoring at levels which could have been achieved by guessing (for those tests where it was practicable to calculate such a level).

(b) an index of the relative power of each task to detect pathological impairment derived from cut-off levels for control subjects.

3) Quantitative analyses would be supplemented by qualitative descriptions.

The data were scored throughout in number of errors rather than number of correct points.

6. Hypotheses

This part of the report of the main experiment is concerned with the first and second aims stated in Section 1: the hypotheses concerned with the three special aspects referred to under the third aim in Section 1 will be formulated in Part Four.

Concerning the first aim, three hypotheses were put forward:

1) That the LBD group would make significantly more errors on the verbal tests than would the RBD and the NBD euphasic groups and that these two latter groups would perform on the standard tests at a level characteristic of their type according to previous studies, thus endorsing their use as representative control groups.

2) That scores on the experimental tests of verbal comprehension would correlate significantly with the standard and clinical verbal tests which had been used as comparison measures (EPVT, TT and Verbal Memory), and would not correlate significantly with the non-verbal measures of age,

months since the stroke, hearing level, visual-interpretive difficulties and intelligence.

3) The two hypotheses listed above were concerned with the extent to which the experimental tests were examining verbal rather than non-verbal effects. The third hypothesis was concerned with qualitative distinctions amongst the verbal tests. It was that the experimental tests were assessing a knowledge of language which both is distinguishable by the three linguistic levels proposed and shows the same qualities of disturbance whether accessed by aural or reading tests and by simple or elaborative gestural responses. If this were so, it was predicted that:

(a) there would be higher intercorrelations amongst test scores within a linguistic level than across linguistic levels;

(b) there would be high correlations between the A and B versions of the syntax tests, as these were designed to examine the same syntactic features though using different lexical items. This would be examined using both the LBD group's and the children's data;

(c) there would be high correlations between the rank orders of difficulty of items in the two picture-choice syntax tests given in the two modalities of listening and reading;

(d) subjects with gesture dyspraxia would not perform significantly worse than eupraxic subjects on the tests which required elaborative gesture response (the Syntax Gesture test and the final section of the TT). Moreover, the dyspraxic subjects would not perform worse on these tests than they did on the equivalent tests which only required a simple pointing response (the aural Syntax-Picture-choice test and the penultimate section of the TT);

(e) there would be high correlations between the rank order of difficulty of distinctive features in the two versions of the Phonological test, which used different responses;

(f) the rank order of difficulty of phonological distinctive features and of classes of syntactic contrasts and the types of errors in the Semantic Field test would correspond with those in previous studies.

Concerning the second aim in Section 1, it was hypothesised that there would be significant agreement between the test scores and both the clinical ratings of comprehension and relatives' opinions.

7. Results

7.1 Experimental design

There were three variables which had been controlled for in the experimental design: 'block' (semantic or sequence block presented first), 'modality' (aural or reading version of the Syntax Picture-choice tests given first), and 'version' (A or B form of the Syntax tests). The effect of this design on the test scores was examined in the following way.

For the nine experimental 'linguistic level' tests (including Word Recognition), the scores of the subjects, in each group separately, were combined according to which block they had received first. For the syntactic tests the scores were in addition, separately, grouped according to the modality received first and, separately, according to the version received. Table 15 gives the means and standard deviations for the scores so grouped for each type of subject.

Mann-Whitney U tests of the differences between the two conditions for each of the variables in the experimental design indicated that none of the differences were significant at the p .01 level in any of the groups of subjects. However, three of the comparisons in the LBD for the variable of block reached a $p < .05$ significance level (Word Recognition, Homonym test and reading version of the Phonological test), and two of the comparisons in the RBD reached a $p < .02$ level (Word Recognition and Homonym test). These few differences reflect a consistent tendency in all the groups for those who were given the semantic block first to make more errors. This may reflect the greater challenge the semantic block had for most subjects, or a chance allocation of less able subjects to the condition with the semantic block first (which showed larger standard deviations). However, as the trend was the same in all groups, it does not invalidate inter-group comparisons.

Nevertheless, because the effect of such an experimental design may be critical in a brain-damaged population which is subject to improvement over time, or to other changes between sessions, a second check was made, using a non-parametric equivalent of analysis of variance through which

Table 15

Experimental design
Grouped means and standard deviations

	NBD (each condition n = 13)	RBD (each condition n = 12, except for reading tests where for semantic block first n = 11)	LBD (each condition n = 20)
BLOCK			
Syntax pictures aural			
Seq. block 1st	2.846 (1.994)	5.083 (3.523)	15.100 (7.279)
Sem. block 1st	2.846 (2.445)	6.083 (4.536)	17.500 (9.399)
Syntax pictures reading			
Seq. block 1st	5.000 (2.856)	6.583 (3.174)	20.050 (8.176)
Sem. block 1st	5.385 (3.371)	8.182 (4.821)	23.250 (8.166)
Syntax gesture			
Seq. block 1st	2.846 (1.657)	4.333 (2.134)	14.100 (7.293)
Sem. block 1st	3.769 (1.761)	5.000 (2.236)	17.700 (7.135)
Phon. pictures			
Seq. block 1st	0.923 (1.206)	1.750 (1.479)	5.100 (3.961)
Sem. block 1st	2.077 (1.940)	3.333 (2.134)	6.500 (4.642)
Phon. printed			
Seq. block 1st	0.846 (0.863)	1.417 (1.605)	4.850 (5.003)
Sem. block 1st	1.615 (1.546)	1.364 (1.068)	7.400 (4.737)
Semantic Fields			
Seq. block 1st	5.231 (2.778)	9.917 (5.484)	23.550 (10.716)
Sem. block 1st	6.462 (3.875)	14.636 (7.866)	23.950 (12.217)
Indefinite Art.			
Seq. block 1st	1.154 (1.167)	5.000 (4.243)	11.400 (5.731)
Sem. block 1st	2.385 (2.588)	8.083 (5.678)	14.550 (5.643)
Homonyms			
Seq. block 1st	2.692 (2.398)	2.917 (1.552)	10.550 (4.577)
Sem. block 1st	4.000 (3.211)	8.167 (4.432)	13.200 (4.082)
Word Recognition			
Seq. block 1st	2.000 (1.414)	2.500 (2.843)	11.850 (5.507)
Sem. block 1st	2.154 (1.561)	7.000 (4.786)	15.850 (7.170)
MODALITY			
Syntax pictures aural			
Aural 1st	3.000 (1.964)	6.083 (3.926)	17.000 (9.105)
Reading 1st	2.667 (2.494)	5.083 (4.192)	15.600 (7.768)
Syntax pictures reading			
Aural 1st	5.071 (2.738)	7.000 (3.133)	19.900 (9.290)
Reading 1st	5.333 (3.399)	7.667 (4.836)	23.400 (6.800)
VERSION			
Syntax pictures aural			
Version A	2.692 (2.398)	5.583 (3.926)	16.200 (7.264)
Version B	3.000 (2.038)	5.583 (4.252)	16.400 (9.562)
Syntax pictures reading			
Version A	5.000 (2.935)	7.455 (4.008)	20.600 (8.387)
Version B	5.384 (3.175)	7.250 (4.225)	22.700 (8.131)

Table 16

Experimental design

Mann Whitney U statistics, comparisons between subgroups classed by experimental conditions

	NBD	RBD	LBD
BLOCK			
Syntax pictures aural	83.5	64	174 (z = 0.703)
Syntax pictures reading	77	54.5	152 (z = 1.298)
Syntax gesture	57	60.5	149.5 (z = 1.366)
Phon. pictures	53	40.5	167.5 (z = 0.879)
Phon. printed	58.5	62	123.5 (z = 2.069) +
Semantic Fields	72.5	44	198.5 (z = 0.041)
Indefinite Art.	64.5	49.5	144.5 (z = 1.501)
Homonyms	64	21*	126 (z = 2.002) +
Word Recognition	81.5	26.5*	118 (z = 2.218) +
MODALITY			
Syntax pictures aural	68	63.5	188.5 (z = 0.311)
Syntax pictures reading	83.5	64	158.5 (z = 1.123)
VERSION			
Syntax pictures aural	72.5	71.5	188.5 (z = 0.311)
Syntax pictures reading	80.5	62	171.5 (z = 0.771)

* $p < .02$ + $p < .05$

Table 17

Experimental design

Kruskall-Wallis tests for interactions

	NBD	RBD	LBD
SYNTAX PICTURES AURAL			
Block/Modality	0.105	0.026	0.757
Modality/Block	0.026	0.419	0.092
Block/Version	0.000	0.316	0.896
Version/Block	0.000	0.007	0.281
Modality/Version	0.339	0.936	0.143
Version/Modality	0.007	0.006	0.323
SYNTAX PICTURES READING			
Block/Modality	0.233	0.521	2.199
Modality/Block	0.162	0.412	1.291
Block/Version	0.667	0.316	0.516
Version/Block	0.655	0.523	1.044
Modality/Version	0.167	0.317	1.563
Version/Modality	0.103	0.000	0.466

$p > .05$ throughout

it is possible to test for interactions (Bradley 1968 page 138). The appropriate test for this purpose when subject groups are independent is the Kruskall-Wallis. This was only done for the Syntax tests, in which the three conditions of block, modality and version were crossed. As this analysis requires equal numbers in each cell, two of the NBD subjects were omitted (the youngest subject in each overfilled cell - see Section 4). The subjects' scores were tabled in three 2 x 2 tables representing block x modality, block x version and modality x version. This was done separately for the Syntax aural and the Syntax reading tests. This was repeated for each of the experimental groups NBD, RBD and LBD. Table 17 gives the Kruskall Wallis values for these 36 calculations: none was significant ($p > .05$).

In respect of the Syntax Picture tests, therefore, there was no effect on the scores which could have been attributed to the experimental design itself.

7.2 First hypothesis: impairment of the left brain damaged

Table 18 gives the means and standard deviations for the error scores of the three groups on each quantitative measure except the non-verbal sequencing tests which will be discussed in Part Four Section 3.

Table 19 gives the Mann-Whitney U statistics for comparisons on each test between the LBD and the pooled results of the two euphasic groups. As the number of subjects exceeded tabled values for the U statistic, tests of significance are based on $\underline{z}$ values. For the purpose of this analysis results from the A and B versions of the syntax tests were combined.

Table 18

Mean error scores (and standard deviations)

	NBD n = 26	RBD n = 24 (n = 23, reading)	LBD n = 40
Age	54.654 (9.919)	55.542 (9.432)	54.100 (10.220)
Hearing	21.120 (8.646) (n = 15)	22.695 (7.284) (n = 21)	16.875 (8.101)
Months since stroke	----	37.625 (31.377)	21.550 (19.241)
Raven's Matrices	24.192 (11.468)	33.125 (12.312)	34.325 (10.941)
EPVT	10.346 (8.881)	14.917 (11.029)	23.975 (13.725)
Token Test	2.769 (3.445)	3.917 (4.624)	51.200 (32.550)
Photos	0.808 (1.266)	2.042 (1.654)	1.175 (1.279)
Syntax Pictures aural	2.846 (2.275)	5.583 (4.180)	16.300 (8.600)
Syntax Pictures reading	5.192 (3.124)	7.348 (4.124)	21.650 (8.432)
Syntax Gesture	3.308 (1.806)	4.667 (2.259)	15.900 (7.530)
Phonological pictures	1.500 (1.749)	2.542 (2.043)	5.800 (4.427)
Phonological printed words	1.231 (1.336)	1.391 (1.375)	6.125 (5.100)
Semantic Fields	5.846 (3.495)	12.130 (7.030)	23.750 (11.622)
Indefinite article	1.769 (2.141)	6.542 (5.357)	12.975 (5.976)
Homonyms	3.346 (2.966)	5.542 (4.324)	11.875 (4.592)
Word Recognition	2.077 (1.521)	4.652 (4.497)	13.850 (6.784)
Verbal Memory	2.865 (0.831)	3.104 (1.032)	5.212 (1.091)

Table 19

Mann Whitney U statistics

Aphasic compared with euphasic (LBD/NBD + RBD)

Age;	953.5 (0.378) n.s.
Hearing:	451 (2.798)*
Raven's Matrices:	724 (2.241)
EPVT:	514.5 (3.942)**
Token Test:	61 (7.625)**
Photos:	945.5 (0.370)
Syntax pictures aural:	151 (6.894)**
Syntax pictures reading:	97.5 (7.279)**
Syntax gesture:	70 (7.552)**
Phonological pictures:	404.5 (4.835)**
Phonological printed words:	310.5 (5.522)**
Semantic Fields:	210.5 (6.347)**
Indefinite article:	246 (6.123)**
Homonyms:	191.5 (6.565)**
Word Recognition:	186 (6.549)**
Verbal Memory:	92 (7.373)**
Months since stroke (LBD/RBD)	316 (2.274)

* $p < .01$ ** $p < .001$ (z values in brackets)

The aphasic group did not differ significantly (at $p = .01$) from the euphasic on age, photo scores or Raven's Matrices scores, nor from the RBD on months since the stroke. The hearing of the LBD was significantly better than that of the subsample of euphasic subjects who had been given a hearing test. The LBD were impaired, at a significance level exceeding $p = .001$ on all the measures of verbal comprehension, and the hypothesis that the LBD would be impaired was therefore unequivocally supported.

The examination of the results of the euphasic subjects on the standard tests (to check on the extent to which they were representative control subjects) gave the following results:

1) On Raven's Matrices the mean NBD score of 35.8 correct (i.e. 24.2 errors) was slightly above the 50%ile score of 33.1 predicted from Heron and Chown's table (see Section 3.2.1) for age 55. The RBD results were below the 25%ile, and were not significantly different from those of the LBD ($U = 454$, $z = 0.361$) but were significantly different from those of the NBD ($U = 180$, $z = 2.554$, $p < .01$) with a one-tailed test. In the NBD and the LBD, but not in the RBD, there was the predicted correlation with age.

2) On EPVT the NBD mean score was 37.7 correct, at the 48%ile according to the norms in Brimer and Dunn (1968). The RBD mean score was 33.1 correct, at the 30%ile, but their impairment below the NBD was not significant with a two-tailed test ($U = 216$, $z = 1.864$). In no subject group was vocabulary score significantly correlated with age:

this is as predicted from previous findings (see Section 3.2.2).

3) With the photo test, in confirmation of Warrington and Taylor's (1973) findings the RBD were significantly impaired in recognising the objects from unconventional viewpoints ($U = 166$, $z = 2.835$, $p < .01$). The RBD also scored worse than the LBD ($U = 330.5$, $z = 2.073$, $p < .05$). (The misrecognitions of the RBD for each photograph, and the semantic misnamings of the LBD on this test, are listed in Appendix F.)

4) On the TT the maximum number of errors made by any NBD subject was 15, and for the RBD 21. All the errors made by euphasic subjects were made in the last section, except for three RBD subjects who began to make errors at 3 and 4 items of information per sentence, and one NBD who began to make errors at 3. A cut-off level of 10 errors would have misclassified 10% of the LBD and 6% of the control subjects. There were two unanticipated behaviours in the control subjects. Firstly, 'touch' was sometimes interpreted as if it was 'cause X to touch Y' rather than 'touch X with your hand'. This was also noted on the equivalent sentences in the Syntax gesture test (Touch the blue square and the yellow circle/Touch the sheep and the car). Some euphasic subjects made no distinction between these sentences and 'Touch the blue square with the yellow circle/Touch the car with the sheep'. 'Touch' can be pseudo-intransitive with a suppressed crossed reflexive (The car and the sheep are

touching' (- each other)) as well as transitive (the sheep touch the car), and it seems that, in some Tyneside dialects, this is the preferred interpretation when more than one object is present. Because of its frequency this kind of interpretation was not scored as an error, though it would have been with conventional scoring. The second unexpected behaviour in the control subjects on the TT was with the sentence 'Touch the circles quickly and the squares slowly'. Some interpreted the adverbs as referring to a single action with one circle and one square, and repeated the action of fast and slow approach to a circle and a square alternately. This also was accepted as correct. 'Between' was most commonly interpreted as in the horizontal plane, but occasionally in the vertical plane (as in a sandwich). Even with the allowance made for these interpretations, the TT was rather more difficult for the euphasic subjects than would have been anticipated.

5) Although not observed on a standard measure, another behaviour in the NBD will be commented on here while dialectal features are being discussed. For a number of subjects, 'the sheep is' did not signal the singular rather than the plural. This was more marked in the Syntax gesture test than in the picture tests: 'the sheep is' and 'the sheep pushes' was acted out with two sheep more often than with one, even by subjects who had made the correct choice of the similar contrast in the pictures. It is possible that the subjects did not observe the nicety of the

discrimination because they were occupied in planning the action, in a similar way to the greater difficulty the LBD had when they were asked to manipulate objects rather than point to pictures. It is also possible that using two sheep was acceptable because it was the singular act performed more emphatically. In fact, as both sheep were typically held together in one hand, this is unlikely. In some dialects 'is' may be used for the plural as well as for the singular; as the writing samples show, two NBD subjects used this form for the plural even in writing. In the picture tests the NBD also failed to make the singular plural distinction more frequently when it was signalled by the verb inflection rather than by the auxiliary verb, and the same occurred with the children. One subject, puzzling over the difference between 'the deer eat' and 'the deer eats', said "Oh, you mean the deer" and chose the singular.

In general, the representativeness of the euphasic groups as control groups was confirmed, and the value of their selection from the same speech communities as the aphasic subjects was endorsed by the dialectal features of interpretation they showed. The NBD appeared to be about average in intelligence and vocabulary.

7.2.1 Relative difficulty of tests

An index of the relative difficulty of some of the experimental tests was obtained by comparing the number of LBD subjects who scored on each test at levels which could have been achieved by guessing (to be referred to as the random levels).

To calculate this level, the following formula was used (Mosteller, Rourke and Thomas 1970 page 288):

$$z = \frac{(e - \frac{1}{2}) - np}{\sqrt{npq}}$$

where z = a normal distribution coefficient (= 1.65 for 5% probability level), n = number of items in the test, p = probability of getting a single item correct, q = 1 - p, and e is the maximum score on the total test which could be obtained with guessing at that level of certainty. For all calculations a z of 1.65 was used. The random e levels for the tests, rounded down to the nearest lower whole digit, are tabled below. Except where stated, p = ½. These figures represent the maximum correct score likely (at 5%) to be achieved if the subject was guessing.

Table 20

Random level scores

	Number of items in test	Random level
Syntax picture-choice, aural	64	40
Syntax picture-choice, reading	64	40
Phonological, picture-choice	38	25
Phonological, printed words	30	20
Semantic Fields	84 (p = 1/3)	34
Indefinite Article	40	26
Word Recognition	60	37

Table 21 shows the number of LBD subjects whose scores could have been obtained by random guessing. With the other groups of subjects, there were three RBD patients (RM6, RF4, RF5) who scored at random level on the indefinite article test; allother scores were above this level.

The table shows that, for the LBD, the easiest tests were those which used single printed words, the Word Recognition and Semantic Fields tests. The qualitative examination of the results of the three people who scored at random level on the Word Recognition test showed that all could reject non-English words and that they therefore retained some reading ability (see Section 7.6.1). Nevertheless, the versions of the phonological test and the syntax test which required reading noticeably enhanced their difficulty over those which only used the aural verbal medium (an increase of from 4 to 11 random scores and from 8 to 18 respectively). Only one patient (LF12) found the reading version of the syntax test easier than the aural - the kind of result which would be associated with the classical picture of word-deafness, though this patient was also completely without speech, and used vocal signs only.

The Indefinite Article test was particularly difficult, with more than half of the LBD scoring at random levels.

No patient scored at random level on all the tasks. Fifteen had no random scores. No clear pattern of dissociation of linguistic levels emerges from this gross measure; one patient, however, (LM11) showed a sharp dissociation between the semantic tests on which he scored at random levels and the other tests which he performed well. LM19 was

Table 21

Left brain damaged subjects scoring at random levels

TEST	PATIENT NUMBER: Men																				Women																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Phonological picture-choice																			x													x	x							x
Phonological, printed words									x					x		x	x							x				x		x		x	x		x					x
Syntax, picture-choice, aural												x					x							x				x	x			x	x							x
Syntax, picture-choice, reading			x						x			x		x		x	x			x				x	x		x	x	x	x		x	x	x	x					x
Indefinite Article		x	x						x		x	x		x		x	x		x	x		x		x	x	x	x	x	x	x		x	x		x		x			x
Semantic Field											x																						x							
Word Recognition	x																												x						x					

x represents an individual subject scoring at a level which could have been obtained by guessing.

also unusual in that he scored at random level on a phonological test but not on any other test (except the Indefinite Article test).

For purposes of qualitative analyses of the different tests, those patients who scored at a random level on the test were excluded from the analysis, so as not to obscure distinctions by including those who were guessing.

7.2.2 Relative power of tests to distinguish aphasic from euphasic

The cut-off point between normal and pathological performance was taken at the level where 92.3% of the NBD scored, because on each test there were one or two of these control subjects whose performances dipped noticeably below the others. As the RBD were significantly impaired on some of the tests (see Part Four Section 2), a similar cut-off point for the combined RBD and NBD subjects was calculated separately. Table 22 shows which LBD subjects scored above these cut-off levels. It shows that neither version of the phonological test was a satisfactory means of distinguishing aphasic from euphasic. 57.5% of the aphasic subjects scored above the cut-off level for euphasic subjects with the picture version, and 42.5% for the printed word version. Thus about half of the aphasic group did not appear to have a deficit in comprehension at the phonological level, in as far as it was measured by these two tests.

In contrast, at least 87.5% had deficits at the syntactic or semantic levels. Between the LBD and the NBD the most satisfactorily discriminating test was the Semantic Field test: only two LBD scored above the cut-off level, and only two LBD had random scores, indicating

Table 22

Left brain damaged subjects scoring at 'euphasic' levels

Worst score (92.3%) NBD	RBD	TEST	PATIENT NUMBER Men 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Women 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	5	Phonological picture-choice	N			N	N	N	N	N	N	N	N	R	N					N		N	N		N			N	R				N			N	R	N	N	N		
3	3	Phonological printed words		N	N	N			N	N		N	N		N							N	N	N	N			N					N			N		N			N	
6	10	Syntax picture-choice, aural	N			R			N	R										N					R								R					N		N		
10	13	Syntax Picture-choice, reading				R			N								N			N			R		R								R					R			N	
6	7	Syntax Gesture				N			NN											N					R													N				
4	14	Indefinite Article	R			R		R	N	N		R			R		R			R			R		N								R			N		N		R	R	
9	23	Semantic Field	R		R	R	R	R	R	R		R		R	R					N	R	R	R	R	R				R		R		R					N		R	R	
3.5	4.0	Verbal Memory							R	R		N			R					N								R	R											N	R	
4	11	Word Recognition				R	R		N	N							R	R		N		R	R				R						R			R		R		R	R	
7	11	Homonyms					R		R	R	R	R	R	R		R	R		R	R	R	R	N		N				R				R			N		N	R	R		R
7	11	Token Test							R	N										N																		N				

KEY: R an individual subject who scored above cut-off level for RBD and NBD

N an individual subject who scored above cut-off level for NBD that this task was well attuned to the range of difficulties experienced by this aphasic sample. The next best discriminating tests were Word Recognition and Verbal Memory. For distinguishing aphasic from euphasic (including RBD) the Syntax Gesture test was the most efficient amongst the experimental tests, although it was not quite as efficient as the TT.

No LBD patient scored above the NBD cut-off level on all the comprehension tasks; with the RBD level included, one LBD patient scored above the euphasic cut-off level on all the tasks, with two other LBD patients dipping below this level on only one task. (If a deficit in comprehension is made a necessary prerequisite to diagnosis as aphasic (see Part One Section 1.3), one patient would therefore appear not to meet this requirement (LM7): his writing and elicited speech showed minimal difficulties, and he was discharged from therapy shortly after this examination.) With the TT as the sole measure, the euphasic cut-off level would have misclassified four aphasic subjects as euphasic. For distinguishing aphasic from euphasic the set of experimental tests therefore offer little advantage over the TT used on its own: their potential value lies in distinguishing the quality of the errors in comprehension which are made. Whether or not they do this is the subject of Section 7.4.

From Table 22 it can be seen that there was a wide disparity between the cut-off levels for NBD and RBD on some of the tests. Table 23 shows the percentages of the RBD who scored below the NBD cut-off level for the tests.

Table 23

Percentage of Right-brain-damaged subjects who scored below the 92.3% cut-off level for the non-brain-damaged

Test	Number scoring below	Percentage
Semantic Field (n = 23)	15	65.2
Indefinite Article (n = 24)	13	54.2
Word Recognition (n = 23)	9	39.1
Syntax Picture (aural) (n = 24)	9	37.5
Homonyms (n = 24)	7	29.2
Syntax Picture (reading (n = 23)	6	26.1
Syntax Gesture (n = 24)	5	20.8
Verbal Memory (n = 24)	5	20.8
Phonological (pictures) (n = 24)	4	16.7
Token Test (n = 24)	3	12.5
Phonological (printed words) (n = 23)	1	4.3

More than half of the RBD subjects scored below the NBD cut-off level on the two semantic tasks.

If a criterion of scoring below the euphasic cut-off level on any test were taken as identifying anaphasic performance, one of the NBD and seven of the RBD would have been misclassified (see Table 24).

Table 24

Euphasic subjects scoring below cut-off level

Subject	Test/s on which an 'aphasic' score was obtained
NM9	Syntax (reading)
RM2	Syntax (aural) Semantic Field
RM6	Indefinite Article
RM11	Syntax (aural) Syntax (reading) Syntax Gesture
RF4	Syntax (aural)
RF5	Syntax (reading) Syntax Gesture Indefinite Article Phonological (pictures)
RF9	Verbal Memory
RF12	Semantic Field Homonyms

All these eight subjects had left school at 14 and most were of social classes IV and V, thus suggesting that, as had been anticipated, educational level and socio-economic class had an effect on test scores.

7.3 Second Hypothesis: correlations of experimental tests with non-verbal and verbal measures

Scattergrams were obtained for all pairs of test scores, using the computer scattergram program of the Statistical Package for the Social Sciences (SPSS) (Nie, Bent and Hull 1970). The scattergrams were examined to see if there was a trend for the relationship between pairs of data sets to be non-linear, where any pattern of association could be visually detected. There was no reason to infer from these scattergrams that a test of linear correlation would be misleading.

Accordingly, Kendall's coefficient of correlation was used to calculate correlations between each of the verbal tests and the standard and clinical control verbal tests (EPVT, TT, Verbal Memory), and the non-verbal measures of intelligence (Raven's Matrices), visual interpretive ability (the photo test), age, and (in the brain-damaged groups) hearing threshold and months since the stroke. This procedure was followed for each group (Tables 25-27).

In the NBD the reading version of the Phonological test was the only test to correlate significantly with age; this and the reading version of the Syntax Picture test correlated with the photo scores; in addition to these two tests the aural version of the Syntax Picture test and the Indefinite Article test had significant correlations with the Raven's Matrices scores. Only two tests appeared to be related to vocabulary level, Word Recognition and the reading version of the Syntax Picture test.

For calculations of the correlations in the RBD group's scores, the illiterate subject was credited with the mean group result for those tests requiring reading which she had not done. Except for hearing threshold, where n = 20, this gave a constant n = 24 throughout. There were no significant correlations with age, hearing threshold or months since the stroke. There were, however, some significant correlations with visual-interpretive ability as assessed in the photo test, and with intellect as assessed by Raven's Matrices. Four of the five picture tests correlated with the photo test scores (the exception was the Indefinite Article test), and so did one which did not use pictures, the Semantic Field test. Four verbal tests correlated significantly with Raven's Matrices scores, the aural version of the Syntax Picture

Table 25

Kendall's Correlation Coefficients - non-brain-damaged subjects

Experimental verbal comprehension tests/control non-verbal and verbal measures

	photo	RM	EPVT	TT	Verb. Mem.	Syn. a-p	Syn. r-p	Syn. a-gest.	Phon. a-p	Phon. a-r	Sem. F.	Ind. Art.	Hom.	WR
NON-VERBAL														
Age	.463*	.431*	.051	.198	.274	.204	.160	.184	.271	.385*	-.122	.318	.063	-.126
Photo		.301	.167	.356*	.203	.312	.355*	.209	.231	.418*	-.095	.294	.239	-.138
RM			.134	.137	.189	.376*	.352*	.310	.057	.413*	.064	.331*	.240	.068
VERBAL														
EPVT				.068	.120	.190	.438*	.298	.170	.199	.154	.290	.321	.336*
TT					.443*	.217	.152	.291	.280	.273	.119	.424*	.126	-.050
Verb. Mem.						.05	.047	.161	.149	.121	.087	.314	.155	.039

KEY (all tables):

RM	Raven's Standard Progressive Matrices.
EPVT	English Picture Vocabulary Test 3.
TT	Token Test.
Verb. Mem.	Verbal Memory.
Phon. a-p	Phonological picture-choice.
Phon a-r	Phonological printed words.
Syn. a-p	Syntactic picture-choice, aural.
Syn. r-p	Syntactic picture-choice, reading.
Syn. a-gest.	Syntactic, aural, manipulation of objects.
Sem. F.	Semantic Fields.
Ind. Art.	Indefinite Article.
Hom.	Homonyms.
WR	Word Recognition.
MSS	Months since stroke.
Hear	Hearing threshold.

* $p < .01$

Table 26

Kendall's Correlation Coefficients - right-brain-damaged subjects

Experimental verbal comprehension tests/control non-verbal and verbal measures

	Photo	RM	EPVT	TT	Verb. Mem.	Syn. a-p	Syn. a-r	Syn. a-gest.	Phon. a-p	Phon. a-r	Sem. F.	Ind. Art.	Hom.	WR
NON-VERBAL														
MSS	.064	.070	.007	.096	-.028	-.015	-.086	-.027	-.139	.008	.060	-.061	.087	-.141
Hear	.024	.356	.027	.277	.103	.094	.129	.074	.081	.222	.259	.325	.073	.255
Age	.259	.082	-.112	.207	.037	.061	.189	.059	.047	-.008	.090	.058	.012	.108
Photo		.367*	.087	.300	.089	.360*	.422*	.317	.377*	.270	.404*	.242	.104	.234
RM			.471*	.525*	.185	.497*	.279	.230	.312	.183	.540*	.491*	.309	.343*
VERBAL														
EPVT				.380*	.270	.361*	.143	.459*	.366*	.203	.423*	.448*	.564*	.473*
TT					.112	.268	.225	.310	.131	.161	.593*	.433*	.260	.318
Verb. Mem.						.245	.013	.386*	.211	.082	.041	.250	.093	.009

* $p < .01$

Table 27

Kendall's Correlation Coefficients - left-brain-damaged subjects

Experimental verbal comprehension tests/control non-verbal and verbal measures

	Photo	RM	EPVT	TT	Verb. Mem.	Syn. a-p	Syn. a-r	Syn. a-gest.	Phon. a-p	Phon. a-r	Sem. F.	Ind. Art.	Hom.	WR
NON-VERBAL														
MSS	.005	.026	.040	.343**	.144	.230	.227	.272*	.153	.220	.310*	.214	.029	.193
Hear	.140	.258*	.070	.074	.095	.182	.263*	.134	.204	.106	.074	.238	.082	.317*
Age	.316*	.325*	-.007	-.039	-.025	.110	.085	.052	.169	.204	.036	.114	-.273*	-.100
Photo		.254*	.237	.000	.017	.185	.196	.071	.107	.108	.017	.021	.014	.084
RM			.307*	.214	.099	.400**	.409**	.327*	.383**	.212	.271*	.344**	.023	.256*
VERBAL														
EPVT				.313*	.304*	.426**	.279*	.321*	.421**	.284*	.365**	.497**	.288*	.324*
TT					.304*	.602**	.587**	.744**	.462**	.580**	.475**	.525**	.121	.425**
Verb. Mem.						.446**	.389**	.394**	.385**	.334**	.356**	.382**	.091	.242

* $p < .01$

** $p < .001$

test, the Semantic Field test, the Indefinite Article test and Word Recognition. All but two of the verbal tests covaried with vocabulary level. The two semantic measures were the only ones to correlate significantly with scores on the TT.

With the results of the LBD, neither age nor visual interpretive ability correlated significantly with any verbal test: hearing loss was not significantly correlated with any measure which used aural input. There was a significant positive relationship with months since the stroke in the aural Syntax Picture test and the Semantic Field test, as well as the TT, i.e. the longer the time which had elapsed the greater the number of errors. This was presumably a function of the inclusion of the women patients who had been discharged from therapy but were still severely aphasic. Seven of the verbal tests correlated significantly with the measure of intelligence: these were the three syntax tests, the two semantic tests, the picture version of the Phonological test and Word Recognition. The TT and Verbal Memory test did not correlate significantly with the Raven's Matrices scores.

Overall these results from the three groups indicate that the scores on the verbal tests were relatively uncontaminated by effects of age, hearing threshold and months since the stroke. With the RBD it appeared that the picture format of some of the tests could be related to their difficulty, but this was not a major factor with the LBD.

With all the verbal tests except the Homonym test, there was some association with intelligence as measured by Raven's Matrices; the most 'contaminated' verbal tests in this respect appeared to be the aural version of the Syntax Picture test, and the Indefinite Article test.

The hypothesis, therefore, that the scores of the LBD on the verbal tests would correlate significantly with the standard verbal tests which had been used, was supported in respect of all the tests except the Homonym test, which correlated only with vocabulary level, and the Word Recognition test which correlated with vocabulary and TT but not with Verbal Memory. This absence of correlation with verbal memory does not invalidate the Word Recognition test; but the failure of the Homonym test to correlate with standard measures of aural comprehension is more serious.

The ratio of correct inclusions to false in the Homonym test meant that undiscriminating acceptance of all the words as meanings of the homonyms gave a spuriously good result, while cautious over-exclusion gave a poor one. Lhermitte et al (1971) reported that over-inclusiveness was positively associated with degree of severity. As has been commented earlier, the Homonym test was also particularly vulnerable to failure to understand the instructions. For both these reasons it was suspected that the Homonym test, although it could provide informative data with the NBD and RBD, was not reliable enough for use with an LBD population which includes severely handicapped patients. The research design provided a means of checking on this suspicion. If the Homonym test was really assessing an ability to recognise the multiple meanings of homonyms, its scores should correlate highly with the number of different senses recognised in the Word Recognition test. A correlation analysis of the two scores in the LBD resulted in a Kendall coefficient of 0.131 (not significant).

The Homonym test was accordingly not used in the further analysis of the LBD results. There were not enough errors of missed senses on the Word Recognition test by the NBD and the RBD to make a correlation analysis feasible with these groups.

The hypothesis, that the scores on the verbal comprehension tests would not correlate significantly with the non-verbal measures used, was supported in respect of all but intelligence and (in the RBD only) visual interpretive abilities.

Accordingly, tables of partial correlations were prepared, using the method recommended by Siegel (1956, page 223-9), with the photo and Raven's Matrices scores partialled out for the RBD and Raven's Matrices scores partialled out for the LBD (Tables 28 and 29). Tests of statistical significance are not available for such non-parametric partial correlations, according to Siegel. It was from these tables that the inter-relationships within the linguistic levels were examined.

7.4 Third hypothesis: linguistic levels

7.4.1 Intercorrelations amongst linguistic levels

In Table 28 of the RBD partial rank correlations, the prediction that there would be higher intercorrelations within the linguistic levels than across them received some qualified support. Correlations within the syntactic tests, between the two phonological tests and between the two semantic tests, tended to be higher than those across these groups, but there were two tests which did not otherwise conform to the predicted pattern, the Syntax Gesture test and the Indefinite Article test. The highest of the correlations, in fact, was between these two tests. The Syntax Gesture test appeared to be aligned more

Table 28

Kendall's Partial Rank Correlations - right-brain-damaged subjects

with Raven's Matrices and Photo scores partialled out

	Syn. r-p	Syn. a-g	Phon. a-p	Phon. a-r	Sem. F.	Ind. Art.	Hom.	WR
Syn. a-p	.486	.352	.061	.016	.100	.451	.284	.115
Syn. r-p		.257	.053	.001	.183	.292	.223	.126
Syn. a-gest.			.381	.356	.171	.493	.232	.305
Phon. a-p				.314	.108	.137	.083	.266
Phon. a-r					.143	.107	.088	.182
Sem. F.						.389	.207	.228
Ind. Art.							.277	.301
Hom.								.467

Key (see Table 25)

Table 29

Kendall's Partial Rank Correlations - left-brain-damaged subjects with Raven's Matrices scores partialled out

	Syn. r-p	Syn. a-g	Phon. a-p	Phon. a-r	Sem. F.	Ind. Art.	WR
Syn. a-p	.601	.634	.609	.484	.433	.536	.443
Syn. r-p		.536	.349	.454	.312	.452	.480
Syn. a-g			.453	.448	.408	.473	.330
Phon. a-p				.381	.357	.486	.258
Phon. a-r					.410	.460	.306
Sem. Field						.348	.354
Ind. Art.							.346

Key (see Table 25)

with the Phonological tests than with the two Syntax Picture tests. The Indefinite Article test correlated more highly with the aural version of the Syntax Picture test than with the Semantic Field test. The intermediacy of the Indefinite Article test between the syntax tests and the Semantic Field test could be attributable to the fact that it employs sentences and some contextual analysis is required, or to factors of picture interpretation which had not been accounted for by partialling out the photo test scores.

From Table 29 of the partial correlations of the LBD scores, it can be seen that the correlations between all the tests were relatively high, even with the Raven's Matrices scores partialled out. They suggested a cluster of the three syntactic tests, with the Indefinite Article test identifying more with this cluster than with the Semantic Field test (as in the RBD). The correlation between the two versions of the Phonological test, however, was considerably lower than that between the picture version of the test and the aural Syntax Picture test. The different methods of response for the Phonological tests must have influenced the results with the LBD more than would have been predicted from the RBD scores.

The table gives more support to the influence of modality factors than to linguistic levels. Amongst tests which used aural input, all except the two versions of the Phonological test had correlations of above about .45. The intercorrelations amongst picture tests also all excceded .45. Factor analysis was not used to corroborate or refute these speculations, because too many of the conditions necessary for such an analysis could not be met. In addition to the need for normal distribution of the data and for equal variances amongst the tests, there should also be at least ten times as many subjects as tests, to reduce the possibility of chance correlations (Nunnally 1967).

From the tables there was more support for the identification of the syntax tests with a distinct ability than for either of the phonological or semantic tests with distinct abilities. Of the two semantic tests, the Semantic Field test appeared to be a 'purer' measure than the Indefinite Article test.

7.4.2 Comparison of A and B versions of syntax tests

Table 30 shows the numbers of errors made by each of the adult groups on versions A and B of the Syntax Picture tests, in its aural and reading forms. There were four examples of most of each of the fourteen features, but eight of prepositions and deep relations, six of the plural and gender, and two of simple active and possessives, so that for these types of contrasts the scores have been adjusted to a scale of four. Those LBD who scored at random levels have been excluded, except four with 25 reading errors.

Table 31 gives the Kendall correlation coefficients between the two A and B versions for the LBD and the RBD. The NBD were not included in the analysis because of the number of zero ties. For the RBD the coefficient was calculated with the ties ordered most favourably and least favourably.

When a large number of errors were made, as with the LBD, the correlation between the two versions was significant, particularly with the reading version, but because of the different probability levels with the two calculations for ties, it is not possible to draw conclusions about the RBD results.

Table 30

Syntax tests errors, for A/B version comparison

Feature	Aural						Reading					
	LBD		RBD		NBD		LBD		RBD		NBD	
	A	B	A	B	A	B	A	B	A	B	A	B
Tense	10	9	5	3	1	1	25	29	8	14	2	17
Verb plur.	23	9	10	7	6	7	13	26	9	12	10	13
Pronoun plural	8	8.3	2.7	5.3	0	2	5.3	6	2	3.3	0.7	0
Pronoun gender	3.3	2.7	2.7	0.7	0.7	0.7	4.6	3.3	0.7	2	0	2.7
Prep'ns (non-rev.)	8.5	6.5	1	3	0	2.5	10	7.5	3	1	2	1
Active simple	16	10	0	0	0	0	16	12	0	4	0	0
Active top'zed	26	27	2	8	3	2	7	7	2	2	1	1
Passive	28	22	11	9	10	4	23	28	14	14	13	12
Possess.	8	20	2	4	0	0	16	14	4	0	0	0
Adj.	14	3	2	0	0	0	12	10	0	2	2	0
Subsid. phrase	19	15	1	1	2	0	20	14	8	3	8	1
Prep'ns revers.	2	2	1	0	0	0	10	9	1	0	0	0
Ind/dir. obj.	36	25	6	8	4	6	21	15	12	6	11	2
Deep relat.	16.5	7.5	7	6.5	4	5	22	18.5	6.5	8.5	6.5	9
n =	17	15	12	12	13	13	14	12	11	12	13	13

Features on a scale of four examples of each.

Table 31

Kendall's Correlation Coefficients between

A and B versions of Syntax Picture tests

	Syntax (aural)	Syntax (reading)
LBD	.619 (z = 3.074) p = .001	.862 (z = 4.294) p = .00003
RBD (ties fav.)	.659 (z = 2.040) p = .021	.549 (z = 1.700) p = .045
RBD (ties unfav.)	.482 (z = 1.492) p = .068	.423 (z = 1.309) p = .095

Amongst the Surrey children, 75 had been given both the A and the B version. As the sample was larger, Pearson's product-moment correlation was used to test the equivalence of the two forms (Nunnally 1970). This correlation was .657 ($p < .001$). Although significant, this indicates that nearly two-thirds of the variability in each version was unaccounted for ($1 - r^2 = .658$). In addition to the syntactic features themselves, it seems therefore that the effects of the particular lexical items and the pictures may not have been negligible. The greater degree of concordance between the reading versions than the aural versions with the LBD also suggests a third source of interference, the investigator's presentation of the items in speech.

7.4.3 Comparison of aural and reading versions of syntax tests

Table 32 shows the Kendall correlation coefficients for the degree of agreement between the rank order of features on the aural and reading versions of the syntax tests, for the RBD and for the LBD, with 'guessers' excluded.

Table 32

Kendall's Correlation Coefficients between

aural and reading versions of Syntax Picture tests

LBD	.363	(z = 1.81)	p = .035
RBD (ties favourable)	.678	(z = 2.486)	p = .006
(ties unfavourable)	.632	(z = 2.316)	p = .010

The aural and reading versions of the test correlated significantly, though to a lesser degree than might have been predicted in the LBD. The reading tests had used the alternative sentence to the one presented in the aural version, and, as Table 30 indicates, this affected the difficulty of two kinds of items for the NBD; specifically, the sentences illustrating tense contrasts in the B version and those illustrating the direct/indirect object contrast in the A version were more difficult.

There were a number of discrepancies between the results of the LBD for the aural and reading forms which could have been interpreted with more confidence had the sentences as well as the pictures been identical in the two forms. The greater difficulty of the reading form was largely dependent on four features (verb tense - in the A version as well as the B - reversible prepositions, before/after in its non-reversible form, and deep relations). In the reading form, the greater difficulty which had been found in the aural test of the inflected form of the verb plurality contrast over the copula forms, and of the topicalized active sentences over the simple was reversed.

7.4.4 Effect of type of response

The sentences for the Syntax Gesture test each included more than one contrasting syntactic feature, unlike the picture-choice tests where the contrasts were of minimal pairs. A detailed rank order comparison of difficulty of features on the two kinds of tests was not, therefore, attempted. Of those items which could be compared, the three most difficult in the aural version of the picture tests were also the most difficult in the gesture form, i.e. the future tense, the verb plurality contrast in either form and the indirect object contrast when expressed without 'to'.

A different method was therefore used to examine whether or not the complexity of the gesture required for the response affected test scores. From the dyspraxia assessment (see Section 3.3.3) patients were given a rating of 0 (no dyspraxia), 1 (hesitations and vagueness on aural commands, but imitation of gesture improved) and 2 (distorted gesture in imitation as well as to command). Sixteen patients were given a rating of 0, twelve of 2. Patients with a rating of 1 were excluded from this analysis as the dyspraxic performance could have been attributed to difficulty in aural comprehension. To examine whether or not dyspraxia was related to the number of errors on the two tests which required elaborative gesture (the Syntax Gesture test and the last section of the TT) the data were arranged in 2 x 2 contingency tables for eupraxic and dyspraxic, and poor test performance and good (above or below the median).

The association of dyspraxia with poor performance on these tests was highly significant. However, dyspraxia is associated with severity of aphasia in general, and on this evidence alone difficulty with the

Table 33

Association of gesture dyspraxia with scores on verbal comprehension tests requiring elaborative gesture

	Syntax Gesture Test		Last section of TT	
	above median 5-14 errors	below median 17-27 errors	above median 0-32 errors	below median 33-74 errors
eupraxic	14	2	13	3
dyspraxic	1	11	2	10

Fisher's Exact Test (using tables of critical values, from Finney, Latscha, Bennett and Hsu, 1963).

p = .005   p = .005 (one tailed)

tests could not be attributed to gesture difficulties enhancing the number of errors. To explore the question further, the twelve dyspraxic patients were ranked in order of severity of dyspraxia on the basis of the detailed record in the dyspraxia assessment (Table 34). The degree of agreement of this ranking for dyspraxia with rankings on the two language-gesture tests was then calculated, using Kendall's coefficient of concordance W, so that it could be compared with the degree of agreement with rankings for the equivalent 'non-gesture' tasks (the aural syntax Picture test, and the penultimate section of the TT). The concordance amongst the rankings for the elaborative gesture tasks with ranking for dyspraxia was significant at $p < .05$ ($W = 0.639$, $x^2 = 21.09$, d.f. 11).

The concordance of rating for dyspraxia with ranks on the tests which did not require elaborative gesture, however, was not significant ($W = 0.511$, $x^2 = 16.847$, d.f. 11, $p < .05$). It seems, therefore, that the number of errors on the elaborative gesture tasks is related to the

Table 34

Ranking of dyspraxic subjects on verbal tests requiring elaborative gesture and simple gesture

Dyspraxia	Elaborative		Simple	
	Syntax-gesture	TT (last section	Syntax picture choice (aural)	TT (penultimate section)
1. LF4	5.5	10	10	5
2. LF9	11	4.5	8	9.5
3. LF6	5.5	3	2	6
4. LF2	1	2	1	3
5. LM9	3	4.5	3	5
6. LM2	2	1	4	3
7. LM12	11	8	12	12
8. LF12	5.5	6.5	10	3
9. LF8	9	12	6.5	9.5
10. LF20	5.5	10	6.5	11
11. LM16	8	6.5	5	1
12. LF13	11	10	10	7.5

degree of severity of dyspraxia, and, as dyspraxia is distinct from aphasia, it is better to use the simple gesture tasks to measure language abilities. Using tasks which require elaborative gesture would seem to include an unnecessary impurity into the measurement of language abilities. Indeed, although the term 'elaborative' has been used in order to make the contrast with the simple gesture required to point to a picture, the gesture is only elaborative in a relative sense: it includes moving objects or tokens, but no long sequences of actions. It suggests that the process of language interpretation for response is sensitive to the very little extra loading added by imposing a response which itself has to be organized rather than being automatic. It also suggests that the common practice of testing auditory comprehension in clinical batteries by "following directions" (Part One, Sections 2.2 and 2.3) needs to be supplemented by investigations where such gesture does not have to be used.

7.4.5 Distinctive features

The fifth of the predictions made under hypothesis three was that the order of difficulty of distinctive features would be the same in both versions of the phonological test, regardless of the two different methods of response.

Table 35 shows how the results of the two phonological measures were distributed according to the variables which had been controlled for (distinctive feature, position in word, type of contrast as syntagmatic, paradigmatic or omission - see Table 9, Section 3.5.1). This analysis is based on the sample of LBD who scored at above random level.

Table 35

Phonological tests

Analysis by Distinctive feature			
	NUMBER OF ERRORS		
	Place	Manner	Voice
Picture-choice (n = 36)			
Paradigmatic contrasts	3	7	5
Syntagmatic contrasts	0	6	15
Printed words (n = 29)			
Paradigmatic contrasts	26	1	4
Syntagmatic contrasts	7	4	6
Analysis by position in words			
Picture-choice	Initial	Medial	Final
Paradigmatic contrasts	5	5	5
Omission contrasts	34	4	2
Printed words			
Paradigmatic contrasts	16	4	11
Omission contrasts	7	6	3

This table gives no support to the prediction that the order of difficulty of distinctive features would be the same irrespective of the medium of response used (the identical tape recorded input was used for each version). Three tendencies towards increase in difficulty were suggested, in (a) voice in syntagmatic contrasts, (b) place in syntagmatic contrasts and (c) initial position in word for omission contrasts; but each of these occurred in one version of the test only and was not corroborated by the other version. The pattern, in fact, suggests isolated difficulties of certain types of contrasts related to specific presentations, rather than any universal linguistic hierarchy.

For the picture test, the number of errors made by the 50 control (NBD and RBD) subjects was examined, to test whether or not any of the pictures were misleading. The most frequent error in these subjects was with 'year-ear' (16 errors); for 'tired-diet' there were 9, for 'appeal-peel' 8 and for 'tending-denting' 5. (In addition one item in the word reversal section which was only given in the picture version resulted in 19 errors, 'chair arm-armchair'.) To test whether there was an ambiguity in the pictures which produced a bias towards selection of the incorrect one, the results of the seven LBD subjects who made at least nine errors were analysed, to see whether they tended to prefer the incorrect picture on these particular items. Four chose the wrong picture for 'year', three for 'tired', five for 'appeal' and six for 'tending', a ratio of 18 errors to the 28 that would have occurred with a strong bias towards the incorrect choice.

Rather than attributing the differences in the two versions of the tests to misleading pictures, it seems, therefore, more productive to look at the different nature of the two tasks for an explanation of the discrepant results. In the picture test, the subject saw the pictures first and may not necessarily have labelled them before he heard the name, or if he did ascribe a name to them it may not have been the one which was spoken. The actual decision was, therefore, probably not based on a matching of an incoming sound pattern with a pre-existing verbal image, but the sound pattern had to trigger off a connection with meaning. There were many errors when the only contrast was the presence or absence of a redundant sound in initial position - it could go unnoticed more easily than a similar contrast in medial or final word position, when the word image was being formed. In the printed word version, on the other hand, the verbal image was preformed before the incoming sound image, and the heard word either matched or did not match this expectation. Additional contrasts were solidly represented in the visual configuration. To some extent the reading version may therefore have represented better than the picture version the process of phonological discrimination in connected speech where there are anticipatory expectations of what the next word is going to be. The two versions may have been examining different facets of the process of phonological discrimination - unprimed and primed discrimination.

7.4.6 Comparison with previous studies

7.4.6.1 Phonological

Previous studies (Blumstein, Goodglass and Baker 1973, Naeser 1974) have reported that place of articulation is more difficult to discriminate in paradigmatic contrasts than is voicing. As Table 35 shows, the results only of the printed word version conformed to this prediction. These previous studies also found no difference in difficulty between initial and final position; both the versions of the present test produced results compatible with this. There are no previous reports of studies with aphasic subjects which have examined syntagmatic or omission contrasts from either measure of articulatory features or position in word.

7.4.6.2 Syntactic

The table below shows the rank order of difficulty of the syntactic contrasts in picture-choice tests which could be compared across five studies with adult aphasic subjects.

Table 36

Rank order of difficulty of syntactic features in five studies

Feature	Fodor (Goodglass 1968)	Doktor & Taylor (1969)	Parisi & Pizzamiglio (1970)	Preliminary experiment (this study)	Main experiment (this study)
He/she		10			5.5
His/her		8			5.5
His/their		7	5	4	9
Verb tense (past)	4	3	3	5	10
Verb plurality (is/are)	3	4			3.5
Verb plurality (inflection)	1	2			8
Simple active	5	9	4	1	7
Simple passive	2	5	2	2	3.5
Indirect object (with 'to')		6	1	3	2
Indirect object (without 'to')		1			1

(1 = most difficult)

For the two studies where each of these items could be included (Doktor and Taylor and the present main experiment), the Kendall correlation coefficient did not reach a .05 level of significance (r = .119).

A more detailed comparison of the rank order of difficulty of items which were duplicated in the preliminary and main experiment was undertaken using data from three groups, LBD, RBD and children from Tyneside.

Table 37

Syntax Picture test (aural), rank orders of items in the preliminary and main experiments

Feature	Preliminary experiment			Main experiment		
	LBD	RBD	Children (age 4-6)	LBD	RBD	Children (age 7-11)
Verb tense (past)	7	2	2	6	4	8
Verb tense (future)	3	3	6	7.5	1.5	1
His/their	9.5	4	8	5	4	6
To/from	9.5	9	9	10.5	9.5	10
Between/beside	7	7	10	9	4	9
Under/on (in)	11	10.5	11	7.5	9.5	7
Simple active	1	5	3.5	4	9.5	7
Simple passive	2	7	6	2	4	2
Sub. phrase	5	10.5	6	3	9.5	5
From-to/ to-from	7	7	3.5	10.5	6.5	11
Indirect object with 'to'	4	1	1	1	6.5	3

Table 38 shows the Kendall's correlation coefficients for comparisons of these rank orders between the preliminary and main experiments for the three groups.

Table 38

Kendall's correlation coefficients:

aural syntax tests in preliminary and main experiments

LBD (ties favourable)	r = .481, z = 2.056, p = .020
(ties unfavourable)	r = .327, z = 1.398, p = .081
RBD (ties favourable)	r = .570, z = 2.436, p = .007
(ties unfavourable)	r = .486, z = 2.077, p = .019
Children	r = .019, z = 0.081 p = .468

Agreement was significant in the results of the RBD between the two experiments, but uncertain in the results of the LBD where agreement is only significant when ties were interpreted favourably. The lack of agreement in the children's results may have been related to the different age levels. These results suggest some caution in defining a hierarchy of difficulty of syntactic contrasts which is independent of the specific lexical items, pictures and patients used. Where the results of previous studies and the present studies overlap, they have in common that pronouns are relatively easy, and sentences which omit 'to' before the indirect object when there is also a direct object are hard. Anaphoric pronouns form a special class of syntactic features: they are essentially 'discourse' features, their referents being named in a different clause or sentence from the one in which they occur. Zurif and Caramazza (in press) have demonstrated that Broca's aphasics who have lost the ability to reconstruct the syntactic structure of a sentence in a metalinguistic task can still associate possessive pronouns with the head nouns they modify: they suggest that these have more semantic content than do articles.

What emerges from the comparison of these results is the importance of surface features of syntactic structure for aphasics. For example, they clearly do not have difficulty with the concept of plurality as such: the plural '-s' on a noun is easily detected (Goodglass 1968), while the singular '-s' on the verb presents major problems, with the singular and plural versions of the auxiliary coming midway between. The indirect object marked by 'to' is more easily distinguished than when it is not so marked: if the deep syntactic construct itself were lost, the presence or absence of a marker to it would make little difference.

From the preliminary experiment it appeared that the young children had more difficulty with the feature of verb tense than they did with the word order contrasts which the adult aphasics found difficult. Table 39 shows the rank order of difficulty for WOC and ONC items for the older children and the aphasics in the main experiment. The Kendall's correlations coefficient for these two ranks was significant (r = 0.641, z = 3.051, p = .001).

Table 39

Syntax Picture test (aural, version A), rank order of difficulty for children and aphasic adults

Features	LBD	Tyneside children (age 7-11)
WOC		
Indirect object	1	2
Simple active	6	11
Topicalized active	3	4
Passive	2	1
Sub. phrase	5	7
Adjectival	7	9
Possessive	10	6
Prepositions (rev.)	13	13
ONC		
Verb plurality	4	3
Verb tense	8	5
Pronoun plural	11	8
Pronoun gender	12	12
Prepositions (non-rev.)	9	10

Within the overall agreement, the same trend for the adult aphasic to find word order contrasts in active sentences hard, and the children to find verb tense relatively harder than the aphasics occurs as with the preliminary experiment. A detailed analysis of the LBD results in respect of word order is reported on in Part Four, Section 3.

In summary, there was a high level agreement when the same test was given to different kinds of subjects (children and adult LBD) but a somewhat uncertain degree of agreement or no agreement between tests which used different pictures and sentences to illustrate supposedly the same syntactic features. If the hierarchy of difficulty of features for aphasics depends on their surface realization and not on the concepts which underlie them, it would not be surprising if the context in which they are realized has an effect on this hierarchy. Again the importance of semantic factors in comprehension which was discussed in Part Two, Section 2.6, must be underlined.

7.4.6.3 Semantic

7.4.6.3.1 Semantic Field test

The NBD found this task approximately as difficult as did the control subjects in Lhermitte et al's (1971) study who were of lower educational level (6.9% errors compared with the French 6.7%). Apart from the one NBD control subject who made 16 errors, the cut-off level was 10 errors: the RBD made a significant number of errors, and their results are discussed in Part Four, Section 2.5; there was no equivalent group to the RBD in the French study.

With the LBD the mean proportion of errors was 28.3%, more than twice that in the French sample (13.4%) from which patients with severe comprehension difficulties had been excluded, unlike the present sample.

Table 40

Semantic Field test - type of errors

of left-brain-damaged subjects

Type of error	Hierarchization		Narrowing	Widening	Major	Total	Items correct out of 7
More errors across Inner Boundary	✓→?	?→✓	?→X	X→✓	✓→X, X→✓		
LM1	7	7	0	0	2	16	2
LM2	9	8	4	3	5	29	0
LM3	4	6	1	3	3	16	2
LM4	4	5	1	2	1	13	1
LM5	6	6	1	1	0	14	1
LM6	4	5	1	2	1	13	2
LM7	4	4	2	2	0	12	2
LM8	5	5	0	0	0	10	2
LM9	8	8	7	7	6	36	0
LM10	8	7	4	3	1	23	1
LM13	6	6	3	3	0	18	1
LM14	8	9	6	7	1	31	0
LM15	7	9	4	6	4	30	1
LM17	10	9	5	4	3	38	0
LM18	2	2	2	2	1	8	3
LM19	5	6	1	2	0	15	2
LM20	5	5	1	1	1	12	1
LF1	6	6	1	1	0	14	2
LF2	6	7	2	3	3	21	1
LF3	9	8	3	2	1	23	2
LF4	9	11	4	6	4	34	0
LF5	10	11	1	2	1	25	0
LF6	3	7	4	8	4	27	0
LF7	8	8	2	2	2	22	0
LF9	6	6	2	2	0	16	0
LF10	9	8	6	5	3	31	0
LF11	5	5	2	2	0	14	2
LF13	9	9	8	8	16	50	0
LF14	10	11	2	3	1	27	0
LF16	2	2	0	0	0	4	5
LF18	3	5	3	5	2	18	2
LF19	5	6	1	2	1	15	2
LF20	9	10	5	6	5	35	0
More errors across Outer Boundary							
LM11	7	9	12	14	12	54	0
LM12	2	3	6	7	1	19	1
LM16	5	6	6	7	1	25	0
LF8	6	10	9	13	6	44	0
LF12	5	8	6	9	3	31	0
LF15	4	7	6	9	3	29	0
LF17	8	12	9	13	4	46	0

As Table 40 indicates, there was an association of severity with narrowing and widening errors (across the outer boundary of the field) rather than hierarchization errors across the inner boundary within the field. Seven of the 40 patients made more errors across the outer boundary than across the inner: the results of one patient, LM11, are particularly interesting. Although superficially producing a random score, his errors showed that the uncertainty lay more with the outer boundary than with the inner boundary of the field: he also made next to the highest number of major errors. This was the patient in whom only semantic comprehension appeared to be materially affected.

This test therefore seemed to have produced results compatible with the French study. It also appears that, as well as being useful in distinguishing linguistic levels, this test could be used in certain cases for the differential diagnosis of disruption of the structure of semantic fields (if semantic fields are indeed a valid model for one aspect of the organization of the meaning).

7.4.6.3.2 Indefinite Article test

There are no precedents in the literature for this test, and the results can, therefore, only be compared with the hierarchy of difficulty predicted from theory, and for their consistency amongst groups. The results of the two adult groups who made a high number of errors, the LBD and the RBD, were tabled according to the type of contrast. The random scorers were excluded from the LBD.

Table 41

Indefinite Article test

		Numbers of errors classed by type								
	Contrast	A	B	C	D	E	F	G	H	I
RBD n = 24		35	21	16	19	14	20	17	10	5
LBD n = 17		24	16	19	18	3	10	8	9	9

(A is represented by 8 items, the others by 4 each)

Kendall's correlation coefficients for these ranked scores and the predicted rank was significant at p .038 for the RBD (S = 18, N = 9) but not significant for the LBD (S = 15, N = 9). (The score for A was halved, as it was from twice the number of items.) Although the predicted rank order of difficulty for all the types was not found with the LBD, for the 20 theoretically most difficult items (types A to D) they made virtually twice as many errors as for the 20 theoretically easier items (types E to I) (77:39). The RBD results, therefore, appeared to be sensitive to all the built-in theoretical variables, but the LBD only to a main contrast between count-mass distinctions (in types A to D) and spelling, etc., distinctions (in types E to I). The items on which the NBD made more than one or two errors were straw (type A, 7 errors), tomato (A, 5), game (B, 5), lemon (C, 4) and fawn (C, 3). The five most difficult items for the RBD were straw (A, 14), race (D, 13), tomato (a, 9), lemon (C, 9) and none (G, 9). For the LBD (excluding random scorers, n = 17), the five most difficult items were lemon (C, 10), tomato (A, 9), straw (A, 8), corn (D, 8) and game (B, 7). For the children from Tyneside the most difficult items were board (B), race (D), grating (F), game (B), fawn (C); and for the Surrey children board (B), fawn (C), race (D), grating (F) and game (B), in that order. The rank orders of difficulty were tabled for the five groups (LBD, RBD, NBD, Tyneside children and Surrey children). The coefficient of concordance amongst these ranks was W = 0.660 (x^2 = 128.7, d.f. 39, $p < .001$). For each group there were fewer errors on items where the 'a' was present than where it was omitted. For the Tyneside children 8 of the 11 most difficult items had the mass or equivalent form with 'a' omitted, while 8 of the 10 easiest items had the count or equivalent form with 'a' present. (For the Surrey children the figures were similar, 7 and 8 respectively.) With the LBD 7 of the 11 most difficult items were without 'a', and 10 of the 18 items on which they (non-random scorers) made no or only one error were presented with 'a'. The children's results also suggest that frequency of usage was more of a factor in their results than in those of any of the adult groups.

Figures 1 and 2 show how the number of errors in the children became lower as age increased; Figure 1 indicates that the Surrey children were in advance of the Tyneside children until about age 11. Individual presentation may have helped the adult NBD, and the figure does not necessarily imply that 11 year old children in Surrey and Tyneside were not yet performing at the adult level. As Figure 2 shows, there was no consistent trend for differences between the sexes in the Tyneside children. The mean performance of both the LBD non-random scorers and the RBD was slightly inferior to that of 10 year old Tyneside children, or to $8\frac{1}{2}$ year old children from the Surrey school. These results support the belief that the indefinite article test was testing the distinctions of meaning which it was intended to.

7.5 Fourth hypothesis (second aim): correspondence with independent assessments

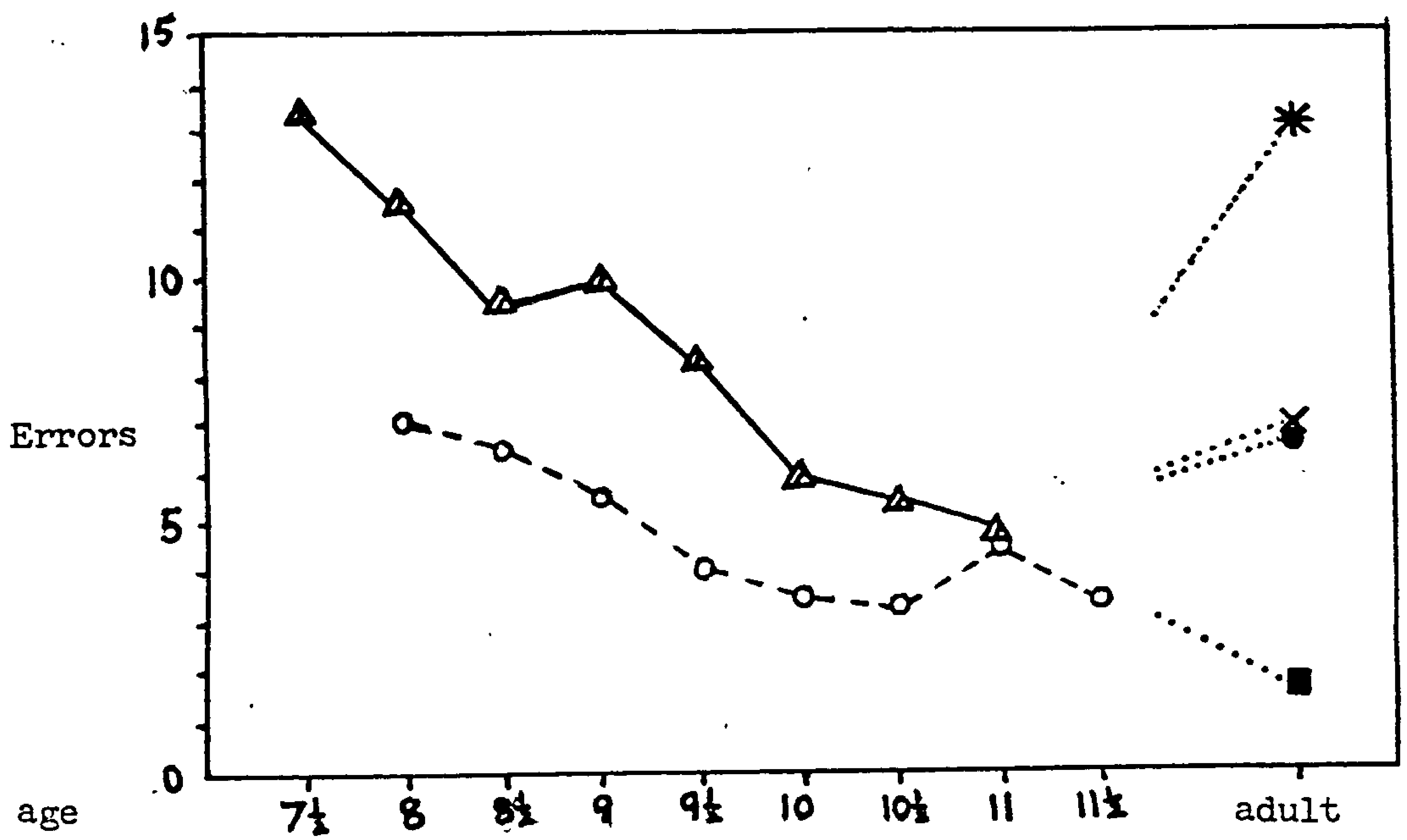
7.5.1 Clinical ratings

In order to compare the speech therapists' ratings of their patients' aural and reading comprehension, the mean rating was taken for each patient for the sections of the assessment form which related to these abilities. The median for these aural comprehension ratings fell between 0.5 and 1.0 and for reading between 1.0 and 1.5.

Figure 1.

INDEFINITE ARTICLE TEST

COMPARISON BY AGE AND LOCATION

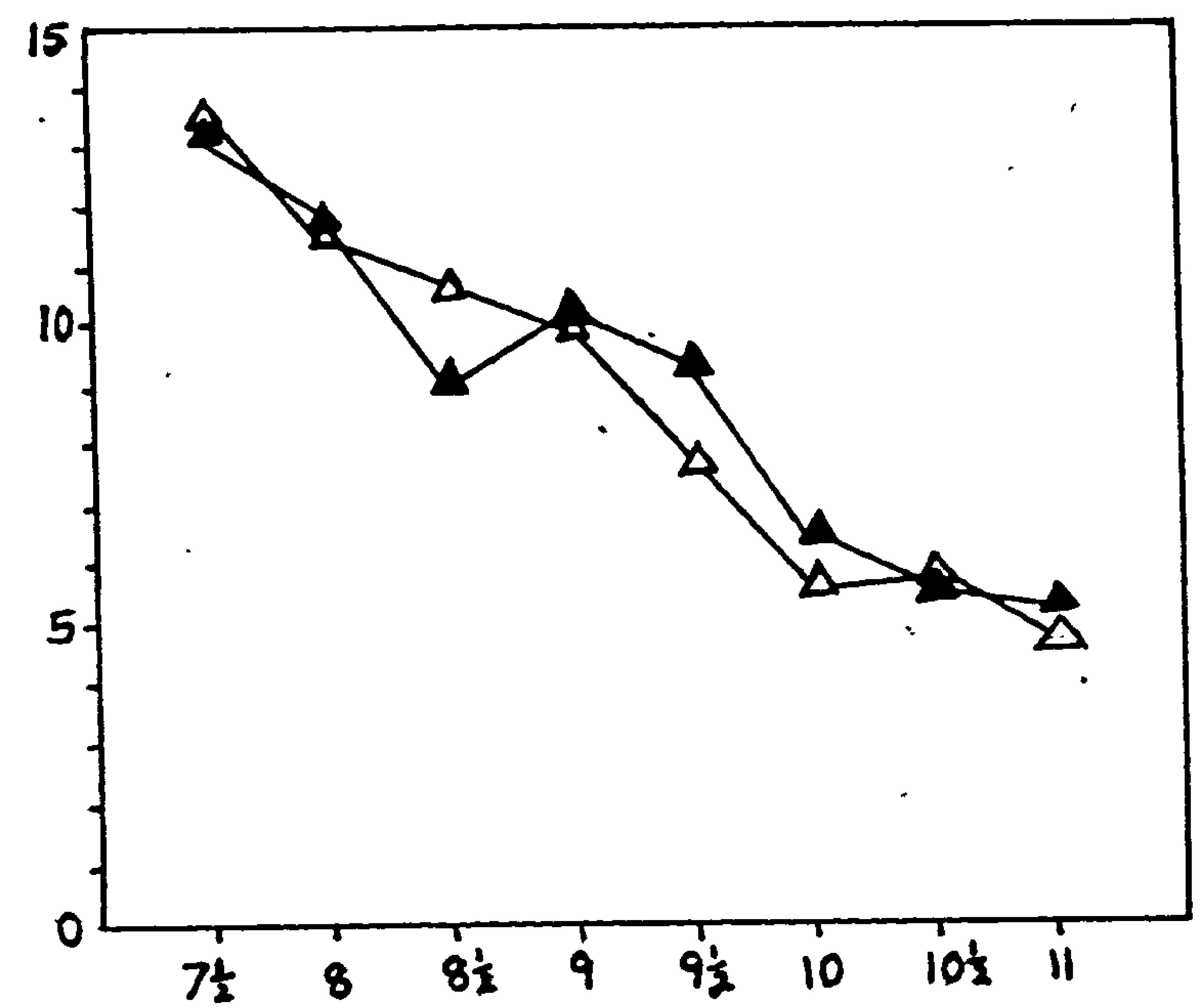


Tyneside	n=	44	63	63	42	49	57	49	58	-
Surrey	n=	-	16	35	37	32	30	21	20	21

Figure 2.

INDEFINITE ARTICLE TEST

COMPARISON BY SEX AND AGE IN TYNESIDE CHILDREN



Boys n=18	31	33	21	17	27	31	32
Girlsn=26	32	30	21	32	30	18	26

Key: —△— Tyneside children; -○- Surrey children; ····■ Tyneside NBD adults; ▲ Boys; △ Girls; ····● Tyneside RBD adults; ····✱ Tyneside LBD adults(total); ···✕ LBD non-random

Accordingly, the patients were dichotomized, for the purposes of this analysis, into those with good or poor comprehension in each modality depending on whether they were above or below these medians (Blomquist's double median test for associations (Bradley 1968 page 208)). They were similarly dichotomized according to whether they scored below (including at) or above the median for errors on each of the linguistic tests and the TT as a comparison control test. For the Syntax Picture (aural) test fewer than 15 errors was categorized as good, for the gesture test fewer than 16, for the indefinite article test fewer than 16, and for each phonological test fewer than 5. The resulting contingency tables are shown below.

Table 42

Association of clinical ratings with test results:

Auditory comprehension

Clinical rating	Syntax Picture good	Syntax Picture poor	Syntax Gesture good	Syntax Gesture poor	Indefinite Article good	Indefinite Article poor
good	13	7	15	5	15	5
poor	8	12	5	15	6	14
	(not significant)		($p < .002$)		($p < .005$)	
	Phonol. pictures		Phonol. printed		Token Test	
good	13	7	15	5	16	4
poor	7	13	7	13	4	16
	(not significant)		($p = .012$)		($p < .005$)	

Reading comprehension

Clinical rating	Syntax Picture good	Syntax Picture poor	Word Recognition good	Word Recognition poor	Semantic Field good	Semantic Field poor
good	14	7	15	6	15	6
poor	5	14	5	14	4	15
	($p = .012$)		($p = .005$)		($p = .002$)	

To test significance, Fisher's Exact Test was used, from the tabled values in Finney et al (1963). The probabilities given are for one-tailed tests. Clinical ratings and test measures of comprehension match better when the comprehension modality is reading or when auditory comprehension is assessed through elaborative gestures. As clinical assessments of reading are likely to be more objective than those of auditory comprehension, because structured material is used in reading, and as auditory comprehension is formally assessed through the patient's ability to execute directions, such a relationship might have been predicted. The therapists' assessments did not correspond with the Phonological test, nor with the test of syntactic features which used aural input and picture-choice response. One explanation could be that these two formal tests do not achieve their aim. However, the therapists' assessments were of overall auditory comprehension, not of specific linguistic abilities, and other studies have reported that objectively examined abilities in phonological discrimination are not related to clinical ratings of aural comprehension (Blumstein et al 1973, Naeser 1974). There is also evidence that patients can be rated on clinical examination as having good auditory comprehension and yet have a major deficit in their tacit knowledge of syntax on a formal test (Von Stockert and Bader, in press, Zurif and Caramazza, in press, Caramazza and Zurif, in press). It is therefore possible that the aural Syntax Picture test and the Phonological tests are genuinely assessing specific abilities but that these abilities do not much influence overall assessments of aural comprehension.

7.5.2 Home questionnaire

There were four questions on the questionnaire which were designed to obtain information about the patient's functional aural comprehension in everyday living.

1) Do you think his hearing has been affected by the stroke? Yes No
If yes, in what ways has his hearing been affected?

2) Apart from hearing, do you think his ability to understand what people say has been affected by the stroke? Yes No
If yes, in what ways has it been affected?

3) Would you say he enjoys TV and radio
More than before the stroke?
About the same as before the stroke?
Less than before the stroke?

4) Do you yourself feel you have changed your way of talking to your husband from the way you talked to him before his speech was impaired?

The first, third and fourth of these questions was included so as to check on how the relative was interpreting the second direct question. The replies given to these questions for the 30 aphasic patients for whom questionnaires were completed (see Table 43) showed that spouses sometimes made allowances in talking to the patient although they said that ability to understand conversation had not been affected: the most frequent comments were about slowing and repetition being needed. The question about TV and radio did not prove informative: the majority of aphasics were reported to enjoy them 'about the same'. All except one of those who now enjoyed TV and radio more than before the stroke were also said to have unimpaired comprehension (and presumably more time on their hands). Comprehension difficulties were partly attributed to impaired hearing in six patients; on audiology, none of these had a

Table 43

Relatives' opinions about their spouses' aural comprehension (from questionnaire)

Patient	Hearing affected?	Ability to understand what people say affected?	Enjoys TV and radio?	Has spouse changed way of talking?
LM1	No	No	Same	No
LM3	No	No	Same	No
LM5	No	Yes, doesn't always understand specific word till it's written down.	Same	Yes, more 'telling' him than 'talking to'.
LM6	No	Yes, but only at times.	Same	No
LM7	No	No	Same	No
LM8	No	No	Same	No
LM9	No	No	More	No
LM10	Yes (right ear)	No	More	No
LM11	No	No	More	Yes, I talk to him more slowly than before.
LM13	No	No	More	No
LM15	Yes (right ear)	Yes, has to concentrate then understands perfectly.	Same	Yes, I do not bother him with business or worries. I tried to involve him and it just upset him.
LM17	Yes, we sometimes have to repeat	No, at least his understanding has not been affected, thank God we've been spared that.	Same	Yes, I find I repeat often to make sure he fully understands.
LM18	No	No	Same	No
LM19	Yes	Yes	More	No
LM20	No	Yes, sometimes thinks I've said something I haven't.	Less	No
LF1	Yes, cannot always fully understand someone at a distance.	No, bit slower in catching on to what people mean.	Same	No
LF2	No	Yes, sometimes she makes one repeat the question.	Same	Yes, I take more time during a conversation.
LF3	No	Yes, she can become confused when many people are talking.	Same	No
LF5	No	Yes, sometimes she takes time to grasp what has been said.	More	Yes, I have to talk slow and explain things.
LF6	No	Yes, you must repeat yourself once or twice.	Same	No
LF7	No	No	Same	No
LF8	No	Yes	Less	No
LF10	No	No	More	No
LF12	Yes, puts hand over right ear, wants TV turned lower.	No	Same	No

Table 43 (continued)

Patient	Hearing affected?	Ability to understand what people say affected?	Enjoys TV and radio?	Has spouse changed way of talking?
LF14	No	Yes, she has difficulty in following a long conversation, unable to follow reason.	Same	Yes, only that more care has to be taken when trying to help her understand something. It has to be explained in easy steps.
LF15	No	No	More	No
LF16	No	No	Same	No
LF17	No	No	Same	Yes, I talk slower, one word at a time.
LF18	No	No	Same	No
LF19	No	No	Same	No

RBD patients (17 questionnaires completed)

RM6	"Sometimes he misunderstands your meaning".
RM8	"He does not always hear the telephone, and also asks people to repeat things on occasion".
RM9	"Much slower in replying to questions".
RF4	"Hearing affected slightly".

hearing threshold of over 25 dB for the speech frequencies, and it seems likely that the patients' need for speech to be repeated was aphasic rather than due to hearing loss. However, unless corroborated by other comments, this was not taken as a recognition of comprehension difficulties by the relative.

Altogether there were 15 patients whose relatives' replies to the second and fourth questions indicated an opinion that they did not have any difficulties in comprehension. To find the extent to which the relatives' opinions agreed with the test categorization of patients as 'euphasic' (i.e. above the cut-off level for NBD and RBD) or as 'aphasic' (below this level) (see Section 7.1.2), contingency tables were drawn up with test classification compared with spouse's classification as normal or impaired in comprehension. This was done for each of the tests of auditory comprehension, and for the Semantic Field test.

Table 44

Association of relatives' opinions with test results

Home Classification	Syntax Pictures		Syntax Gesture		Indefinite Article	
	'euphasic'	'aphasic'	'euphasic'	'aphasic'	'euphasic'	'aphasic'
Normal	5	10	3	12	9	6
Impaired	1	14	1	14	6	9
	(not significant)		(not significant)		(not significant)	
	Phon. pictures		Phon. printed		Semantic Field	
Normal	11	4	7	8	11	4
Impaired	9	6	7	8	7	8
	(not significant)		(not significant)		(not significant)	
	Token Test		Verbal Memory			
Normal	4	11	14	1		
Impaired	0	15	7	8		
	(p = .050)		(p = .007)			

A contingency table was also drawn up to compare the therapists' ratings of auditory comprehension with the relatives' opinions:

Table 45

Association of relatives' opinions with clinical ratings

	Clinical rating by therapists	
Home Classification	good	poor
Normal	10	5
Impaired	7	8
	(not significant)	

The relatives' opinions did not agree, at a confidence level of .05, with the therapists' ratings, nor with any of the experimental linguistic tests. They did agree significantly with the test of memory for verbal sequences and with the other test which, it has been suggested, is also influenced by verbal memory, the Token Test.

These results suggest that relatives tend not to notice (or if they do notice, do not attach importance to, or perhaps deny) the subtle difficulties in auditory comprehension which formal tests expose and which influence clinical ratings. The incidence of comment on their spouses' comprehension problems (50%) is less than that in a survey of wives' opinions about their aphasic husbands (75%) undertaken by Artes and Hoops (1976). The relatives' comments suggest that when difficulty in comprehension is admitted it is more often considered to be a delay in comprehension or a need to hear the utterance again than a fundamental inability to understand. Delayed comprehension, or comprehension of slowed utterances suggests a linguistic comprehension which is essentially intact but less efficient. Comprehension only when an utterance is repeated, or reworded, or supplemented by non-verbal reinforcement, may be functionally adequate but may indicate a major reduction in linguistic skills - it would, for example, be compatible with insensitivity to syntactic distinctions. Relatives' opinions are significantly in agreement with test scores for verbal memory, and it seems likely that the formal tests of linguistic levels are accessing a different dimension from functional comprehension according to relatives' opinions. They were designed so as to place minimal load on verbal memory, and delays in comprehension and any repetitions needed were not penalized in the scores.

The question therefore arises of the value of formal linguistic tests, if they are not related to functional comprehension. We must ask whether, if functional comprehension is related to tests of verbal memory, such tests are not more useful. Linguistic tests can be justified on the grounds of providing evidence relevant to the proving of linguistic theory, but the question of importance to the individual patient and his therapist is whether or not they can provide information which is relevant to the restoration of functions, the ultimate criterion for which is functioning in everyday life, not success in formal clinical tasks.

Firstly, it is not certain from these results that formal linguistic tests are not related to functional <u>linguistic</u> comprehension, as opposed to verbal memory and to intellectual comprehension. There is more than a hint that some relatives interpreted the question about understanding what people say as implying intellectual integrity, and were denying the implication of mental impairment. It is also likely that by several months after the stroke relatives had made adjustments towards the patients' linguistic comprehension of which they were no longer aware. Furthermore, there was not a significant correspondence between relatives' and therapists' opinions, and the therapists' ratings were also partly based on functional comprehension, but with more sensitivity to linguistic rather than general cognitive skills.

Secondly, supposing that functional comprehension and comprehension assessed by linguistic tests were indeed to be distinct, it becomes all the more necessary to supplement functional assessments by formal assessments in order to find out what the patient's residual linguistic capacities are and to make a differential diagnosis for planning therapy. Let us suppose that a Broca's aphasic whose functional comprehension is adequate (as it is commonly considered to be in such patients) shows a major deficit in tests of syntactic knowledge (as is not uncommon), The therapeutic approach will have to be different from that for a Broca's aphasic with the same functional abilities whose syntactic knowledge on formal testing proves to be good. Awareness of impairment of formal linguistic measures may help the therapist to devise procedures which ultimately can extend the patient's functional comprehension beyond the protected environment of relatives who have become adjusted to his difficulties.

A third possibility is that the patient does indeed understand language better at home and in informal conversations. This would support the notion of functional levels of availability of language in comprehension as well as in speech (see Part One, Section 3.4). The redundancy of situational and verbal context would mean that the patient did indeed understand adequately in everyday living. This presupposes that linguistic and functional levels interact, although it is convenient to think of them separately (and the lack of agreement in the contingency tables suggests they are, indeed, rated independently). When neurological models of language can progress beyond the atomistic to the holistic stage, it may be possible to include both linguistic and functional comprehension within the same model; for the moment, to simplify an extremely complicated problem, it seems to be justifiable to examine linguistic comprehension as conceptually distinct from functional.

7.6 Modality assessments

To complete this account of the general results of the main experiment, the results of three additional measures need to be described: these are the assessment of elementary reading skill (Word Recognition test), of speech and of writing.

7.6.1 Reading: Word Recognition

This test was well matched with the range of abilities in the sample of aphasic patients, with three scoring above the 92.3% NBD cut-off level, and three producing random level results. In fact, when the results of these three latter patients were examined, it was clear that their performance was not entirely guessing: two correctly rejected all the non-English words, and the other rejected 9 out of 10 of them. All but one of the patients retained the ability to reject non-English words in reading: the exception was LF4 who made five errors out of ten possible ones. Kremin and Goldblum (1975) have recently reported a similar finding. This patient achieved a better than random overall score by a strategy of accepting rather than rejecting words, thus making only 2 errors in the rejection category:

a similar behaviour was noticed in four other patients, who incorrectly accepted at least five more words than they rejected. However, with the group totals there was an overall tendency to reject (303 errors) rather than to accept (227 errors), although when the non-English words are excluded the ratio of incorrect acceptance to incorrect rejections is approximately even (209:202). It has sometimes been suggested that aphasic patients may have a tendency towards acquiescence which can give misleading test results under some circumstances. This kind of behaviour has been commented on in the Homonym test, but it did not appear to have distorted the results of the easier Word Recognition test.

There was no indication that the theoretical distinction which had been made between 'not acceptable to word class' and 'acceptable to word class' had had any effect in the intended direction; in fact, slightly more errors were made with word endings which were not acceptable to word class.

Table 46

Word Recognition

Mean number of errors of left-brain-damaged subjects (to scale of 10 maximum)

Not English	Not acceptable to word class	Acceptable to word class	Correct words rejected
0.450	2.950	2.275	2.525

This test also made it possible to compare syntactic-type reading errors in single words with semantic-type. The test included nine word endings where the sense of the stem + suffixes became changed (e.g. div-ide, div-ine, div-er). For comparison with these, inflections on three other root stems (beauti-, admir- and slow-) were syntactic (e.g. slow-ing, slow-ly, slow-ness, slow-ed, slow-er). (As 9 semantic errors were possible, and 15 syntactic errors, the latter were adjusted by halving the number of errors made on the 12 inflections for admir- and slow-.) The ratio of semantic to syntactic errors was 71:110.5. There was therefore more difficulty, in the aphasic patients as a group, in recognising syntactic inflections than in recognising semantic suffixes. A Wilcoxon matched pairs signed ranks test showed that this was significant ($T = 100.5$, $z = -3.216$, $p = .0007$). Only eight subjects made proportionately more errors on the semantic decisions than on the syntactic, and as the low T value for a sample of this size indicates, the discrepancies in this direction were not large. If it were possible to select root stems which were less syntactically ambiguous, and suffixes which were more exclusively restricted to one syntactic class of word, so that this test could also provide another index of sensitivity to syntactic structures, it could have a useful potential as a quick and pleasant clinical test for the differential diagnosis of semantic and syntactic sensitivities. For the present investigation it served the purpose of showing that some reading ability was retained by all the subjects, with the possible exception of one.

7.6.2 Speech

Details of individual aphasic patients' abilities in speech and the ratings given to them are reported in Part Four, where the comparison is made between speech and the results of the comprehension tests. The results from the euphasic control subjects will be described here.

7.6.2.1 Story

Six of the NBD, all men, did not arrange the five pictures in the expected sequence for the story; four of them put the second picture (the dog thinking) at the end or at the beginning of the story. Any of these five variants was accepted as a correct interpretation for the aphasics. Even allowing for these five possible arrangements, there were, in the RBD group, 6 women and one man whose arrangements did not conform to any of these (29%); while in the LBD group 7 women and 7 men produced deviant story sequences (35%). Five topics were included in the story by 81% of the NBD and by 63% of the RBD (dog leaves, thinks, follows, jumps, school). Transcripts of the tape recorded stories are given in Appendix D.

7.6.2.2 Sentences

The euphasic subjects were also asked to describe the six pictures taken from the syntax tests, after they had gone through these tests. The pictures were aimed at eliciting active, passive, comparative, past, future and plural copula constructions and the preposition 'between'. The results from the control subjects were used in order to see to what extent the aphasic subjects might be presumed to be aiming for these constructions. For the active sentence 'The boy kicks the girl', six NBD produced it in that form, sixteen in a progressive form, one as a passive, one topicalized, one pronominalized and one with the articles omitted. Ten of the RBD produced the standard form, eight the progressive, while five produced sentences with articles omitted, and one 'This is a picture of a boy kicking a girl'. The passive construction was elicited spontaneously from only five of the NBD, and from one of the RBD. The comparative was used by eight NBD (and was elicited more easily by the toy figure demonstration than by the picture - sixteen produced the comparative for this). Ten RBD used the comparative. The past tense was used for the picture by 23 of the NBD (sometimes as 'has fell'), with one patient using a subordinate clause with 'after'. All but three of the RBD also used the past ('has fell', 'is fell'). In the NBD only three used the modal 'will' to indicate the future, eleven acknowledging it by 'is going to', 'is about to', 'is ready to', 'is beginning to', while the remaining twelve used the main verb in the present tense. The modal came even less readily to the RBD, and was used by only two. For the picture of the two sheep six of the NBD said 'the sheep is', and two of them also used 'is' for writing a description of two sheep under a box. Thirteen of the RBD used 'are' with the remaining eleven either missing out the copula or using 'is'. 'Between' was elicited spontaneously from all but two of the NBD and seven of the RBD (all women).

These results suggest that the LBD could not be confidently assumed to be attempting to produce the passive, comparative, future or, indeed, even the plural 'are', but that active sentences, past tense and 'between' could have been elicited.

7.6.3 Writing

Writing was included in the investigation, as a check on whether or not any patient would show superior abilities at any linguistic level in this modality to those he showed in speech.

Seven of the LBD spontaneously resorted to writing when speech failed them, and one woman sometimes spelled a word out. Spontaneous writing, however, in all these cases was restricted to single words, and the words were often incomplete or mis-spelled. They were sometimes clear and relevant enough to convey information which the patient could not express in speech; this occurred in five patients with poor phonetic and phonemic ratings in speech. A second use of spontaneous writing in two patients with good phonetic ratings in speech was to help the patient himself to 'find' the word in speech. This argues for some independence of graphemic and phonemic aspects of speech: the graphemic structure was sometimes accessible when the phonemic apparently was not. Sometimes the patient was not able to read back aloud what he had correctly written.

In the sample of elicited writing, five of the LBD could not write their names without assistance, and a further five wrote their names but with spelling errors. Three of the most impaired patients continued the automatic process by writing their addresses.

Table 47 shows the rating scale for writing ability which was used; it includes four dimensions - degree of spontaneity, spelling accuracy, semantic content, and size of the linguistic unit which was achieved (word, two words, sentence).

Table 47

Rating scale for writing

10 self-initiated, correct, appropriate sentence.
9 recalled, correct, appropriate sentence.
8 self-initiated, incorrect or inappropriate sentence.
7 dictated, correct sentence.
6 self-initiated, correct and appropriate two words.
5 recalled, correct and appropriate two words.
4 self-initiated, correct and appropriate single word (excluding 'the').
3 recalled, correct and appropriate single word (excluding 'the').
2 dictated, correct, single word.
1 copied, correct, single word.

In two cases (LM16 and LF16) writing ability was rated superior to the level which syntactic speech ratings would have suggested, indicating that in these patients difficulties of articulation may have blocked a better potential for sentence construction (see Part Four, Section 1.2, Table 4). Patient LM16, though rated at 1 for semantic ability and at 7 for syntactic ability in speech (see Figure 1 in Part Four), showed himself able to recall two sentences correctly in writing without help. His attempts at self-initiated writing, however, showed syntactic abilities which would have been rated at 7 in speech (see Part Four, Section 1.2) ('The moto has horserider', 'Box no sheeps', 'The sheeps has (was?) motor', 'The sheet has farmer'). Patient LF16 achieved a writing level of 10, but was rated at 8 for both syntax and semantics in speech. With these two exceptions, the expression of syntactic abilities was either similar in writing and speech or, more commonly, more restricted in writing. In 95% of the LBD group, therefore, the comparison of speech and writing confirmed that speech gave as good or better an index of syntactic ability as writing.

The picture was less certain for the semantic rating; there were six other patients besides the two mentioned (LM2, 5, 10, 20, LF9, 15) whose use of spontaneous writing was such as to suggest a superior level of semantic ability than the speech rating gave credit for; the speech rating of semantic abilities was thus confirmed for only 80% of the group.

8. Summary

1) There were probably no material effects on the results due to the experimental design.

2) The LBD were significantly impaired on all the verbal tests.

3) The two euphasic groups were representative of their kind; and some dialectal features of comprehension were noted.

4) The results of the LBD showed the expected correlations with standard verbal tests, and non-significant correlations with non-verbal measures, except in respect of the measure of intellect ability used, Raven's Matrices.

5) With the effect of Raven's Matrices scores partialled out, for the LBD scores, and with photo scores also partialled out for the RBD scores, the pattern of intercorrelations indicated that the syntactic tests were the most closely associated together, the phonological were not, and the Indefinite Article test was more associated with the syntactic tests than with the Semantic Field test. The Homonym test did not appear to give reliable results for the LBD.

6) The tests most appropriate for the range of difficulties of the LBD group were the Semantic Field and Word Recognition tests: the latter indicated that all but one of the LBD retained some ability to read single words. The Indefinite Article test was too difficult for the LBD, but was well matched to the abilities of the RBD. The two versions of the Phonological test were too easy for the LBD, in that about half of them scored within the normal range.

7) The different versions of the Syntax Picture tests (A and B, aural and reading) showed significant agreement in their results, but with a substantial amount of variance unaccounted for.

8) The kind of response required had an effect on the results, with both the phonological and the syntax tests; subjects with gesture dyspraxia achieved poorer results on tests which required following of directions than on those which required simple gesture.

9) There was satisfactory agreement between the experimental tests and therapists' ratings of the LBD for reading and on tests of following directions, but not between the picture test of phonology or the picture test of auditory syntactic comprehension. Relatives' declarations about the patients' abilities to understand everyday speech did not agree with most of the formal clinical tests, nor with the therapists' ratings. They appeared to be most related to verbal memory.

It therefore seemed probable that the experimental tests were examining abilities which escaped notice in everyday behaviour, but which nevertheless might be relevant to the restoration of function. However, the tests were not 'pure' measures of abilities at the three linguistic levels. They appeared to be contaminated more by variants in the response required than by variants in input. Nevertheless, there was sufficient consistency amongst the Syntax Picture tests, and of the Semantic Field test with earlier results to justify their use as measures of syntactic and lexical-semantic abilities.

For the further examination, through the comparison of speech and comprehension, of the extent to which the linguistic tests accessed central aspects of language knowledge in the LBD, the most representative tests for the syntactic level were the two picture tests, because the gesture test reflected dyspraxic difficulties in addition to aphasic difficulties; for the semantic level the Semantic Field test appeared to be more useful because the Indefinite Article test produced a high proportion of random scorers in the LBD; and for the phonological level both the versions were necessary as they appeared to be examining complementary aspects.

PART FOUR Experimental: the main experiment - three topics

PART FOUR

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PART FOUR

Experimental: the main experiment - three topics

1. Speech and comprehension

1.1 Background: competence and performance

If tests of comprehension were accessing a central knowledge of language rather than modality-specific reception, it might be predicted that they would reveal the same quality of disorder as do analyses of speech - if indeed the issue were to be as simple as that. Because it is not, this section requires an introductory survey.

In Part Three it was concluded that there was significant agreement between the aural and the reading versions of the syntactic tests, and that therefore a common disability was being measured which was at least partially independent of the input medium used. It also seemed that the specific medium of response required could influence the results, and therefore that peripheral disabilities could obscure the possible nature of the central disorder. It remains to be tested whether or not the data from the main experiment show that the measures of comprehension which did not require elaborative gesture were accessing the same central linguistic knowledge which the patients in the aphasic group were demonstrating in speech. If they were to prove to do so over the whole group, the tests could be useful in revealing underlying knowledge in those patients whose expressive abilities are so reduced that speech cannot be used as an indication of linguistic knowledge.

We must ask, therefore, what justification there is for expecting speech and comprehension to show the same underlying pattern of disorder, particularly when (as was commented in Part One Section 1.2) the basis for a number of classifications of aphasia is the opposition of impairment in speech and in comprehension. For such classifications there is a strong presumption that speech is impaired in a way which comprehension is not: though speech is always abnormal in both the two main types of aphasia which several classifications identify under different labels (Broca's and Wernicke's), comprehension can nevertheless, it is said, be normal in one of them (Broca's). Weigl and Bierwisch (1970), according to Zurif and Caramazza's interpretation (in press), have equated this dissociation between speech and underlying knowledge with the distinction between linguistic performance and competence first made by Chomsky (1965). As envisaged by Chomsky, competence was an abstract concept, the intuitive knowledge of his own language by an ideal speaker-hearer, and the subject matter for linguistic theory, undisturbed by the irregularities of the realisation of that competence in performance in actual speech or comprehension, "such grammatically irrelevant conditions as memory limitations, distractions, shifts of attention and interest, and errors (random or characteristic)" (1965, page 3). This distinction between competence and performance does not translate easily from this abstract plane into a description for individual speaker-hearers, particularly for abnormal ones, but nevertheless the translation has been attempted: the distinction has an illuminating appeal for aphasiologists because it attempts a distinction between the noumenal and the phenomenal, and initially appeared to offer a simplification to a complicated problem.

If a patient could demonstrate in any modality (including comprehension) that he retained any specific linguistic capacity, competence must be retained, and his inability to produce it in other modalities must be only a performance limitation, which therapeutic intervention could help to 'deblock' (Weigl and Bierwisch 1970). Evidence that competence is retained, Weigl and Bierwisch suggest, is that most patients can at some times and under some circumstances show abilities superior to those they show at others: they argue that this fluctuation in performance shows that it is indeed only performance which is damaged - the underlying knowledge is not lost but is not always accessible. According to Weigl and Bierwisch, linguistic competence is retained despite the brain damage, with the possible exception of permanent global aphasia. Hécaen (1972), like Weigl and Bierwisch, has put forward arguments "in favour of this integrity of the model of competence" in aphasia:

> "in cases of aphasia the deficit is not concerned with the components of rules (semantic, syntactic, morphophonological) but with the activation of these components" (page 625).

These arguments are based on the dissymmetry of deficits (as between emission and reception, speaking and writing) and on their variability (as when a motor aphasic produces a combination at one moment which would be impossible the next).

> "In an elementary way, if one posits that the models of the emittor and of the receiver are derived from a single model of competence, and that their differences are due to various factors which enter into the emission and reception of language, one ought to establish that the model of competence remains intact" (page 626).

Such an interpretation has an attraction for aphasia therapists because it implies that capacities are retained which the therapist can help to reactivate, to make more accessible through practice, and to reintegrate into a new system in which balances of availability have become readjusted and co-ordinated. With this view comprehension as linguistic knowledge is retained (though modality-specific aspects of comprehension presumably may be impaired) despite poor performance in speech.

An opposite argument has been put forward by Whitaker (1971). Although he too first supported the case for the retention of competence in aphasia (1970), he has later come to the conclusion that the distinction between competence and performance is not a useful one. If aphasia is distinguished from other kinds of language disorder because all modalities are affected after brain damage, the neurological substrate of the central language system must have been damaged, and competence, if it has any meaning other than on an abstract theoretical level, must therefore have been impaired. If both competence and performance are necessarily disrupted, it is not helpful to make a distinction between them.

However, both these interpretations of competence are limited in that they consider competence as an undifferentiated totality. They are attempting to apply to the study of disordered language in individuals a term which was originally defined in such a way as specifically to exclude such a study. The extension of meaning which Chomsky's term, 'linguistic competence', has acquired in its application to live speaker-hearers (in addition to its qualitative change into 'communicative competence' which will not be discussed here) has sprung from three amendments: that there are degrees of competence, different competences for speech and for comprehension, and different competences for different linguistic levels. Performance, as defined by Chomsky, cannot accommodate these distinctions, which appear to be at a more central level than mere faults of execution.

1) Within the same language, and even within the same speech community, Ohman (1972) suggests - and observation amply confirms - that there can be degrees of linguistic competence related to social class, educational level, age and individual characteristics. Within the same community people can have a good or bad 'command of language': linguistic knowledge has to be acquired and there are stages of acquisition of this knowledge (Hymes 1971). Moreover, there are stages where rules are half acquired and insecure: for example, some children apparently become worse at understanding the passive because they change from a heuristic strategy to an algorithmic one which relies on syntactic rules which are not yet stabilized for them (Maratsos 1974, Beilin 1975).

2) Jakobson's (1964) substitution of the terms 'encoding' and 'decoding' for expressive and receptive in describing aphasic disorders carried the dissociation between speech and listening to a central level of coding. His most recent statement (in press) is the explicit one that there are different competences for speech production and for comprehension. A fundamental difference between speech and comprehension is that comprehension is probabilistic whereas speech must be at least partially pre-planned. Communication and syntax have different importances to comprehension and to speech; comprehension must be part of communication, while

speech need not be: speech (beyond the single word) necessarily uses syntactic structure, while comprehension need not. Fodor, Bever and Garrett (1974) make two suggestions about comprehension: firstly that algorithmic strategies are used only if heuristic processes do not obtain a solution, and alternatively that heuristic processes serve to restrict the space for search but that both processes are used in comprehension. Whichever suggestion is valid, algorithmic syntactic rules are less critical in comprehension than in speech. In fact, conceptual relations are extracted which are not present in the original sentence either as specific lexical items or specific syntactic forms: for example, 'John liked the painting and bought it from the duchess' becomes confused with 'The painting pleased John and the duchess sold it to him' (Johnson-Laird and Stevenson 1970). Experiments by Bransford, Barclay and Franks (1972) and by Barclay (1973) have also shown that subjects recall not only sentences which they have actually listened to but inferences derived therefrom which they had not actually heard: they suggest that inferences are not necessarily distinguished from perceived sentences.

Further evidence that comprehension and production have some different characteristics comes from developmental studies. Comprehension and production proceed out of step. In general, the young child's comprehension of language is said to exceed his production of language (Fraser, Bellugi and Brown 1963).

Because comprehension is assisted by non-verbal context, the child can perform more adequately in his role as an interpreter than as a speaker; he is able to make use of cues beyond the lexical and syntactic information realized in the utterance itself (Clark, Hutcheson and Van Buren 1974). However, comprehension in the full sense requires an ability to put oneself in the other speaker's place, which young children have not yet developed. When knowledge of syntactic structure as such is tested, it is also clear that production can sometimes apparently precede comprehension. Children who are already capable of producing well-formed subject-verb-object sentences in their spontaneous speech may not yet be capable of making the correct choice between reversible sentences, when the only cue is the precedence of one noun before the other to indicate its syntactic role as subject rather than object (Chapman and Miller 1975). Clark et al (1974) have suggested that the relationship between comprehension and production in the acquisition of language needs to be analysed more closely: they attribute the discrepancies between production and comprehension to the ability to exploit non-verbal cues rather than taking the view that a different verbal grammar underlies each process. (Bloom (1974) accounts for the comprehension-production gap by the hypothesis "that the two represent mutually dependent but different underlying processes, with a resulting shifting of influence between them in the course of language development" (page 286). She comments that "creating the mental representation as input to linguistic encoding may be cognitively less complex than deriving a mental representation as a result of linguistic decoding" (page 307) - a research investigation showed that children produced far fewer utterances in response to what someone else said than they produced spontaneously: comprehension is, in fact, more cognitively demanding than speech, rather than the reverse.

There is also evidence from developmental disorders of phonology that production and comprehension can reflect different 'competences'. Children who themselves are unintelligible because of phonological deviancy in speech, in the majority of cases, have no difficulty in understanding other people's speech (when the lexical content is appropriate for their age). Under test conditions they can typically recognize, as appropriate and meaningful, phonemic contrasts which they do not signal themselves, but they do not understand their own deviant speech if it is recorded and played back to them (Panagos and King 1975). They will, in fact, vehemently reject 'fis' as meaning 'fish' although they themselves use this form in speech (Berko and Brown 1960). It would seem that they have acquired a phonological competence for comprehension, which is the same as that of their community. However, analysis of the speech sounds which these children produce sometimes shows that the phonological systems which they use in speech are not so much inadequate realizations of the phonological system they use in comprehension (due to neuromuscular inco-ordination, inattentiveness etc.) as a different and consistent phonological system, in which the boundaries the child has drawn in the phonological space do not quite coincide with (or are not as detailed as) those of his community (Applegate 1961, Compton 1970, Oller 1973, N.V. Smith 1974). If he has different systems for speech and for comprehension, he would have to be described as having different competences or knowledge.

3) From what has been said so far, it is clear that, besides making a distinction in competence between speech and comprehension, it is also useful to make distinctions in competence by linguistic levels. If we conceive of there being different competences for phonology, syntax and lexical-semantic organization, some part of the discrepancy between speech and comprehension can be explained by the different demands both make on syntactic and lexical competences.

There is some evidence for the separation of competences at the different linguistic levels. The evidence from developmental disorders is that the phonological misalignments described above are not only primarily in speech rather than in comprehension, but that they are not indicative of delayed acquisition of syntactic or lexical competence. Indeed, the assumption is made that the child's lexicon is nearly enough appropriate to his age for naming of pictures to be used as a means of access to his phonological system which cannot be interpreted in conversational speech. Much of the evidence in support of selective linguistic competences for aspects of language organization has been sought for in aphasia. Whitaker (1971), Von Stockert (1972) and Schnitzer (1974) have offered evidence from single cases that semantic and syntactic organization can each be at least partially disrupted independently; and Von Stockert and Bader (in press) have extended this to a study with a larger number of patients, even suggesting that the two levels can be differentially disturbed in global aphasia. Hécaen and Dubois' (1971) syndrome of "Broca's aphasia without articulation disorder", and Brown's (in press) distinction between anarthric aphasia and agrammatism, acknowledge the separation of syntactic and phonological disarray in 'anterior' as well as in 'posterior' aphasias, although as most descriptions of Broca's aphasia illustrate syntactic and phonetic disorders are often associated. Disorders of phonemic selection and seriation (without phonetic deviation) can be found without a marked syntactic or lexical disorder (in 'conduction' aphasia), or with an ill-defined syntactic disturbance which is different from that found in Broca's aphasia (the paragrammatism of jargon aphasia). The 'isolated speech area' syndrome in which the patient can repeat back stretches of speech he has heard but apparently does not understand may exemplify the separation of phonological and semantic levels.

To summarize these three extensions of the meaning of 'competence' and their relevance to aphasia, it seems that one might expect there to be at least partially independent impairment of phonological, syntactic and lexical-semantic competences, that speech and auditory comprehension do not necessarily show the same quality of disorder because of the peculiar nature of each of these language modalities and the different demands they make on language structures, and that individual differences in linguistic competences which have nothing to do with the nature of any disorder will overlay and obscure patterns of disruption. The most important changes from the original definition of competence are that knowledge which is accessible for speech is not always accessible for comprehension and vice versa, and that there may be different systems of knowledge for different aspects of language rather than one competence. The distinction between performance and competence/s is still useful. Performance limitations are those due to states of reduced efficiency because of fatigue, inattentiveness, muscle spasticity, intoxication, emotional stress, etc. Limitations of memory, regarded as performance factors in the original definition, now fall somewhat ambivalently between competence and performance. In our revised definitions of competence we have implicitly allowed for the inclusion of 'availability of knowledge' rather than limiting competence to an abstract intuitive 'knowledge' accessible only indirectly through performance which the original definition required - for example, lexical-semantic impairment implies that lexical information is no longer precisely available rather than that all knowledge of certain items in the vocabulary is lost. If knowledge implies reconstitution of its components, i.e. is dynamic rather than static, use becomes part of competence. The short term memory limitations which may be germane to aphasia are, therefore, not overlying obscurations of knowledge but inherent restrictions within it. Schuell (1966), who considers that the effects of a reduction in auditory retention span are observed across all modalities and that there is therefore a general reduction of verbal retention span, hints (Schuell et al 1969) that agrammatism may be due to an inability to sustain the pregrammatical speech intention long enough to clothe it in syntactic structure. Of two subjects studied, she writes "the evidence seems to indicate that both subjects experienced difficulty holding sentence constituents in short term memory while others were being processed" (page 805). In view of the complexity of the inter-relationship between speech and comprehension, it is not surprising to find conflicting opinions from experimental and observational findings at each linguistic level:

1) At the lexical-semantic level, a number of investigators have suggested that impairment is central, and that anomic speech and circumlocutions are reflections of a reduction of semantic knowledge which is also revealed in judgement and comprehension tasks (Alajounanine et al 1964, Lhermitte et al 1971, Derouesné et al 1972, Von Stockert 1974, Zurif et al 1974, Gainotti 1976, Goodglass and Baker in press). On the other hand there is, in Wernicke's aphasia, typically a discrepancy between what the patient understands in the way of lexical items and the content of his speech: by about two months after the lesion, comprehension of high imagery words (as in a picture vocabulary test) is often good while the patient continues to use very few of such words in his spontaneous speech (Gregory 1975).

2) At the syntactic level, the agrammatism of Broca's aphasia is reported to reflect a central reduction by Von Stockert and Bader (in press) and by Zurif et al (1972), while Goodglass and his colleagues (Goodglass et al 1972, Gleason et al 1975) take the opposite view. The searchings and self corrections of the Broca's aphasic while he is attempting to produce specific syntactic constructions suggest that the target structures are held in mind by the patient but cannot be elicited at will. At some time or other all the patients in Goodglass' studies produced the whole range of syntactic constructions required, and Goodglass concludes that despite agrammatism in speech syntactic competence may be retained. The inclusion of 'availability' within competence helps to bring together these two views. It may be that the agrammatic patient retains the capacity for structure but can only retrieve fragments of it for use, in speech or comprehension, at any one time: despite an agrammatism demonstrated in all modalities we could infer that the structures are potentially retained if different fragments of them become available at different times. On this basis we would not expect tests of syntactic comprehension to show a consistent impairment of the same facets on each occasion they were used, just as in speech it is claimed that different facets of the desired structure can be retrieved each time. For Wernicke's aphasics the picture is equally uncertain: they apparently retain a free use of syntax in speech (as far as can be deduced from the uncertain lexical

content), yet they are more impaired on tests of syntactic comprehension. When severity levels are equated, they show little or no qualitative difference in syntactic comprehension from Broca's aphasics (Pizzamiglio and Parisi 1970, Gardner and Zurif 1976), though Goodglass et al (1970) found them significantly more impaired than Broca's aphasics on preference for prepositions which encode idiomatic relations. However, the problem in assessing impairment in syntactic comprehension in Wernicke's aphasics is, as we have already seen, that syntactic comprehension is compounded with lexical-semantic comprehension, and that an impairment at the lexical-semantic level may therefore produce poor results on a syntactic test.

3) At the phonological level, Alajouanine et al (1964) found that fluent patients with phonemic jargon in speech (but without phonetic disorder) were impaired in tests of phonemic discrimination, while Gainotti, Caltagirone and Ibba (1975) found less convincing the degree of association between phonemic disorder in speech and in a test of phonemic discrimination. Phonetic disintegration in speech can occur without involving other language abilities in dysarthria from subcortical lesions (but see Lebrun, Buyssens and Henneaux 1973 for a contrary opinion about cortical anarthria), but the independence of the combination of phonetic and phonemic disorders known as verbal dyspraxia from other aspects of language is keenly disputed. Halpern (1972), Aten, Johns and Darley (1971) and Aten, Darley, Deal and Johns (1975)

maintain that verbal dyspraxia occurs in isolation from other symptoms of language disorders, and that it therefore is not aphasia (and responds to a different kind of therapy from that appropriate for aphasia). Martin (1974) in contrast argues that, as it is an impairment of phonological organization and not simply of neuromuscular co-ordination like dysarthria, it is an aphasic disorder and that it should therefore be accompanied by some reduction in comprehension, particularly in phonemic discrimination; if evidence for such impairment is so far suggestive rather than conclusive, it is because the tests which have been used are too easy according to Martin. Verbal dyspraxia has been equated with Luria's afferent motor aphasia (Goodglass and Kaplan 1972) (though somewhat equivocally): Luria, like Darley and his colleagues, interprets the disorder as essentially one of a high level of neuromuscular sensorimotor co-ordination, but considers it comes within the scope of the aphasias and that there are secondary effects on phonemic discrimination, such as the motor theory of speech perception (Liberman et al 1967) would account for. Needham and Swisher (1972) have reported that patients categorized as having apraxia of speech or dysarthria show impairment of comprehension on the Functional Communication Profile.

For these reasons, therefore, it remains an open question whether or not tests of comprehension at the linguistic levels will show, in a group of aphasics, the same qualities of disorder as do measures of the aphasics' speech by the same linguistic levels. For each linguistic level, therefore, in the present analysis the null hypothesis was put forward that there would be no association between number of errors on the comprehension tests and ratings of ability in speech, and, as no direction of association was predicted, two-tailed tests of significance would be appropriate.

1.2 Ratings of speech at the linguistic levels

The tape recorded samples of speech from the aphasic patients were listened to, transcribed, and listened to again after an interval of approximately one month by the investigator and a second judge, a psychologist who was also a qualified speech therapist (see Appendix D for these transcriptions). Each patient was given a rating of from 1 to 10 for each of the three linguistic levels, with phonetic and phonemic abilities rated separately. A rating of 0 was used where the patient had no intelligible speech. The reference standard for the degree of syntactic and semantic complexity which could be expected and phonetic and phonemic acceptability was the tape recorded samples of speech from the NBD (see Part Three, Section 7.6.2.1). Where the ratings of the two judges disagreed, the recordings were replayed. It was usually possible to resolve the disagreement; where disagreements remained, a middle ranking was given. The criteria by which the speech samples were ranked are given below.

Phonetic ranking

This was based on the proportion of phonemes recognisable as a distorted attempt at the correct phoneme, and not as clearly articulated substitutes for another phoneme. Ambiguous cases (e.g. /ðə / rendered as / də /, simplification of clusters by omission of a fricative or lateral) were classed as phonetic rather than phonemic deviancies if they were in a general context of articulation difficulties. Two other factors were taken into consideration in the ranking: restriction of phonemic repertoire and articulatory effort. 'Automatic' speech and 'asides' such as 'what was it again', 'you know', 'I dunno' were included as evidence for the phonetic rating, but not for the other ratings: they represent a different functional level of availability for the other linguistic levels, but the neuromuscular inco-ordination which results in phonetic deviancies would be expected to apply to all functional levels.

Phonemic ranking

This was based on the proportion of literal paraphasias in the sample of speech, i.e. errors in which incorrect but clearly articulated phonemes were substituted for a target phoneme, or transposed, or in which phonemes are omitted in a general context of good phonetic production. The target word could either be deduced and recognised from the context, or its existence could be inferred from attempts to self-correct or 'zero-in' by changing phonemes. A ranking for phonemic deviancy could only be given when the phonetic ranking was at least 5.

These two phonological rankings were based on the criteria given in Lhermitte et al (1971) and Poncet et al (1972). For the syntactic and semantic rankings there was no such helpful precedent in the literature. In their rating scale of speech characteristics for the Boston Diagnostic Aphasia Examination, Goodglass and Kaplan (1972) make no distinction between semantic and phonemic paraphasias in running speech, and, at the syntactic level offer two simple scales - phrase length (the number of words from 1 to 7 in the longest occasional run) and variety of grammatical construction (a seven point scale from no grammatical constructions available to normal range, with "limited to simple declaratives and stereotypes" at the mid point of the scale). Hécaen et al's (1968) scheme based on Yngve (1969) depth was devised for fluent 'sensory' aphasics and is not suitable for a group which includes the non-fluent. Gosse et al's (1972) scheme is too complex for the present small sample. Crystal et al's (1976) scheme uses levels of complexity based on children's age of acquisition and these do not necessarily conform to aphasic breakdown.

For the syntactic rankings, therefore, a more objective scale was devised which was based in part on the rankscale categories of Halliday's systemic grammar, as expounded by Muir (1972).

Syntactic ranking

Rating	Unit	Class/Structure	Example
0		Unintelligible or stereotypies	
1	Word	(Free morpheme)	'nice', 'man', 'school', 'window'
2	Word	(Bound morpheme)	'sniffing'
3	Group	Nominal	'the boy', 'the story', 'that one'
4	Group	Adverbial	'in the window'
5	Clause (incomplete)	Nominal group + uninflected verb	'the dog jump'
6	Clause	Inflected verb + adverbial group or complement	'walking to school', 'does that', 'climbs up on the window'
7	Sentence	Simple alpha	'he meets him', 'it's at the school', 'it's happy', 'the boy waves to the dog'
8	Sentence	Compound (incomplete or distorted)	'he has a go to sleep and then he wakes up here', 'I can see it better now when I've been when I've put that when I've put that way I can'
9	Sentence	Compound	'the dog, you know, the dog misses him and follows, follows him to school'
10	Sentence	Complex	'I don't know where he's gone in this one', 'it frightens the school because it's pleased to see the boys'

The scale was so arranged that rankings of 0 to 5 would correspond to agrammatism, with rankings of 6 to 10 corresponding to paragrammatism or to acceptable grammar. Because the sample of speech obtained was so restricted, even one example of any of these types of structure led to the speaker's being credited with its ranking as indicating that that structure was retained and available in speech to the patient. Lexical deviancies were not considered in the syntactic ranking.

Semantic ranking

This was based on two factors, the proportions of semantic paraphasias and of circumlocutions (i.e. misleading or incomplete information, and low information value). Examples of semantic paraphasia are 'mother' for 'teacher' and 'Sheba' for 'dog', and of circumlocution, 'that one's running away' and 'I think that one there'. Errors which were attributable to literal paraphasia were not included. When there were snatches of intelligible speech in a generally unintelligible context because of jargon which might have been due to phonemic or phonetic deviances, the rating was based only on the quality of the intelligible speech. The semantic ratings of patients with a high proportion of unintelligible speech may therefore have been unduly high, but as unintelligible speech was omitted from the other rankings, to be consistent it was also omitted from this ranking as it could not contribute to differential analysis by linguistic levels. In six cases there was so little intelligible speech that a semantic ranking could not be given or so little speech of any kind that a ranking of nought was given.

As a check on the reliability of the speech ratings, the chief speech therapist whose clinic 26 of the 40 patients had attended, was asked to rank these 26 on four measures of speech, i.e. articulation, syntax, naming and substantive-word finding in connected speech. As this ranking could not be done until the final composition of the group of aphasics was known, this meant that in some cases the therapist was ranking on her memory of what the patients had been like some months before (and in two cases after the patients were dead). The articulation, syntax and word-finding ranks from the therapist were compared with the phonetic, syntactic and semantic ratings from the judges, and the therapist's ranking for naming ability was compared with the ranking derived from the naming of the ten conventional photographs in the Photo Test. (For the scoring of naming on the Photo Test failure to speak an appropriate name at the first attempt was considered an error, but phonetic and phonemic deviations were disregarded.)

Table 1

Kendall's correlation coefficient between therapist's and judges' rankings of 26 LBD patients on linguistic levels in speech

Phonetic	0.727**
Syntactic	0.646**
Semantic	0.440**
Naming	0.383*

* $p < .01$; ** $p < .001$

Under the circumstances in which the rankings were given, the significant agreement between rankings derived from the therapist and the judges (Table 1) was considered satisfactory. Because the lowest agreement was between the rankings for naming, the photo naming scores were not used in the later analysis of comparison of speech and comprehension as a measure of semantic abilities in speech. Because, out of the remaining rankings, the semantic appeared the least secure, the correlations amongst the different levels within the therapist's and within the judges' rankings were calculated.

Table 2

Kendall's correlation coefficients within the therapist's rankings

	Articulation	Syntactic	Word-finding
Syntactic	0.491**		
Word-finding	0.454**	0.815**	
Naming	0.576**	0.599**	0.578**

** $p < .001$

Table 3

Kendall's correlation coefficients within the judges' ratings

	Phonetic	Syntactic	Semantic
Syntactic	0.381*		
Semantic	0.359*	0.346*	
Photo naming	0.288	0.572**	0.585**

* $p < .01$, ** $p < .001$

It is evident that the correlations within the therapist's rankings were higher than those within the judges' ratings and that, in particular, there was a very high association between syntactic and substantive word-finding rankings in the therapist's scale but not in the judges' scale. As separation of the linguistic levels was the aim of the study, the judges' ratings would appear to be more pertinent, where the two do not agree.

As a further test of the freedom from bias of the judges' ratings for speech, Noether's test for cyclical trend (Bradley 1968, page 179) was used to test whether or not the allocation of ratings for the linguistic levels was random. Because of the number of subjects who could not be rated for phonemic ability in speech, the phonetic rating only was used at the phonological level. The semantic rating was arbitrarily given the number 1, the syntactic 2 and the phonetic 3.

Observations where syntactic ratings tied with semantic or phonetic were dropped, leaving 20 observations in the analysis. Of these observations, 5 were ordered monotonically (i.e. as 123 or as 321). With a p of 1/3 for monotonic orderings, and 5 such orderings out of 20,

Table 4

Expression in speech and writing

	Naming		Speech Ratings				Writing		Praxis
	Memory objects	Conventional Photos	Phonetic	Phonemic	Syntactic	Semantic	Level	Spont.	
LM1	2	5	9	8	9	7	7	yes	0
LM2	6	8	2	?	6	1	6	yes	2
LM3	9	8	1	?	7	8	5		1
LM4	5	8	8	9	10	9	9		0
LM5	5	6	9	7	7	3	7	yes	0
LM6	5	7	10	9	8	2	6		1
LM7	10	10	7	10	10	9	10		0
LM8	10	10	8	10	10	10	10		0
LM9	-	4	1	?	3	?	5		2
LM10	4	0	4	?	3	3	6	yes	1
LM11	7	4	10	9	10	2	8		0
LM12	1	0	9	9	9	2	5		2
LM13	6	7	7	7	8	9	6		0
LM14	4	4	3	?	1	3	1		1
LM15	8	5	4	?	10	7	8	yes	1
LM16	-	0	3	?	7	1	9	yes	2
LM17	-	0	4	?	0	0	1		1
LM18	10	10	9	10	9	10	10		0
LM19	6	6	6	2	3	5	2		1
LM20	5	7	10	9	10	4	9		1
LF1	9	10	10	10	9	9	10		0
LF2	4	0	5	8	4	6	7		2
LF3	9	10	9	10	6	8	7		0
LF4	1	0	5	?	1	4	3	draw	2
LF5	9	4	1	?	5	6	7	yes	0
LF6	8	7	10	9	3	8	3		2
LF7	-	2	3	?	3	3	5		1
LF8	-	0	0	?	0	0	3		2
LF9	5	1	10	9	8	1	9	spell	2
LF10	-	0	6	?	1	?	1		1
LF11	8	9	8	9	9	9	10		0
LF12	-	0	0	?	0	0	2		2
LF13	2	7	2	?	7	1	2		2
LF14	8	8	7	7	10	7	3		0
LF15	5	1	6	8	2	4	6		1
LF16	8	7	7	2	8	8	10		0
LF17	6	7	5	8	10	5	8		1
LF18	5	4	8	1	7	7	6		0
LF19	9	10	8	10	8	10	9		0
LF20	-	0	4	?	0	0	2		2

For key to writing level, see Part Three, Section 7.6.3, (Table 47)

Praxis: 0 = no dyspraxia, 1 = hesitation, 2 = dyspraxia.

the hypothesis of randomness cannot be rejected ($p = > .05$). There was thus no marked evidence of bias towards higher or lower ratings for any of these three linguistic levels in the judges' ratings. Table 4 shows these ratings for speech, together with the naming scores, ratings for praxis (see Part Three, Section 3.3.3).

1.3 Results

For graphic display (Figures 1 and 2), the speech ratings are shown together with the deciles of scores on the comprehension tests for each of the LBD patients. Raw scores could not be used because of the different scales for the tests, and grading against the only absolute standards available (the euphasic cut-off levels and the random guessing levels) did not provide information about the middle range of scores. Deciles have the disadvantage of being influenced by the range and spread of the distribution of scores in the sample, but so also does the alternative commonly used method of making different scales compatible, z-scores. As the speech ratings were also influenced by the range of abilities in the sample (with standard for the lowest rating being the worst performance in the group), the influence of range was not too disadvantageous. Deciles have the advantage over z-scores of having a more even spread over the extremes of the distribution, and of making a graphic comparison with a 10 point rating scale easy.

To obtain the comprehension deciles for the comparisons, the mean of the two deciles for the phonological tests was used; for the syntactic deciles the aural and reading versions of the picture tests were

Part Four

Figure 1.

COMPARISON OF SPEECH RATINGS AND COMPREHENSION DECILES

LEFT BRAIN DAMAGED MEN

Part Four Figure 2.

COMPARISON OF SPEECH RATINGS AND COMPREHENSION DECILES

LEFT BRAIN DAMAGED WOMEN

Key: see Figure 1

calculated separately from the mean of the WOC and ONC deciles with DR items omitted from the scores, so as to achieve a 'purer' syntactic measure, and for the semantic decile the field test on its own was used.

A first glance at the figures gives an impression of individual variability: the forty subjects display a large number of the possible combinations of relative rankings. To test statistically whether or not there was a significant agreement between semantic, syntactic and phonetic rankings for speech and semantic, syntactic and phonological deciles for comprehension, a binomial sign test was used. Pairs of rankings which agreed were signed '+', and pairs which disagreed signed '-'; pairs where such a comparison could not be made because either speech or comprehension rankings included ties were omitted. Of the 11 pairs left, one was signed '+' and ten '-'. The probability of such an occurrence by chance is .02. The proportion of rankings which disagreed between speech and comprehension was therefore significant: and the impression from the graphic display of heterogeneity was corroborated.

Closer inspection of the figures suggests that the heterogeneity was related more to syntactic, semantic and phonemic rankings for speech than to phonetic. There were eight patients whose syntactic ratings were two or more points below their semantic ratings (M 14, 19, F 2, 3, 4, 6, 15, 19), but only three of these showed the same relative disparity in comprehension. Thirteen subjects were rated as being more impaired semantically than syntactically (M 1, 2, 5, 6, 11, 12, 14, 15, 16, 20, F 9, 13, 17) and only three of these showed the same disparity in comprehension. Two patients (F 16, 18) had marked literal paraphasia and low ratings at the phonemic level in speech: in both, phonological comprehension was relatively good. The phonological comprehension deciles were, in fact, closely related to overall severity: scores in or above the fourth decile for errors were invariably associated with low ratings for all levels in speech or with a low rating for semantic ability in speech. Although the relative positions of the linguistic levels did not match between speech and comprehension there was an overall indication that comprehension was within or near to the severity range spanned by the speech ratings for each subject; with the exception of F14, good speech was accompanied by good comprehension, and poor speech by poor or moderate comprehension.

A more detailed examination of the relationship of the linguistic levels in speech and comprehension was undertaken, using firstly contingency tables, and secondly discriminant analysis.

1.3.1 Non-parametric analyses

For the contingency tables, except where there was a theoretical categorical distinction, as between agrammatism and para/grammatism, subjects were grouped dichotomously by the median, with scores falling at the median placed in the upper or lower categories in such a way as to maximize the equality of each category. For the semantic ratings, n = 36, and for the phonemic ratings n = 24: for all other tables the full number of subjects was used, n = 40.

Table 5

Association of comprehension deciles and speech ratings within linguistic levels

Semantic comprehension

Semantic Speech Rating	'good' (error decile under 5)	'poor' (decile 5 or over)
'informative' (≥ 6)	13	5
'Uninformative' (≤ 5)	6	12

(Fisher's Exact Test, two-tailed, p = .044)

Syntactic comprehension (aural)

Syntactic Speech Rating	'good' (error decile under 5)	'poor' (decile 5 or over)
'grammatic' (≥ 6)	16	9
'agrammatic' (≤ 5)	8	7

(x^2 = 0.111, p = 0.70)

Syntactic comprehension (reading)

	'good' (error decile under 6)	'poor' (decile 6 or over)
'grammatic'	18	7
'agrammatic' (as table above)	2	13

(Fisher's Exact Test, p = .006)

Phonological comprehension

Phonemic Speech Rating	'good' (error decile under 2)	'poor' (error decile 2 and over)
'phasic' (⩾ 9)	7	7
'paraphasic' (⩽ 8)	2	8

(Fisher's Exact Test $p > .05$)

Phonological comprehension

Phonetic Speech Rating	'good' (error decile under 3)	'poor' (error decile 3 and over)
'mild or no articulation difficulty' (⩾ 7)	17	3
'poor articulation' (⩽ 6)	3	17

(Fisher's Exact Test $p < .008$)

(Bradley's tables were used to find the significance levels of the Fisher Tests which were used when there was a cell frequency of less than 5, or when row or column totals were equal: the one-tailed probabilities from the table were doubled to find the two-tailed, an accurate procedure, according to Bradley (page 198) when either row or column totals are equal.)

From these tables it appears that, in this group of aphasic subjects,

1) Semantic ratings for speech were significantly associated with semantic deciles for comprehension. This agrees with the majority of the opinions expressed in Section 1.2, but leaves unexplained the apparent dissociation of semantic comprehension

and speech reported by Gregory in Wernicke aphasics. The data were therefore further examined for differences of trend between patients with 'informative' and those with 'uninformative' speech using Jonckheer's modification of Kendall's S, with the 'nautical' method (see below).

2) Syntactic ratings for speech were significantly associated with syntactic deciles for comprehension only when the results of the reading test and not the aural test were used. This also was further explored by the same method.

3) Phonemic ratings for speech, in the reduced sample where these could be given, were not significantly associated with categorization according to phonemic discrimination tests.

4) Phonetic ratings for speech were significantly associated with the phonemic comprehension test deciles. In order to test whether this were a function of overall severity, rather than a specific relationship between phonetic difficulties in speech and phonemic difficulties in comprehension, contingency tables were drawn up to discover the association between phonetic ratings and the tests at other linguistic levels. Tables were also drawn up for comparisons between the other speech ratings and different linguistic levels.

Table 6

Association of comprehension deciles and speech ratings across linguistic levels

Phonetic Speech Rating	Semantic comprehension		Syntactic comp. (aural)		Syntactic comp. (reading)	
	'good'	'poor'	'good'	'poor'	'good'	'poor'
'mild etc.'	15	5	16	4	15	5
'poor artic.'	8	12	8	12	5	15
	p = .054		p = .022		p = .004	

Semantic Speech Rating	Phonological comprehension		Syntactic comp. (aural)		Syntactic comp. (reading)	
	'good'	'poor'	'good'	'poor'	'good'	'poor'
'informative'	15	3	16	2	14	4
'uninformative'	5	13	7	11	5	13
	p < .006		p = .004		p = .006	

Syntactic Speech Rating	Semantic comprehension		Phonological comprehension	
	'good'	'poor'	'good'	'poor'
'grammatic'	16	9	16	9
'agrammatic'	3	12	4	11
	p = .016		p = .048	

From the above tables it seems that, though the phonetic rating in speech was associated with the syntactic comprehension scores as well as the phonemic comprehension scores, it was less associated with semantic comprehension. The syntactic ratings for speech also showed some degree of autonomy from the comprehension scores for the other linguistic levels in that the association, though significant at $p<.05$, was not as great as for the semantic ratings for speech. The top right hand cells contain the frequency of subjects whose performance would have been that predicted for Wernicke's aphasics - good syntactic ratings in speech, but poor semantic and phonological comprehension - but there were not sufficient of them to outweigh the overall trend for association of syntactic speech ratings with grading for severity in comprehension. Similarly, the bottom left hand cells for the phonetic rating give the frequency of subjects who would conform to the picture of a Broca's aphasia with articulation difficulty but with retained comprehension; the trend suggests that semantic comprehension is more often retained in such patients than is syntactic comprehension assessed through reading. It would seem that the association of the phonetic rating for speech with the phonological comprehension deciles conceals more than overall severity: the findings are compatible with the classical association of articulation difficulties with syntactic impairment (in this case in comprehension) and better retention of lexical-semantic knowledge.

To examine further the association of semantic and syntactic ratings for speech with semantic and syntactic deciles for comprehension, the predictions were examined that the higher ratings for speech for lexical-semantic 'informativeness' would be associated with a trend for lower deciles for errors on semantic comprehension than on syntactic (i.e. as in the classical picture of Broca's aphasia), and that higher ratings for grammaticality in speech would be associated with a trend for lower deciles for errors on syntactic comprehension than on semantic comprehension (i.e. as in Wernicke's aphasia).

Table 7

Association of speech ratings for syntax and semantics with relative degree of impairment in syntax or semantics in aural comprehension

Speech Rating	Number of LBD with lower error deciles in comprehension for Syntax-aural (than Sem.)	Semantics (than Syntax)	Speech Rating	Number of LBD with lower error deciles in comprehension for Semantics (than Syntax)	Syntax-aural (than Sem.)
'agrammatic'	1	2	'uninformative'	1	0
	1	2		3	1
	1	0		2	1
	3	2		2	2
	0	0		2	1
	1	0		1	1
'grammatic/paragram.'	1	1	'informative'	0	1
	2	2		1	3
	0	5		1	2
	1	3		4	1
	4	4		2	1
	(4 subjects with equal difficulties in syntax and semantics omitted, therefore n = 36)			(4 subjects with equal difficulties in semantics and syntax and 4 unrated subjects omitted, therefore n = 32)	

The trend was significant only for informative speech (ratings 6 to 10) to be associated with lower error deciles for semantic comprehension than for syntactic comprehension (Kendall's Sc = -35.5, z = 1.918, p = .027). This is compatible with the picture of continuing difficulties with syntactic comprehension but improving abilities in semantic comprehension as speech becomes semantically informative. But the group of patients with uninformative speech, i.e. who made the semantic paraphasias and circumlocutions associated with Wernicke's aphasia, appeared to have more difficulty with the comprehension of the aural syntax test than with the semantic test. When rated on grammaticality in speech, the more fluent aphasics (who included those with mild aphasia as well as some with severe semantic paraphasia) also appeared to have more difficulty with auditory comprehension of syntax than with the Semantic Field test. A similar table was drawn up for comparison of deciles using the reading version of the syntax test.

Table 8

Association of speech ratings for syntax and semantics with relative degree of impairment in syntax and semantics in reading comprehension

		Number of LBD with lower error deciles in comprehension for Syntax-reading than Semantics	Number of LBD with lower error deciles in comprehension for Semantics than Syntax		Number of LBD with lower error deciles in comprehension for Semantics than Syntax	Number of LBD with lower error deciles in comprehension for Syntax-reading than Semantics
0	'agrammatic'	0	3	'unin-formative'	2	0
1		0	3		3	1
2		0	1		2	1
3		2	3		3	1
4		1	0		3	0
5		0	1		1	1
6	'grammatic/ paragram-matic'	1	1	'inform-ative'	1	1
7		1	4		3	1
8		0	5		3	1
9		0	5		4	1
10		4	4		3	0
		(1 subject with tie omitted, n = 39)			(4 unrated subjects omitted, n = 36)	

None of the corrected S coefficients was significant at .05 for these trends, though the trend for agrammatic subjects to improve more on syntax than on semantics as the ranking increased from 0 to 5 reached a probability of .067. Even more than the aural version, the reading version of the syntax test was predominantly more difficult for the patients in every group than was the semantic test, and these data did not, therefore, prove useful in this kind of analysis.

From these results it seems that:

1) agrammatism in speech is associated with difficulties in syntactic interpretation through reading more than through listening;

2) the association of degree of semantic impairment in speech with degree of semantic impairment in comprehension is detectable at the higher speech ratings, but not at the lower, the more impaired patients with semantic deficits in speech being more impaired in aural comprehension of syntax than in semantic comprehension. This corroborates Gregory's claim that in fluent Wernicke-type aphasics a degree of recovery of aural semantic comprehension is achieved early, although speech continues to show a marked semantic disorder;

3) there is a significant association between phonetic (articulatory) ratings in speech with phonemic discriminatory abilities in comprehension, but that there is no such relationship between phonemic comprehension and phonemic disorders in speech ('literal paraphasias') when these are not accompanied by a major phonetic deficit.

1.3.2 Discriminant analysis

Discriminant analysis distinguishes statistically between two or more groups by forming one or more linear combinations of variables into 'discriminant functions'. If there are more variables than are necessary to achieve a satisfactory distinction between the groups, a stepwise procedure can be used to select the most discriminating variables, variables which do not further contribute being rejected. Once a set of variables is found which provides satisfactory discrimination for groups with known membership on the basis of some external criterion, the classification functions derived can permit the categorization of cases of unknown membership. Thus, if a discriminant function can be derived from groups of aphasics who can be independently distinguished by some external criterion, it can be used to classify aphasics whose category membership is unknown. Discriminant analysis thus offers two attractions for the clarification of syndromes in aphasia: firstly it defines a discriminant function/s in terms of the variables used (e.g. which test scores are the most discriminating in terms of the external criterion) and secondly it classifies subjects whose placement by the external criterion is not known. At first glance it would therefore appear to offer a solution for the vexed problem of classification in aphasia.

However, it makes some assumptions which may not be met with data from aphasics; it assumes that the data are normally distributed and that variances are equal. Morrison (1969) cautions against its indiscriminate use: the degree to which violations of these assumptions can be tolerated is not known. It has proved useful, however, for example in experimentation with average evoked potentials (Walter, Rhodes, and Adey 1967, Donchin 1969), and Walter et al comment that "the linear formulas are very complicated functions whose justification must be left to the experts ... since these functions generate the automatic categorizations reported, we regard them as being justified by their fruit". It has been applied in research in speech pathology by Goodglass et al (1966) and Yoss and Darley (1974): Goodglass and his colleagues classified aphasic subjects as Broca, Wernicke or amnesic type on the basis of clinical criteria, and used discriminant analysis to discover which tests of semantic ability showed differences amongst the groups, while Yoss and Darley used it to select the variables which best distinguished two kinds of children with defective articulation.

For the present investigation, it was decided to test whether the results of discriminant analysis and the non-parametric analysis undertaken would be mutually corroborating, and if so, whether it might be possible to make further inferences from the results of the discriminant analysis. Two groupings by external criteria were used so that only one discriminant function could be obtained.

To test the effect of the phonetic rating in speech on the comprehension scores, two groups were defined in terms of their phonetic ratings as low or high: the six members of the low group had phonetic ratings at least 3 points below their syntactic or semantic speech ratings, and the six members of the high group were rated at 9 or 10 for phonetic but, in order to match the other group approximately for overall severity, they each had a syntactic or speech rating of 4 or under. A stepwise discriminant analysis (Statistical Package for the Social Sciences, version 6 - Nie, Hull, Jenkins, Steinbrenner and Bent 1975), using the method of Wilks lambda U statistic, resulted in a discriminant function, the x^2 for which had a probability level of .056. Two out of the tests contributed to the function, the picture version of the Phonological test with a negative loading of 0.502, and the Word Recognition test with a positive loading of 0.681. Group one (low phonetic in speech) had a centroid on this function of -0.439 (i.e. more errors on the phonological test and fewer on the Word Recognition test), with group two having a centroid of +0.439 (i.e. the reverse).

Although the test did not have statistically significant results, at $p < .05$, the trend was in the same direction as the findings from the non-parametric analysis in the contingency tables for a significant relationship between phonetic speech difficulties and scores on the phonological comprehension test. Out of all the tests of auditory comprehension included in the analysis (EPVT, TT, Syntax Picture, Syntax Gesture, plus Semantic Field and Word Recognition), the analysis selected the Phonological test and the Word Recognition test as contributing most to the discrimination between the groups, thus corroborating the association of phonetic impairment in speech with the Phonological test.

To test the effect of the syntactic rating for speech on the comprehension scores, two groups were defined in terms of their syntactic ratings as agrammatic (excluding the two women without speech, n = 11), and as grammatic or paragrammatic (n = 6). For this analysis, the two control tests of Raven's Matrices and Photo recognition were included. The resulting discriminant function had an x^2 which was significant at $p = .008$ and which correctly identified 100% of the 17 subjects. Its coefficients were as follows:

Photo test	-.087
Token Test	+.359
Syntax Pictures (aural)	-.294
Syntax Pictures (reading)	+.088
Syntax Gesture	-.202
Semantic Field	-.070
Indefinite Article	+.088

The centroid for group one (agrammatic) was +.152, and for group two was -.279. The separation of the two groups in the two-dimensional space was therefore not great. Group one was characterised by better abilities (positive loading on a negative function for errors) on the photo test, the Semantic Field test and the two aural syntax tests (picture and gesture), and by worse abilities on the Token Test, the Indefinite Article test and the reading version of the Syntax Picture test. The agrammatism in speech was therefore not clearly identified with a syntactic factor as such in comprehension. As with the non-parametric analysis there was a discrepancy between the results for the aural and reading versions of the Syntax Picture tests with impairment on the reading version being associated with agrammatism in speech. The aural version was more aligned with scores on the Semantic Field and photo tests, compatible with the finding from the non-parametric analysis that patients with 'uninformative speech' (Wernicke-type) were impaired on aural syntactic comprehension. The discriminant analysis classed 11 of the ungrouped aphasics as belonging to group one, and the remaining 12 as belonging to group two. Contradictory to prediction, however, the speech syntax ratings for these additional members to group one was nearly as high as that of group two (a mean of 6.818, compared with a mean of 7.167 for the additional members of group two). Although group one was originally defined in terms of agrammatism, this label could, therefore, not be extended to all members of the enlarged group. The lack of separation of the two groups' centroids on the discriminant function makes their definition in terms of clear labels too difficult.

In order to identify the nature of the semantic impairment, use was made of the fact that a number of the RBD subjects were significantly impaired on the semantic tests of comprehension (this analysis, therefore, is not a direct test of the relationship between speech and comprehension at the semantic level). The two groups were defined in this way: group one consisted of 13 RBD subjects with an impairment restricted to semantic comprehension, defined as making 10 or more errors on the Semantic Field test and 10 or fewer errors on the Syntax Picture Aural test; group two consisted of nine LBD subjects with a bias towards syntactic impairment in comprehension, defined as making 12 or more errors on the syntax test and 19 or fewer errors on the Semantic Field test. The discriminant function which distinguished these two groups was significant at $p<.001$, and the centroids of the two groups were separated by +.488 (group one) and -.705 (group two). The function misclassified one LBD subject as belonging to the RBD group, giving a correct classification of 95.45%. It was characterised by these coefficients:

Photo test	+.187
Token Test	-.258
Syntax (reading)	-.470
Semantic Field	+.127

In the secondary classification, of the ungrouped RBD subjects, it correctly classified all but one as belonging to group one. Of the 31 ungrouped LBD 12 were classified as group one, and 19 as group two. In this way the total LBD group was subclassified into 12 with a 'semantic comprehension deficit' defined in terms of the quality of deficit in the RBD, and 28 with a 'syntactic + semantic deficit' supposedly more characteristic of left brain damage. The function distinguishing these two groups showed that the 'semantic' type were higher on photo recognition errors and Semantic Field errors, and the 'syntactic + semantic' type were higher on Token Test errors and errors on the reading version of the Syntax Picture test. The separation of these two empirically derived LBD groups on other measures was then examined through a further discriminant analysis from which the four tests in the previous analysis were omitted (leaving Raven's Matrices, EPVT, the two aural Syntax tests - picture-choice and gesture - the Indefinite Article test, the two Phonological tests and Word Recognition). To see whether the 9 subjects would still match up with the 'syntactic + semantic' group if it was redefined along the parameters of these tests without the original discriminating ones, only the 31 LBD subjects in the secondary classification of the previous analysis were used in order to define the two groups. The discriminant function defined from this new analysis proved also to be significant at $p < .001$, and to separate the centroids of the groups at +.652 (group one) and -.412 (group two). The standardized discriminant function coefficients were:

EPVT	+0.176
Syntax gesture	-0.652
Word Recognition	-0.137

It resulted in 87% correct grouping of the 31 subjects. Of the original 9 LBD in the previous analysis, five, including the woman misclassified on the previous analysis, were reclassified as belonging to the 'semantic' group one type. The discriminant function corroborates the separation of the two groups, with vocabulary, Semantic Field test and photo scores towards one pole and Syntax reading and gesture tests, Token Test and Word Recognition towards the other pole. Although, as has been pointed out, too much reliance should not be put on the results of the discriminant analysis, where its results can be compared with those of the non-parametric analysis, they agree. Tentatively, therefore, an association is suggested between lexical comprehension and visual interpretive abilities, and between syntactic impairment and low scores on verbal gestural and reading tests.

1.4 Discussion

Although inferences can only be made with reservations from discriminant analyses of these kinds of data, the combined results of these and the non-parametric analyses suggest that although there is a relative autonomy of aural syntactic comprehension from syntactic production in speech, comprehension of syntax through reading is more closely associated with the grammatical quality of speech. A simple explanation would be that the reading test was mediated by reading aloud or subvocally, and therefore the syntactic structure of the sentence had to be reconstituted through speech, while comprehension through listening was immediate. This would be more compatible with a theory of direct decoding in aural comprehension than with a theory of decoding-by-encoding (Glucksberg, Trabasse and Wald 1973). At the phonological level the association of phonetic difficulties in speech with errors in phonemic comprehension could be used to support one version of a decoding-by-encoding theory, the motor theory of speech perception. However, Nebes (1975) gives an account of a patient with a severe oral apraxia and a "total inability to speak" who nevertheless showed normal patterns of behaviour on tests of internal vocalisation (recognising rhymes, omitting silent 'e's' on Corcoran's crossing-out test, etc.). He suggests that the different results reported by Luria (1966b), who asked aphasics to hold something in their mouth to prevent overt verbalisation and found that internal vocalisation was also disrupted, could be due to the amount of cortical destruction having made even the most simple verbal processes non-automatic and dependent on kinaesthetic feedback from the speech musculature. A similar explanation can be offered for the present findings, without its being necessary to conclude that speech perception is normally mediated through the same neural mechanisms which are used in speech movements.

It is noteworthy that the experiments which have endorsed the expectation that syntactic impairment in speech is a reflection of a central reduction in syntactic knowledge have so far used printed words as input (Von Stockert 1972, Zurif et al 1972, Kremin and Goldblum 1975, Von Stockert and Bader in press), while those which have suggested that syntactic competence or comprehension may be retained in Broca's aphasia to the same degree as in fluent aphasia have used aural input (Goodglass et al 1972, Gleason et al 1975, Pizzamiglio and Parisi 1970). An early account of agrammatism (Low 1931) reported that the disturbance was confined to reading aloud. Hécaen and Consoli (1973) have commented that comprehension deficits in Broca's aphasia are more exposed with written materials. Gardner et al (1975) also observed that 'anterior' patients found the reading version of their syntactic judgement test harder, and the 'posterior' patients found the aural version harder.

In the overall group results there was a tendency for severity in speech symptoms and comprehension to be linked: the group results could not be used to support a separation into syndromes characterised by poor speech with good comprehension or good speech with poor comprehension. Nor could they be used to support a distinct separation of linguistic levels cutting across both speech and comprehension. With an etiology of stroke, the patients probably had lesions that were more extensive and symptoms which were more mixed than had the head-injured soldiers on whom some classifications into distinct syndromes have been based. Within the present group the disparity between semantic and syntactic levels tended to be less in comprehension than in the speech ratings. Of the individual cases who showed a great superiority of syntax over semantics in speech, only one showed the same in comprehension

(M11 - possibly also F4, F17). In one case (F9) the position was reversed with syntactic comprehension markedly inferior despite marked superiority of syntax in speech. Amongst those with low semantic ratings in speech, as many had good semantic comprehension (M5, M6, F9) as had poor semantic comprehension (M11, M12, F13).

People with low syntactic ratings in speech were as likely to be more impaired in semantic comprehension as they were to be more impaired in syntactic comprehension: there was thus no evidence in this sample of patients for the preservation of lexical knowledge in agrammatism defined solely in terms of speech, as Von Stockert suggests. People with low semantic ratings in speech were also as likely to be more impaired in syntactic aural comprehension as they were to be more impaired in semantic comprehension. It would appear from these findings that at severe levels of impairment both linguistic levels are impaired in association. This does not endorse Von Stockert and Bader's claim (in press) that severely impaired global aphasics can be distinguished as Broca-type and Wernicke-type according to whether they arrange cut-up sentences by lexical content or by morphological inflections, indicating selective impairment at either the syntactic or semantic level. At the higher speech ratings for semantics, semantic comprehension improved significantly in parallel with the improvement in speech. But at the higher speech ratings for syntax, syntactic aural comprehension did not improve significantly in parallel with the higher speech ratings. The fluent speakers may still have difficulty with aural comprehension of syntax (a result compatible with the classical picture of aural comprehension difficulties in fluent Wernicke's aphasia).

2. The lateralization of language

2.1 Background: hypotheses

In 1861 Broca demonstrated to the Society of Anthropology in Paris that injury to the frontal lobes of the brain could result in permanent loss of the "faculty of articulated language", and that the injury was probably in the second or third frontal convolution. By 1863 he had become more certain that it was the third convolution which was the site of the critical lesion; and in 1865 he defined the site further to the Society by presenting evidence which "it is impossible to deny" that "the left hemisphere plays a preponderant role in articulated language" (Broca 1865, reprinted in Hécaen and Dubois 1969, page 118). Although, as he reported, statistical investigations had shown that right brain injury was about as frequent as left brain injury, some 19 out of 20 'aphemics' had left brain lesions. The asymmetry of the human brain for language, first proposed by Dax in 1836 but without the impact of publication given to Broca's statement, has been repeatedly confirmed since; ideas about the character of this lateralization have developed and may currently be categorized as centering on the four notions, which are listed below, and will then be explicated further.

1) The first emphasises the lateralization of language in its entirety in the normal human brain, stressing the distinction between 'verbal' abilities in the left hemisphere and 'non-verbal' in the right. The assumption is that all language processes are undertaken by the left brain, the specialism extending even to subcortical structures, and that the right brain is completely

non-verbal. This notion is the basis for several hypotheses of differences in functional organization in the two cerebral hemispheres.

2) The second proposes (as Broca did) that the executive skills of language are controlled by the left brain (speaking and writing), but allows that the right brain understands language and therefore shares in linguistic competence. The possibilities are threefold: each hemisphere can process language independently; both necessarily participate in comprehension (in non-pathological conditions); or the left brain is superior in comprehension in normal functioning but the right hemisphere, normally inhibited, participates when the left becomes overloaded and if the task is complex.

3) The third stresses individual variations in the lateralization of language. It proposes a continuum of degrees of specialization of the left hemisphere, with a reversal of dominance for language in some individuals, and links this continuum with degrees of lateralization of manual skills, with age (in children and, according to one theory, throughout the whole lifespan) or with sex.

4) The fourth draws attention to the uses to which language is put, and proposes that different functions of language are differentially lateralized, the left brain having superiority for propositional but not emotional, reactive language.

2.1.1 Left brain verbal, right brain non-verbal

The evidence for this is anatomical, physiological, pathological and psychological.

The left hemisphere is, in a majority of brains, somewhat larger than the right in the area which is usually associated with language processing (Geschwind and Levitsky 1968, Whitaker and Selnes 1975), and anatomical and cytological differences in this area have even been found in the brains of stillborn babies for whom there is no question of specialization for language having been acquired through learning (Witelson and Pallie 1973). Such an observation tempts the speculation that the 'language acquisition device' proposed by McNeil (1970) has an anatomical correlate.

In the living brain electroencephalograms have indicated specialization of the left hemisphere for verbal activities. McAdam and Whitaker (1970) found a negative shift in DC potentials which was more marked on the left than the right fronto-temporal area, just before subjects pronounced speech sounds, but not just before they produced similar non-verbal sounds such as coughing. Galin and Ornstein (1972) report a greater ratio of right to left hemisphere power in recordings from temporal and parietal scalp areas when writing a letter or mentally composing one (i.e. greater involvement of the left hemisphere in the task) than when assembling or mentally devising spatial patterns.

Although Grabow and Elliott (1974) have attributed the effects found in McAdam and Whitaker's study to the artifacts of the glossokinetic potential in preparation for speech, Grözinger, Kornhuber and Kriebel

(1975) found that there was still evidence of interhemispheric asymmetry of brain potentials even when a number of artifacts including the glossokinetic potential were accounted for. Wood (1973) was able to demonstrate a difference in potentials when speech was heard, rather than produced; he concluded that phonetic processing was distinct from non-verbal auditory processing. In newborn human babies the right hemisphere shows electroencephalographic responses to rhythmic lights (photic driving) before the left (Crowell, Jones, Kapnuiai and Nakagawa 1973), suggesting an early specialization of the right hemisphere for visual abilities.

Physical interference with the live brain has also demonstrated that electrical stimulation disturbs speech when electrodes are inserted into certain areas of the left brain (Penfield and Roberts 1959) or produces auditory hallucinations (but never evokes speech). Injection of sodium amytal into the left internal or common carotid artery disrupts counting and naming in the great majority of people when similar injections to the right artery do not (Wada and Rasmussen 1960). Blume, Grabow, Darley and Aronson (1973) describe a quick test for aphasic-like behaviour during the twelve minutes or so after such injections while the patient is alert but not yet fully recovered: auditory comprehension is measured by asking the subject to "Stick out your tongue", "Wiggle your tongue from side to side", and to "Blow", and reading is tested through recognition of the printed words 'horse', 'tree' and 'sheep' (the method of response, speech or pointing to pictures, is not described). Bogen and Gordon (1971) report gross disturbance of singing after right carotid injection, and in five out of six cases slight slowing and slurring of words and the presence of some monotonicity, but no other effect on speech. Interference with the live brain by electroconvulsive therapy has also shown that shocks to one side of the brain disturb the ability to give a name for a definition and that this can be used as an index of laterality (Warrington and Pratt 1973).

Much of the evidence for specialization between the hemispheres for the perception of language comes from studies using either dichotic listening or hemifield viewing. Kimura (1961) explained the right ear advantage for verbal material under dichotic listening by assuming that contralateral projection is more effective than ipsilateral and that language material is processed in the left hemisphere. Sparks and Geschwind (1968) agree with this explanation, though they extend it to the statement that the neural projections used under these circumstances are exclusively (not just primarily) contralateral, and hence verbal information projected to the right hemisphere becomes degraded or at least delayed by its passage secondarily to the left hemisphere. Both models assume that language is not processed by the right hemisphere. Kinsbourne (1974) describes experiments by Morais and Bertelson which show that an effect of right ear advantage is still found when two loudspeakers placed one to the hearer's left and one to the right give conflicting messages although both ears receive both messages. Kinsbourne explains this in terms of alerting of the left hemisphere by verbal activity biassing the subject's attention.

Utilizing the fact that fibres in the optic nerve cross at the optic chiasma in such a way that the left visual field of both eyes (i.e. sensed by the right halves of each retina) is relayed only to the right hemisphere and the right visual field only to the left, hemi-field viewing has been used to test differences of function in the hemispheres. Again a superiority for verbal material is found for material presented to the left hemisphere (see reviews by White 1969, 1973). Use of this technique is also reported for the investigation of the side of laterality of brain damage (Beaumont and Dimond 1973).

Arising from this overwhelming evidence for the superiority of the left hemisphere in the majority of right-handed people for verbal processing, several theories have been proposed which attribute different qualities to left and right hemisphere functioning. Bever and Chiarello (1974) summarize them as the left hemisphere's being propositional, analytic and serial and the right hemisphere's being appositional, synthetic and holistic. Semmes (1968), from comparisons of the sensorimotor capacities of the hands in people with unilateral brain injuries, has proposed that the left hemisphere is organized focally, and the right diffusely;

> "Focal representation of elementary functions in the left hemisphere favors integration of similar units and consequently specialization for behaviors which demand fine sensorimotor control, such as manual skills and speech. Conversely diffuse representation of elementary functions in the right hemisphere may lead to integration of dissimilar units and hence specialization for behaviors requiring multimodal coordination such as the various spatial abilities". (Page 11)

Nebes (1971, 1974) observed that many analyses of differences in the hemispheres have in common that they assign to the major hemisphere the task of sequentially analysing sensory input and abstraction of relevant details, while the right hemisphere attends to the overall configuration and synthesizes fragmentary chunks into a meaningful percept. In confirmation he found that, in split-brain patients, the right hemisphere was significantly better in a task where part-whole relationships had to be recognized, i.e. a whole figure had to be recognized from a fragment. A similar distinction of abilities in the hemispheres has been expressed by Cohen (1973) as being one of serial and parallel processing. She identified serial processing as being detectable through a greater number of items taking a longer time to be processed, while in parallel processing reaction times are unchanged by increase in number of items. Tachistoscopic projection of linguistic material to each hemisphere (alphabet letters) was compared to projection of other typewriter symbols which could not be so easily verbalized. For these 'unnameable shapes' both hemispheres appeared to process in parallel, but for the alphabet letters the left hemisphere only processed in series;

> "if verbal analysis forces a serial procedure while visuo-spatial analysis permits parallel processing, then the results can be explained in terms of the lateralization of these modes of analysis". (Page 349)

Several pieces of evidence have been found which support this notion, in that brain-damaged people with left sided lesions show an inferiority to those with right sided lesions in tasks which require serial processing (see Section 3). Somewhat different analyses have been offered by Gardner and Denes (1973) and Gainotti (1972). Gardner and Denes suggest that the left hemisphere operates in an all-or-none fashion like a digital computer, while the right hemisphere is sensitive to details and responds to degrees of change, like an analogue computer (and hence to nuances of connotative meaning). Gainotti expresses the contrast between the hemispheres as between conceptual and elaborative processing in the left and emotional and immediate in the right. Broadbent (1974) cautions against oversimplifying interpretations of specializations of the two hemispheres, and draws attention to a number of studies in which processes sometimes thought to be undertaken separately in different hemispheres have apparently interfered with each other, e.g. remembering alphabet letters interferes with reaction times to stimulation of the fingertips of the left hand). Nevertheless, he hazards speculation that:

> "the processes that are differentiated between the so-called major and minor hemispheres are those of categorizing changes in the environment on the one hand and sustaining the continuing representation of the environment on the other" (page 40).

2.1.2 Speech is strongly lateralized, but comprehension is bilateral

Broca continued his comments on the preponderance of left hemisphere damage with aphemia (aphasia) by saying:

> "That is not to say that the left hemisphere is the exclusive seat of the general faculty of language, which consists of the establishing of a specific relationship between idea and sign, nor is it even of the particular faculty of articulated language, which consists of establishing a specific relationship between idea and articulated word; the right hemisphere is no more foreign than the left to this special faculty, and what proves this is that an individual rendered aphemic by a deep, extensive lesion in the left hemisphere is generally deprived only of the ability to reproduce for himself the articulated sounds of language; he continues to understand what is spoken to him, and consequently he is perfectly aware of the connections of ideas with words. In other words the faculty of conceiving these connections belongs at one and the same time to two hemispheres, which can compensate for each other in case of injury; but the faculty of expressing them in coordinated movement, which is only acquired after very long practice, seems to belong to one hemisphere only, which is nearly always the left hemisphere" (1969, page 115, translated).

Wernicke's discovery shortly afterwards of 'rare' cases of inability to understand language after lesions of the temporal lobe appeared to cancel out Broca's observations that the aphasic always continued to understand language because the right hemisphere was capable of sustaining this. Recent evidence has, however, given some support to Broca's original hypothesis.

Studies of some 16 patients in California in whom the corpus callosum has been severed to alleviate otherwise intractable epilepsy have suggested that, in most of them, the disconnected right hemisphere is capable of some verbal comprehension (Gazzaniga and Sperry 1967, Sperry and Gazzaniga 1967, Gazzaniga 1970, Sperry 1974). The right hemisphere cannot initiate a speech response (thus confirming the lateralization of speech), but by initiating a pointing response with the left hand it can apparently show comprehension of the names of objects, and even make semantic associations (i.e. select a coin for 'something which is kept in the bank'). This right hemisphere ability to decode speech contrasts strikingly with its absence of control over speech output. Anderson and Jaffe are cited by Kinsbourne (1974) as even suggesting that some people habitually decode speech with their right rather than with their left Wernicke's area. He also comments that:

> "If a right-ear advantage in verbal dichotic listening is accepted as indicating left hemisphere lateralization of language, then the fact that only about 75% of right handers show a right ear advantage would, taken literally, indicate right hemisphere dominance for decoding speech input in far more people than have right hemisphere dominance for encoding speech output" (page 267).

In a small sample of aphasic subjects, retention of language competence by the right hemisphere has been demonstrated and its secondary acquisition of control of speech: intracarotid injections of amytal on the right side disrupted their recovered speech, though left sided injections did not, yet clearly speech had initially been lateralized to the left hemisphere because it was injury to the left brain which had produced the aphasia (Kinsbourne 1971).

Despite such evidence from exceptional cases, not everyone would agree that the right hemisphere has any linguistic competence. Although she describes in one paper (1974a) right hemisphere comprehension of language in terms of auditory Gestalten matching up with phonological shapes of words in long term memory, Levy (1974b) considers that "the functions of the two hemispheres seem to be logically incompatible" (page 180) and therefore each cannot be duplicated in the other. The right hemisphere is a concrete spatial synthesiser which maps into a visuoconstructional realm all material, whether nameable or not, while the left hemisphere is an abstract temporal analyser which maps stimulus input into semantic and phonemic realms whether pictorial or not. Perceiving words as auditory Gestalten, even though, through this, meaning is recognised and acted upon, seems to be considered by Levy as essentially non-linguistic.

Carhart, however (Hirsh 1967), argues that the fact that dichotic presentations can be selectively attended to means that the stimuli are kept separately and that the right hemisphere is therefore capable of some linguistic processing. Further evidence comes from adults who have had a hemisphere removed presumably after normal acquisition of lateralization in childhood. (Child left hemispherectomees, like other unilaterally brain injured children, make somewhat suspect witnesses for evidence of lateralization. According to some statements, they can acquire normal language, particularly if the damage is extensive enough to reverse lateralization completely and if the trauma occurs early in life - Annett 1973, Gott 1973, Basser 1962, A. Smith 1974). Amongst the deductions made by Smith (1969a) reporting on a 47 year old man whose left hemisphere (dominant for language) was removed to excise a tumour, was that:

> "Adult hemispheric functions differ quantitatively rather than qualitatively, with a markedly greater role of the left hemisphere in speech, reading and writing (but not verbal comprehension) than that of the right in nonlanguage or visual ideational functions. Each adult hemisphere alone is capable of performing in more limited and varying degrees those functions in which the opposite hemisphere is specialized". (1969b, page 444)

The ability to comprehend speech by this patient, which was the least impaired modality initially, showed striking and continuing improvement until recurrence of the tumour. The marked recovery of auditory comprehension to nearly normal levels was reflected in clinical studies and in increasing scores in Peabody Picture Vocabulary Tests (98 at 13 months postoperatively, and surpassing a score of 95 by another patient examined 15 years after a right hemispherectomy). These findings are compatible with the quick recovery of picture comprehension vocabulary reported in Wernicke's aphasia by Gregory (1975).

Much of the evidence adduced for the strict lateralization of language to the left hemisphere is not, when examined closely, incompatible with the hypothesis that the right hemisphere has some verbal competence for comprehension. Dichotic and hemifield experiments typically reveal a right ear or right field advantage (Kinsbourne 1974), but superiority does not necessarily imply that no processing has taken place in the right hemisphere (in many tests of hemifield superiority the subject is asked to name a central fixation symbol before the lateralized word - such a practice would, if Kinsbourne is correct, bias the results by activating the hemisphere responsible for speech). Similarly, after right sided amytal injection, the patient can usually obey written and spoken commands which do not require speech (Rossi and Rosadini 1967, Milner 1967, Kinsbourne 1971). Moscovitch (1973, 1976) proposes a functional localization model which stipulates that the hemisphere which is functionally superior for an ability suppresses the potential in the other hemisphere, which can, however, execute it if this control is for any reason released. The suppression can take the form of inhibition, interference, bypassing or competition. For the motor control of speech where delicate timing of bilaterally innervated movements is needed, competition between the hemispheres would be a serious disadvantage (and perhaps would result in symptoms which are found in some kinds of stuttering); but for comprehension some sharing of processing would be advantageous (though incomplete lateralization has been suggested as a cause of developmental dyslexia, Zangwill 1975). Because responding by the hand innervated by the 'specialist' hemisphere is not faster than responding by the other hand, which has presumably to have instructions relayed back to it from the specialist hemisphere, Moscovitch (1976) concludes that in the intact brain verbal comprehension is completely suppressed in the right hemisphere; if the right hemisphere participated at all in the experimental comprehension tasks given (letter matching and phoneme comparison) responses with the left hand to left visual field presentation would have been faster than responses with the right hand. Callosal section or hemispherectomy or drugging of the left hemisphere releases the right hemisphere's capacities for verbal comprehension from this suppression, he suggests. Butler and Norsell (1968) suggested that vocalisation could be initiated by the right hemisphere in a callosally sectioned patient, albeit after some delay, perhaps due to its release from inhibition. Kinsbourne (1970, 1975) advances a similar proposal: in the normal brain the linguistic capacities of the right hemisphere are inhibited by the left, presumably through the mediation of the corpus callosum, and the attentional ascendancy of the left hemisphere over the right for verbal material has a cumulative effect on the potential verbal competence as dominance increases during childhood.

2.1.3 Individual differences

All studies of the human brain are compounded by individual differences of functioning, and even of anatomical development. Whitaker and Selnes (1975) have described not only wide variations in the development of cerebral arteries, but even a case where motor and sensory areas of the primary cortex were apparently reversed. It is not surprising that lateralization of language is also considered to be subject to individual variation.

The main candidate for accounting for some stable individual differences in lateralization is handedness. Handedness itself is not an all-or-none phenomenon, and besides pure left-handers and pure right-handers there is a proportion of people with mixed preferences for motor skills between the left and right side (Annett 1967, Studdert-Kennedy and Shankweiler 1972). Thompson and Marsh (1976) put the proportion of the ambidextrous at 32.6%. Goodglass and Quadfasel (1954) concluded that there was no one-to-one relationship between side of manual dexterity and lateralization of language; but there is evidence that some 16% of left-handers without early brain damage display disturbances of speech after the Wada injection in either hemisphere and therefore presumably have bilateral representation of language (Milner et al 1964). Moreover, aphasia is said to be more frequent after lesions on either side in left handers and also is ameliorated more quickly (Hécaen and Ajuriaguerra 1964). In such cases, disorders of understanding, word deafness and alexia are very rare. There are, however, some reports of 'crossed aphasia' in right handed people after right hemisphere lesions (Brown and Hécaen 1976). Zangwill (1960) has described dominance for language as a graded characteristic varying in scope and completeness from individual to individual. Luria (1966a) also proposes that "the degree of dominance of one hemisphere in relation to lateralized processes such as speech varies considerably from case to case" (page 89). Studdert-Kennedy and Shankweiler (1972) have shown that the size of the ear advantage in a dichotic task of listening to stop consonants covaries significantly with the degree of measured handedness and suggested that dominance "should be viewed as a continuum across individuals" (page 38). Kreindler, Fradis and Sevastopol (1966) describe eight possible ways in which three skills can be partitioned between the hemispheres (motor superiority/handedness, language and visuo-spatial orientation) and cite example cases of all of them deduced from the effects of unilateral lesions. They concluded that these three functions are relatively independent of each other. In part clarification of such inconsistencies, it has been proposed that familial left handers show more degree of bilateral language representation than do left handers without such a family history (in whom traumatic or other environmental rather than genetic influences may have produced the hand preference)

(Bryden 1965, Zurif and Bryden 1969, Hécaen and Sauguet 1971). On the other hand, Newcombe and Ratcliff (1973) suggest that "mixed handers and non-right handers with a family history of sinistrality are more likely than the remaining non-right handed group to have language represented predominantly in the left hemisphere" (page 404). Familial left handedness also seems to be influential on right handed people's lateralization of language (Subirana 1969, Hines and Satz 1971, Hannay 1976a).

A second variable which has been proposed as influential on the lateralization of language is age. It is not disputed that brain lesions early in life often do not have the damaging permanent effects on language that do similar lesions in adults and Lenneberg (1967) and Kinsbourne (1975) have suggested that the brain retains some plasticity for compensation by the uninjured hemisphere up till puberty, although a major amount of lateralization occurs before 36 months. A recent study by Smith and Sugar (1975) of a young man now in his twenties who had suffered left hemispherectomy at age 6 suggests that acquisition of superior verbal and performance skills can continue, even in one hemisphere, well on into adulthood. Brown and Jaffe (1975) suggest that lateralization of receptive speech continues throughout adult life as a continuous process of differentiation and specialization. Hence disorders of comprehension in aphasia after left-sided lesions are more common in an elderly population than in the middle aged. They extend their hypothesis to suggest that even within the left hemisphere there is continuing specialism of structure and areas for language abilities through the lifespan. However, the complexity of the situation is illustrated by an experiment by Molfese, Freeman and

Palermo (1975) in which it was found that cerebral asymmetry in auditory evoked responses declines with age to non-speech stimuli and to speech stimuli, again supporting observations of a preprogrammed ability at birth or very early in life to differentiate between verbal sounds. They suggest that cerebral asymmetry declines with the myelination and maturation of the corpus callosum. Aphasia in children, which one might have hypothesized would produce symptoms like that in an adult familial left hander, in fact does not entirely. Disorders of comprehension occur in about a third, but , as with left handers, motor disorders predominate and agraphia is frequent (Hécaen 1972).

A third variable whose influence is less clear is sex. To some extent this interacts with age as girls mature earlier than boys, and acquire verbal skills at a younger age (Buffery 1970, Taylor and Ounsted 1972). Buffery and Gray (1972) review a number of studies which show that girls are superior to boys in verbal fluency, articulation and grammar, while boys are often found to be superior in verbal comprehension and verbal reasoning. They propose that an innate 'linguistic device' for speech perception develops earlier in females than males; as Kimura (1963) has demonstrated, girls earlier show a right ear advantage for verbal materials in dichotic listening. Buffery and Gray also cite some evidence for greater anatomical asymmetry for structures in female brains than in male brains. Buffery and Gray propose that females have relatively more specialization of the hemispheres for visuo-spatial or verbal abilities, and that the male advantage in visuo-spatial tasks is due to their more bilateral representation of this ability. Marshall (1973), however, comments that the evidence for biologically determined sex differences in visuo-spatial ability is far from conclusive. Whatever the underlying variations in dominance, there is a known higher incidence of language disorders such as stuttering and dyslexia in boys than in girls. The literature is sparse on sex differences in the effects of brain lesions in adults. Although there is a higher incidence of stroke in men than women at all ages (Matsumoto et al 1973), possible differences in incidences of language disorders after stroke in men or women do not seem to have been explored. Brown and Hécaen (1976) report a higher incidence of aphasia in women than men after a left hemisphere lesion, but only in left handers, not right handers. Buffery and Gray comment that the theory that female brains show earlier and stronger lateralization of verbal abilities than male predicts that after left brain injury girls should be slower in compensatory development, but no experimental evidence seems yet to have been produced. Even the theory is insecure: Hannay (1976b) proposes that there is less complete lateralization of linguistic and spatial functions in females than in males. He found a right visual field superiority only for men for short term retention of verbal material (vertical nonsense words).

These are only three of the variables that have been pointed out as affecting individual lateralization of language. Gloning and Gloning have advanced the hypothesis of less marked lateralization in polyglots (cited by Hécaen 1972). Marshall (1973) comments that when laterality is measured it is also influenced by the strategy which the individual subject brings to the task: such things as cognitive style or 'imaginal type' might be related to the pattern of observed deficit after brain injury. A major problem in clarifying the situation is that experimenters often do not take into account possible influences of the kind of linguistic tasks that are given, but treat any sample of language as providing evidence which can be extrapolated to all language. The next two sections describe theories which take into account the kind of language.

2.1.4 Differential lateralization of propositional and emotive language

Baillarger (1865 reprinted in Hécaen and Dubois 1969) described an incident in which an aphasic woman who was without speech recovered it suddenly in a fit of jealousy over her husband's behaviour, only to lose it when she became calm. The left hemispherectomised aphasic patient examined by A. Smith (1974) is described as, after struggling to organize a meaningful reply, uttering expletives and short emotional 'nonpropositional' phrases: "he also spontaneously articulated words and short phrases but could not communicate an idea in speech" (page 15). This is not an unusual circumstance in severe aphasia. Jackson (Taylor 1958 page 130) hypothesised that the left hemisphere controlled propositional speech, the ability to use symbols to express thought, while the right hemisphere controlled emotional speech. It has already been commented that Gainotti (1972) has more recently suggested that the right hemisphere is the emotional hemisphere, and there is a little tentative experimental support for this. Rossi and Rossadini (1967) have commented on emotional reactions after Wada injections. Using dichotic listening Haggard and Parkinson (1971) found a left ear advantage for emotional words. With the same technique, Van Lanckner (1972) found that there was no right ear advantage for automaticcliches and swear words, and that mishearings by the left ear were more often reported as automatic or swear words, while mishearings by the right ear were more often reported as being propositional words.

2.1.5 Differential lateralization of linguistic levels

Added to the four 'historical' notions about lateralization we may propose a fifth one. Like the fourth topic just mentioned, this draws attention to the heterogeneity of language, rather than treating it as a unit which is functionally lateralized in its entirety either completely or to varying degrees but still homogenously, or is distinguished only in behavioural terms of production and perception. Unlike the fourth one it makes the distinctions in language not in terms of functional usage or emotional content, but in terms of linguistic structure.

The evidence is somewhat piecemeal. Gazzaniga (1970) suggested that the right hemisphere in split-brain patients finds it easier to understand nouns than verbs or than nominalizations from verb bases (e.g. 'butter' is more easily understood than 'smile' or 'teller'). Gazzaniga gives only a few examples of the material which he used, did not control for word frequency, and there may have been some question of ipsilateral sensory feedback or non-callosal cross-cuing. In contrast, Caplan, Holmes and Marshall (1974) have produced evidence from normal subjects which could be interpreted as indicating a right hemisphere superiority for agentive nouns (such as 'teacher', 'helper') or words of ambiguous syntactic class (such as 'order', 'butcher') rather than for 'pure' nouns (such as 'danger' and 'grocer'). Zaidel (in press b) has also been unable to support Gazzaniga's claim of part-of-speech being influential in the right hemisphere. The apparent incompatibility between this and the earlier split-brain findings may be explained by the methodological inadequacies of the latter, or perhaps by the possibility that the mode of operation of the split-brain is radically different from the intact brain (Caplan et al 1974). Marshall, Newcombe and Holmes (1973) have suggested that, while the left hemisphere is organized in such a way as to give preferential access to nouns irrespective to a considerable extent of their frequency, the right hemisphere gives preferential access to high frequency items irrespective to a considerable extent of their part of speech. Marshall, Newcombe and Holmes (in press) suggest that superior recognition of nouns over verbs by the left hemisphere in normal subjects is not primarily due to their part of speech, but to the number of underlying relationships in which they can participate. 'Give' and 'gift', for example, imply three entities: donor, recipient and object given. Although nouns, verbs and adjectives can each individually have differing numbers of implied relationships or 'place functions' inherent in their meaning, it so happens that more verbs than nouns tend to have triple or double place functions involved than single functions. The apparent increase in difficulty for verbs can, therefore, be conceptualized as due to the greater complexity of the number of base structures into which lexical items can enter which happens to be greater for verbs on average than for other substantive parts of speech. We could extrapolate from this to suggest that the right hemisphere is not influenced by these sentential implications in the same way as is the left.

Further work with commisurectomised patients has corroborated the relative insensitivity of the right hemisphere to sentence structure.

Gazzaniga and Hillyard (1971) reported that the only syntactic dimension the right hemisphere could decode with certainty was the negative-affirmative one. It failed with reversible active sentences, with the passive, with contrasts of present and future tense and with singular-plural noun plus verb inflections. (The task was to choose an alternative spoken sentence for a picture flashed tachistoscopically and the experimenters do not say whether they controlled for pictorial complexity.) The enterprising invention of a piece of apparatus which allows for prolonged presentation of material to one visual field (a stabilized projection on to the retina using a contact lens - see Zaidel 1975) has allowed the use of long standard tests with split-brain patients, thus permitting direct comparisons of the right hemisphere function with test norms. Zaidel (in press, a) reports that the disconnected right hemisphere has virtually no ability to understand the sentences in the Token Test, but that (Zaidel, in press, b) it has a fair comprehension vocabulary, which can range from that of an 8 to a 16 year old child (mean 11.7 years).

These results are compatible with the speculation that the right hemisphere is little involved in syntactic organization but that semantic aspects of language may be less lateralized than other aspects of language. Liberman (1974) has suggested that 'grammatical reading' from deep to surface structure in syntax, and from surface to phonetic in phonology, requires specific mechanisms in the left hemisphere. By implication, what he calls the "other end of the language system", semantic and cognitive representation, is not so specifically lateralized.

When the evidence for the lateralization of language is re-examined from the perspective of the linguistic levels, it appears that there are most studies at the phonological level. Milner, Taylor and Sperry (1968) and Sparks and Geschwind (1968) demonstrated that the right hemispheres of split-brain patients were almost totally incapable of extracting phonetic information from the left ear member of dichotically presented digits, and Zaidel (1974) repeated this finding with nonsense syllables. Levy (1974a, b) also showed that although the right hemispheres in such patients could recognize names of objects, they were unable to recognize that these names rhymed with other words. Pizzamiglio has reported similar findings (1975). In an application of the dichotic listening technique to unilaterally brain damaged people, Oscar-Berman, Zurif and Blumstein (1975) tested whether or not duplicating phonetic information to the two ears facilitated performance. Normal subjects and right hemisphere damaged subjects did profit when the two inputs shared the feature of place or voice (e.g. /pa/ and /ba/ or /ta/), but left hemisphere damaged did not. The findings were interpreted as supporting the hypothesis that there are special lateralized linguistic decoding mechanisms which transform auditory dimensions such as pitch, loudness and timbre into phonetic features (Studdert-Kennedy and Shankweiler 1970). With monaural presentation there is a right ear superiority with right hand responses when the task is to distinguish an initial phoneme in a syllable, and when the task is to identify the whole syllable there is none (Bever 1976).

As Zurif (1974) comments, there have been fewer studies of the higher levels of language organization, the syntactic and the semantic, using dichotic presentation, because with the greater number of linguistic features present it is more difficult to isolate the effects of each feature individually. In his review of prosodic and syntactic factors in auditory lateralization, Zurif describes an experiment by Clark which adapted to dichotic presentation the technique of insertion of clicks into sentences at or near constituent boundaries. Clark found that subjects typically 'heard' the click as at the constituent boundary when they attended to a sentence in the right ear, but not when they attended to a sentence in the left ear, though this effect was only obtained when the sentences were given with normal intonation rather than monotonically. Zurif summarizes a number of monaural studies of interactions between ear of listening and grammatical complexity by saying:

> "those investigators who have not obtained laterality effects with monaural presentation have used a series of lexical items, whereas the few who have found a significant right ear advantage have used sentences" (page 400)

although he mentions one exception (Bakker 1970). Furthermore, monaural experiments by Bever (1971) discovered hemispheric asymmetry for structured sentences but not random word strings, although Bever and Zurif prefer to interpret this as a possible superiority of the left hemisphere for inductive, non-grammatical strategies in speech comprehension. In a later paper, however, Zurif (Caramazza and Zurif, in press) proposes that just these strategies are retained in Broca's aphasia.

Evidence at the semantic level for hemispheric specialization is even sparser. Levy (1974b) describes a split-brain patient who could arrange plastic letters with her hidden left hand into "a sensible word" at a level far beyond chance, though it is not clear what ability this was tapping in the right hemisphere: the lack of co-operation of the left hemisphere's speech mechanisms is demonstrated by the fact that she could not name the spelled words she had produced. Levy found a left hemisphere domination in recognition of chimeric stimuli presented to split-brain patients (line drawings of objects), and concluded that the left hemisphere was dominant for 'visuo-semantic' mapping as well as for visuo-phonic mapping. However, Hines (1976) found a larger visual hemifield asymmetry for unfamiliar words than familiar (which was unrelated to syntactic class) and for familiar abstract ones than concrete ones. A superiority of the left hemisphere was not demonstrated for familiar concrete words, and Hines suggests that the right hemisphere can understand these.

2.2 Observations of language impairment after right brain damage

If the semantic level of organization is selectively less lateralized than other aspects of language, we might expect there to have been reports of semantic disturbances after right brain damage. There are reports of language disturbances in people who, after right brain damage, are not sufficiently impaired as to be classed as aphasic, but the picture is compounded by two factors. One is that an overall unspecific reduction in measured cognitive abilities is often found after any sizeable brain damage, and the other is that because of individual variability in lateralization some degree of linguistic impairment might be expected in all language abilities, speech as well as comprehension, and at all linguistic levels in a proportion of right hemisphere damaged people, although it may not reach 'clinical' levels.

Critchley (1962, 1970) has put forward a plea for the closer examination of the linguistic capacities of the minor hemisphere. He lists a number of clinical data suggestive of some involvement of the hemisphere in language: transitory articulation disorder, injury of creative literary faculties, hesitations or blockage in word-finding and metonymous paralogia, learning difficulties for new linguistic material, 'non-aphasic' misnaming plus difficulties in comprehending the real signification of pictorial matter owing to a disorder of one of the modalities of symbolic formulation. Zangwill (1967) reports that there is evidence that right cerebral lesions, while producing no clinically apparent aphasia, may none the less give rise to subtle language defects such as changes in the quality of definitions and in the grasp of abstract meanings. Carroll (1958) used a standard aphasia battery (the MTDDA) to examine twenty right brain damaged patients, and found that at least 65% of them partly failed 17 of the 70 subtests: in auditory comprehension they tended to fail items concerned with time or judgement and she attributed the impairment to a deficit in judgement about visuomotor, temporal and spatial concepts. A recent study also using a standard clinical battery for aphasia (the Aphasia Language Performance Scales) found the right-handed patients who had suffered right brain strokes were significantly poorer than normal controls on three of the language modalities, auditory comprehension, reading and writing (Basili 1975): this investigator concludes that "the integrity of the right hemisphere is important for unimpaired language functioning", and that mild difficulties in auditory comprehension and the secondary language skills go unnoticed because verbal expression is generally intact.

Hécaen (1971) reports, on a study of sentence production, that a group of right handed patients with confirmed right hemisphere lesions showed a higher coefficient of failure than the control normal population when asked to produce sentences involving the integration of four words. Almost half the group made mistakes, and the number of errors was greater in those with temporal lobe lesions than those with lesions in other areas.

> "The mistakes were primarily due to faulty integration of words, but the patients also produced a relatively high amount of agrammatical sentences (not well-formed syntactically)" (page 282).

Eisenson considers (1962, 1973) that right brain damage can have implications for language functioning when such functioning is related to high-level intellectual processes. Comparing right-brain-damaged and non-brain-damaged subjects he found a significant difference on 15 items of vocabulary recognition, and on sentence completion particularly when abstract rather than concrete words were required. Eisenson holds that such findings do not necessarily implicate the right hemisphere in "superior or extraordinary language functions", but that they may reflect the contribution which the right hemisphere makes in a non-specific way to all intellectual functions, or "a general reduction in intellectual functioning with implications for language after any cerebral damage". Deficits of the right-brain-damaged on language tasks have similarly been explained away by Archibald and Wepman (1968) and Marcie, Hécaen, Dubois and Angelergues (1965). Archibald and Wepman examined eight right-brain-damaged people who made more errors than normal on the Language Modalities Test for Aphasia. The expressive errors that six of them made on the stimulus-response sections of the test were described as syntactic, through three of these patients made primarily semantic errors in the story-telling section. They also made higher errors on matching tasks, several of which involve comprehension of language symbols. On the basis of their scores on four non-verbal cognitive tasks, Archibald and Wepman concluded that the subtle language impairment shown by this group was attributable to general mental deterioration involving decreased attention to the task in hand. Marcie et al reported, in 28 right-brain-damaged subjects, greater phonic errors in speech disturbances than in a control group with Parkinson's disease, a vocabulary selection deficit and difficulties in a test of changing syntactic transformations and constituting words into sentences. They considered that the deficits, more marked in patients with parietal lesions, were due to inertia or perseveration of a preceding response. Caramazza, Gordon, Zurif and Deluca (1976) have recently observed that right-brain-damaged subjects give incorrect answers to questions such as "John is taller than Bill, who is shorter?", but not to "John is shorter than Bill, who is shorter?". They explain the deficit, not in linguistic terms, but as due to a reduced ability to perform the imagery or spatial representations which they believe such sentences require. With the easier sentences "an answer can be obtained directly from the linguistic assertion of the premise, thus bypassing the need for an image search" (p 44). An alternative linguistic explanation could be in terms of the necessity for making a semantic distinction between marked and unmarked terms.

Gardner (1975) writes of deficits in linguistic competence after right-brain-damage:

> "The patient's command of grammar and sound structure seem unchanged, but the relationship between his capacity to express himself in language and his knowledge of the world is impaired. He resembles a kind of language machine, a talking computer that decodes literally what is said and gives the most immediate (but not necessarily the implicitly called for) response, a rote rejoinder insensitive to the ideas behind the questions, the intentions or implications of the questioner" (page 296).

A Norwegian neuro-anatomist (Brodal 1973) suffered a stroke in the right hemisphere, and although he was not diagnosed as aphasic, wrote of the difficulty he had in coping with complex linguistic material such as scientific papers; "In part this seemed to be due to a reduced capacity to retain the sense of a sentence long enough to combine it with the meaning of the next sentence". Brodal felt that Eisenson's (1962) description of language impairment in right-brain-damaged patients was pertinent to his own case. "There seemed to be more circumlocution, more hunting for the right word in the patients than in adults free of brain damage". (Page 686)

None of these studies has proposed a dissociation of lexical-semantic performance from the other linguistic levels in the same way that this has been proposed after left brain damage in Wernicke's aphasia, unless interpretation as a 'cognitive' rather than a 'verbal' deficit can be so construed. Warrington (1975) has, however, distinguished a selective impairment in semantic memory from intellectual impairment and from expressive language disorders in three patients who had diffuse cerebral lesions. She identifies this with the agnosias for names of objects which present in such a form that the patient can describe, copy or repeat the stimulus item but does not relate it to meaning. The patients were intellectually superior or average, and had good comprehension of sentences and of the Token Test, but impairment of comprehension of single words. Digit span was at least 7. Their visual agnosia was restricted to objects and pictures of faces. Although they could not recognise photographs of objects, a probe test showed that they were not entirely without semantic information as to what the object was: specifically they had most information about the superordinate category to which the object belonged but virtually none about its attributes (e.g. found indoors, not a bird) or associations (e.g. foreign). Warrington suggests that the storage system of semantic information was damaged in these patients, and not simply retrieval from this storage system: the gaps in their lexical information were consistent over time. These findings support the separation of the semantic level of organization from other levels of language organization, from perceptual deficit and from general intellectual ability. Although from this study there is no direct evidence implicating the right hemisphere in semantic storage as well as the left, it is interesting to note that visual object agnosia such as Warrington here identifies with an impairment of semantic memory is very rare and is associated with bilateral rather than with unilateral lesions (Hécaen 1975).

2.3 Modifications from the preliminary experiment

The results of the first preliminary experiment (Part Two Section 1.5.3) had suggested a selective impairment in semantic comprehension in the right-brain-damaged subjects. One of the aims of the main experiment was to test this hypothesis using additional controls.

To meet the possibility that scanning over four pictures, including left to right, might have influenced the results, all the picture tests used a binary top and bottom choice. Semantic comprehension was tested using both pictures and printed words to discover whether the effect was due to the specific nature of the picture tasks. A measure of visual-interpretive ability was also included. There was a stringent exclusion of subjects in whom bilateral damage was suspected (although the information available was still limited); there were equal numbers of men and women, and handedness was ascertained. Speech and writing samples were also obtained from the right-brain-damaged subjects as a check on their diagnosis as not being aphasic.

2.4 Results

Table 9 shows the differences between the RBD and the two other groups tested by the Mann Whitney U statistic. Although significantly better (at $p < .01$) than the LBD on all the test measures except Raven's Matrices and the Photo Test, the RBD were significantly worse than the NBD, as predicted, on the Photo Test, the Semantic Field Test and the Indefinite Article Test. For these comparisons, the linguistic level tests were scored so as to make them as restricted as possible to the level they were intended to assess, i.e. the Phonological test in the picture version was scored without including the 'word reversal' items, leaving 30 items; the Syntax Picture tests were scored without the DR items, leaving 56 items; the Indefinite Article test was scored without the F, G, H and I items, leaving 24 items. The analysis also showed

Table 9

Comparisons between right-brain-damaged, left-brain-damaged and non-brain-damaged subjects Mann-Whitney U statistic (z values in brackets)

Test	RBD/NBD	RBD/LBD
Raven's Matrices	180* (2.554)	454 (0.361)
EPVT	216 (1.864)	304.5* (2.434)
Token Test	255 (1.107)	34** (6.185)
Photos	166* (2.835)	330.5 (2.073)
Syntax, Picture, aural	200.5 (2.165)	97** (5.311)
Syntax, Picture, reading	208 (1.823)	87** (5.325)
Syntax, Gesture	198 (2.214)	63** (5.793)
Phonological, picture-choice	237.5 (1.447)	303.5* (2.448)
Phonological, printed words	275.5 (0.471)	150.5** (4.418)
Semantic Field	131.5** (3.356)	173.5** (4.090)
Indefinite Article	129** (3.618)	221** (3.661)
Homonyms	214 (1.903)	139.5** (4.738)
Word Recognition	221 (1.563)	131** (4.787)
Verbal Memory	244.5 (1.311)	55.5** (6.013)
Number of words in story	301.5 (0.204)	-----
Age	301 (0.214)	
Hearing	136.5 (0.674)	

* p <.01; ** p <.001 (two tailed tests for RBD/NBD, one tailed for RBD/LBD)

Syntactic picture tests scored without DR items (56 items)
Phonological picture test scored without word reversal items (30 items)
Indefinite Article test scored without F, G, H, I items (24 items)

that the RBD were not impaired on a crude measure of speech - the number of words spoken in the story.

The Semantic Field test correlated significantly with the Raven's Matrices and Photo Test scores, and the Indefinite Article test with Raven's Matrices scores in the results of the RBD (see Table 26 in Part Three Section 7.3). An analysis of covariance was accordingly carried out with the effects of these two measures of 'intelligence' and 'visual interpretive ability' partialled out for the two tests on which the RBD appeared to be significantly impaired in comparison with the NBD (Tables 10 and 11). The impairment was still significant. However, because this parametric analysis assumes homogeneity of within-class regression (Winer 1970 page 583), a non-parametric analysis was also undertaken. To obtain a weighting for the effect of Raven's Matrices scores, the mean score on each of the Semantic Field and Indefinite Article tests was calculated for NBD subjects who scored on Raven's Matrices above or below the median of 27 errors. For the Indefinite Article test, the difference in these means was 0.923; for the Semantic Field test the difference was exactly nil. Accordingly, the Indefinite Article test was rescored with those RBD subjects who scored more than 27 errors given a weighting of minus one error (slightly exceeding the NBD effect) thus reducing the number of errors scored where these patients might have shown an effect of impaired intelligence. With the RBD scores thus weighted, the U statistic for comparison with the NBD was 143 ($z = 3.339$, $p = .0005$). The impairment of the RBD was therefore still significant with the effect of Raven's Matrices scores partialled out on this non-parametric measure.

Table 10

Semantic Field Test: RBD and NBD
Analysis of Covariance, partialling out
Raven's Matrices and Photo Test scores

	Sum of squares	D.F.	Mean square	F	Signif.
Covariates	757.201	2	378.600	16.645	.001
Raven's Matrices	294.827	1	294.827	12.962	.001
Photo Test	107.309	1	107.309	4.718	.035
Main effect					
Group	143.223	1	143.223	6.297	.016
Residual	1023.531	45	22.745		
Total	1923.955	48*	40.082		

Table 11

Indefinite Article test: RBD and NBD
Analysis of covariance, partialling out
Raven's Matrices and Photo Test scores

	Sum of squares	D.F.	Mean square	F	Signif.
Covariates	138.109	2	69.055	13.254	.001
Raven's Matrices	67.216	1	67.216	12.901	.001
Photo Test	8.489	1	8.489	1.629	.208
Main effect					
Group	42.230	1	42.230	8.106	.007
Residual	239.659	46	5.210		
Total	419.998	49	8.571		

* the illiterate RBD subject was omitted from the results for the Semantic Field test.

As a weighting was not indicated for Raven's Matrices scores on the Semantic Field test, and as it was desired to have some means of checking the parametric analysis, a different method was used. The results of the 7 RBD subjects who made more than the maximum number of errors made by any NBD subject (40) were excluded (RM2, 6, RF4, 5, 6, 7 and RF9, who was already excluded as illiterate), thus equating the groups for range of Raven's Matrices scores. With these groups the U statistic was 130 ($z = 2.286$, $p = .011$). Again the significant impairment of the RBD was endorsed. As the Photo Test did not correlate significantly with results of the Indefinite Article test whether scored with 40 items or with 24 ($r = .259$, $p = .110$), and as there was no reason to expect a visual interpretive effect with printed words, a further analysis weighting for Photo scores was not undertaken.

The effect of sex was examined on the test scores (see Table 12 for means, standard deviations and U statistics for comparisons of men and women). No comparison reached significance, but there was a trend towards greater impairment in the women on all the tests except the Photo test, the two versions of the Phonological test and the Syntax Gesture test.

Table 12

Comparisons between RBD men and women

Means, standard deviations and Mann Whitney U statistics

	Men	Women	U statistic men/women
Age	55.167 (9.428)	55.917 (9.839)	69
Hearing	19.16 (7.432)	25.909 (5.421)	26.5 (n_1 = 10, n_2 = 11)
Months since stroke	36.250 (36.330)	39.000 (28.705)	62.5
Number of words in story	53.167 (34.676)	55.167 (19.604)	50.5
Raven's Matrices	28.750 (10.101)	37.500 (13.160)	48
EPVT	11.667 (8.732)	18.167 (12.452)	47
Token Test	2.167 (1.697)	5.667 (5.929)	42.5
Photos	2.167 (1.403)	1.917 (1.929)	59.5
Syntactic, picture choice, aural	3.833 (3.538)	5.083 (3.288)	55
Syntactic, picture choice, reading	5.833 (3.486)	6.250 (4.224)	61
Syntactic, gesture	5.000 (2.132)	4.333 (2.425)	60.5
Phonological, picture choice	1.833 (1.586)	1.750 (2.006)	65
Semantic Field	10.500 (7.305)	13.758 (6.646)	45.5
Indefinite Article	5.583 (6.067)	7.500 (4.602)	50
Homonyms	4.250 (3.388)	6.833 (4.896)	45
Word Recognition	4.167 (3.950)	5.142 (5.112)	62
Verbal Memory	2.875 (1.090)	3.333 (0.278)	57

$p > .05$

The effect of word frequency on the two tests on which the RBD were impaired was also examined. The number of errors for each 'head word' in the Semantic Field test was not related to its frequency in the Thorndike Lorge counts (sign test p = .500).

Table 13

Effect of word frequency on errors on 'head' words in Semantic Field test

Head word	Frequency	Number of RBD subjects making errors on this item
cook	AA	19
oak	A	16
father	AA	14
canary	8	13
cloth	A	11
teach	AA	10
fire	AA	8

Of the words for sorting into categories, 63 had a frequency of A or AA, and 21 of below A. A ratio of 1 infrequent to 3 frequent words would therefore be predicted both in items on which many errors were made and in items on which few errors were made, if there was no effect of word frequency. When the 19 items on which RBD subjects made more than 4 errors were examined, the ratio of infrequent to frequent words was 6:13 - more than predicted. For the 15 items on which the RBD made no errors the ratio was 3:12 - fewer than predicted. There would therefore appear to have been some effect of word frequency on the RBD results on the Semantic Field test.

For the Indefinite Article test the ratio of infrequent to frequent words in the 24 items which were used in this comparison was 1:2 (8 to 16). Amongst the 8 items on which the RBD made more than four errors (straw, race, tomato, lemon, game, board, fawn and change) the ratio of infrequent to frequent words is 1:1. Amongst the nine items on which they made no errors or one error the ratio of infrequent to frequent words is 1:2 (3 to 6) (cloth, flower, sweet, copper, plaster, paper, glass, home, hare). From this it would not be possible to rule out entirely some effect of word frequency also on this test.

To test the influence of familial handedness, the eight RBD who had left handers in the family or were themselves of mixed handedness (M1, 4, 7, 8, F1, 3, 8, 11) were compared with the sixteen who had no familial left handers (15 in the reading tasks):

Table 14

Effect of familial handedness on results of right-brain-damaged subjects

	Mean number of errors					
	Phon. pictures	Phon. print.	Synt. aural	Synt. read.	Ind. Art.	Sem. Field
Sinistral-family dextrals/ambid.	0.875	1.125	3.125	4.750	2.875	7.000
Dextral family Dextrals	2.250	1.533	5.125	6.733	4.813	14.867
U-test for signif. between subgroups (2-tailed)	U=36 z=1.786 p=.072	U=34 z=1.753 p=.080	U=43 z=1.295 p=.194	U=44 z=1.042 p=.148	U=45 z=1.173 p=.120	U=19 z=2.657 p=.008

There was a significant difference between the two subgroups on the results of the Semantic Field test, the implications of which are discussed in the next section.

2.5 Discussion

The RBD group showed the overall tendency to impairment that is predicted from any brain damaged group. But over and above this they showed, besides the impairment on recognition of unconventionally photographed objects that endorsed the findings of Warrington and Taylor (1973), an apparently selective deficit in semantic comprehension, with relative sparing of phonological and syntactic comprehension. This impairment occurred in both the test which used pictures and that which used printed words, and also does not seem to have been attributable to intellectual deficiency as far as that was measured by Raven's Matrices. It was also not attributable to poor vocabulary as such, on which the RBD group (unlike that in the first preliminary experiment) were not significantly impaired (at a probability of .01). They were also not impaired on the Homonym test which, it was suggested in Part Three, Section 3.5.3.2, may measure the ability to change set from one verbal meaning to another.

Despite the attempt made to partial out the effect of a disability in picture interpretation, the possibility of some interaction of picture difficulty with semantic difficulty on the Indefinite Article test cannot entirely be ruled out. The Photo Test might have required an ability to extract three dimensional information from two dimensional tones of grey, which may not in fact be the same ability as that which the picture tests required for linking line drawings with semantic meaning - the kind of ability which Critchley (1970) suggests is impaired in right brain damage. The lack of a significant correlation between the Indefinite Article test and the Photo test scores would suggest that this indeed was the case. However, the measure of intelligence used also was in the visual medium, and part of the correlation of the picture semantic test with Raven's Matrices could have been due to this common medium. As the impairment was significant with Raven's

Matrices scores partialled out, and occurred also when only printed words were used, however, the semantic impairment would not seem to have been entirely dependent on an interaction with visual difficulties.

A factor which cannot be ruled out so clearly is that of attentiveness. In terms of the number of decisions which had to be made, the Semantic Field required the most (84 words had to be sorted, whilst the longest of the other tests required 64 - the syntax picture tests - or 60 - the Word Recognition test). There was, however, no significant relationship between the number of errors made for a head word and its position in the test: (sign test p = .500).

Table 15

Effect of position in test on errors on 'head' words in Semantic Field test

Head Word in order of presentation	Number of RBD subjects making errors
fire	8
canary	13
oak	16
teach	10
cloth	11
father	14
cook	19

It thus seems unlikely that flagging attention could account for the high number of errors in this test for the RBD. Test length could also not have accounted for the selective impairment of the RBD on the semantic test of the first preliminary experiment.

It is also unlikely that the impairment of the RBD was due to subclinical damage in the left brain as well as the known damage in the right brain, although in a population of this age with a history of stroke the possibility of some minimal bilateral dysfunction cannot be excluded. The RBD were not aphasic in speech, and, moreover, were not aphasic in auditory verbal comprehension in the test which is customarily used to detect 'latent aphasia' (Boller 1968). It has been suggested that the Token Test makes particular demands on memory for sequence and on syntactic abilities (Lesser 1976) rather than asking for fine semantic discriminations. The subjects whom Warrington (1975) described as having selective semantic impairment also achieved good Token Test scores and Zaidel's examination of split-brain and hemidecorticated subjects (in press, b) also indicates that the right brain can have a fair picture vocabulary, even though (Zaidel, in press, a) it has little capacity for the Token Test. It therefore seems probable that the left hemispheres were functioning adequately enough in the RBD group to sustain most aspects of language. The significant finding is that the damaged right hemispheres apparently disrupted one selective aspect of language enough to interfere with its normal functioning in the left hemisphere. Damaged tissue in the opposite hemisphere is known to interfere with normal functioning of an intact hemisphere, and indeed this forms the justification for the operations of comissurotomy and of hemispherectomy for infantile hemiplegia: after hemispherectomy, despite the removal of the contralateral hemisphere, some improvement in the hemiplegia is often reported due to improved functioning of ipsilateral control when released from contralateral interference (A. Smith 1974).

The possibility must also be considered, however, that the two semantic tests were 'difficult' in some unspecified way which could not be accounted for either linguistically, visually or by whatever aspect of intellect Raven's Matrices measures. The Indefinite Article test, although requiring fine discriminations, was performed without error by eight people in a non-brain-damaged group, in whom exactly that number made no errors on a test which is usually considered easy for normal subjects, the Token Test, scored (see Part Three Section 7.1.2) in this investigation more leniently than it customarily is. By the criterion of the proportion of LBD who scored at random guessing levels, the Semantic Field test could also not be described as inherently more difficult than the tests at other linguistic levels - in such terms it should have been the easiest.

Chapman and Chapman (1973) have suggested, however, that differential performance on tests of cognitive abilities may sometimes be an artifact of the different discriminating powers of the tests. The discriminating power of a test is a function of mean item difficulty, dispersion of item difficulty, mean item variance and number of items. If two tests of cognitive abilities differ in these factors, they produce an apparent discrepancy at different levels of difficulty which is an artifact, rather than truly reflecting differences in the cognitive abilities. The artifactual appearance of difference is greatest at the 50% level of difficulty (or, in binary choice tests where chance score is 50%, at slightly above 75%). Consequently, an impaired group whose results are at this level necessarily appears to show a greater discrepancy between the tests than does a superior group whose results are closer to 100% accuracy. The artifactual differences between the tests therefore become exaggerated with the impaired group at the middle range of difficulty (although the gap closes again at the hardest level of difficulty). Chapman and Chapman therefore suggest that to measure differential cognitive deficit in pathological populations one should use tests which are shown from normal subjects to have equivalent discriminating power.

A pathological group will show the greater performance deficits on tests which have higher reliabilities: tests with higher reliabilities are expected to have lower variances for item difficulty and higher variances for test difficulty for subjects.

To check on whether or not the apparent 'semantic' deficit in the RBD was an artifact of the different discriminating powers of the semantic and other tests making an unreal distinction within the generalized lower abilities of the RBD group, coefficient alphas were calculated for the reliabilities of the tests with the NBD, using the Kuder-Richardson 20 formula (Nunnally 1967, page 197). This formula assumes that all the items in a test measure only one common factor; an assumption which is rarely met, and probably was not in each of these tests even with the NBD data. However, Guilford (1954, page 383) reports studies which show that even when the assumption is violated, the formula can give fairly accurate results, with slight underestimation of the reliability. For the calculations the reduced 'pure' versions of each test were used.

Table 16

Discriminating power of tests: K-R20 coefficient alpha reliability from NBD subjects

	No. of items	Item variance	Subject variance	Coefficient alpha
Syntax Pictures aural	56	3.189	3.656	.524
Syntax Pictures reading	56	11.087	6.802	.600
Phonological pictures	30	2.490	2.039	.583
Phonological printed	30	4.833	1.785	.452
Semantic Field	84	6.916	12.215	.633
Indefinite Article	24	4.082	1.563	.430

From these coefficient alphas, artifactual differences in discriminating power amongst the tests would be expected to show an appearance of greater RBD deficit in this order (from greatest to least): Semantic Field, Syntax reading, Phonological pictures, Syntax aural, Phonological printed words, Indefinite Article. Chapman and Chapman comment that:

> "In some situations tasks unmatched on discriminating power may give legitimate evidence of differential deficit in ability. If the control task is a more discriminating measure of nonpathological differences in ability than the experimental task and if, despite this disparity, the experimental task yields the greater difference between pathological performance, one must attribute the differential performance to a true differential deficit rather than to a generalized deficit coupled with a difference between tasks on discriminating power". (Page 384)

The Indefinite Article test had the lowest reliability and would therefore be expected to show the least performance deficit: the significant impairment of the RBD on this test cannot therefore be dismissed as an artifact. The position with the Semantic Field test is less secure: the most that can be said is that the difference between its reliability and the other tests' does not seem great enough to account for the greater impairment in the pathological population being entirely an artifact.

A further question is how far, despite its theoretical justification, the Indefinite Article test might be considered to be accessing the semantic level of language organization rather than the syntactic, in view of its higher correlations with syntactic tests than with the Semantic Field test. A partial explanation could be the use of picture material, but this cannot satisfactorily account for the relationship as there was a high correlation with the gesture version of the syntax test and with the syntax picture tests, even when effects of Raven's Matrices and photo scores were partialled out (Table 28, Part Three, Section 7.4.1). The syntax and Indefinite Article tests have in common that they use sentences rather than single words; in the present ignorance of the nature of semantic organization and possibly neurological correlates of it in the brain, we cannot assume that lexical-semantic organization studied through single words will necessarily show the same patterns as semantic organization studied through sentences or 'semotactics'. In the case of the Indefinite Article test, a surface syntactic feature, the indefinite article, gives a cue to a change of meaning, rather than, as in the Semantic Field test, knowledge of ramifications of meaning being explored as a metalinguistic task through single words.

To test whether or not another use of sentences could help to clarify this distinction, the sentences which attempted to assess 'deep relations' in the two syntax picture tests were examined. These are reported on in detail in Section 3 of this part, as their purpose was primarily for comparison of surface sequence and deep relations in the LBD. Table 25 in Section 3.2 indicates that for the RBD there was no significant difference in difficulty between 'deep' and 'surface' sentences on either the aural or the reading version of the tests, although the 'surface' sentences were significantly harder than the 'deep' for the LBD on the aural version. The reading version produced somewhat ambiguous results, as will be discussed later (Section 3.3). The results could tentatively be interpreted as not being inconsistent with a hypothesis of more impairment in the RBD in deep relationships than in the surface structure analysis of sentences, and this would be compatible with the general hypothesis of semantic impairment in the RBD. The process of analysis in the deep relations sentences, however, is not the same as in the Indefinite Article test; whereas, in the latter, cues to lexical meaning are derived from a surface structure feature, in the former it is a 'case' feature in meaning (perhaps the same as Marshall et al, in press, describe as 'place functions') which give clues to deep structure. These configurative relationships, it is suggested, may be semantic in nature rather than syntactic, in that they have no linear order as is implied in syntax (see Section 3.1.2.2).

We cannot leave entirely out of account in studies of the organization of the lexicon the fact that words are rarely used in isolation from each other, although, in an attempt to simplify an enormously complicated situation the lexicon is usually conceived of as a store of single words, or word elements. It is quite clear that there are important phonological and syntactic components in the lexicon, in that aphasic misnamings show phonological resemblances to the target word (Carter 1969, Rinnert and Whitaker 1973) and part of speech is a significant variable in retrieval (Diamond, Epstein and Bender 1969, Holmes, Marshall and Newcombe 1971, Newcombe and Marshall 1972). Features such as stress pattern, number of syllables and alphabetical indexing of the initial grapheme are sometimes accessible when a full 'reading' of a word is not, as experiments on the tip-of-the-tongue and feeling-of-knowing phenomena (Blake 1973, Rubin 1975, Baars, Motley and MacKay 1975) and studies of aphasia (Barton 1971) demonstrate. Root forms of a word can be retrieved separately from its morphological inflections (Gibson and Guinet 1971), and these processes can be independently impaired in aphasia (Whitaker and Whitaker, in press). Intonation can also supplement or even contradict the dictionary version of a word's meaning. Observations from aphasia indicate that items in the lexicon may be available through reading or through the kinaesthetic feedback from hand movements for writing when they are not available through listening or for spontaneous evocation in speech (and when the difficulty cannot be attributed to articulation as such).

From studies of aphasia such as that of Goodglass and Baker (in press), however, it seems probable that we are justified in considering the semantic content of a 'word' as distinct from its phonological shape as a word. Goodglass and Baker concluded that a semantic field can exist without its name. Attention has already been drawn (Part One, Section 3.1.3) to the interpretation of some types of aphasia as a dissociation between meaning and sound, and there is a developmental equivalent in the rare disorder of hyperlexia in children (Mehegan and Dreifuss 1972).

Considering, therefore, only the abstract level of semantic organization before 'words' become clothed in the phonological and syntactic shapes they must take for speech, it is also clear that partial information about word meaning may sometimes be available when full information is not (Warrington 1975). At this 'pure' semantic level several influences of retrieval have been suggested. These include picturability (Paivio 1973), the perceptual clarity of the stimulus to which the name is to be related (Bisiach 1966), the multiplicity of sensations provided by the stimulus (Gardiner and Brookshire 1972), operativity (Gardner 1973, 1974), concreteness (Goldstein 1948), ease with which an object can be designated as belonging to a location (Corlew 1971), age of acquisition (Rochford and Williams 1962, Carroll and White 1973), frequency of use of the word in the language (Siegel 1959) frequency of experience of the designated object or image (Riegel and Riegel 1967), hierarchical relationships to other 'words' (Miller 1972, Rips, Shoben and Smith 1973), category size (Wilkins 1971, Landauer and Meyer 1972), emotional content (Weinstein and Keller 1963, Weinstein 1964), and number of associations (Lesser 1973). When meaning is considered in the context of sentences rather than as single 'word' units, other factors have been proposed as well, for example, presuppositions (Leontiev 1975), 'case' relationships (Fillmore 1971) and social context (Lakoff 1972). The claims become stronger that semantic organization must include encyclopaedic knowledge as well as dictionary information (Maclay 1971, Lenneberg 1975). It would be somewhat implausible to suggest that the right hemisphere is isolated from encyclopaedic knowledge and all these components of semantic organization listed above.

It is difficult to know where, if at all, it is possible to draw a line between conceptual and 'semantic', when by semantic we wish to indicate linguistic meaning but without its phonological and syntactic form. Deese (cited by Osgood 1963, page 501) is not alone in considering that the primordial thought that gives rise to language is not itself linguistic. However, the cognitive categories he proposes, of grouping, contrast, similarity and classification are the very ones by which semantic meaning must also presumably be at least partly organized. Perhaps the distinction between the conceptual and the semantic can be made in terms of the stability of these groupings. A stable identification of a concept is required before a label can be attached to it which can take a phonological form. If we define as semantic such concepts which have become organized into stable, or predominantly stable, relationships, perhaps describable as 'semantic fields', then one might hypothesise that only in the left brain do these semantic concepts, shared by both hemispheres, become realizable in their phonological and syntactic shapes as speech. Indeed, Semmes' theory (1968) of multimodal co-ordination in the right hemisphere would favour this hemisphere as the neurological substrate for semantic meaning in which so many diverse components have to be simultaneously integrated. It is intuitively plausible that semantic knowledge should have a more diffuse representation in the brain than the specialized technical skills of phonology and syntax which require a sophisticated combination of simultaneous and sequential processing, and indeed it is usually agreed that word-finding difficulties are common to every type of aphasia whatever the site of lesion. The present findings suggest that the right hemisphere plays a sufficient enough part in semantic knowledge (though not necessarily a major part) for damage to it to affect materially the semantic resources available to the patient. A proposal such as Gazzaniga's (1970) that the right hemisphere acts as a reverberating circuit for the verbal material which the left hemisphere originates would be compatible with some reduction in verbal ability after right brain damage. But, in psychological rather than physical terms, one must consider this as implying that the right hemisphere makes a real contribution to language, or else no interference would occur and no advantage would be lost if the right hemisphere were to be disorganized by brain damage. It is the selectivity of the interference in language by such damage which is noteworthy in the present findings.

Support for the bilateral representation of semantic knowledge is obtained from some recent observations of Brown (1975a, in press). He distinguishes three types of semantic disorders: semantic aphasia, characterised by circumlocutory conversational speech; semantic paraphasia, characterised by associative misnamings; and semantic jargon, characterised by both. "The semantic disorders are associated with bilateral or less commonly left, temporal lobe pathology. Semantic paraphasia tends to occur with diffuse or bilateral involvements and has been correlated with bilateral limbic-temporal lesions". He also comments that there are observations which suggest that semantic aphasia is correlated with bi-temporal or generalised lesions and that, in younger patients, semantic jargon is associated with bilateral temporal lobe pathology or with a unilateral lesion with some dysfunction in the opposite hemisphere. A disorder at a more advanced stage of word retrieval, anomia, where the 'word' is selected but cannot be immediately evoked in phonemic encoding "does not have a strong anatomical correlation and tends to occur with neocortical lesions distributed throughout the dominant hemisphere, as well perhaps as with large right hemispheric lesions". Disorders of phonemic encoding itself, evidenced by fluent phonemic paraphasias or by articulatory disability, in contrast are not only more strongly lateralized but are focally localised within the language dominant hemisphere. Agrammatism also appears to be associated with unilateral lesions.

Dennis and Kohn (1975) report a study of nine hemidecorticated patients, age 8 to 28, which also supports a special role for the left hemisphere in the recognition of syntax (though, as these patients had all had early brain damage, their organization of language is not necessarily typical of that in normal subjects, as has been commented earlier). The five patients who had had the left cortex removed and the four who had had the right cortex removed were of equal verbal intelligence as measured by the Wechsler Adult Intelligence Scale or Wechsler Intelligence Scale for Children, and none had signs of speech disorders or aphasia. Nevertheless, those who retained their left hemispheres intact were significantly better than those who only retained the right cortex on comprehending passive-negative sentences, though there was no difference between the groups in the comprehension of simple active sentences, whether affirmative or negative. Dennis concludes that in such patients "syntactic skills are not mediated equally by left and right remaining hemispheres". This study also underlines the separation of syntactic comprehension, as measured by a sentence-picture matching task from both everyday speech and verbal I.Q.

Gosnave (in press) reports that amongst subjects with damage to the left temporal lobe, even patients without aphasia were impaired on a task where they had to combine sets of given words (from two to four) into a sentence.

These observations are all compatible with the present findings in suggesting a greater degree of lateralization for syntax than for semantic knowledge.

In the present investigation, amongst the RBD the reduction in semantic knowledge would seem to have occurred specifically in those who had no left handers in the family. The dextral-family dextrals were significantly more impaired on the Semantic Field test than were the sinistral-family dextrals/ambidextrals, though they were not significantly more impaired on the other linguistic tests. Some caution must be exercised in interpreting this result because it is possible that the more alert RBD were more aware of left handers in the family, and hence this subgroup may partly reflect a general superiority in performance. However, if we can accept the sub-grouping according to familial sinistral tendencies at its face value, it is again the selectivity of the discrepancy on the semantic test which has implications. (The results of the Indefinite Article test again appear to pattern with the Syntactic tests, as has been discussed.) A tentative interpretation which would account for the effect of familial handedness is as follows. Dextral-family dextrals would have strong lateralization of syntactic and (possibly) phonological organization but would utilize both hemispheres for semantic organization in such a way that damage to the right hemisphere would interefore to some degree with the semantic system. In view of the prevailing opinion that familial left handedness is associated with less lateralization of functions, it is unlikely that semantic processing is more lateralized in the sinistral-family dextrals/ambidextrals than in the dextral-family dextrals; an acceptable interpretation in these terms would be that they would have a more bilateral representation of all levels of language, but a representation of such a nature that each hemisphere could function relatively autonomously, so that unilateral brain damage would not materially and lastingly disrupt any level of language organization. Some partial support for this is the lower incidence of people with familial left handers in the LBD group (1 in 8 compared with 1 in 3 in the RBD). Like other discussions of the relationship between handedness and cerebral function, this is highly speculative; but it does suggest that familial handedness (even in right handers) is a variable which should be controlled for in future investigations.

3. Left brain, temporal sequence and language

It was suggested in Section 2 that the left brain is specialized for those aspects of language which require, besides simultaneous processing, the integration of sequences through time, specifically the processing of syntactic and phonological form. The first and second preliminary experiments suggested that the left-brain-damaged aphasic subjects had difficulty in understanding reversible sentences, and one of the aims of the main experiment was to test, at both the phonological and the syntactic level, the hypothesis that some of the difficulty in the perception and comprehension of language which such people experience can be attributed to temporal sequencing.

3.1 Background - two perspectives

There are two perspectives from which this hypothesis can be examined:

1) Evidence that the left brain is specialized in temporal sequencing, and that the left brain damage disturbs this capacity.

2) An examination of the extent to which sequence is a significant component in the comprehension of language, and how, therefore, a disturbance in aphasia of capacity for sequencing would disrupt the comprehension of language.

3.1.1 Left brain specialization for serial organization

The interpretation of differences in hemispheric function in terms of serial and simultaneous processing has already been mentioned in Section 2 (Cohen 1973). Heilman (1973) reports Liepmann as proposing in 1908 that the left hemisphere contains engrams for sequential movements. The intimate relationship between speech and sequencing has frequently been acknowledged, some investigators being of the opinion that speech is lateralized to the left hemisphere because of its specialization for sequential processing, others generalizing from the verbal capacities of the left hemisphere to inferences of fundamental differences in the organization of each hemisphere. Papçun, Krashen, Terbeck, Remington and Harshman (1974) found that short Morse code signals were interpreted more accurately by the left hemispheres of experienced or naive Morse operators whether or not they were meaningful, although naive subjects showed a right hemisphere dominance for longer stimuli of more than seven sounds: Papçun et al suggest that in such cases the subject was obliged to use a holistic rather than a serial strategy, and that "the lateralization of speech and language may be due to more general properties of the human brain, e.g. the propensity of the left hemisphere to deal with the sequential elements that comprise a whole". Bosshardt and Hörmann (1975) propose that the encoding of temporal or sequential information is of crucial importance for the explanation of the laterality effect found in dichotic listening: items received by the right ear are recalled much more precisely in the order in which they are presented than are items received by the left ear. Halperin, Nachshon and Carmon (1973) have reported a shift to right ear superiority when non-verbal stimuli become temporally patterned, indicating, they believe, left hemisphere superiority in time patterns independently of whether the material is linguistic or not. When both hands are used together the right hand is better on a sequencing task and the left hand on a spatial task (Nachshon and Carmon 1975). An apparent contradiction to the theory of specialization of the left hemisphere for temporal sequencing is the right hemisphere superiority which has been found in the perception of melodies (Kimura 1964). But an explanation for this has been offered by Gordon (1970) which maintains the superiority of the left hemisphere in temporal sequencing: he found the left ear advantage only for the perception of musical chords and not for recorder melodies, and suggests, therefore, that it is only such simultaneously integrated aspects of melody as timbre and tone which are processed by the right hemisphere.

Lateralized brain damage also provides evidence for the specialization of the left hemisphere for non-verbal serial processing.

Constructional praxis is considered to have two contributory components - spatial and serial organization. Warrington (1969) suggests that constructional apraxia after right brain damage reveals a disintegration of the spatial component, and after left brain damage of the serial. Kimura and Archibald (1974) have refuted the somewhat vague notion that constructional apraxia is a 'symbolic' disorder. They tested left- and right-brain-damaged subjects on sets of imitative hand movements, and reported that it was only with sequences of hand movements and not with copying of single hand positions that the left-brain-damaged were inferior to the right-brain-damaged, and that this was so even when these sequences had no symbolic value and could not easily be labelled. They therefore relate apraxic difficulties after left brain damage to the degree to which motor sequencing is involved in the task. With some imitative motor tasks with a spatial component such as flexion of individual fingers, they state that the left hand performs better than the right, again evidence of the superiority of the right hemisphere in spatial tasks. Kimura and Archibald did not find that errors in movement copying by the left-brain-damaged correlated significantly with auditory comprehension errors on subtests of the MTDDA. They therefore hypothesise that:

> "The unique functions of the left hemisphere in speech as well may be related to motor sequencing rather than to symbolic or language functions.... Speech disturbances and apraxia are simply different manifestations of an impairment in the control of motor sequencing". (Page 349)

In a recent study Lomas and Kimura (1976) have confirmed that speaking interferes with the simultaneous activity of sequencing finger or arm movements. Lenneberg (1967) made the claim that: "Almost all of the central nervous system disorders of speech may be characterised as disorders of timing mechanisms".

This is an extreme claim, and one which gives primacy to the motor articulatory aspects of speech. But an equally extreme opinion about aphasia relates it to temporal analysis in perception rather than in speech. Efron (1963) suggests that:

> "We should not look upon the aphasias as unique disorders of language but rather as an inevitable consequence of a primary deficit in temporal analysis".

This hypothesis was based on the discovery that aphasic subjects were markedly impaired in ability to report which of two sounds had occurred first: Efron used pure tones of widely differing frequencies lasting ten milliseconds. For normal subjects the gap between tones required for accurate discrimination of sequence is about 50-60 milliseconds. (Hirsh, 1959, reports that for trained listeners it can be reduced to as brief as 20 milliseconds.) For some of the aphasic subjects in Efron's study a 75% correct response could only be obtained when the gap between tones was over a second. Efron's findings have been corroborated by later studies with children and adults (Lowe and Campbell 1965, Carmon and Nachshon 1971, Brookshire 1972, Swisher and Hirsh 1972).

Hirsh (1967) is of the opinion that the recognition of successivity in temporal ordering occurs at a central level of processing rather than being modality dependent. Although the auditory and visual modalities differ greatly in their threshold for flicker fusion (the auditory being lower) both need approximately the same time gap for accurate judgement of precedence in stimuli. Hirsh therefore proposes "some kind of time organizing system that is both independent of and central to the sensory mechanism". If this is so, we should expect the radical defect in temporal analysis attributed to aphasia to be revealed in the visual as well as the auditory modality; and this indeed has been reported. Although auditory discrimination of sequence seems typically to be more impaired than visual, Brookshire (1972) suggests that this is merely a reflection of a discrepancy between modalities which normal subjects show. Brookshire and Lommel (1974) have attempted to examine the effects of different combinations of modality and sequencing by using an auditory sequencing task with spatially distributed stimuli, and a visual sequencing task with temporally distributed stimuli. The visual temporal sequencing task proved harder, but harder for both left- and right-brain-damaged subjects, implicating a visual component in the right hemisphere and a temporal one in the left hemisphere which was not restricted to the auditory modality.

The claim which Efron makes that aphasia is an epiphenomenon of a primary deficit in temporal analysis would imply that difficulty in temporal discrimination should correlate closely with clinical ratings of severity. Studies, however, report non-significant correlations (see Efron's comments on the paper by Hirsh 1967, and Brookshire 1972). One complicating factor is that auditory sequencing deficits are severe in Broca's aphasia (Cermak and Moreines 1976), severer in fact than in 'receptive' aphasia (Efron 1963, Brookshire 1972) even though the former are clinically rated as having less difficulty in understanding speech. This raises two possibilities: firstly, that a central disturbance of temporal sequencing may be related in some way to agrammatism; and secondly, that phonetic disorders in speech are intimately related to phonemic disorders in comprehension through a common mechanism of sequencing. Several clinical studies have extracted from Efron's findings the implication that aphasic patients will understand slow speech better than fast (Edwards 1968), and there is experimental evidence which supports this (Albert and Bear 1974, Weidner and Lasky 1976, Cermak and Moreines 1976) provided that intonation patterns are maintained.

There have been some attempts to relate this mechanism of sequencing which seems to be common both to modalities and to verbal and non-verbal material to its underlying physiological processes. These were initiated by Lashley (1951) in his classical paper on the serial organization of behaviour in which he suggested that "the understanding of speech . . . definitely demands the postulation of an after-effect or after-discharge of the sensory components for a significant time following stimulation". Luria, Sokolov and Klimkowski (1967) have suggested that, in a case of aphasia, "A restriction of the dominance range of excitation can be supposed and it can be thought that the level of excitation . . . rapidly approaches a threshold equal to the thresholds of different . . . connections" so that discriminations of sequence cannot be made. Lenneberg (1971, page 179) argues that motor organization implies underlying rhythms (though not specifying, as do Robinson and Solomon (1974) that "rhythm is in the speech hemispheres"), and draws an analogy for these rhythmic patterns or wave fronts with coupled oscillators. When these are hooked up together in series and in parallel, a change of frequency in one results in a spreading wave of out-of-phase oscillation. Pillon and Lhermitte (1974) describe a saturation effect within physiological networks depending on the rhythm of stimulus presentation. Birch, Belmont and Karp (1965) have attributed the underestimation of the second of two stimuli by brain-damaged subjects to the prolongation of inhibitory effects from the first stimuli. Luria (1966a) makes a distinction between inertia -

a difficulty in reaching threshold for activation - and a disorder in the sensorimotor feedback system. Both have different disrupting effects on temporal sequence, which take, in aphasia, the different forms of efferent and afferent motor disorders.

Bertaux, Lecours and Lhermitte (1968), Lhermitte, Lecours and Bertaux (1969) drew an analogy between sequential errors in speech and the behaviour of a cybernetic system. By analogy with the computer simulation of a cybernetic system, they hypothesise that there must be physiological entities in the brain which correspond to linguistic units such as phonemes and monemes (morphemes), and that these are functional elements which become activated every time the corresponding unit is received from the environment or produced by the person. These functional elements, they suggest, contain chains of sequences of signs; for each sequence of signs there is therefore a macro-element at a higher level of organization. Bertaux et al conclude that:

> "It seems established that the seriation errors are not due to a destruction of the information storage but to a dysfunctioning of the selection-seriation mechanisms". (Page 375)

In psychological, rather than physiological terms, disorders in sequencing of percepts have been described as involving a reduction of short term or working memory. Tzortzis and Albert (1974) have interpreted examples of conduction aphasia as characterized by a disorder of memory for sequences, as have Warrington and Shallice (1969) and Saffran and Marin (1975). Schuell (Schuell and Jenkins 1959, Schuell 1966) has drawn attention to the reduction in auditory memory in aphasia, with digit span severely limited. Lashley (1951) suggested that memory traces (such as in digit span) have spatial characteristics and that temporal order is imposed on them by directional arousal or rhythmic alternations which may reassort them. Memory is transformed into succession by the scanning of this spatial system by some other level of the co-ordinating system, perhaps rhythm. However, memory for items must be conceptually distinguished from memory for the sequence of these items. Studies with normal subjects have been able experimentally to distinguish order from item information. Bower and Minaire (1974) compared scores on serial recall for a 15-word list from subjects who had also had to learn new word lists with those from subjects who had had to learn the same list in a scrambled order. The first group showed a loss of item availability, but not of order information, while the second showed the opposite. Bower and Minaire interpret these results in terms of 'response availability' from the whole context for information about items, and specific serial associations for information about order. Healy (1974) states even more explicitly that order and item errors in recall are caused by two different processes. She gave some subjects the same set of four letters in different arrangements and other subjects larger sets of letters but with a maximum permutation of three in any one temporal position. The first subjects were asked to recall order, the second items. When recall of words in these strings was tested by probed recall, a bow-shaped serial-position curve was found only when order information had to be learned but not when it was only the item information which had to be learned. Detterman and Brown (in press) found nearly equivalent item retention for free recall and ordinal recall, when ordinal recall was examined by giving the subjects sheets with numbered spaces on which to write the items but without specifying that they should recall them for writing in chronological order. Two conditions were used, with instructions for recall specified either before or after presentation; not knowing which method of recall was to be used had little influence on item retention, but markedly changed the shape of the serial position curve. There is thus considerable evidence that order and item information in memory can be distinguished and that subjects can pay attention selectively to one or other of them.

Albert (1976) has applied a similar analysis to aphasia. Using a modified version of the Verbal Auditory Sequence Test (Albert 1972a, b) a further version of which has been used in the present investigation, he found that aphasics (but not non-aphasic brain-damaged subjects) had a significantly impaired memory for both items and order information. A third of errors made by aphasics resulted from a specific separable defect in short-term memory for sequences, with memory for sequences becoming more critical as the information load increased (from two to four items). Aphasics can sometimes remember all of the items in a given set, but not the order of the items in the set. No difference was found between types of aphasia in this respect: the deficit appeared to be ubiquitous.

In view of the major claims which have been made for aphasia as an epiphenomenon to temporal sequencing, supported by the evidence for the specialization of the left hemisphere in this function, it is surprising to find but few experimental investigations of specifically verbal deficits in the perception of sequence in aphasia. Apart from Albert's and Goodglass et al's (1970) studies of sequences of names, two studies have enquired in part about temporal sequencing at the phonological level. Carpenter and Rutherford (1971), relating the verbal comprehension difficulties in seven of the fifteen aphasic subjects they tested to a reduced ability to discriminate acoustic cues for speech sounds, noted that they experienced significantly more failures on temporal cues such as stop-gap duration than on spectral cues such as for a consonantal burst peak. Blumstein et al (1973) examined, amongst other aspects of comprehension at the phonological level, the effect of metathesis in which phonemes are presented in contrasting order in words (e.g. name/main; scottie/stocky). The subjects were impaired on this aspect of phonological comprehension as well as on others, but not apparently to any peculiar degree which merited special comment, and the investigators did not draw any conclusions about perception of sequence at the phonemic level from this preliminary experiment.

Jakobson (1964) has approached the notion of impaired sequencing in language in aphasia from a different perspective. He proposed three intersecting dichotomies of impairment of language in aphasia, by which different types of aphasia could be classified: a dichotomy of selection versus combination (aligned with 'decoding' and 'encoding'); a dichotomy of limitation or disintegration (though this appears to be to some extent a contrast of degree only); and, of most relevance to the present survey, a dichotomy of sequencing versus concurrence. Jakobson proposed that only three types of aphasia are disorders of sequencing: efferent motor aphasia, which is an encoding disorder of sequence, in which, for example, phonemes may be produced in incorrect sequence (in contrast to afferent motor aphasia in which the concurrence of distinctive features into a single phoneme is disturbed); dynamic aphasia in which the sequencing disorder is also in encoding and affects not the phoneme or the sentence but "only those verbal contexts which contain more than one sentence"; and amnestic aphasia. It is only in amnestic aphasia that a disturbance of sequential selection in comprehension or 'decoding' is proposed in Jakobson's scheme, and it is a limited one. It applies only to co-ordinative groups of words or clauses (e.g. 'eye and ear', 'John sang, Peter played and Mary danced') because these are the only syntactic groups with freely additive and omissible members and without an internal syntactic hierarchy. This acknowledges a distinction between time-sequence and structure which is also applied by Lyons (1969) in his division of syntagmatic relations into ones which are sequential and ones which are not (e.g. the different expressions of subject-verb-object relations in an inflected language such as Latin where order is not crucial and in a relatively uninflected language such as English where order is the medium through which such relations are expressed).

A slightly different application to aphasia of the linguistic Saussurian fundamentals, simultaneity and successivity, has been made by Sabouraud, Gagnepain and Sabouraud (1963 , Jaffrain 1968). It distinguishes two main levels in language, the phonological and the semiotic and describes each level in terms of axes of simultaneity and successivity. On the semiotic level language is realized by lexical selection and insertion into a succession of words, and on the phonological level by selection from the limited list of phonemes and by combination into a 'phonic chain' or word. The four co-ordinates of phonological, semiotic and (intersecting them) selection and sequential combination define four types of aphasia: semiological Broca's, phonological Broca's, semiological Wernicke's and phonological Wernicke's. It is the two Broca's aphasias only which show disorders of textual sequencing, and it is only in semiological Broca's aphasia that the theory predicts a sequencing disorder in comprehension. In this kind of aphasia there can be an ability to understand isolated words but without their textual combinations, whilst in semiological Wernicke's aphasia the reverse occurs, with textual combinations comprehensible but not isolated words. No disorders of comprehension are predicted in the phonological aphasias: "ils sont presentés dans l'expression orale et n'interessent qu'elle seule".

There is thus a certain inconsistency between the neuropsychological observations that there is a general disability in sequencing behaviour after left brain damage, of which the language disorder in aphasia is the supreme example both in speech and perception, and the neurolinguistic observations that only some kinds of aphasic disorders exhibit problems in sequencing and that these are largely restricted to 'encoding' rather than 'decoding'. The reason, perhaps, is that modern linguistic analyses tend to give less prominence to the serial organization of language than do neuropsychological or neurophysiological ones which stress the observable behaviour of language, speech. The next section reviews the role which has been attributed to serial organization in two disciplines which have concerned themselves primarily with language rather than with general psychological processes, that is to say, speech perception (phonetics) and linguistics.

3.1.2 Serial organization in the comprehension of language

3.1.2.1 Speech perception theories

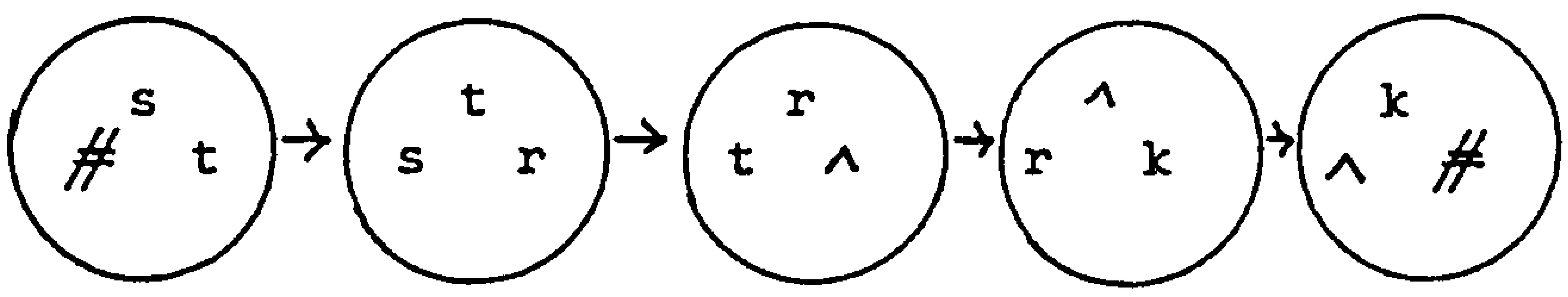
Speech perception theories have not made a sharp dichotomy between producing and perceiving speech. Indeed, the best known theory, emanating from the Haskins laboratory, explicitly proposes that perception of speech is mediated through the same neural patterns which are activated in the production of speech. The "motor theory of speech perception" is an extrapolation of the theory of analysis-by-synthesis which Miller, Pribram and Galanter (1960) put forward. Although a too literal interpretation of the theory that perception of speech is mediated through duplication of the speech movements by the hearer must be modified because of evidence that people with lifelong paralysis of the musculature for articulation need have no impediment of perception (Lenneberg 1962, Fourcin 1974), the role which sequencing plays in speech perception is essentially conceived of as related to the role which sequencing plays in articulation.

Two main kinds of models have been proposed to describe the way serial behaviour is organized in speech, the 'chain' and the 'comb' models. The 'chain' model conceives of a continuum of behaviour in which the feedback from one element of behaviour guides its successor. Lashley pointed out the inadequacy of such a model in 1951. Sensory feedback is too slow to make such a model practicable (Kent and Moll 1975). Lashley postulates:

> "the existence of generalized schemata of action which determine the sequence of specific acts, acts which in themselves or in their associations seem to have no temporal valence".

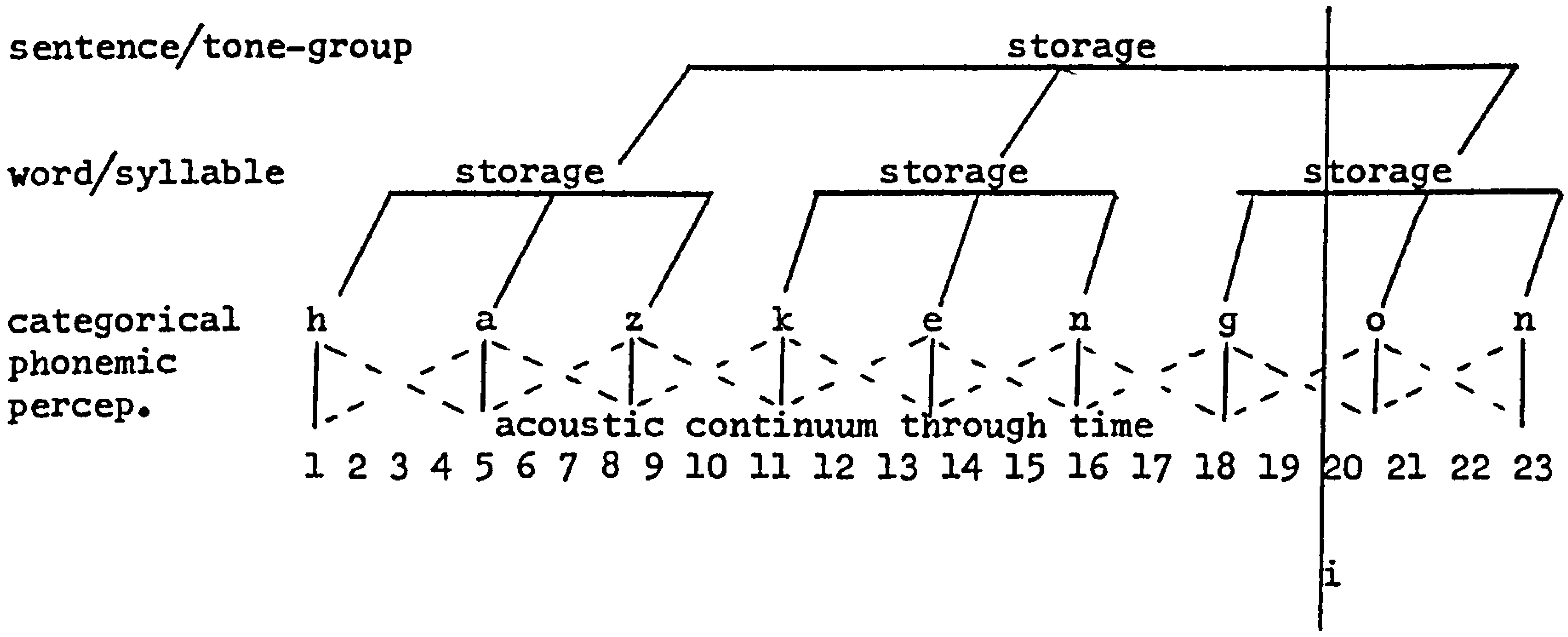
This is a general attribute of all serial behaviour, and Lashley relates it not only to motor organization of body movement, but specifically to speech and to speech perception. When we hear a sentence such as "Rapid/ɹaɪtɪŋ/ with his uninjured hand saved from damage the contents of the capsized canoe", we suspend judgement about the meaning of writing/righting until a complete enough segment is available for interpretation: with a segment size of a phrase the hearing of 'hand' is likely to prompt a read-out of 'writing', but with a segment size of the whole sentence the last word 'canoe' is likely to prompt a read-out of 'righting'.

A comb model of behaviour in production or perception therefore implies segmentation into chunks of behaviour, yet acoustically speech is heard as a continuous stream of sound. Moreover Lashley's schemata of actions "which . . . seem to have no temporal valence" have to be reconciled with language as it unfolds in real-time. Wickelgren (1972) has proposed a model which is essentially of the 'chain' type, but which allows for some pre-planning. It attempts to reconcile the continuum of physical reality with the production and perception of a series of subjective units. He suggests that each phoneme is in fact a "context-sensitive allophone", a combination of itself, its predecessor and its successor: for example, for the word 'struck' he proposes



There are some difficulties with this model. Firstly, Wickelgren finds it necessary to include an unspecified "phrase priming level" which is in operation at the same time as this associative chain. Secondly, even at the phonetic level, there is evidence that in most languages the context which precedes a phone has more influence on its production than the context which follows it. MacNeilage (1972) cites Moll and Daniloff as suggesting that these anticipatory cues have perceptual advantages in providing redundancy. Moreover these anticipatory co-articulatory cues can extend up to at least four phones in advance; for example, the vowel rounding gesture needed for / u / begins four consonants before the vowel in words like 'construe'. Thirdly, the evidence from speech errors in spontaneous speech (Fromkin 1973) indicates that word structure, syllable position, the integrity of some clusters of consonants, and the acceptability of certain combinations of phonemes in the language must be represented in phonemic ordering. Although real-time ordering of speech and perception must be sequential in time, at every moment of this time some higher levels of organization must be operative.

Quantum can be reconciled with continuum through hierarchical organization, which allows for serial processing at the same time as parallel processing. Each segment is linked into a higher order segment which in turn is linked into a higher order segment and so on. In this way a parallel processing occurs of different levels of organization at the same time, so that, although each segment of behaviour exists at a unique moment in time, it represents in fact several moments of time, preceding, instantaneous and consequent. A simplified illustration is given below. For simplification the illustration is of a three-monosyllabic-word sentence, 'Has Ken gone?', so that we can equate segments of speech which have articulatory and respiratory correlates (syllable and tone-group) with abstract linguistic constructs (word and sentence). It also bypasses distinctions which have been made between auditory and phonetic and linguistic processing (Lehiste 1972).



At any one point of time, i, perception is still operating with information contained in time segments 1 to i, because processing occurs on different levels.

In perception (though not production which requires pre-planning) the model predicts that most confusions of sequencing at any level of organization will occur within the unit of segmentation for that level because differentiation will be least enhanced, and it is therefore relevant to ask what evidence there is for the perceptual reality of these units. The subphonemic units which have been proposed, distinctive features, are distinguished in terms of paradigmatic contrast within a time segment or 'phonemic bundle'. The smallest linguistic units which can evidence errors of sequencing when combined into larger segments are therefore phonemes.

The perceptual reality of consonant phonemes as segments of language was demonstrated by Liberman, Harris, Hoffman and Griffith (1957) when they showed that subjects can make finer discriminations at the boundaries of a phone class in listening to synthesised speech than they can within the phone class. Chistovich and Kozevrikov are reported by Lehiste (1972) to have recently demonstrated a similar effect with vowels. Consonant clusters have also been proposed as perceptual units (Neisser 1967), but Bond (1972) points out that clusters containing /s/ are often heard as reversed. Intrusion errors indicate that phonemes in the same syllable are coded in working memory independently of each other (Cole 1973).

According to Lehiste (1972) there is no satisfactory evidence for the perceptual reality of the linguistic construct of the morpheme.

An experiment by Fry did not find the longer reaction times which would have been predicted for bi-morphemic monosyllabic words such as 'lacks' than for their mono-morphemic equivalents such as 'lax'. On the other hand there is good evidence for the perceptual reality of two segments which have physical correlates, syllable and tone group, as well as for the linguistic construct of word. Savin and Bever (1970), Warren (1971), Massaro (1974) and Cole (1973) have concluded that syllables are recognised before phonemes in speech. Warren, for example, demonstrated that identification time for words or for syllables, even though these were nonsense, was shorter than identification time for phonemes or phoneme sequences. (Bond 1976, however, considers such experiments to be inconclusive in support of the syllable as the primary unit of speech perception because phonemes are probably remembered by subjects as alphabetic characters and therefore require a 'double-think'.)

The integrity of words as perceptual units is illustrated in Day's (1970) experiment in phoneme fusion in dichotic listening. When subjects listen to /bankət/ in the right ear and /lankət/ in the left, even though presentation is asynchronised they invariably hear 'blanket'. Click localization experiments have been interpreted as confirmation of the psychological reality of syntactic constituents. Fodor and Bever (1965) found that clicks are reported by subjects as occurring closer to the nearest major syntactic boundary than their actual insertion. It was suggested that these results could not be explained away by pause patterns (Garrett, Bever and Fodor 1965) or by transitional probabilities (Bever, Lackner and Stolz 1969). Chapin, Smith and Abrahamson (1972), however, found that clicks were attracted to major surface constituent boundaries even when these did not coincide with the boundaries of underlying structure clauses, and emphasise the importance of surface features in speech perception. They suggest that listeners attempt to close constituents of the highest possible level at the earliest possible point. The storage units in perception are not predetermined as they are in production; they are subject to revision as the perception of an utterance continues. Attention has therefore been drawn to features of intonation in surface structure. Lehiste (1972) found that stressed words tend to 'attract' clicks, and that clicks inserted before unstressed words are identified more accurately than clicks before stressed words. Bond (1972) suggests that recoding cannot take place efficiently until an adequate amount of information is available and proposes that these units of perception are tone groups defined by stress and intonation: the first step in speech perception is a segmentation of the acoustic speech signal into units defined by suprasegmental factors which are then analysed for syntactic function and lexical content. Reaction time measures to click recognition are sensitive to the first step, and localization of clicks to the second. Bond (1976) has also demonstrated that organization of sequences of four non-speech sounds (hiss, beep, honk and rumble) into patterns with identifiable stress, as in speech, facilitates recognition of their correct sequence, in normal subjects. It did not, however, help aphasic patients.

There are therefore several candidates for the size of the perceptual unit in which sequencing errors might operate in aphasia. Efron's analysis would suggest that it could be an elementary acoustic unit even before the phonetic analysis of speech is begun (see Lehiste's 1972 distinction between the auditory and the phonetic and the linguistic).

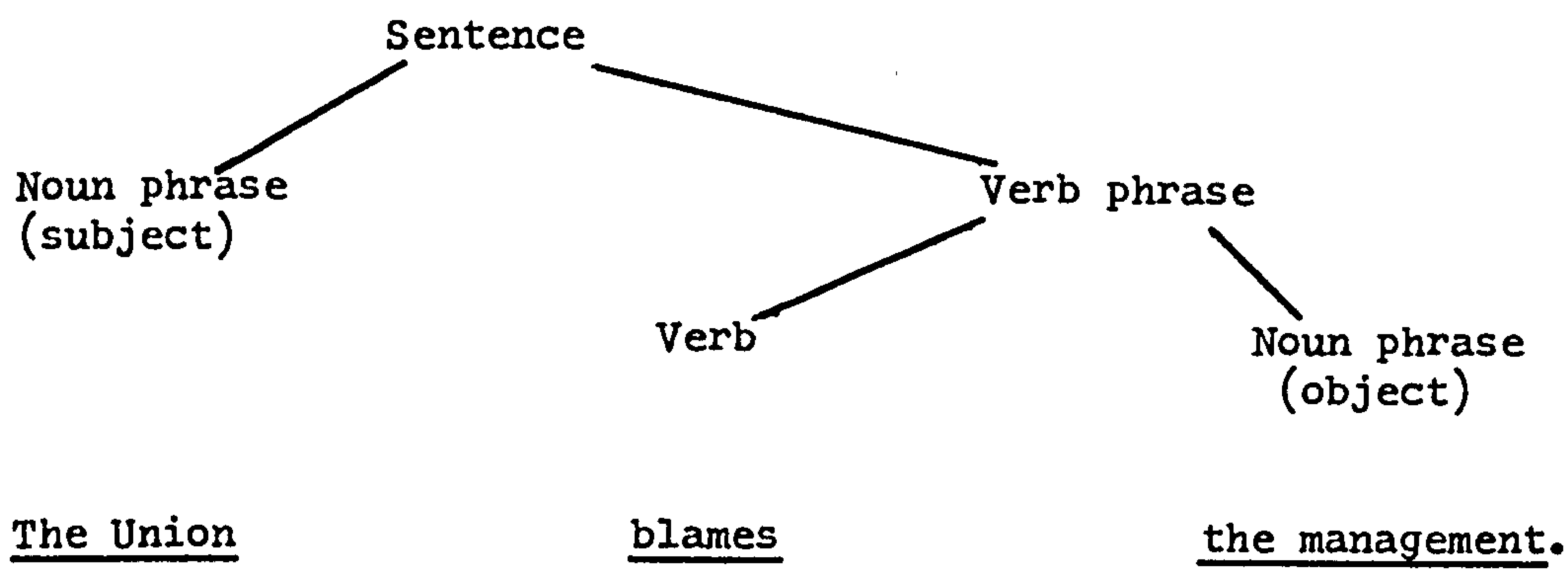
Blumstein's evidence tentatively suggests that phonemic patterns within words are subject to reversal in perception (as there is ample evidence they are in the production of speech, in literal paraphasias - see, for example, Fay's review, 1966). Albert has clearly demonstrated that aphasics have a disability in the recall of sequences of single words. Jakobson considers that there can be a disruption in one kind of aphasia of the decoding of sequences of noun phrases and of co-ordinate sentences. Bond's findings suggest that the tone group (at least as identified by a pattern of stress) may be a functional perceptual unit for aphasia within which sequencing errors occur. This leads to the speculation that not only might co-ordinated noun phrases be confused but also noun phrases which are functioning in different roles within a syntactic unit - of how much, in fact, the abstract linguistic structure of a syntagm "protects" it, as Jakobson claims, from the disruption of temporal sequence which is evident in non-verbal sounds and in sequences of words which are not differentiated by syntactic class.

3.1.2.2 Linguistic theories

Some speech perception theories appear to have relegated temporal order to an extra-linguistic role in language. For example, Day (Gilbert 1972) is reported as saying that:

> "correct temporal order may be represented in the system at some point in time, but later stages of processing mold this information to conform to the linguistic structure of the language. Hence nonlinguistic information concerning ... temporal order is lost only after it enters higher stages of linguistic processing".

The kind of linguistic structure which would supposedly make higher order processing independent of temporal order may perhaps be illustrated by the phrase structure of a simple active affirmative declarative transitive sentence:



It is clear from such a structure that the two nouns are distinguishable by more than their sequence in the sentence. If such a model has validity as a mental process (a claim which linguists would not necessarily make), subject and object are abstracted at different levels of analysis. The sentence structure is decoded, not as subject + verb + object (S + V + O), but as S + VO, with VO secondarily analysed as V + O. The implication is that once the process of speech perception reaches this level of linguistic analysis, the temporal organization of the segments of sound in speech is no longer of critical importance.

Recently, however, linguists have become increasingly interested in the question of the extent to which order is represented in the organization of language. A recent book (Li 1975) is devoted to this topic.

In the surface structure of language, the sequence SO is so common as to have been proposed by Greenberg (1963) as the first candidate for a linguistic universal:

> "In declarative sentences with nominal subject and object, the dominant order is almost always one in which the subject precedes the object".

Even in 'free-order' languages like Russian it would appear that there is some greater appropriateness in such a sequence. It has been suggested that word order in sentences represents an 'iconic' aspect of physical experience: Jakobson (1963) proposes that the "order of elements in language parallels that in physical experience or the order of knowledge". Watt (1970) and Osgood (1971) consider that the sequence SO is attributable to the salience of the actor in the action. The action is an integral part of the actor; it is only secondarily applied to the passive recipient of the action. It is interesting to note that this would not predict an underlying structure of S + VO, but rather a structure SV + O. Either of these structures, however, would be consistent with the independence of higher levels of language processing from the temporal sequence in which speech is heard. They would strongly argue for the maintenance of SVO relationships in aphasic comprehension.

Experiments and observations of children's comprehension of sentences have tended to confirm the universality of this sequence of subject preceding object. It would appear to be an underlying rule which, at some stages of acquisition, makes the passive misinterpreted and is used as a strategy for comprehending sequences of words which have recognisable parts of speech (verb infinitives, nouns) but no phrase structure (Huttenlocher, Eisenberg and Strauss 1968, Sinclair and Bronckhart 1972). Observations of the spontaneous speech of young children acquiring language are less conclusive, however (Brown 1973); they lead to the impression that children maintain a consistent order but that it may be idiosyncratic rather than patterned on the parent language, and that it is not invariably one in which subject precedes object. They do, however, indicate that sequence as such is important in children's construction of language.

It has consequently been proposed that sequence is represented in the base structures underlying sentences as well as in its surface structure. This is the position taken by standard transformational grammar, even though Chomsky modified his first proposal that deep structure "kernel" sentences took the form of a simple active sentence. A representation of order in base structure would account for the lack of ambiguity in such pairs of sentences as 'John killed Bill', 'Bill killed John'. Bach (1975) reviews the evidence that there is order in base structure and comes to the conclusion that on the whole the claim is supported: "It seems to me that there is something inherently linear in language" (page 338).

Others have a different conceptualization of deep grammar. Interpretive semantics (Jackendoff 1972) and conceptual dependency theory (Schank 1972) relegate sequence to the surface syntactic level of language, proposing that at the deep level (which is semantic or conceptual rather than syntactic) the relationships between, for example, Bill and John in the examples above would be expressible in terms of a configuration of dominance relationships rather than of sequence. Fillmore (1968) offers something of a compromise, a partially ordered case system which gives the verb a priority in the generation of the sentence, but considers that the case relations which are inherent in the verb are themselves unordered. Sanders (1975) offers the Derivational Theory of Ordering, in which phonetic constituents are conceived of as related to each other by ordering (asymmetric and non-commutative), and there is an invariant order constraint for certain features of surface structure (such as the determiner preceding the noun), but "all constituents of the terminal semantic representation are related to each other by grouping and not by ordering", grouping being associative and commutative.

Waugh (1976) has observed that the pre-positioning of adjectives in a language where they usually follow the noun, such as French, argues for a pre-supposition of the lexical meaning of the noun which is modified. She concludes that "language in general is a paradigmatic system where categories or elements or features co-exist simultaneously and can combine simultaneously to form a given linguistic unit". Palmer (1964) tried to clarify the situation by making a distinction between order and sequence, sequence relating to observable speech events and order to the linguist's constructs. "The problem is to decide to what extent sequence is or should be an exponent of order". He points out that the same sequence in surface structure can have different tree structures: 'The man came from the Gas Board' may be either 'The man from the Gas Board + came' or 'The man + came from the Gas Board', with the same sequence thus representing different configurational 'orders'. He suggests that it is not necessary to make the same decision about the role of sequence for each level of language. Morphology may be wholly independent of sequence: for example, the past morpheme may be incorporated in the word ('took') or at the end of the word ('liked'). Or phonology may be wholly dependent on sequence: for example, there is no semantic relationship between 'top' and 'pot', and the similarity is fortuitous because sequence is an exponent of language at this level. The same symbol can be used in different places to indicate different things; the place in the sequence, not only the symbol, is significant.

Such analyses of the role of sequence in language as Bach's, Sander's and Palmer's focus on the anatomy of language's different levels of description. Another way is to consider the dynamics of sentence generation or interpretation within a level. The theory of transformational grammar known as Generative Semantics (or Semantic Syntax, Seuren 1974) argues for sequential processes in transformations and lexical insertion. Some transformations must occur after lexical insertion, some (or at least one) must occur before lexical insertion, as can be deduced from the sphere of influence of operators such as negatives, 'many', 'often' and 'almost'. The sphere of influence of operators can sometimes be inferred from surface order (e.g. 'I think he doesn't' contrasts in meaning with 'I don't think he does'), but sometimes cannot (as in Macawley's illustration given below). The sphere of influence need not only relate to the deep structure of a sentence, but can relate to semantic elements within a word. Macawley, for example, has analysed causative verbs such as 'kill' as being formed of elements such as 'cause+ to become+ dead'. The sphere of influence of 'almost' can operate on any of these elements in a way which cannot be inferred from surface sequence. Hence the threefold ambiguity of 'I almost killed Fred' (I almost caused Fred to become dead/I caused Fred almost to become dead/I caused Fred to become almost dead - or in other words I almost grabbed a knife to kill him/I nearly gave him the wrong medicine/I beat him up badly). We therefore find evidence of spheres of operation which can be directly related to sequence, as it is made explicit in surface structure, and evidence which cannot be related directly to sequence, if the reconstitution of a word such as 'kill' from these hypothetical elements is conceived of as a simultaneous rather than sequential process. The notion of 'cyclical' which transformational grammar has introduced to describe the process of transforming allows micro-events to be postulated as having a sequential order without necessarily implying that the macro-event has any location in time, as part of a sequential process of language generation. Even within a cycle the ordering of rules is not universally postulated. Kautsoudas (cited by Neeld 1976) has put forward the "unordered rules hypothesis", and indeed Neeld goes on to argue that it is not even necessary to postulate the cycle.

Linguistic theory therefore leaves us somewhat uncertain about the level and process of language at which sequential operations are implicated. At some conceptual level, be it pre-linguistic or semantic, the preparations for speech are derived from a configuration which is not a linear sequence but a "determining tendency" (Pick 1973). Beyond this different theorists introduce the idea of linear sequence at different stages of the process, some at a base structure level which may therefore already be described as syntactic, others only in surface syntactic structure and phonology.

The major difficulty in the application of linguistic theories in aphasiology is their utter divorce (unlike speech perception theories) from neurophysiological processes. Jacobson (1975) writes, of generative and transformational grammars:

> "It is very doubtful whether they have any meaning in relationship to brain mechanisms subserving language. It is hardly an exaggeration to say that in so far as the propositions of linguistic analysis refer to the nervous system they are uncertain, and in so far as they are certain they do not refer to the nervous system" (page 106).

However, linguistic theory is now being tested for its psychological reality in innumerable psycholinguistic studies, and it becomes more reasonable to use the link aphasia provides between an abstract language system and its neurological correlates to test out linguistic theories against the realities of brain dysfunction, and to use evidence from brain dysfunction to clarify controversial linguistic theories.

The intimate relationship of language and sequencing ability has some empirical support from other sources in the association of developmental dyslexia with poor performance on sequencing tasks (Zurif and Carson 1970, Corkin 1974), with a similar deficit in deaf children (O'Connor and Hermelin 1973) and with an association of 'high verbal ability' in university students with success in non-verbal cognitive sequencing tasks, which equally intelligent 'low verbals' do less well (Hunt, Lunneberg and Lewis 1975). Such a relationship may be supposed to be more than one of peripheral motor activity in speech or peripheral storage of sequences of perceived sounds.

Linguistic theory does not rule out the possibility that a radical disruption of mechanisms of sequencing at a central level after left brain damage would block the realization of language at an early stage of its formulation, and/or impede its comprehension because a holistic configuration could not be extracted from surface sequence although the series of segments could be accurately registered. On the other hand, if the tree-like structure of sentences provides them with an internal hierarchy of syntax, and if the capacity for utilizing this structure is maintained in aphasia, difficulties in understanding reversible sentences must be attributed to some process of registration or storage at a peripheral level. Some insight can be obtained by testing in two modalities. If reversible sentences are difficult both in listening and in silent reading (which by-passes the real-time restrictions of temporal sequence in listening), then we would have to conceive of the disturbance as occurring at a level of linguistic processing at which material had already become abstracted from its specific medium.

The following analysis tests the hypotheses that left-brain-damaged aphasic subjects would have difficulty with non-verbal sequencing and verbal sequencing; that they would show greater difficulty in comprehending sentences for which the sequence of words is critical to interpretation than they would in comprehending sentences in which it was not, while control subjects would find such sentences of equal difficulty; that this difficulty would occur with both listening and reading, and that similar difficulties would be evidenced at the phonological level of language; and that these difficulties would be general rather than restricted to one kind of aphasia.

3.2 Results

The verbal and non-verbal sequencing tasks were described in Part Three, Sections 3.3.2 and 3.5.5). The table below gives the results for the three groups of subjects on the non-verbal tests of memory for sequences:

Table 17

Non-verbal sequencing:

Means and standard deviations (errors)

	NBD	RBD	LBD
Hand gesture	1.269 (0.710)	1.896 (0.834)	2.438 (0.778)
Tapping	2.173 (1.349)	2.979 (1.678)	4.200 (1.413)
Visual	3.192 (0.906)	3.792 (0.859)	4.237 (0.981)

(The hand gesture test had a maximum of 5 errors, the others had 8.)

The LBD were impaired on all these non-verbal tasks which involved sequencing. The significance of the impairment was tested through the Mann Whitney U statistic: (z equivalent in brackets).

Table 18

Non-verbal sequencing:

Mann Whitney U statistics

	LBD/NBD + RBD combined aphasic/euphasic	LBD/RBD left/right brain damage
Hand gesture	469 (4.312)**	317 (1.750)
Tapping	421 (4.701)**	574.5 (1.324)
Visual	589 (3.337)**	363.5 (1.653)

** $p < .001$

The LBD were significantly worse on all the tasks than the euphasic combined groups, even on sequencing tasks which did not (overtly) require language. The prediction of a general impairment associated with left brain damage in tasks which required sequencing was therefore supported. However, the difference between the two brain-damaged groups just reached a significance level of .05 (1-tailed) with the hand gesture and visual tests, but not with the tapping test, suggesting some reduction in the ability for serial organization after right brain damage as well as left.

The prediction that the LBD would have more difficulty with sentences and with words which were reversible than with ones which were not was then examined by means of the five verbal tests in which a direct comparison between ordered and non-ordered items had been incorporated. For this purpose the Syntax Gesture test was rescored for number of errors on ONC and WOC items separately, with the number of ONC errors multiplied by 2 and the number of WOC errors multiplied by 3 to give both a scale of a maximum of 66. Table 19 gives the means and standard deviations of the three groups on the subsections of these five tests. The significance between the types of errors for each group was tested with the Wilcoxon matched pairs signed ranks test (Table 20). As the prediction was that simple reversible and non-reversible material would not inherently present difficulties to the control subjects, two-tailed tests were used. With a one-tailed test for the LBD, the probability levels given in the tables would be halved, increasing the significance.

The results supported the prediction that the LBD would have more difficulty with items in which sequence was critical to meaning than with those in which it was not. The reversible and non-reversible materials were not of equal difficulty for the two other control groups. The NBD made more errors on the ONC items than the WOC items on the Syntax Gesture test (partly due to a common failure to demonstrate the future tense), but this significant difference with the NBD was transformed into a significant difference in the opposite direction with the LBD. Similarly the paradigmatic items on the printed word version of the Phonological test were significantly harder than the syntagmatic for both the NBD and the RBD, but this difference was wiped out in the LBD. The difference between the paradigmatic and syntagmatic medians for the NBD was one error. With the LBD scores adjusted by reducing the paradigmatic scores by 1, the syntagmatic items were significantly harder, $T = 32$ $(N = 25)$, $p = .0002$. In the picture version of the Phonological test, paradigmatic and syntagmatic items were of equal difficulty for the control subjects but the syntagmatic items proved significantly harder than the paradigmatic for the LBD. (The

Table 19

Verbal sequence and non-sequence sub-tests
Means and standard deviations

	NBD	RBD	LBD
Syntax			
Picture-choice (aural)			
ONC	0.962 (1.113)	2.125 (2.290)	5.275 (3.916)
WOC	1.192 (1.201)	2.333 (1.993)	9.000 (4.076)
Picture-choice (reading)			
ONC	2.038 (1.907)	2.913 (2.193)	7.875 (4.096)
WOC	1.962 (1.455)	3.130 (2.262)	10.300 (4.462)
Gesture			
ONC	4.923 (2.952)	5.833 (3.953)	25.750 (16.059)
WOC	2.654 (1.958)	6.000 (3.539)	30.150 (18.505)
Phonological			
Picture-choice			
Paradigmatic	0.154 (0.464)	0.500 (0.659)	0.825 (1.394)
Syntagmatic	0.423 (0.703)	0.625 (0.711)	1.625 (1.531)
Printed word			
Paradigmatic	0.846 (0.881)	0.826 (0.717)	2.450 (2.012)
Syntagmatic	0.269 (0.533)	0.261 (0.864)	2.400 (2.122)

Table 20

Wilcoxon T values for sequence/non-sequence comparisons

Syntax			
Picture-choice (aural)	62.5 (N=18) p=.316, n.s.	85.5 (N=21) p=.267, n.s.	30 (N=37) p=.000002** (more errors with WOC)
Picture-choice (reading)	99 (N=20) p=.822, n.s.	64 (N=17) p=.554, n.s.	105 (N=37) p=.0002** (more errors with WOC)
Gesture	39 (N=25) p=.0009** (more errors with ONC)	107.5 (N=21) p=.780, n.s.	225 (N=38) p=.035 (more errors with WOC)
Phonological			
Picture-choice	3 (N=7) p=.063, n.s.	12 (N=8) p=.401, n.s.	62.5 (N=29) p=.0008** (more errors with syntagmatic)
Printed words	25.5 (N=18) p=.009* (more errors with paradigmatic)	13 (N=14) p=.001** (more errors with paradigmatic)	186 (N=28) p=.698, n.s.

N is the number of pairs which showed differences. (2-tailed tests) discrepancy between the picture and printed word version for the control subjects corroborates the inherently different nature of the two tasks, which was commented on in Part Three, Section 7.4.5). The increased difficulty with the WOC items on the syntax test occurred with the reading version as well as the aural version. The greater difficulty of the LBD with these verbal items which require registration of sequence was therefore corroborated at both linguistic levels and in different modalities of input and response.

Table 21

Verbal sequence and non-sequence sub-tests

K-R20 coefficient alpha reliability from non-brain-damaged subjects

Syntax picture-choice	
aural	
ONC	.327
WOC	.370
Syntax picture-choice	
reading	
ONC	.610
WOC	.402
Phonological	
picture-choice	
paradigmatic	.359
syntagmatic	.346
Phonological	
printed word	
paradigmatic	.243
syntagmatic	.108

To check on whether the greater impairment of the LBD on the 'sequence' subtests could have been an artifact of the differences in discriminating power of the tests (see Section 2.9), coefficient alphas were calculated for the subtests (Table 21). The 'sequence' subtests had lower reliabilities than their correspondong non-sequence subtests, or had reliabilities which were close, and the impairment of the LBD cannot therefore be attributed to an artifact of differences in discriminating powers enhancing the discrepancy in the pathological group.

For the aural picture version of the syntax test, it was also possible to obtain an index of the relative difficulty of ONC and WOC items for the children of age range 7 to 11 from the Tyneside schools, and from age 8 for the Surrey school. The table below gives the mean error scores for each group for each category of sentence (DR sentences are also included for comparison, adjusted to the same scale of a maximum of 28 errors as the other types of sentences).

Table 22

Mean error scores for children on verbal sequence and non-sequence subtests (syntax)

		n	ONC	WOC	DR
Tyneside (Version A)					
boys - age:	7.6 to 8.5	46	4.61	5.54	9.98
	8.6 to 9.5	54	3.14	5.44	9.40
	9.6 to 10.5	47	2.53	3.35	8.28
	10.6 to 11.5	60	1.92	2.96	6.37
girls - age:	7.6 to 8.5	51	5.38	6.53	11.06
	8.6 to 9.5	54	3.01	4.81	9.21
	9.6 to 10.5	60	1.59	2.69	8.12
	10.6 to 11.5	41	1.09	2.27	5.06
Surrey (Version A)					
boys - age:	8.6 to 9.5	20	1.45	2.75	7.56
	9.6 to 10.5	8	0.63	2.25	6.13
	10.6 to 11.5	23	0.96	1.96	5.17
girls - age:	8.6 to 9.5	22	1.77	3.00	6.68
	9.6 to 10.5	16	2.13	3.19	6.56
	10.6 to 11.5	28	1.00	1.86	4.50
Surrey (Version B)					
boys - age:	8.6 to 9.5	18	1.50	3.17	3.50
	9.6 to 10.5	18	1.39	2.22	1.36
	10.6 to 11.5	17	1.18	1.83	1.65
girls - age:	8.6 to 9.5	22	1.64	2.68	3.82
	9.6 to 10.5	23	0.83	2.13	2.59
	10.6 to 11.5	21	1.00	1.76	1.00

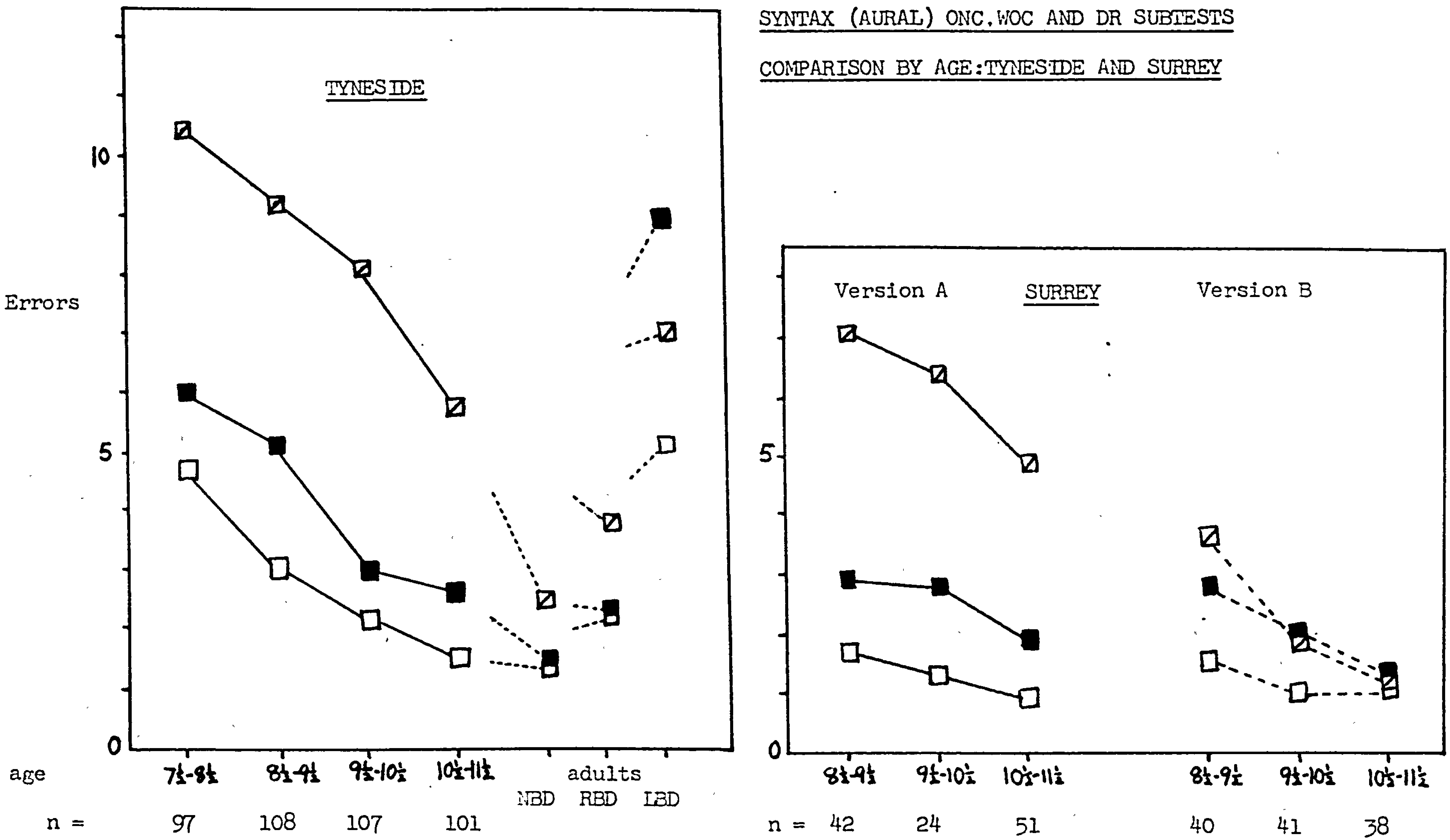
These results are shown graphically in Figure 3. There is a consistent trend for improvement on all types of sentences with age, marred only by girls from the Surrey School age $9\frac{1}{2}$ to $10\frac{1}{2}$ who took version A (this sample included two girls who made an exceptional number of errors). For versions A and B there was a tendency for the WOC sentences to be harder than the ONC at all ages (significant at all ages except $7\frac{1}{2}$ for version A - see Table 23 - but not in version B). The DR sentences were conspicuously more difficult at all ages in version A. In version B, the slightly greater difficulty of DR sentences at age $8\frac{1}{2}$ to $9\frac{1}{2}$ was resolved by age $10\frac{1}{2}$ to $11\frac{1}{2}$. At age 11 the Tyneside children were still having rather more difficulty with the WOC sentences than were the non-brain-damaged adults; at this age they were rather better than the RBD with ONC sentences but were about the same with WOC sentences. (In making these comparisons it should be remembered that the individual presentation may have favoured the adults.) It would appear that by age 11 virtually all children have reached adult competence with the ONC items, but that there may be some difficulty left in some children with reversible sentences. There is clearly still a considerable difficulty for some children with some sentences where the underlying relationship between actor and object is not made explicit in the surface structure; this supports the findings by Chomsky (1969) that some children still had difficulty with this kind of construction at age 11, and Cromer (1970) that children do not begin to acquire such discriminations till age 6+. Cambon and Sinclair (1974) report a majority of children as having acquired this distinction at age 8+.

Part Four

Figure 3.

SYNTAX (AURAL) ONC.WOC AND DR SUBTESTS

COMPARISON BY AGE:TYNESIDE AND SURREY



Key:
□ ONC sentences (Order Not Critical)
■ WOC sentences (Word Order Critical)
▨ DR sentences (Deep Relations) (prorated to scale of 28 items)

Table 23

Comparison of ONC/WOC sentences, Tyneside children
(Boys' and girls' results combined)

	Age							
	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{1}{2}$	11
Wilcoxon T	259.5	351.5	344	88	94.5	209.5	129.5	71
N	38	50	62	34	34	46	38	38
probability	.054	.003	.000005	.0002	.0003	.0002	.0002	.000007

The LBD made rather more errors with ONC sentences than did the youngest children with whom it was possible to make comparisons, the $7\frac{1}{2}$ to $8\frac{1}{2}$ year olds. A similar finding was observed with the Indefinite Article test (Part Three, Section 7.4.6.3.2). With the WOC sentences, however, there was a marked increase of difficulty for the LBD, well below the 7 year old age level (a linear extrapolation would give an age of $3\frac{1}{2}$ to $4\frac{1}{2}$). The difference is so great as to suggest a qualitative difference between LBD and children in this respect, in support of the claim that sequencing difficulties after left brain damage distort results on verbal comprehension tasks as they do on non-verbal tasks. In contrast to the WOC sentences, the LBD showed a difficulty on the DR sentences which was approximately the same as that of 10 year old children (Tyneside or Surrey) on version A (these are the combined A and B results for the adult subjects).

On the aural test, the DR sentences were intermediate in difficulty between the ONC and WOC sentences for the LBD, although for both the NBD and the RBD they were harder than either (though not with as great a discrepancy as with the children). DR sentences of the type used might be predicted to present an inherently greater difficulty than most of the WOC sentences for all subjects because they used infinitival complements, and therefore may represent two underlying base forms. For example, 'The lion is eager to kill' may be derived from 'The lion is eager' + 'The lion kills'. To make a closer analysis of the relative difficulty of types of sentences, the DR sentences were compared with a subset of the WOC sentences which also represented two underlying base structures, i.e. the sentences topicalized with 'it's'. These six WOC sentences were compared with six of the DR sentences, omitting the two DR sentences with the most complicated structure, those using contrasts of ask/tell and promise/persuade (these sentences, e.g. 'The girl asks the boy what to paint', include an indirect object and a direct object which is the verb complement, and they are also in part open to word order confusion). The sentences which were compared are listed below, with the number of errors made on each item in the different versions; these subsets of the DR and WOC sets will be labelled 'deep' and 'surface' to distinguish them from the complete sets.

Table 24

'Deep' and 'surface' sentences: number of errors

	NBD		RBD		LBD	
	aural (n=13)	read (13)	aural (12)	read (11)	aural (17)	read (14)
Version A						
Deep						
The bear is tempting/tempted to touch	4	0	5	0	12	3
The fish are slow/hard to bite	0	0	0	5	2	11
The people/sausages are too hot to eat	0	8	1	5	1	7
The soldier is easy/eager to shoot	0	0	3	0	6	1
The soldier is hard/easy to see	0	1	0	0	0	1
The shop is keen/cheap to buy	1	2	1	1	1	10
Surface						
It's the horse the boy frightens	3	1	0	1	8	3
It's the motorbike the car follows	0	0	1	0	8	2
It's the girl hits the swing	0	0	1	1	5	0
It's the boy kicks the horse	0	0	0	0	5	2
It's the dog the horse is bitten by	4	9	6	8	9	9
It's the car the van is pulled by	3	3	5	6	6	6

	NBD aural (n=13)	NBD read (13)	RBD aural (12)	RBD read (12)	LBD aural (15)	LBD read (12)
Version B						
Deep						
The doctor wonders/advises what to take	0	0	2	0	2	1
The man/bridge is too weak to cross	0	1	1	0	2	4
The lion is eager/easy to kill	0	1	1	0	1	4
The boy is easy/hard to hear	2	5	3	4	2	8
It is long/sharp enough to cut	2	3	1	3	1	4
The monkey is frightened/ frightening to touch	0	2	1	3	2	7
Surface						
It's the doctor the patient visits	1	0	6	1	10	1
It's the brick the man hits	1	0	0	0	7	3
It's the jug fills the pan	0	0	2	1	2	3
It's the burglar sees the guard	0	1	0	0	8	1
It's the girl the boy is splashed by	4	7	7	5	11	6
It's the ball the man is hit by	0	4	0	9	4	6

(For the deep sentences the aural version is given before the slash, the reading after the slash. For the surface sentences the aural version is as listed, the reading version having the nouns reversed. LBD exclude random scorers.)

From the list above, it was evident that one of the items in each type of sentence resulted in an unacceptable number of errors in the NBD group in the reading version. A cut-off of four errors was arbitrarily taken to be acceptable, thus the analysis for the reading version omitted the four sentences on which the NBD exceeded this number. In one case the picture seemed to be ambiguous; in the others the difficulty of the construction seemed to be enhanced by the semantic items used. Even with these items excluded, the reading version was considerably more difficult for the NBD than the aural version (mean errors 3.692 and 1.923 respectively), but only rather more difficult for the RBD (4.609 and 3.917) and the LBD (7.923 and 6.625). Other things being equal, one might have predicted that sentences which required accurate registration of sequence (such as 'It's the dog the horse is bitten by') would have been easier in the printed version where they could be visually checked; however, this does not seem to have occurred with the NBD.

Table 25

'Deep' and 'Surface' sentences

Wilcoxon T values (signed ranks for matched pairs)

	NBD	RBD	LBD (two-tailed tests)
Syntax pictures (aural)	18 (N = 12) p=.098, n.s.	60 (N = 18) p=.267, n.s.	27.5 (N = 32) p=.00001** (more errors with surface)
Syntax pictures (reading)	40 (N = 13) p=.751, n.s.	24 (N = 13) p=.124, n.s.	123 (N = 30) p=.024 (more errors with deep)

The differences between the deep and surface sentences were not significant in either the aural or reading version for the NBD and RBD. The predicted significant difference was found in the aural version for the LBD, but not in the reading version, in which the deep sentences were more difficult than the surface. Inspection of the number of errors in Table 24 suggests two factors responsible for this effect: one is that the surface sentences resulted in fewer errors when the LBD were able to rehearse them in reading, an effect which was probably enhanced by the omission of a greater number of random scorers; the second is that sentences where the underlying deep relationship was such that the subject of the sentence was not the subject of the verb complement tended to be more difficult than when the subject of both the underlying structures was the same; and by chance the reading versions contained more examples of these. For example, 'hard to bite' (= 'hard to be bitten') resulted in 11 errors from 14 subjects, while 'slow to bite' resulted in 2 errors from 17 subjects. In reading version A, three of the five sentences in the analysis were non-congruent in this way, and in version B four of the five were non-congruent. If these kinds of sentences are derived from two underlying sentences, it is plausible that the fact that the two sentences have different subjects makes them more difficult than sentences in which the subjects are the same. Of the 12 sentences in the two aural versions, seven were 'congruent' and five 'non-congruent', presumably lessening their inherent difficulty. The effect of difficulty for the surface sentences is so great that it cannot be dismissed as an artifact of the lesser inherent difficulty of the aural deep sentences, but as well as the influence of surface structure order there is clearly a probably influence of the nature of the deep relationships in the underlying structure. Further research would have to control for this variable. On top of this effect, it would also appear that this reduced sample of LBD (with random scorers excluded) was able to use the printed input to assist them in understanding these sentences which were amongst the most difficult in the whole test. These particular sentences have something of the nature of verbal reasoning tasks in them: as an exercise in reasoning such sentences may well have been easier in a reading version for the aphasic patients rather than in the transitory medium of sound.

The aural version of the phonological test had included a small number of items which measured sequencing in larger chunks than single words. Table 26 below shows the relative difficulty of sequence in these items in comparison with the items in which reversibility occurred either within words or within sentences.

Table 26

Mean number of errors in the aural comprehension of verbal sequence at different levels (to scale of 4 maximum) (LBD random scorers excluded. Phonological n = 36, Syntax n = 32)

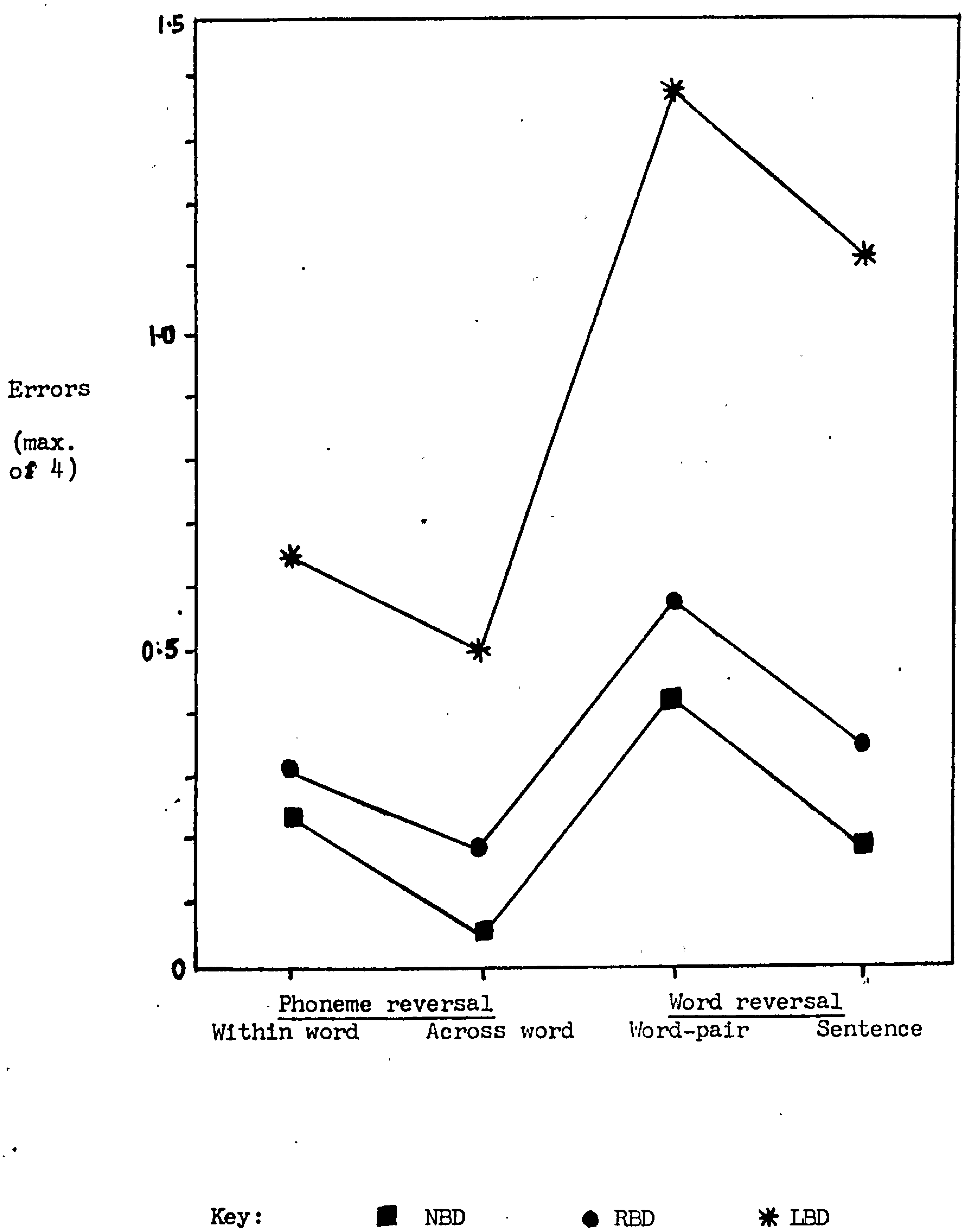
	NBD	RBD	LBD
Phonological syntagmatic within word	0.212	0.313	0.652
Phonological syntagmatic across word boundary	0.038	0.167	0.500
Syntagmatic word reversals	0.423	0.583	1.389
Sentences (syntax aural WOC)	0.170	0.333	1.103

Although the number of examples is small, Figure 4 suggests an approximately parallel increase of errors in the RBD over the NBD group at all levels of organization, while the LBD appear to find sentences and word reversals proportionately more difficult than phonological discriminations of sequence, whether these cross a word boundary or not.

The final analyses of the data on verbal sequencing concerned the question of whether some types of aphasia would show a greater degree of difficulty with sequencing than other types. Two possibilities were examined: that agrammatic patients might have more difficulty in understanding verbal sequence in the syntax aural picture test and the syntax reading test (as implied in the findings of Goodglass et al 1970), and that patients with articulation difficulties would have more difficulty with the syntagmatic items on the phonological test (as implied in findings such as Aten et al 1971). In the light of the general discussion in Section 3.1.1, however, it was predicted that these groups would not show greater impairment in sequencing than others. Two-tailed tests were therefore used.

Part Four Figure 4.

AURAL COMPREHENSION OF VERBAL SEQUENCE AT DIFFERENT LEVELS



Thirteen patients who were non-fluent (speech ratings for syntax of 5 or less) were matched for mean ONC comprehension scores on the syntax aural test with ten patients who were fluent (speech rating at least 7). The mean ONC score in the fluent was 6.50, in the non-fluent 6.69. The scores of these two groups on the WOC items (means 8.80 and 10.77) were then compared using the Mann-Whitney U test. The difference was not significant (U = 49.5). A similar analysis was undertaken for the reading test. Eight fluent patients with a mean ONC score of 8.50 were compared with ten non-fluent patients with a mean ONC score of 8.90. The mean WOC score for the fluent was 9.25 and for the non-fluent was 13.70. The difference, again, however, did not reach a probability level of .05 (two-tailed) (U = 18.5).

Thirteen patients with 'poor articulation' defined as a phonetic or phonemic rating of 5 or less, with a mean paradigmatic score on the phonological picture test of 0.375, were compared with fourteen patients with 'good articulation', defined as with phonetic and phonemic rating of 8 or more, with a mean paradigmatic score of 0.357. For the poor articulation group the syntagmatic mean score was 1.23, and for the good articulation group 1.07. Because of the large number of ties (i.e. 15 with a score of 1 and 6 with a score of 0) the U test was not used. The ratio of syntagmatic scores in good articulators to poor articulators (1.07:1.23) barely exceeds that which would be predicted from their paradigmatic scores (1.07:1.11). For a similar analysis with the printed word version of the phonological test, eight poor articulators with a mean paradigmatic score of 1.50 were compared with the fourteen patients with good articulation who had a mean paradigmatic score of 1.43 on this version. The syntagmatic means were, respectively, 1.38 and 1.50 with slightly more errors from the good articulators, instead of the poor articulators.

It was concluded that aphasic classification (from speech) as agrammatic or fluent, or as having poor or good articulation was not related to difficulties in sequencing in comprehension tasks at the syntactic and phonological level. The significant disability in comprehending sequence in verbal material which had been found in the whole group appeared to be general rather than related to any one category. This would agree with Albert's (1972a, b) conclusion rather than with that of Goodglass et al (1970). In syntax the impairment was greater in agrammatic patients, in line with Goodglass's findings, but the trend did not reach significance in this sample.

3.3 Discussion

The conclusions that can be drawn from these results depend on the validity of the assumption that the variable which had been incorporated in the design of the test material was indeed the variable which was influencing the results. Two other candidates which must be considered in influences on verbal comprehension in brain damaged subjects are word frequency and complexity of structure.

Word frequency had been controlled in the phonological test, and the discrepancy between paradigmatic and syntagmatic contrasts could not have been due to this factor. The syntax tests also used a simple vocabulary of, inevitably, picturable nouns and verbs. However, in order to check on the possible effect of word frequency, the vocabulary of substantive words in the eight most difficult sentences for the LBD

(11 or more errors) was compared with that of the eight sentences on which they made no errors:

Table 27

Word frequency in hard and easy sentences

Hard sentences				Easy sentences			
Man	AA	Visit	AA	Man	AA	Play	AA
Boy	AA	Hit	A	Dog	AA	Old	AA
Dog	AA	Patient	A	Bridge	AA	Breakfast	A
Girl	AA	Sheep	A	Break	AA	Rope	A
Guard	AA	Brick	49	Chair	AA	Favourite	A
Doctor	AA	Chase	48	Hat	AA	Shed	45
Show	AA	Lamb	45	Grass	AA	Twist	42
See	AA	Splash	20	Fire	AA	Piano	26
Bring	AA	Donkey	16	Light	AA	Bike	*
		Burglar	6	Cut	AA	Lawnmover	*

* unlisted in million count, but bike has frequency of 6 per 4 m.

It would not seem that word frequency could account for the difference in difficulty.

A second candidate, the structure of the sentences, would seem to have had some influence. In a sense this was inescapable in the test, where a number of heterogenous items were being used to examine reversibility, although at a simple level direct comparisons could have been made of equivalent structures (for example 'The sheep follows the farmer' could be contrasted with ONC 'The sheep follow the farmer' or with WOC 'The farmer follows the sheep'). Because the generality of the sequencing difficulty was being examined, some WOC sentences were used which were based on two underlying structures (e.g. topicalised sentences, 'Before' as a conjunction rather than as a preposition, subordinate phrases) while the ONC sentences were not. The rank order of difficulty of types of sentences (Table 39 in Part Three, Section 7.4.6.2) shows that fewest errors were made amongst all the sentences on one type of WOC sentence - those with reversible prepositions (e.g. 'The bike is behind the shed'), with the simple structure of Noun phrase + copula + adverbial phrase. There were 15 errors with WOC 'before/after' as a conjunction compared with 9 as an ONC preposition, on the aural versions (21 compared with 17 on the reading versions). The simple active sentence, in the context of ONC (verb plurality) and of WOC (reversibility) were of approximately the same difficulty in the aural version (12:13 errors) though with the reading version the verb plurality contrast was appreciably harder (22:14). The most difficult sentences of all, those with the direct/indirect object contrast, required the abstraction of structure from a series of four substantive words (e.g. 'The man brings the girl the donkey'). It would seem that the critical difficulty in the WOC sentences is best described in terms not so much of sequencing as of the abstraction of structure from sequence. However, the difficulty cannot be entirely simply in the peripheral registration of the sequence in which the elements of the structure are received: it occurred both in listening and in reading. It must be, in part at least, abstraction at a higher level of linguistic processing. The relative ease with which the structure of an adverbial phrase was retained suggests that the difficulty is not so much at this surface level of the structure tree, but at a level where V + NP needs to be reconstituted into VP, in fact in what Crystal et al (1976) describe as the clause level rather than the phrase level. Such a difficulty seems to be particularly enhanced if the sequence V + NP in clause structure does not match the surface sequence of words ('It's the patient the doctor visits'. 'It's the boy the girl is splashed by') but it also does occur when sequence and structure do match ('It's the guard sees the burglar').

That registration of sequence at a peripheral level cannot on its own account for the greater difficulty of WOC sentences is indicated by three further observations. The first is that these sentences were more difficult for some children, even at age 10, in whom it seems unlikely that short term memory for sequences of this length could have been so impaired. The second is that when the correlations of ONC and WOC scores with measures of non-verbal sequencing were examined, they did not prove to be higher for the WOC scores. The third is that a high proportion of the LBD subjects began to make errors on the Token Test, in terms of the numbers of items of information which could be coped with in a sentence, at a level below that which the Verbal Memory test for pointing to single named objects indicated they could process in the correct sequence. One factor may have been 'semantic overlap' in that the Verbal Memory items were chosen for semantic distinctiveness, whereas items in the Token Test are semantically close. In the syntax test also it is plausible that semantic similarity between subject and object (boy and girl) may enhance the difficulty of either registering sequence or abstracting structure from it: a lack of definition in semantic boundaries could make distinctions of sequence more difficult because of the semantic overlap. Such a variable was not systematically controlled for in the present investigation, as would be desirable in further investigations. However, all these three observations combine to suggest that something more than peripheral registration of sequence was involved in this difficulty in syntactic sequencing.

The difficulty in matching up sequence with an internal structure which has been suggested as accounting in part for the difficulties at the level of syntactic organization cannot be used as an explanation at the phonological level without some modification. The linguistic theories described in Section 3.1.2 attribute more importance to sequence at the phonological level as a simple matter of registration of acoustic sequence. However, two observations are pertinent. One is that a structure has been proposed for the syllable (MacKay 1972) which is remarkably like the structure for a simple active affirmative declarative sentence. Where phrase structure has S (sentence) → NP + VP with VP later rewritten as V + NP_2, syllable structure, it is proposed has S (syllable) → ICG (initial consonant group) + VG (vocalic group), with VG later rewritten as V (vowel nucleus) + FCG (final consonant group). The evidence is that speech errors such as Spoonerisms show that syllabic initial consonants are almost never transposed with syllable final consonants and vowels and consonants are never transposed (as verb and noun are also not). However, the second observation also relates to this, and that is that co-articulatory effects within a syllable give the sequence of sounds within it acoustic distinctions such that an initial consonant is not the same as its equivalent in final position. There is no equivalent to this at the syntactic level (unless we wish to include distinctions from another level, prosody). Because right-to-left co-articulation effects are stronger for vowels than consonants, it has even been proposed that the internal structure of a syllable is best expressed in terms of CV + C (consonant and vowel plus consonant) rather than C + VC (MacNeilage and De Clark 1969). Whatever the internal structure proposed, it might be predicted that co-articulatory effects would operate to preserve the word from confusions of sequence. In addition to this, as with reversible sentences, every syntagmatic contrast represents two paradigmatic contrasts with double the cues for correct interpretation. For example, if the first part of the monosyllable was misinterpreted a correct choice could be made only from the last. Most important of all, and unique to the phonological level, would be protection from errors of sequencing because of co-articulatory effects distinguishing the percepts. Yet the LBD found the syntagmatic contrasts harder at the phonological level, as they did with sequenced items at all levels (although Figure 4 suggested that the discrepancy was not quite as great as at the other levels).

The syntagmatic contrasts which were used in the test were of two kinds: contrasts of initial single consonant with final or medial consonant, and /s/ clusters. In the LBD results on the picture version the mean number of syntagmatic errors from the 40 subjects for each of the single consonant items was 4.33, and for the clusters 5.16. This effect of greater confusion for clusters was also observed on the printed word version, despite the different method of response having materially affected the quality of the errors in other respects. In the printed word version the ratio of cluster error to single consonant error was 8.33 to 6.67. The greater difficulty of clusters may therefore be attributable to an inherent difficulty in the material which the two versions had in common, the auditory input. This may imply that discriminations are more difficult the closer the two confusable sounds are together in time, as Efron's findings suggested. In this case syntagmatic contrasts would be difficult because of problems of peripheral registration or maintenance in transitory buffer storage prior to analysis at a higher level. Confusions of sequence of single consonants which are separated by a vowel, and where anticipatory articulatory cues are available already implies some abstraction has taken place from a phonetic to a phonemic level, and that the consonants are perceived as categorical discrete items, while confusions between, for example, /st/ and /ts/ could be due to failure to detect the point in time at which the fricative burst occurs.

A reasonable speculation, therefore, may be that sequencing difficulties at the phonological level represent a difficulty at a peripheral level of linguistic or extra-linguistic analysis, in that elements which are closer together in time are more confused, while at the higher level of linguistic processing of syntax, sequencing difficulties, while still partly explicable in terms of confusion of time of arrival of similar elements, represent also a specific disability in the abstraction of a configuration of relationships from a temporal sequence. Although the results from the 'deep' sentences are complicated by the uncontrolled variable of whether the agent in the two underlying structures was the same or not, the fact that they were significantly easier than 'surface' sentences in one version would be compatible with an interpretation of deep structure being better interpreted as a 'configuration of dominances' rather than as a linear sequence; if the configuration involved only one agent it could be abstracted more easily when this abstraction did not depend on the linear organization of surface structure. Such a hypothesis would have to be tested out with a larger number of sentences and with the 'agent' variable controlled.

The present investigation permitted the examination of individual patients for difficulties in sequencing in a wide variety of tasks, so that the generality of the disability in any one patient could be examined. It transpired that the ability to sort printed names of the months into chronological order was retained even by the 'global' aphasics, and with only one patient failing on this task. Arranging words into sentences was considerably more difficult, and whether the sentences were ONC or WOC made no difference (mean errors for ONC 23, for WOC 24.5 from the 40 LBD).

Table 28

Errors in sentence arrangement (six sentences)

LM1	1	LM11	2	LF1	1	LF11	2
LM2	6	LM12	5	LF2	4	LF12	6
LM3	6	LM13	6	LF3	2	LF13	6
LM4	0	LM14	4	LF4	6	LF14	4
LM5	3	LM15	1	LF5	4	LF15	6
LM6	6	LM16	4	LF6	6	LF16	2
LM7	0	LM17	6	LF7	5	LF17	2
LM8	0	LM18	0	LF8	5	LF18	2
LM9	5	LM19	6	LF9	6	LF19	1
LM10	6	LM20	0	LF10	4	LF20	5

Sentence 1	Total errors 22
2	21
3	26
4	26
5	25
6	26

Thirteen of the patients showed no ability at all in this task, even with the simple active sentence, 'The boy kicks the girl'.

Ability to arrange the five pictures for the story was quite distinct from ability to arrange five words into a sentence. Several patients who failed on the verbal task succeeded on the picture task. On the other hand, a patient who made no errors on the sentence task, LM20, was unable to extract the conceptual sequence from the pictures, and was apparently unable to realise that the same dog was represented throughout. Another patient who had no difficulty in sentence arrangement, LM8, arranged the pictures correctly but reversed the gist of the story he told, with the boy leaving school and searching for the dog. The results of the RBD also confirm the separation, at least in part, of these two abilities. Yet the picture arrangement task also required an ability to abstract a configuration from a sequence.

Although, therefore, these findings have demonstrated in general a disorder in sequencing ability in left-brain-damaged aphasics, it would seem that from the point of view of individual diagnosis a multiplicity of measures of sequencing ability is needed. Sequencing in the comprehension of language, while having something in common with non-verbal sequencing in imitative motor tasks and in conceptual figurative tasks (and with verbal sequencing measured by a series of unconnected items) may also have qualitative differences. At the phonological level the closeness in time at which acoustic discriminations have to be made may play a part, but such an explanation cannot, on its own, account for difficulties in understanding reversible sentences where the reversible segments are widely separated in time and when reading as well as aural comprehension is impaired. The ability to abstract a configuration of deep semantic relations from a linear sequence of segments by means of the tree-structure of the phrases which underly it may be peculiarly impaired in aphasia.

SUMMARY AND CONCLUSIONS

A review of experimental studies, theory and clinical practice, showed that there was a need for the application of linguistic principles in the investigation of the disturbances which can occur in the ability to understand language after brain damage.

Such an investigation, mainly with patients who had suffered cerebro-vascular accident ('stroke'), was undertaken, applying in particular the description of language in terms of three levels, phonological, syntactic and semantic.

A preliminary experiment confirmed the practicality of measuring verbal comprehension using picture tests which examined these levels. A second experiment demonstrated that

a) aphasic and control subjects had more difficulty in comprehending reversible than non-reversible sentences;

b) the left-to-right congruence of figures in the pictures with actor and acted-upon in the sentence had no appreciable influence on the results, and

c) some semantic features were important even in a measure of 'syntactic' comprehension.

These two experiments were followed by a comprehensive investigation of various aspects of verbal comprehension in sixty-four people who had brain damage from stroke. Forty had been diagnosed as aphasic after left brain damage; twenty-four had not been diagnosed as aphasic after right brain damage. Twenty-six non-brain-damaged people were control subjects, all but two of them being close relatives of the patients and from the same speech community. The tests and measures were designed to assess

a) verbal comprehension at the three linguistic levels;

b) non-verbal influences on test performance, and

c) memory for sequence, verbal and non-verbal, and the role of serial organization in the comprehension of language.

Samples of speech were obtained for comparison with results on the measures of comprehension. Opinions on the patients' ability to comprehend language were obtained from their relatives, and, in the case of the aphasic subjects, from their speech therapists.

The results of the investigation showed that the aphasic subjects were significantly impaired on all the verbal tasks, with every individual evidencing some degree of difficulty on at least one task. Patients who were agrammatic in speech had relatively poorer scores on syntactic comprehension, when this was measured through reading, than did patients who were not agrammatic. There was no significant difference between these two kinds of patients, however, when syntactic comprehension was measured through listening. Fluent aphasic speakers appeared to be as impaired on aural syntactic comprehension as on semantic. In patients whose speech showed mild, rather than severe, semantic deficits, semantic knowledge as tested in the formal task showed a degree of impairment which paralleled speech. Impairment in comprehension on the phonological measures was significantly related to phonetic disorders in speech, but apparently not to disorders of phonemic organization in speech.

The results from the aphasic subjects indicated that dyspraxic disabilities could influence the results of some tests of verbal comprehension. Aphasic subjects also had particular difficulties on tests of immediate memory which required serial organization, whether verbal or non-verbal. At both the phonological and syntactic levels of language organization, they had more difficulty in comprehension when confusions of sequence were possible than when they were not. At the syntactic level this could not be attributed to peripheral misregistration of time of hearing words, as it occurred with both reading and listening. It was suggested that the difficulty was not entirely in serial organization as such, but was in the abstraction of a structural configuration from a linear sequence. Such disturbances of serial organization in language may differ from those in non-verbal organization.

The opinions of the relatives of aphasic patients about their functional comprehension were related to formal clinical tests which examine memory for verbal sequence rather than to those which examine linguistic levels, suggesting that memory for verbal sequence is functionally important in everyday living, when finer levels of linguistic ability isolated from their non-verbal context are not. The speech therapists' opinions were related to the tests which used reading or which required more than a simple pointing gesture as response.

It is suggested that 'linguistic' tests, such as those used in the present investigation, may be particularly useful when executive speech is too impaired to be used as an index of underlying competence, and when there is an element of gesture dyspraxia which makes the tests of verbal comprehension at present in use somewhat unreliable. However, they clearly need to be supplemented by an assessment of functional comprehension in everyday living, as this is the final criterion by which the success of therapy must be judged.

There is a strong implication that much more attention needs to be paid to possible difficulties of sequencing in verbal comprehension at the syntactic level in aphasia than has hitherto been paid. It is an aspect of comprehension for which no standard clinical assessment as yet exists, and the tests used in the present investigation could provide a starting point for the development of such an assessment. How the therapist can set about assisting a patient to restore order into a blur of sequential impressions remains yet to be explored. At the micro-level various possibilities should be investigated such as training in sequential memory span. At the macro-level, it may be that a principal benefit which therapy can have for aphasic patients is to impose the ordered pattern on their verbal environment which they now have difficulty in structuring for themselves. For patients who have especial difficulties in structuring sequence, this would argue against the blanket, general stimulation approach which is sometimes advocated as the palliative for the aphasic's language disorder.

The right-brain-damaged subjects in the study were significantly and selectively impaired on the tasks which claimed to measure semantic knowledge, and in a manner which could not be attributed either to general intellectual impairment or to visuo-interpretive difficulties. The hypothesis is advanced that both halves of the brain make a contribution to semantic knowledge, while the syntactic and phonological mechanisms are lateralized. These findings applied to right handed people who had no left handers in the family: in people with familial left handers there are indications that the distinction between linguistic levels may not follow the same pattern. It would seem that a systematic investigation of the linguistic capacities of the right hemisphere, using the framework of different linguistic levels, would be justified.

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