Large Scale Research Project

An investigation of the association between adverse childhood experiences and cognitive functioning

and

An exploration of cognitive disengagement syndrome, daily functioning, intolerance of uncertainty, executive functioning, and worry

Doctorate in Clinical Psychology

200750952

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This thesis is submitted as partial fulfilment of the degree of Doctorate in Clinical Psychology

Table of Contents

Thesis Abstract

Adverse childhood experiences (ACEs) influence mental and physical health throughout the lifespan, and a wealth of literature attests to its impact on neurodevelopment. This has implications for cognitive functioning in adulthood, including executive functioning (EF), which is conceptualized as an overarching cognitive domain accounting for such functions as response inhibition, working memory and cognitive flexibility. Previous reviews have sought to qualitatively study the relationship between ACEs and EF in adulthood, though this research sought to expand on this by providing the first quantitative synthesis of this body of research. A systematic review and meta-analysis was conducted.

Twenty-five eligible studies (N = 8073) were extracted, with 55 effect sizes (Pearson's *r*). Overall, a small and significant association was found between ACEs and EF (r = - .126, 95%CI: -.152, -.10) and heterogeneity was high (I^2 = 99.50, p < .001). Type of EF measure and EF domain were established as small but significant moderators on the ACE-EF relationship. The findings are consistent with prior narrative syntheses of the ACE-EF relationship, and with meta-analyses which have explored the impact of ACEs on distinct EF subgroups. Methodological issues across this body of research, and in relation to the current meta-analysis are discussed as potential influences on the results of this study.

A separate and unrelated empirical study was conducted exploring cognitive disengagement syndrome (CDS). Growing interest in CDS as a distinct set of symptoms from ADHD has prompted research exploring its impact on functional abilities, mental health and cognitive functioning. These broadly point to CDS negatively impacting these domains, though it remains scarcely considered in clinical practice. This study aimed to expand the understanding of CDS by considering its association with daily functioning, executive functioning (EF), intolerance of uncertainty (IU), and worry.

This cross-sectional study utilized self-report measures of CDS (ACI), daily functioning (IWPQ-A), IU (IUS-R), worry (PWSQ-3), and executive function (ADEXI). The main analysis included adult participants (N = 399, Age range: 18 – 79). The findings suggest a direct CDS-daily functioning relationship, and established this is moderated by EF. IU was not found to be a mediator of this relationship, though IU was found to mediate the relationship between CDS and worry, as was daily functioning. Alongside the key findings, this study provides further evidence for CDS operating independently from ADHD, and discusses the implications for clinical practice and for future research.

Words: 390

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Literature Review

Adverse childhood experiences and executive functioning in adulthood: A systematic review and meta-analysis

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0.0. Abstract

Background

Adverse childhood experiences (ACEs) influence mental and physical health throughout the lifespan, and a wealth of literature attests to its impact on neurodevelopment. This has implications for cognitive functioning in adulthood, including executive functioning (EF), which is conceptualized as an overarching cognitive domain accounting for such functions as response inhibition, working memory and cognitive flexibility. Previous reviews have sought to qualitatively study the relationship between ACEs and EF in adulthood, though this research sought to expand on this by providing the first quantitative synthesis of this body of research.

Method

Systematic reviews were conducted across the APA PsychINFO, Medline, and Embase via Ovid, Scopus, Web of Science, and Proquest electronic databases from June 2019 to 6th July 2023. Sources identified in a similar qualitative review published in 2022 were also reviewed for inclusion. Meta-analysis including moderator analyses were completed to determine the strength of the ACE-EF relationship and identify potential moderators. Methodological quality of all studies included in the review was conducted.

Results

Twenty-five eligible studies (N = 8073) were extracted, with 55 effect sizes (Pearson's *r*). Overall, a small and significant effect size (r = - .126) was found for the ACE-EF relationship (95%CI: -.152, -.10) and heterogeneity was high (I^2 = 99.50%, p < .001). Type of EF measure and EF domain were established as small but significant moderators.

Conclusion

A significant small effect was established between ACEs and EF in adulthood. Implications for clinical practice and recommendations for future research are discussed.

Word count: 246

1.0. Introduction

1.1. Adverse childhood experiences

Adverse childhood experiences (ACEs) are some of the most pervasive sources of stress that children are exposed to. The term describes various types of abuse, including violence between parents or caregivers, psychological, physical or sexual abuse towards children, neglect, maltreatment, household dysfunction such as substance or alcohol use, parental death, and community, peer and collective violence (World Health Organisation (WHO), 2020).

Within the literature, the term ACEs is synonymous with the landmark study conducted by the Centers for Disease Control and Prevention (CDC) and the Kaiser Permanente health care organization in California in the 1990s (Felitti et al., 1998). The 'ACEs study' was the first of its kind to consider how ACEs mapped onto health outcomes in adulthood by recruiting over 8,000 participants to complete questionnaires related to ACEs and health-related behaviors and problems. The researchers established a strong graded relationship between the amount of exposure to ACEs and the risk of developing chronic and life-limiting conditions such as ischemic heart disease, chronic lung disease, liver disease, cancer and skeletal fractures (Felitti et al., 1998). They proposed this relationship was indicative of the increased risk of health-harming behaviours among individuals exposed to ACEs, such as smoking, substance misuse, overeating or sexual risk taking (Felitti et al., 1998).

Subsequent research in this area has corroborated the cumulative impact of ACEs on health conditions (Anda et al., 2008; Brown et al., 2010; Dong et al., 2004) and on increased risk of health harming behaviours (Andersen & Teicher, 2009; Dube et al., 2002; Ford et al., 2011). Exposure to ACEs is also now well established as being a risk factor for mental health functioning, with studies utilizing the CDC-Kaiser data set demonstrating an association between cumulative ACEs and the risk of suicidality (Dube et al., 2001; Ng et al., 2018) depressed affect and depression (Anda et al., 2002; Chapman et al., 2004; Edwards et al., 2003; Merrick et al., 2017; Nanni et al., 2012), as well as with severity of hallucinations and delusions in people experiencing psychosis (Bailey et al., 2018).

There is also evidence attesting to the impact of ACEs on cognitive functioning in adulthood (Lu et al., 2017; Masson et al., 2015). The mechanisms through which ACEs are said to influence cognitive functioning throughout the lifespan can be explained by what is referred to as the ‘toxic stress’ hypothesis (National Scientific Council on the Developing Child (NSCDC), 2012) which has its basis in neurobiology and neuroendocrinology. The model proposes that prolonged exposure to stress during childhood, a developmentally sensitive period, impacts on the architecture of the brain. The concept of *allostatic load* (McEwen, 2012; NSCDC, 2020) helps to explain how this neurobiological disruption occurs, by drawing our attention to the body’s physiological response to threat. While a more comprehensive explanation of allostatic load can be found elsewhere (McEwen, 2012), it refers broadly to the results of over-activation of the brain’s threat response systems (the hypothalamic-pituitary-adrenocortical and the

sympathetic-adrenomedullary systems). These hormonal systems produce cortisol and adrenaline respectively in response to threat, which under normal circumstances help prepare the body to cope with stressors. However, sustained high levels of these hormones (toxic stress) can have a significant wear and tear effect on the brain and other biological systems (NSCDC, 2020). Toxic stress has been implicated in the autoimmune system by negatively affecting resilience to disease (Asmussen et al., 2020), and in the development of chronic physical health problems (Heim et al., 2000). Three main brain systems seem to be especially susceptible to the effects of toxic stress: (1) emotion regulation (amygdala); (2) memory (hippocampus); and (3) executive function (prefrontal cortex; McEwen et al., 2015; NSCDC, 2020). Reviews by Lupien and colleagues (2018; 2009) highlight that exposure to toxic or chronic stress can reduce the production of white matter in the brain, which is recognised as important to the development of executive functions. Exposure to childhood adversity then, according to the toxic stress hypothesis, can have potentially permanent implications for the development of brain and bodily functions.

1.2. Executive functioning

Executive functions (EFs) are higher-level cognitive processes which are essential for navigating the demands of daily life. EFs help us to understand and process multiple streams of information simultaneously, to monitor our mistakes, make decisions, initiate and change plans if necessary, and control our impulses (Jurado & Rosselli, 2007; Snyder et al., 2015). They represent what the NSCDC (NSCDC, 2011) refer to as the “air traffic control system” of the brain, coordinating and organizing information the brain

receives and responding accordingly. EF is broadly understood as an umbrella term for three distinct, but inter-related aspects of cognitive functioning: a) Working memory; b) Inhibitory control; and c) Cognitive flexibility (Diamond, 2013; Miyake et al., 2000; NSCDC, 2011).

Working memory is the capacity to hold and manipulate information in our minds for short periods of time, such as remembering a telephone number or directions. Inhibitory control is the skill used to master and filter our thoughts and impulses, allowing us to think before we act and to regulate our emotions (NSCDC, 2011). Cognitive flexibility is the ability to adjust in the face of new information, catch mistakes and fix them, think of things from a different perspective, and apply different rules in different settings (e.g. behave differently in professional settings when compared to being at home).

A more exhaustive review of EF sub-domains can be found elsewhere (Diamond, 2013), though worth noting here is that the brain regions associated with EF are closely connected to deeper brain structures that control a child's responses to stress and threat (Bush et al., 2000; Drevets & Raichle, 1998; Kuhl & Kazén, 1999). The prefrontal cortex, that is the area of the brain most closely associated with EF skills, develops mostly between the ages of 8 and 25 years (Lupien et al., 2018). This suggests the developing EF system is both affected by, and influences, a child's experience and response to threat and stress (Blair et al., 2005; NSCDC, 2011; Rueda et al., 2005).

1.3. Childhood adversity and executive functioning

The relationship between ACEs and EF has been examined in several studies, with some concluding there is a significant association between the variables (Letkiewicz et al., 2021; Majer et al., 2010; Nikulina & Widom, 2013) and others finding no association (Gonzalez et al., 2012). A prospective, longitudinal examination of child maltreatment and executive functioning in middle adulthood conducted by Nikulina and Widom (2013) followed a large sample of child participants (N = 792), who were categorized as either having experienced abuse and neglect or age-matched controls. They assessed the executive functioning and non-verbal reasoning of participants in middle adulthood, and collated data related to PTSD, depressive symptoms, IQ, and excessive alcohol use to establish if they had any mediating or moderating effects. The authors found that childhood maltreatment (most notably neglect), predicted deficits in executive functioning which could not otherwise be explained by the aforementioned factors (Nikulina & Widom, 2013).

A more recent cross-sectional study conducted by Letkiewicz et al. (2021) indicated a negative association between performance on self-report and task-based measures of EF and ACE score in undergraduate students (N= 162). Higher levels of childhood maltreatment predicted poorer inhibition, cognitive shifting and working memory independent of psychopathology (anxiety and depressive symptoms; Letkiewicz et al., 2021).

Within the last decade, a growing awareness of the variability in methodological approaches to exploring the relationship between ACEs and EF has prompted extensive reviews of the literature. For example, a meta-analysis conducted by Masson et al. (2015) included 50 studies reporting on the relationship between early life adversity and cognition in adulthood. Of these studies, 37 examined the relationship between childhood maltreatment and EF. The authors found an association between childhood maltreatment and cognitive functioning, including EF, though this effect size *(g* = -0.437, 95%CI = -0.557 – -0.317) was smaller than that seen in other areas of cognition (e.g. attention (*g* = -0.628, 95%CI = -0.825 – -0.431) and working memory (*g* = -0.653, 95%CI = -0.825 – -0.481); Masson et al., 2015). It is however worth noting that, as has been outlined above, working memory is considered a sub-domain of EF. This makes interpretation of their results slightly less clear, given that there is likely overlap in these two cognitive domains.

Reviews looking specifically at the relationship between ACEs and EF, or indeed sub-domains of EF, help to expand our understanding of the implications of ACEs on EF. A review conducted by Goodman and colleagues (2019) systematically explored the literature on the relationship between ACEs and working memory (WM). Their review considered the moderating impact of the type of task used to assess WM, type of ACE experienced, and clinical status of participants in the studies. They identified 26 sources in total for the review, 23 of which were included in a meta-analysis (N participants = 17,442). Upon reviewing the combined effect size of all the WM measure outcomes reported in those studies (Hedge's *g* = 0.22, 95% CI [0.16, 0.27]; *z* = 7.68, *p* < .001),

Goodman et al. (2019) concluded that individuals who had experienced ACEs were significantly more likely to demonstrate impairments in WM ability, than those who had not experienced ACEs. In their analysis, they also established that the relationship between ACEs and WM was not moderated by the clinical status of participants, and that across the studies, 10 different measures of WM were utilized (Goodman et al., 2019). They reflected that the amount of heterogeneity across the studies identified, not least in terms of the variability of WM measures and outcome metrics utilized, warranted further exploration of potential moderators of the relationship between WM and ACEs.

Lund and colleagues (2022) conducted a narrative review of the literature pertaining to ACEs and overall EF in adult populations, seeking to incorporate some of the recommendations about moderating variables (Goodman et al., 2019). Specifically, the authors sought to explore whether any differences observed across studies in adult EF functioning with ACEs were also implicated in psychopathological presentation. In order to establish this, Lund et al. (2022) searched 33 scientific and grey literature databases, identifying 17 sources in total which met their review criteria (N participants = 10, 105). The authors proposed the findings indicated ACEs increased the risk for EF difficulties among individuals diagnosed with schizophrenia, bipolar disorder, post-traumatic stress disorder (PTSD), and those experiencing a first episode of psychosis, though not those diagnosed with major depressive disorder (MDD). Evidence from non-clinical samples, the reviewers proposed, also supports a relationship between EF and ACEs in adulthood and middle adulthood, though this seemed to be dependent on type of adversity experienced (Lund et al., 2022).

Closer scrutiny of the review completed by Lund and colleagues (2022) does however reveal a lack of rigor. Methodological choices around their search strategy resulted in their identifying over 400,000 sources from the 33 databases searched, of which only 4858 were screened by the reviewers. While the authors do acknowledge their review is not exhaustive and could largely be considered as in the preliminary stages, there also does not appear to have been any consideration given to quality assessment or risk of bias in the sources identified, which is an important component of a thorough systematic review (Sanderson et al., 2007). Additionally, their decision to synthesise the data in narrative form leaves questions around strengths of association between the concepts of ACEs and EF, which could have been addressed by a meta-analysis of the studies included in the review, largely unanswered.

1.4. Rationale and aims of current research

The primary rationale for this research project is to extend and update Lund and colleagues' (2022) review of the literature, by completing an updated search between June 2020 and July 2023. This additional literature is currently unaccounted for within the field. Secondly, the strength of the relationship between ACEs and EF (as an overarching concept) in adulthood remains unknown, highlighting the need for a comprehensive synthesis and review of this body of literature.

The current review therefore seeks to provide a quantitative summary of the empirical studies investigating the nature of the ACE-EF relationship in adults. First, this study will

describe research exploring this relationship, including the tool(s) utilized to measure EF. It will then quantify the strength of the association between ACEs and EF, utilizing the data extracted during the present review, and by the author from sources identified within the review completed by Lund and colleagues (2022). Finally, this review will investigate the impact of the following methodological factors on this relationship: study population, study design, EF measure type, and EF domain.

The research questions are:

1. What are the main features of studies investigating ACEs and EF?
2. What EF measurement tools are utilized across studies?
3. What is known about the strength of the relationship between ACEs and EF?
4. Is this relationship moderated by methodological factors?

2.0. Method

2.1. Pilot and Scoping Review

A scoping review was conducted to ensure there were no existing systematic reviews in this area by searching PROSPERO, Google Scholar and the Cochrane Database of Systematic Reviews in September 2021. No existing reviews exploring similar lines of enquiry were identified. A pilot review was therefore completed in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al., 2018). This pilot review demonstrated proof of concept, by identifying a sufficient number of sources for the full review.

The scoping review was laterally repeated in February 2023 before commencement of database searches for full review, which revealed that a review (Lund et al., 2022) had been completed addressing similar research questions. At this stage, a decision was taken to amend the scope of the review, to account for more recent developments in the evidence base. Namely, the present review adapted its search strategy, to ensure the inclusion and exclusion criteria, and the terms used for the search, remained consistent with those in the Lund et al. (2022) review.

2.2. Pre-registration of protocol

The protocol for this systematic review was pre-registered with the International Prospective Register of Systematic Reviews (Ref: CRD42023360245) on the 26th of June 2023. The meta-analysis is reported in accordance with PRISMA guidelines (Page et al., 2021).

2.3. Literature Search

2.3.1. Source eligibility

The inclusion and exclusion criteria have been predominantly modelled on the previous review completed by Lund and colleagues (2022). Sources must have: (1) identified any type of formally classified ACEs (emotional abuse, physical abuse, sexual abuse, emotional neglect, physical neglect, violence against the mother, household member with substance use problem, household member with a mental health problem, or a family member who had been incarcerated); (2) quantitatively compared any EF in

individuals exposed to ACEs compared to those not-exposed to ACEs or compared different types of ACEs and resultant EF outcomes; and (3) been written in the English language, peer-reviewed, and published since June 2019 (when the searches for the Lund et al., 2022 review was completed).

Sources were excluded if they; (1) included participants with traumatic brain injuries; (2) only considered maternal perinatal substance use as the indication of ACE; (3) had insufficient information to extract methodology and results of the study; (4) included children or adolescents (below the age of 18) within the sample and not distinguished between these participants with adult participants in analyses; (5) used data from an earlier published study.

Titles and abstracts of all sources were initially screened for their relevance to the research area, and the full text of the remaining sources were reviewed against the inclusion and exclusion criteria.

2.3.2. Database searches

The following databases were searched from June 2019 (when the Lund et al. (2022) search was conducted) to July 2023: APA PsychINFO, Medline, and Embase via Ovid, Scopus, Web of Science, and Proquest. These databases were selected due to their inclusion in previously published reviews (Goodman et al., 2019; Lund et al., 2022),

though also according to their breadth of coverage across psychological and medical literature bases.

2.3.3. Search strategy

The search terms employed by Lund et al. (2022) were run in a pilot scoping review to determine their specificity and sensitivity. Reviews of keywords associated with relevant literature alongside these former search terms facilitated the development of this review's search strategy.

The systematic literature review employed a Boolean search strategy, comprising the core search components of 'adverse childhood experiences' and 'executive functioning'. An extensive range of relevant synonyms was utilized for each ACE component, though it was determined in respect of EF that even where sources may be investigating subdomains of the concept, utilizing this term accompanied by 'executive dysfunction' would be sufficient to capture relevant sources. Searches were broadened using truncations, notably use of a wildcard suffix (asterisk [*] at end of term) where a term might have a variety of endings. See Appendix 1 for full search strategy. Final searches were undertaken on 6th July 2023. Additional sources were identified by utilizing subject heading searches across each of the databases.

As has been highlighted above and elsewhere (Diamond, 2013), EF is an overarching, umbrella term which incorporates the subdomains of working memory, inhibitory control

and cognitive flexibility. Consistent with Lund et al.'s (2022) search strategy, this review only included sources which made reference to some of the key latent variables of EF: working memory, attention, inhibitory control (inhibition), cognitive flexibility (set-shifting), planning, and initiation (Naglieri & Goldstein, 2013). It therefore omitted sources that referenced only assessing processing speed, fluid reasoning, verbal ability or other variables commonly implicated in broader assessments of intellectual functioning, as well as emotion regulation due to its well documented evidence base elsewhere (see Dvir et al., 2014).

2.3.4. Study selection

After sources were identified in the databases, they were imported to Endnote 20 to organize the references and to remove duplicates. Duplicates were identified utilizing the EndNote software in the first instance, and thereafter by reviewing the references by hand.

Screening involved assessment of article titles and abstracts to ascertain relevance to the review topic of ACEs and EF. Full-text screening was then conducted on all potentially relevant articles and the data extracted from sources which adhered to the inclusion and exclusion criteria.

In instances where sources were potentially eligible but did not provide zero order correlations between ACEs and EF measures, the required data were requested from

the authors. Authors were also contacted in instances where there was not access to a full text.

All studies identified in the review conducted by Lund and colleagues (2022) were also screened for inclusion in this review. As the present review employed a similar search strategy to the previous review, the screen of the Lund et al. (2022) sources predominantly focused on whether the data could be extracted for the meta-analysis.

2.4. Data extraction

A data-charting template on Microsoft Excel was used to extract relevant study information from the articles which met the inclusion/exclusion criteria. The following information was extracted:

- Characteristics of sources of evidence
  - Author(s)
  - Year of publication
  - Location of study
  - Sample size (N)
  - Mean sample age
  - Sample characteristics
  - Study design

- Results of individual sources of evidence
  - Outcome measure of ACEs
  - Method of analysis
  - Number of independent effect sizes from study
  - Outcome measure of EF (name, EF domain, whether performance based or self-report measure)
  - Correlation coefficients between ACEs and EF measures

Data extraction was completed twice by one researcher, to reduce extraction errors. Double filtering and repeated data extraction will be completed prior to submission for publication.

2.5. Critical appraisal of individual sources of evidence

The methodological quality of the studies included in this review were appraised using a tool developed by Goodman and colleagues (2019), with minor adaptations to fit with the current research question (Table 1). This tool was utilized as the methodological heterogeneity of the studies included meant that utilizing a standardized risk of bias tool was less appropriate. It should be noted that bias ratings relate to the research questions in this review and are not necessarily a reflection of the overall quality of the study rated.

Sources were assessed utilizing the criteria outlined in Table 1. Accordingly, each source was given a score of 0, 1, or 2 for each criterion, where a score of 0 indicated "not met", a score of 1 indicated "partially met" or "required further information from authors" and a score of 2 indicated "fully met". Each source was given a total score out of a possible 8 points. A final summary rating was provided to indicate the overall quality of sources included in the review. Study quality descriptors will be applied, based on the following cut off scores: Poor (0-2); Fair (3-5); and Good (6-8) (Goodman et al., 2019).

Table 1. Explanation of point allocation for each study quality criterion

Criterion	**0 points**	**1 point**	**2 points**
1. Childhood adversity measure	Neither objective NOR validated	Objective OR validated	Objective AND validated
2. Executive function measure	Neither objective NOR validated	Objective OR validated	Objective AND validated
3. Sample size:			
Means	< 15 per group	15 – 30 per group	> 30 per group
Correlation	< 30	30 – 50	> 50
Regression	< 10 per predictor	10 – 20	> 20 per predictor
4. Data availability	Insufficient for meta-analysis AND not provided by author on request	Insufficient for meta-analysis but provided by author on request	Sufficient data for meta-analysis included in source

Note: Possible scores ranged from 0 to 8. Descriptors were applied based on total score: Poor = 0 – 2, Fair = 3 -5, Good = 6 – 8

2.6. Analytic procedure

2.6.1. Effect size coding

Twenty-five studies were included in the meta-analysis. Pearson's correlation coefficient (*r*) was selected as the effect size for this meta-analysis. While previous reviews in this area have tended towards using Hedges *g,* (see Goodman et al., 2019 and Masson et al., 2015) this study chose to utilize *r* according to the presence of single groups studies and its inherent interpretability when compared to other effect sizes.

Four studies reported two different groups, and eleven studies reported more than one EF outcome; each sample and EF outcome was coded and included as an individual observation. This resulted in 55 effect-sizes. One study (Kalia et al., 2021) reported the data with an adult and student population separately, and according to both groups comprising a healthy community sample, the data was combined and averaged. Another study reported outcomes by subtype of ACE (Aas et al., 2012), and in this instance only data from the group who had been exposed to sexual abuse was used. For studies that employed a prospective or longitudinal design, either baseline cross-sectional data (timepoint 1; Kalla et al., 2022) or data from the timepoint at which the EF measures were administered (Chakrabarty et al., 2020; Guo et al., 2022; Harris et al., 2021; Maxfield et al., 2023) was included in the meta-analysis. In these latter instances, this study took the view that reported ACE experiences would remain consistent across different timepoints. Seventeen studies employed a between-groups design wherein the mean difference was converted into a point bi-serial correlation (*r*).

Coding of EF domain for each effect size was completed by the author and two clinical psychologists working within a neuropsychology service. They were each blind rated and any areas of disagreement were resolved by way of consensus.

Cohen's (1988) conventions were used to interpret effect sizes (small: r = .10, moderate: r = .30, and large: r = .50), with 95% confidence intervals. For the meta-analysis, R-type effect sizes were converted to Fisher's Z (Cooper & Hedges, 1994), though were converted back to Pearson's r for final reported effect sizes.

Many studies reported different EF outcomes, with only 25% of effect sizes being independent in nature (i.e., one outcome per study). Further, this study combined multiple EF outcomes in cases where the outcomes represented the same subgroup of EF, or where they represented two or more individual scores for the same tests (e.g. PG-NG, TMT). Consistent with guidance from Borenstein et al. (2011), in these instances the outcomes were averaged for each sample. When all outcomes are analyzed together, the assumption of independence is broken, however the ES was reweighted to not inflate total N. The SE used in these cases was based on N/number of ES in study. Analyses of single outcomes are not affected in this way, however there are relatively few sources for some outcomes.

2.6.2. Extraction and conversion of data

Where possible, data was extracted regarding the means and SD of scores on ACE and EF measures. When authors had reported t value, this was extracted, though if not, the data was converted by the present author to determine the t-test value. The following formula was utilized to calculate t-test value: $(\bar{x}_1 - \bar{x}_2) / S_p(\sqrt{1/n_1 + 1/n_2})$, where $S_p = \sqrt{(n_1-1)s_1^2 + (n_2-1)s_2^2 / (n_1+ n_2-2)}$. T-test values were thereafter converted to a point-biserial r (pbr) using the following formula: $r_{pb} = t / \sqrt{t^2 + df}$. In cases where *r* was reported, this value was extracted instead of this pbr conversion procedure. See Appendix 2 for conversion of specific outcome measures by study.

All EF outcome measure data was thoroughly reviewed to ensure consistency in the reporting of effect sizes, so as negative effect sizes relate to higher ACEs being associated with poorer neuropsychological outcomes. Where study authors had not reported data in this manner, the present author inversed data as indicated.

2.6.3. Meta-analytic model

The meta-analyses were conducted utilizing JASP software (Version 0.18.1; JASP Team, 2023) and SPSS. The DerSimonian-Laird random-effects models was used to calculate pooled effects sizes (DerSimonian & Laird, 1986).

To account for anticipated heterogeneity between the studies, a random-effects model was used to analyse effect sizes. Distribution of effect sizes were examined using tests of heterogeneity (Q and I^2 statistics), which provide an index of the estimated variation

in effect sizes across the identified studies attributable to heterogeneity (Higgins et al., 2003). Higgins and colleague's (2003) classifications for interpreting I^2 heterogeneity values were utilized (low= 25%, medium= 50%, high= 75%). Sensitivity analyses were also conducted to detect the presence of outliers.

2.6.4. Moderator analyses

Seven moderator analyses were conducted to determine whether EF domain, EF measure type (self-report vs. performance-based), study population (clinical vs. non-clinical), study design (between-groups vs. within groups), mean sample age, sample size or gender could explain variability in effect sizes across outcomes. Continuous moderators (age, sample size and gender) were explored using meta-regression, while subgroup analyses were conducted for categorical moderators (EF domain, measure type, study population and study design). In the former, the meta-regression explains statistical heterogeneity as the method models the relationship observed between the effect size and continuous variables (Borenstein et al., 2011). In the analysis of categorical moderators, a mixed effects model was used and pooled effect sizes were calculated for each subgroup and statistical comparisons made between-subgroups.

2.6.5. Publication bias

To address publication bias, Egger's test was used to establish if the likelihood of studies being published was dependent on the direction of the observed effect (Egger et

al., 1997). Rank correlation tests (Begg & Mazumdar, 1994) were also used to evaluate publication bias.

Forest plots were created for each analysis with standard error (measure of sample size) plotted against the corresponding effect size (Fisher's Z). The Trim and Fill method (Duval & Tweedie, 2000) was used to examine whether outliers or missing studies had influenced overall effect estimates.

3.0. Results

3.1. Study selection

The PRISMA flow diagram (Figure 1; Page et al., 2021) illustrates the search and selection process for this review. The search provided a total of 3236 citations. Following title and abstract review, 1011 sources were discarded as they were irrelevant and failed to meet the inclusion criteria.

Of the 98 full-text sources identified for the review, a further 82 did not meet the inclusion criteria. Common reasons for exclusion were that studies included children within their sample, studies did not employ a measure of EF or ACE, or that they omitted a direct analysis of the relationship between these two constructs.

Contact was made via email with corresponding authors in cases where sources met the inclusion criteria but did not provide extractable data. Thirteen requests for additional information were made; 2 responded to the requests for data (11 were unable to provide the requested information), though unfortunately the data provided by these authors was not sufficient to be included in the review. At the final stage, the outlined screening procedure identified 16 eligible studies fulfilling the specified criteria for inclusion in the meta-analysis. Upon reviewing the data available from the studies identified in the work of Lund et al. (2022; n= 17), just over half of these sources (53%; n= 9) had sufficient data for inclusion in the current meta-analysis. This meant the total number of studies included in the meta-analysis was 25 (see Figure 1).

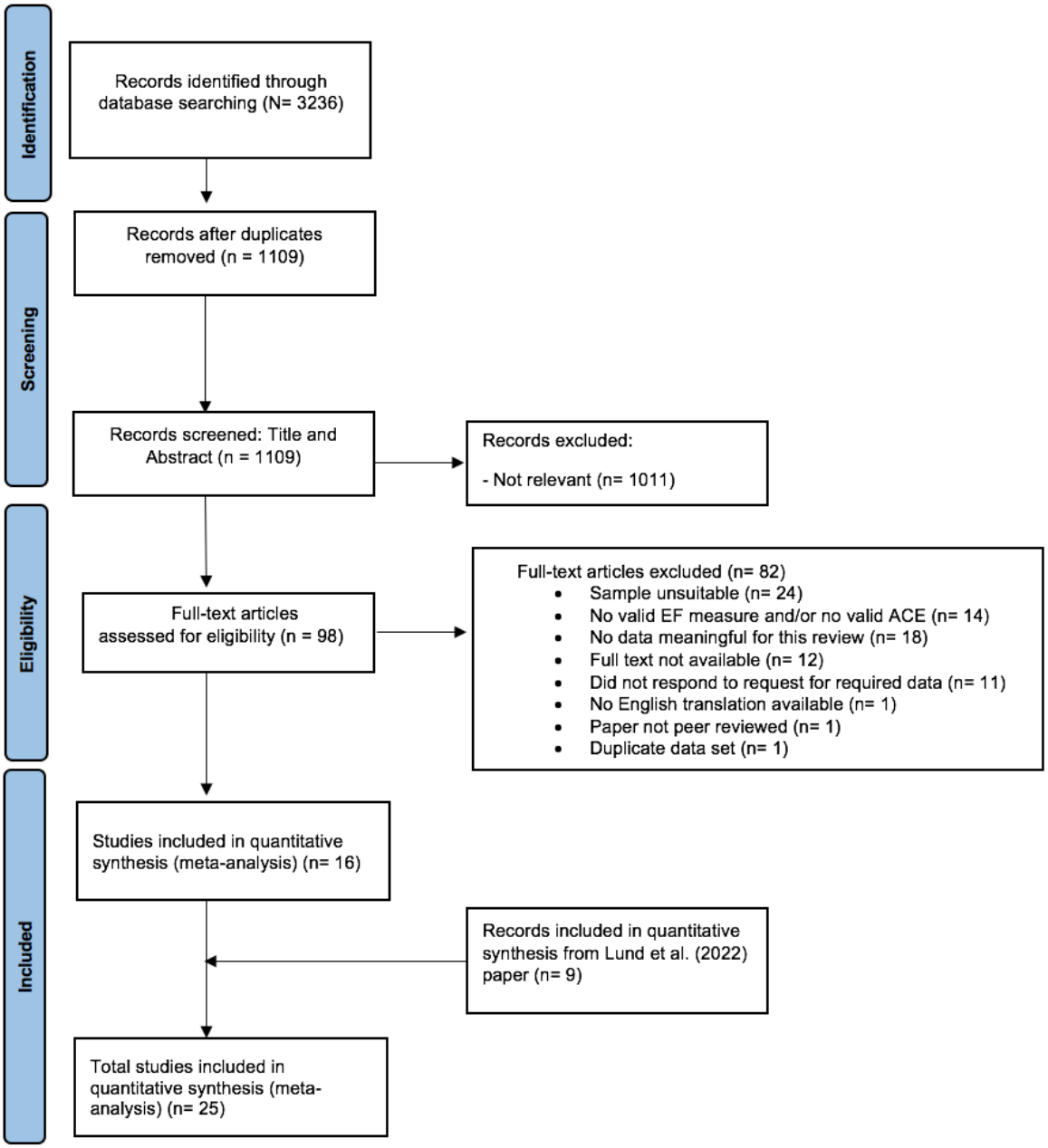

Figure 1. PRISMA flow diagram for inclusion and exclusion of studies

3.2. Study characteristics

Characteristics of the selected sources of evidence are presented in Table 2. Pertinent clinical and demographic characteristics are included to facilitate comparison between

studies. The meta-analysis included 25 studies, with 55 independent effects. The total sample across studies was N = 8073, with n = 7384 included in the final analyses.

The studies were published between 2008 and 2023; most were conducted in the USA, Canada, and Europe, and the majority used within-subjects designs (58%, k = 15). Most participants were from a non-clinical population (73%; n = 5413). Among the clinical characteristics of the samples were psychotic disorders (k = 5), major depressive disorder (k = 3), suicidal ideation (k = 1) and alcohol use disorder (k = 1). Average sample age was 29.86 years (SD = 6.98, Range = 19 - 53). Approximately 50% of the sample were female (n = 3708; not reported in 3 studies).

Table 2. Characteristics of sources of evidence

Author(s) and year	Country	Sample size	Mean age in years (SD) or range	% Female	Sample characteristics	Study design
Aas et al. (2011)*	UK	276	31.4	50.4	First episode of psychosis (50%; n= 138) and non-clinical controls	Cross-sectional
Aas et al. (2012)*	Norway	406	30.07 (3.00)	52.7	Psychotic disorders (100%)	Cross-sectional
Chakrabarty et al. (2020)	Canada	285	34.47	63.2	MDD (64%; n= 183) and non-clinical controls	Prospective cohort study
Cheng et al. (2020)	China	37	36.7 (8.5)	0	Alcohol use disorder (100%)	Case control
D'Amico et al. (2022)	USA	1541	53.4 (12.4)	53.3	Community	Cross-sectional
Daly et al. (2017)*	USA	110	20.36 (1.38)	71.8	University students	Cross-sectional
Ehrlich et al. (2023)	USA	405	38.79	70.9	Bipolar disorder (100%)	Case control
Gould et al. (2012)*	USA	93	29.83 (7.54)	69.9	Community	Cross-sectional
Guo et al. (2022)	China	295	34.96	55.3	MDD (52%; n = 153) and non-clinical controls	Prospective cohort study
Guss et al. (2020)*	USA	73	25 (5.71)	89	Community	Cross-sectional
Harris et al. (2021)	Canada	114	31.31 (5.18)	100	Post-partum mothers (100%)	Longitudinal
Kalia & Knauft (2020)	USA	486	33.10 (9.66)	30.9	Community	Cross-sectional

Table 2. Continued

Author(s) and year	Country	Sample size	Mean age in years (SD) or range	% Female	Sample characteristics	Study design
Kalia et al. (2021)	USA	510	27.67	53.3	Community (n = 295) and university students (n= 215)	Cross-sectional
Kalla et al. (2022)	Israel	86	18-20	0	Armed forces (100%)	Prospective cohort study
Kalpidou et al. (2022)	USA	194	19.31 (1.11)	80.4	University students	Cross-sectional
Mark & Poldavski (2023)	USA	84	21.04 (6.87)	91.7	University students	Case control
Marshall et al. (2016)*	USA	323	38.6	65.9	Bipolar disorder (72%; n = 233)	Cross-sectional
Maxfield et al. (2023)	USA	807	41	49	Child maltreatment court cases (57%; n = 458) and control group	Prospective cohort study
Peterfalvi et al. (2019)	Hungary	42	35.40 (9.73)	78.6	MDD (100%)	Case control
Rivera-Velez et al. (2014)*	Puerto Rico	24	29.33 (4.64)	100	History of sexual abuse and receiving treatment from sexual assault centres (50%; n = 12) and non-clinical controls	Cross-sectional

Table 2. Continued

Author(s) and year	Country	Sample size	Mean age in years (SD) or range	% Female	Sample characteristics	Study design
Rogerson et al. (2022)	UK	457	32.43 (11.22)	75.5	Community dwelling adults who reported suicidal ideation in past 12 months (100%)	Cross-sectional
Schroeder & Kelley (2008)*	USA	272	22.36 (7.12)	/	University students	Cross-sectional
Sideli et al. (2014)*	UK	259	28.65	38.6	First episode psychosis (52%; n = 134) and non-clinical controls	Cross-sectional
Tinajero et al. (2019)	USA	79	27.0 (6.5)	68	University students	Cross-sectional
Wong et al. (2022)	Hong Kong	126	23.23	60.3	ICD-9 child maltreatment syndrome (100%)	Case control

*Denotes sources identified in review conducted by Lund et al. (2022)

3.3. Quality assessment

Quality assessment was completed independently by two assessors (writer and a qualified clinical psychologist). Inter-rater assessment was completed on 48% of the sources identified (k = 12). There was inter-rater agreement for 42/48 ratings (88%). Disagreements were discussed and resolved.

Quality assessments are presented in Table 3; all studies were rated as having good quality. Six studies used a measurement of ACE which was either objective or validated, while the remainder used both objective and validated measures. Eighteen studies used a validated and objective EF measure (72%). One study had a poor sample size (Rivera-Velez et al., 2014) for the method of analysis they utilized. All studies were deemed to have sufficient data available for inclusion in the review, which is perhaps unsurprising considering they had been screened according to the data being sufficient for inclusion in the meta-analysis.

Overall, the quality assessment tool did not indicate any systematic methodological issues with the studies identified in this review. The methodological quality of these studies can generally be considered to be good.

Table 3. Quality Assessment

Author and Year	**Criterion**				**Total score**	**Descriptor**
	Childhood adversity measure (1)	***Executive function measure (2)***	***Sample size (3)***	***Data availability (4)***		
Aas et al. (2011)	2	2	2	2	8	GOOD
Aas et al. (2012)	2	2	2	2	8	GOOD
Chakrabarty et al. (2020)	2	2	1*	2	7	GOOD
Cheng et al. (2020)	2	2	1*	2	7	GOOD
D'Amico et al. (2022)	2	2*	2	2	8	GOOD
Daly et al. (2017)	2	2	2	2	8	GOOD
Ehrlich et al. (2023)	2	2	2	2	8	GOOD
Gould et al. (2012)	2	2	1*	2	7	GOOD
Guo et al. (2022)	2	2	2	2	8	GOOD
Guss et al. (2020)	1	1	2	2	6	GOOD
Harris et al. (2021)	2	2	2	2	8	GOOD
Kalia & Knauft (2020)	2	2*	2	2	8	GOOD
Kalia et al. (2021)	1	2	2	2	7	GOOD

Table 3. Continued

Author and Year	Criterion				Total score	Descriptor
	Childhood adversity measure (1)	***Executive function measure (2)***	***Sample size (3)***	***Data availability (4)***		
Kalla et al. (2022)	2	1	2	2	7	GOOD
Kalpidou et al. (2022)	1	2	2	2	7	GOOD
Mark & Poldavski (2023)	2	2	2	2	8	GOOD
Marshall et al. (2016)	2	2	2	2	8	GOOD
Maxfield et al. (2023)	1	2	2	2	7	GOOD
Peterfalvi et al. (2019)	2	2	1	2	7	GOOD
Rivera-Velez et al. (2014)	2	2	0	2	6	GOOD
Rogerson et al. (2022)	2	1	2	2	7	GOOD
Schroeder & Kelley (2008)	1	1	2	2	6	GOOD
Sideli et al. (2014)	2	2	1	2	7	GOOD
Tinajero et al. (2019)	2	2	2	2	8	GOOD
Wong et al. (2022)	1	1	2	2	6	GOOD

Note: Possible total scores ranged from 0-8. Descriptors were applied as followed based on total score: Poor = 0-2, Fair = 3-5, Good = 6-8; *Denotes scores which were resolved through discussion between raters

3.4. Results of individual sources of evidence

The extracted data (Table 4) demonstrated that the selected sources (N = 25) utilized a range of measures to quantify experiences of adversity and to establish EF performance. The majority of studies used either the full or short version of the Childhood Trauma Questionnaire (Bernstein et al., 1994; n = 13) to determine the extent to which their sample experienced ACEs. Across the studies, a total of 10 measures and methods were used to quantify ACE exposure.

A total of 31 EF measures were used across the studies included in this review, the majority of which were performance-based measures (87%; n = 27) as opposed to self-report measures (n = 4). The only EF self-report measures used were the Brief Test of Adult Cognition by Telephone (BTACT; Tun & Lachman, 2006), the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A; Roth et al., 2005), the Adult Executive Functioning Inventory (ADEXI; Holst & Thorell, 2018) and the Cognitive Flexibility Inventory (CFI; Dennis & Vander Wal, 2010). The most frequently utilized performance-based measures of EF were the Trail Making Test (TMT; Armitage, 1946; Delis et al., 2001), the Stroop Color and Word Test (also known as the Color-Word Interference Test; Delis et al., 2001; Golden et al., 1978), and the Verbal Fluency Test (Delis et al., 2001).

Table 4. Results of sources of evidence

Study	ACE measure	Method of analysis	No. of effect sizes (*k*)	EF outcome measure	EF domain	EF measure type	Participant subgroup	r
Aas et al. (2011)	Childhood Experience of Care and Abuse Questionnaire (CECA)	Correlation	2	TMT-B; L-NS	Composite	P	HC	0.039
							CP	-0.073
Aas et al. (2012)	Childhood Trauma Questionnaire (CTQ; Norwegian)	Regression	1	VFT	VF	P	CP	-0.092
Chakrabarty et al. (2020)	CECA	Comparison of means	6	CPT	CC	P	HC	0.066*
							CP	-0.190*
				SDC	PS	P	HC	-0.150
							CP	-0.157
				STROOP	RI	P	HC	-0.022*
							CP	-0.107*
Cheng et al. (2020)	CTQ	Correlation	3	MMCB	PS	P	CP	-0.262
					R	P		-0.413
					WM	P		-0.152
D'Amico et al. (2022)	CTQ	Correlation	1	BTACT	Composite	S	HC	-0.070
Daly et al. (2017)	Childhood Trauma Questionnaire- Short Form (CTQ-SF)	Comparison of means	5	D-KEFS VFT (1-3)	VF	P	HC	-0.154
				D-KEFS TMT (1-4)	CF	P		-0.026

Table 4. Continued

Study	ACE measure	Method of analysis	No. of effect sizes (*k*)	EF outcome measure	EF domain	EF measure type	Participant subgroup	r
				D-KEFS TOWER	R	P		-0.031
				STROOP	RI	P		-0.137
				BRIEF-A	Composite	S		-0.338*
Ehrlich et al. (2023)	CTQ	Comparison of means	1	TMT-A/TMT-B/SDC/STROOP/PG-NG/VFT	Composite	P	CP	-0.139*
Gould et al. (2012)	CTQ	Comparison of means	4	CANTAB IED	CF	P	HC	-0.205
				CANTAB DMS	R	P		-0.237
				CANTAB AGN	RI	P		-0.145*
				CANTAB SWM	WM	P		-0.304*
Guo et al. (2022)	CTQ	Comparison of means	2	DS-B; STROOP; TMT-B; VFT	Composite	P	HC	-0.175
							CP	-0.218
Guss et al. (2020)	The Adverse Childhood Questionnaire	Correlation	1	BRIEF-A	RI	S	HC	-0.330*
Harris et al. (2021)	CTQ	Correlation	1	WCST; STROOP	Composite	P	CP	0.070
Kalia & Knauft (2020)	ACE Scale (10 item)	Correlation	1	CFI	CF	S	HC	-0.235
Kalia et al. (2021)	ACE Scale (10/17 items)	Correlation	1	WCST	CF	P	HC	-0.080
Kalla et al. (2022)	CTQ	Comparison of means	2	BRIEF-A	RI	S	HC	-0.366*

Table 4. Continued

Study	ACE measure	Method of analysis	No. of effect sizes (*k*)	EF outcome measure	EF domain	EF measure type	Participant subgroup	r
					WM	S		-0.346*
Kalpidou et al. (2022)	The Adverse Childhood Questionnaire	Correlation	2	CPT	CC	P	HC	0.100
				FT	RI	P		-0.020*
Mark & Poldavski (2023)	The Lifetime Report of Physical Abuse (LPAA), the Lifetime Report of Psychological Abuse (PALA), and the Lifetime Report of Sexual Abuse (SALA)	Comparison of means	3	CPT	CC	P	HC	-0.085*
				WCST	CF	P		-0.128
				OSPAN	WM	P		-0.198*
Marshall et al. (2016)	CTQ	Correlation	1	PGN-G	RI	P	HC	-0.160
Maxfield et al. (2023)	Review of court records to establish child maltreatment	Comparison of means	2	TMT-A & B	CF	P	HC	-0.138*
				MR	R	P		-0.186
Peterfalvi et al. (2019)	CTQ-SF	Comparison of means	2	CPT	CC	P	CP	-0.273*
				WCST	CF	P		-0.020

Table 4. Continued

Study	ACE measure	Method of analysis	No. of effect sizes (*k*)	EF outcome measure	EF domain	EF measure type	Participant subgroup	r
Rivera-Velez et al. (2014)	Physical and Childhood Sexual Abuse- Short Scale	Comparison of means	4	CT-B	CF	P	HC	-0.204*
				SDC	PS	P		-0.298
				PA	R	P		-0.240
				DS-B	WM	P		-0.218
Rogerson et al. (2022)	CTQ	Correlation	1	DEX	Composite	S	CP	-0.210*
Schroeder & Kelley (2008)	Children of Alcoholics Screening Test	Comparison of means	2	BRIEF-A	RI	S	HC	-0.103
					WM	S		-0.139
Sideli et al. (2014)	CECA	Comparison of means	2	TMT-B; DS; SS	Composite	P	CP	-0.057
							HC	0.266
Tinajero et al. (2019)	CTQ	Comparison of means	3	DFT; VFT; L-NS	CC	P	HC	0.195
				STROOP; TMT; CPT	RI	P		-0.188
				BRIEF-A	Composite	S		-0.342*
Wong et al. (2022)	Review of government database to ascertain diagnosis of child maltreatment syndrome (ICD-9) <18yrs	Comparison of means	2	ADEXI	RI	S	CP	-0.030*

	WM	S	CP	0.029*

*Data inversed by either present author or original study authors. Note. Negative effect sizes indicate that poorer EF associated with higher ACE scores. EF outcome measures: TMT = Trail making test, L-NS = Letter-number sequencing, VFT = Verbal fluency task, CPT = Continuous performance task, SDC = Symbol-digit coding, MMCB = The MATRICS Cognitive Consensus Battery, BTACT = Brief test of adult cognition by telephone, D-KEFS = Denis-Kaplan Executive Function System, BRIEF-A = Behaviour Rating Inventory of Executive Function- Adult, PGN-G = Parametric go-no go, WCST = Wisconsin card sorting test, CANTAB = Cambridge Neuropsychological Test Automated Battery, IED = Intra-extra dimensional set shifting, DMS = Delayed matching to sample , AGN = Affective go-no go, SWM = Spatial working memory, DS-B = Digit span- backwards, CFI = Cognitive flexibility inventory, FT = Flanker task, OSPAN = Operation span test, MR = Matrix reasoning, CT-B = Colour-trail- backwards, PA = Picture arrangement, DEX = Dysexecutive questionnaire, DS = Digit span, SS = Spatial span, DFT = Design fluency task, ADEXI = Adult Executive Functioning Inventory. EF Domain: VF = Verbal fluency, CC = Cognitive control, PS = Processing speed, RI = Response inhibition, R = Reasoning, WM = Working memory, CF = Cognitive flexibility, Composite = Scores combined by study authors. EF measure type: P = Performance based, S = Self-report. Participant subgroup: HC = Healthy control, CP = Clinical population.

3.5. Results of synthesis

3.5.1. Outliers and sensitivity analysis

In the overall analysis, three studies were identified as outliers (Kalla et al., 2022; Sideli et al., 2014; Tinajero et al., 2019). Sensitivity analyses were conducted to determine if these outliers had a significant impact on the summary estimate. When tested individually and together, these sources did affect the mean effect size estimate, though their exclusion versus inclusion did not influence the overall magnitude of effect (Cohen, 1988). The features of each of these studies were reviewed to consider reasons for their being flagged as outliers.

In respect of Kalla et al. (2022), the EF measure utilized was the BRIEF-A (Roth et al., 2005). This test contains two subscales, the *metacognition* and *behavioural regulation* indexes, which were reported separately by the authors. Only the *behavioural regulation index* (BRI) effect size was flagged as an outlier. Notably, this study recruited a sample (100% male) from the Israel Defence Forces elite combat parachute unit and assessed EF prior to and following combat training (only former included in current study). It is unclear the extent to which individuals perceived their participation in the study was mandatory or voluntary, though it is likely that having been recruited via their employment, social desirability bias impacted scores on the BRI (e.g. 'I have angry outbursts') to a greater degree than the MI ('I have trouble sitting still'). The BRIEF-A does contain three validity subscales (*inconsistency, negativity* and *infrequency*), though these were not reported by the authors. While the impact of social desirability was likely exacerbated in this sample, and the sample differed significantly in

demographic characteristics compared to the other studies, the present author has determined it seems more appropriate to retain this data point for the present meta-analysis. Removing it had a very marginal impact on the overall mean ES estimate, as social desirability is likely to confound scores on the BRI regardless of the sample.

The Sideli et al. (2014) outlier related to the ES for the control participants only (i.e. not 'clinical' psychosis group). The authors of this study provided a composite score for EF, utilizing different measures (Trail Making Test-B, Digit Span and Spatial Span) which were summed and averaged by the authors. The same procedure was followed with the clinical group. In looking at the sample size of control participants, it is clear the 'no ACEs' group (n = 100) is significantly larger than the 'ACEs' group (n = 25). This may have skewed the results towards the larger 'no ACEs' group exerting more influence on variance estimates and possibly obscuring variability within the 'ACEs' group. Despite this, sensitivity analysis revealed that removing this outlier had little impact on the overall mean ES, and the random-effects model utilized in this meta-analysis accounts for heterogeneity in the data set, so accordingly this outlier was retained in the overall analysis.

The final outlier identified from the Tinajero et al. (2019) study related to the 'EF-cognitive control' ES. The authors summed participant performance on three different EF measures (Design and Verbal Fluency Tasks, and Letter-Number Sequencing) with seven outcome scores and generated what they refer to as an 'arithmetical mean' to provide a composite score. This process seems to have generated a small positive

effect size (0.197) for the cognitive control outcome. There do not appear to be relevant sample considerations with this study (given the same sample was utilized for the other two ES extracted from this study, which were not flagged as outliers). So, while this study's treatment of data may have influenced its being identified as an outlier, to maintain consistency in approach with above two cases (and thus avoid selection bias), this ES was retained in the meta-analysis.

3.5.2. Meta-analysis

Effect sizes have been converted back to Pearson's *r* from Fisher's *Z* values for consistency in reporting.

There was significant heterogeneity (Q (54) = 10822.77, p <.001), and the I^2 estimate was indicative of high heterogeneity, with almost all of the total variance explained by heterogeneity between effect sizes (99.50%, 95%CI: 99.73, 99.88).

The first analysis examined the combined overall effect size of the outcomes reported in Table 4. The combined random-effects point estimate yielded a small overall effect size (*r* = - .126) for the relationship between ACEs and EF (95%CI: -.152, -.101, *z* = -9.816, *p* < .001, *k* = 55; Weighted N = 7,234). This can be observed in the forest plot below (Figure 2), wherein the overall effect size and its confidence intervals are represented by the diamond shape at the bottom of the plot. Above the overall effect size, each study and/or outcome's weight is indicated by a square, which is proportional to the

sample size. Effect sizes below zero are indicative of poorer EF scores being associated with greater experience of ACEs.

Separate analyses were conducted to examine the effect size for the relationship between ACEs and the EF domains which were most frequently reported across the studies, namely, composite EF, response inhibition, cognitive flexibility, and working memory. Looking first to the composite EF domain, the combined random-effects point estimate yielded a small and significant effect (r = - .148) for the relationship between ACEs and composite EF (95%CI: -.195, -.102, z = -6.242, p < .001, k = 12, N = 3536). This can be observed visually in Figure 3.

For cognitive flexibility, combined random-effects point estimate established a small and significant effect size (r = - .130) for the relationship between ACEs and cognitive flexibility (95%CI: -.189, -.072, z = -4.367, p < .001, k = 8, N = 2156). This can be observed visually in Figure 4.

In respect of response inhibition, combined random-effects point estimate established a small and significant effect size (r = -.146) for the relationship between ACEs and response inhibition (95%CI: -.199, -.093, z = -5.381, p < .001, k = 11, N = 1641). This can be observed visually in Figure 5.

Finally, for working memory, combined random-effects point estimate also established a small and significant effect size (r = -.190) for the relationship between ACEs and

working memory (95%CI: -.296, -.084, z = -3.521, p < .001, k = 7, N = 722). This can be observed visually in Figure 6.

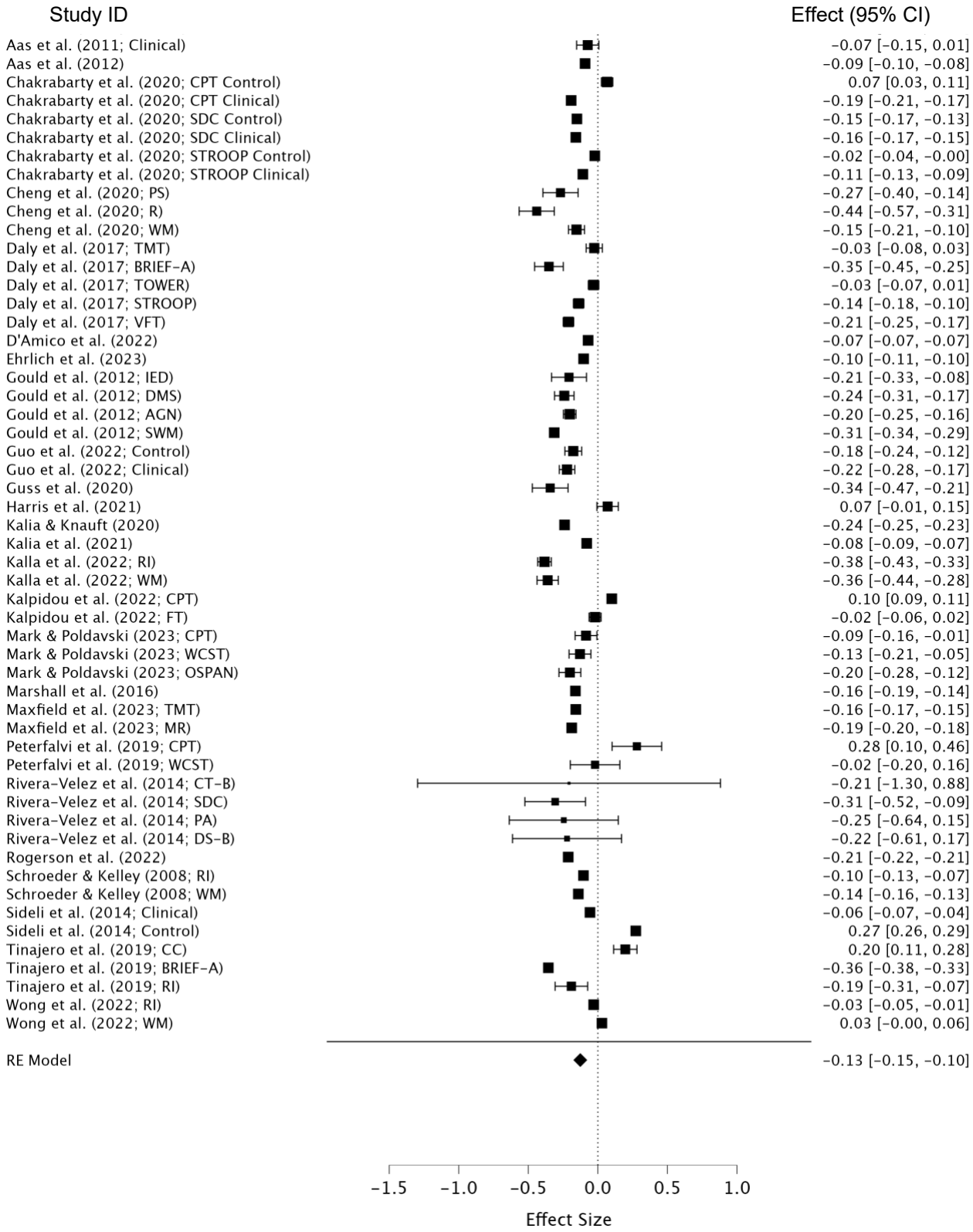

Figure 2. Forest plot of the ACE and EF relationship

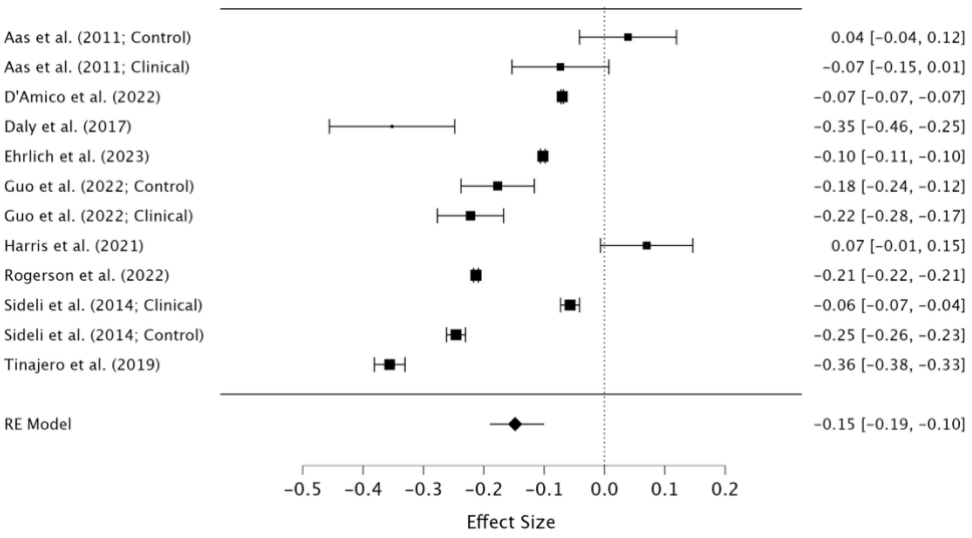

Figure 3. Forest plot of the ACE and composite EF

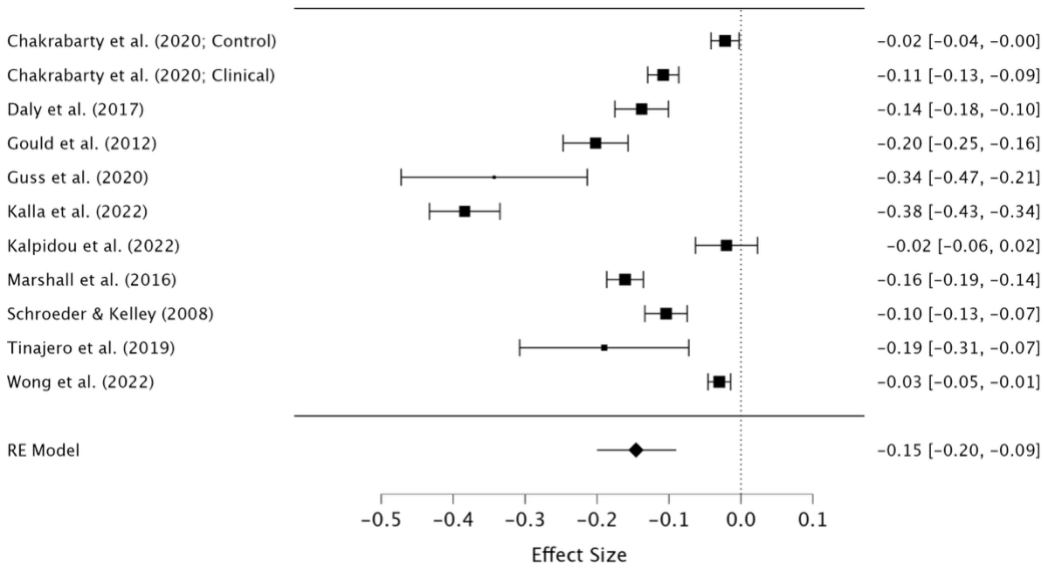

Figure 5. Forest plot of the ACE and response inhibition relationship

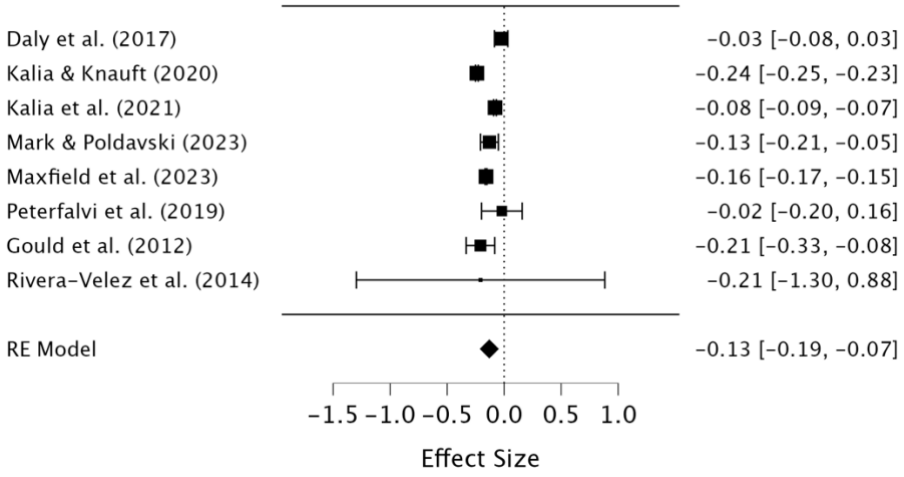

Figure 4. Forest plot of the ACE and cognitive flexibility relationship

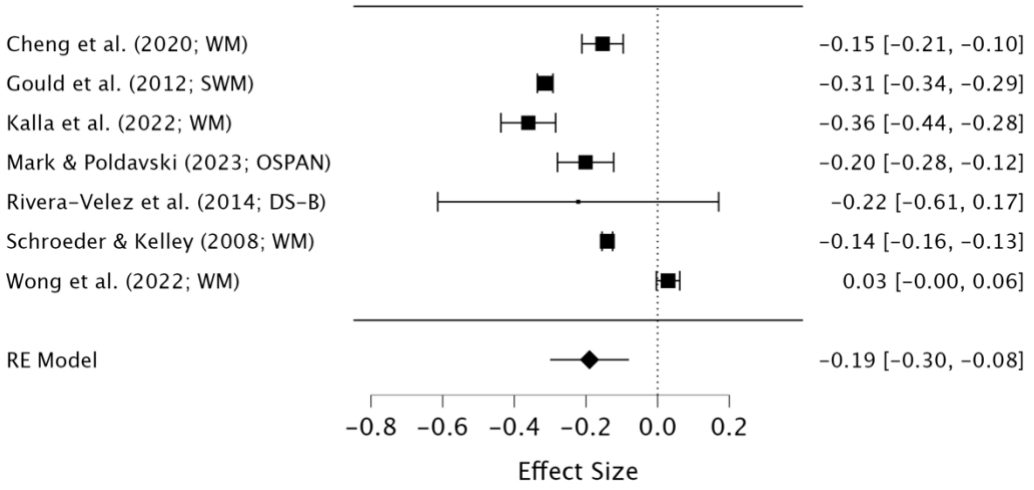

Figure 6. Forest plot of the ACE and working memory relationship

3.5.3. Publication bias

Publication bias was assessed through the visual inspection of a funnel plot (Figure 7), Egger's and the rank correlation test.

The funnel plot was mostly symmetrical, suggesting a low likelihood of publication bias. Egger's test for funnel plot asymmetry (t = -1.380, p = .168) and Kendall's rank correlation test (τ = .143, p = .124) were non-significant, suggesting no publication bias. However, visual inspection of the plot suggests some areas of asymmetry in the top left and bottom left. The Trim and Fill procedure (Duval & Tweedie, 2000) imputed eleven studies for an adjusted effect-size estimate of r = -.097 (95%CI: -.136, -.057), which remains small and significant.

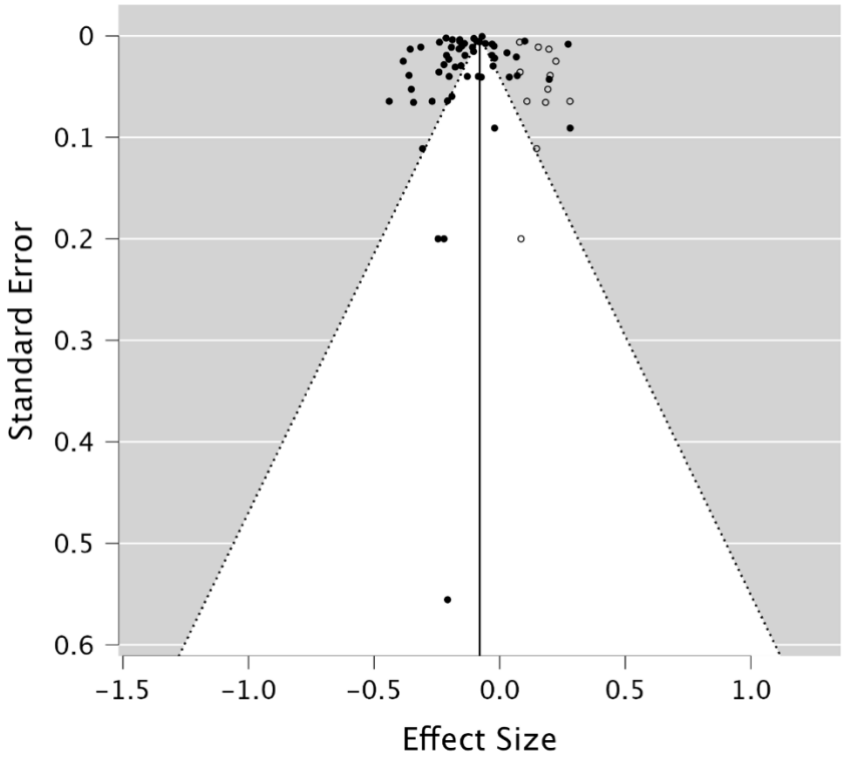

Figure 7. Funnel plot with Trim and Fill

3.5.4. Moderator analyses

3.5.4.1. Categorical moderators

Subgroup analyses were conducted on categorical moderators to establish any potential sources of difference. The total effects and associated heterogeneity measures were calculated and are presented in Table 5. Two significant moderators were identified: EF measure type and EF domain.

Comparison of EF measure type (performance-based vs. self-report) indicated an overall random-effects point estimate of r = .103 (95% CI: -.137, -.069), with a significant Q-value ($Q_{between}$ (7) = 8.465, p = .004, k = 55) and I^2 for the model indicating high heterogeneity (99.5%). The random-effects point estimates for self-report (r = -.103, 95%CI: -.173, -.034, k = 12) was lower than for performance-based measures (r = -.117, 95%CI: -.145, -.088, k = 43).

Comparison of EF domain yielded an overall random-effects point estimate of r = .041, with a significant Q-value ($Q_{between}$ (7) = 25.036, p < .001, k = 55), and I^2 also indicating high heterogeneity (99.42%). The random-effects point estimate for the reasoning domain (r = -.250, 95%CI: -.375, -.124, k = 5) was higher than other domains, while the composite EF random-effects point estimate (r = -.156, 95%CI: -.253, -.059, k = 12) was lowest.

Table 5. Random effects estimates for continuous and categorical moderators

Categorical moderator	**$Q_{between}$**	***df***	***p***	***I^2***	**Level (*k*)**	**Effect size (r)**	**Lower CI**	**Upper CI**
EF Domain	25.036	7	<0.001	99.419%				
					CC (k = 6)	0.053	-0.091	0.197
					CF (k = 8)	-0.169	-0.280	-0.059
					COMP (k = 12)	-0.142	-0.240	-0.044
					PS (k = 4)	-0.241	-0.373	-0.109
					R (k = 5)	-0.250	-0.375	-0.124
					RI (k = 11)	-0.188	-0.287	-0.088
					WM (k = 7)	-0.229	-0.340	-0.117
EF measure type	8.465	1	0.004	99.504%				
					Self-report (k = 12)	-0.103	-0.173	-0.034
					Performance based (k = 43)	-0.117	-0.145	-0.088
Study population	0.812	1	0.367	99.384%				
					Clinical (k = 17)	-0.109	-0.156	-0.061
					Non-clinical (k = 38)	-0.027	-0.085	0.031
Study Design	0.689	1	0.406	99.479%				
					Between-groups (k = 46)	-0.133	-0.164	-0.101
					Within-groups (k = 9)	0.032	-0.043	0.106
Continuous moderator	**$Q_{Moderator}$**	***Df***	**p**	***I^2***	**Estimate**	**SE**	**Z**	**Lower CI**	**Upper CI**
Mean sample age (*k* = 52)	0.826	1	0.363	99.453%	-0.002	0.002	-0.909	-0.006	0.002
Sample size (*k* = 54)	0.431	1	0.511	99.387%	4.466×10^{-5}	6.801×10^{-5}	0.657	-8.864×10^{-5}	1.780×10^{-4}
Gender (k = 52)	8.062	1	0.005	99.486%	0.002	5.945×10^{-4}	2.839	5.228×10^{-4}	0.003

Note. Negative effect sizes indicate that poorer EF associated with higher ACE scores. Level: CC = Cognitive control, CF = Cognitive flexibility, COMP= Composite EF, PS = Processing speed, R = Reasoning, RI = Response inhibition, WM = Working memory.

3.5.4.2. Continuous moderators

Continuous moderators were tested with meta-regression, and can also be seen in Table 5 above. One significant continuous moderator was identified: gender. The bubble plot below (Figure 8) illustrates the relationship between the ACE-EF effect size and gender ratio. The y-axis plots the study-specific effect sizes, while the x-axis plots percentage of female participants in each study. The sizes of the 'bubbles' indicate precision of study, based on their weighting where bigger bubbles represent greater weight/bigger sample size.

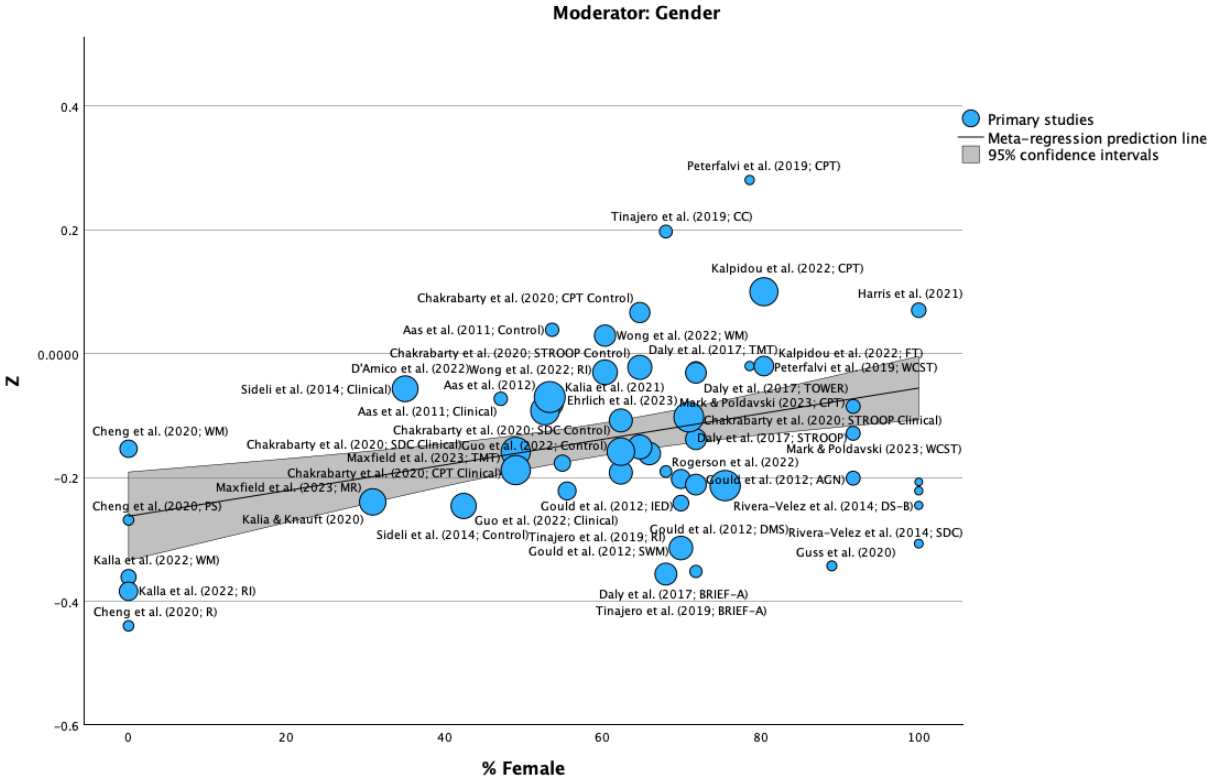

Figure 8. Bubble plot of gender

The results suggest percentage of females in sample gender moderated the relationship between ACE and EF scores, with a significant slope co-efficient of 0.002 (95%CI: 5.228×10^{-4}, .003, Fisher's Z = 2.839, p = .005). The proportion of total between-study variance explained by gender was 58.8% (R^2= .588).

4.0. Discussion

4.1. The relationship between ACEs and EF

As noted above, previous reviews of the relationship between ACEs and EF have either been narrative syntheses (Lund et al., 2022) or distilled the focus of meta-analyses to specific subdomains of EF, such as working memory (Goodman et al., 2019). A broader review conducted by Masson et al. (2015) on the relationship between cognitive function and ACEs established a small effect size for ACE exposure and executive functioning across child, adolescent, and adult samples. Goodman and colleagues' meta-analysis (2019) indicated a small effect of ACEs on working memory, though they highlighted adults who had experienced ACEs were significantly more likely to have difficulties in working memory tasks. The authors established the relationship was not moderated by the clinical status of participants, and that there was significant variance across the studies in terms of how working memory was assessed.

The present review is among the first to provide a meta-analytic summary of the relationship between ACEs and all aspects of EF in an adult population and identify potential methodological factors that may moderate this relationship. The primary objective of this review was to quantify the strength of association between ACEs and EF. Overall, 7384 participants from 25 studies with 55 effect samples published from 2008 to 2023 were included. The meta-analysis found a small overall effect size (r = - .126) of ACE on EF (95%CI: -.152, -.101, p < .001). Looking at the subdomains of EF most frequently reported within the literature, such as cognitive flexibility, response inhibition, composite EF scores, and working memory, separate meta-

analyses also identified a small and significant effect of ACEs on these domains (*r* = - .130, -.132, -.158, and -.190 respectively). This is an important extension of the narrative review conducted by Lund et al. (2022) which concluded that EF difficulties associated with ACEs persist into adulthood. The present review suggests this may be an accurate summary of the ACE-EF field of research, with the findings of this meta-analysis suggesting a small effect of ACE exposure on EF in adulthood.

Further aims of this study were to describe the main features of studies investigating ACEs and EF, and to establish what EF measurement tools are utilized across these studies. This paper found that across the studies included in the review, 31 measures of EF were used, four of which were self-report measures and the remainder performance based. These measures largely mapped on to those identified in prior reviews (Goodman et al., 2019; Masson et al., 2015), and similarly highlighted the variability across this field of research in terms of how EF is assessed and reported (see *Limitations* section below for a further discussion of the EF measures identified in this review).

4.2. Factors moderating the relationship between ACEs and EF

The final aim of this review was to determine whether methodological factors, such as EF domain, EF measure type (self-report or performance-based), clinical status of sample, study design, mean sample age, sample size, or gender moderated the relationship between ACEs and EF. Meta-regression and subgroup analyses were conducted for continuous and categorical variables respectively.

Contrary to Goodman and colleagues' (2019) exploration of working memory subdomains, some significant differences were found in the present review between EF subdomains. This is consistent with what we might have expected particularly in respect of working memory, which in prior meta-analyses has seemed to be an area of functioning more likely implicated by exposure to ACEs (Goodman et al., 2019; Masson et al., 2015). In the present meta-analysis, reasoning, processing speed, and working memory were the EF domains which yielded the highest effect sizes.

EF measure type (self-report or performance-based) was the other significant moderator of the relationship between ACEs and EF, with performance-based assessments of EF yielding a marginally higher effect size than self-report measures. Letkiewicz et al. (2021) highlight that performance-based measures assess the behavioral impact of EF under well-controlled circumstances, while self-report measures are designed to index performance in daily life and account for a meaningful portion of variance in important outcomes beyond what is predicted in performance-based measures. Self-report measures are also a relatively efficient means of assessing EF, and provide an opportunity to hear directly from individuals about their felt experience of cognitive strengths and potential deficits (Kalia & Knauft, 2020). Notwithstanding the benefits of self-report measures, it is worth highlighting how the increased vulnerability to developing psychopathology upon exposure to ACEs (Bailey et al., 2018; Merrick et al., 2017; Ng et al., 2018) might too impact on an individual's perceived strengths or deficits. In this sense, individuals may overestimate or overreport their deficits when completing self-report measures of EF. Common method bias is also evident in instances where self-report measures

are utilized to quantify ACE exposure and cognitive function, which could inflate the interactions observed in the data (Podsakoff et al., 2024).

Gender was the only continuous variable found to be a significant moderator of the ACE-EF relationship. This was suggestive that as the ratio of females increased in study samples, the impact of ACEs on EF became more pronounced. This finding may be representative of the gender differences highlighted in the literature in respect of reported rates and types of ACEs (Baglivio et al., 2014, Dierkhising et al., 2019) and levels of reported distress in adulthood (Haahr-Pedersen et al., 2020). These broadly indicate that females are at greater risk of experiencing ACEs when compared to males, and highlight males are more likely to experience physical abuse as opposed to females, who are more likely to be exposed to sexual abuse (Baglivio et al., 2014; McAnee et al., 2019; Dierkhising et al., 2019). Moreover, Haahr-Pedersen et al. (2020) proposed that females tended to report more complex and varied patterns of ACEs than males, which are associated with poorer mental health, emotional and social outcomes in adulthood. Identifying gender as a moderator in the ACE-EF relationship in the current study may therefore be in part attributable to differences in reporting rates, as well as potential differences in exposure to different rates and types of ACE.

4.3. Strengths and limitations

4.3.1. Strengths

The findings of this meta-analysis should be interpreted with consideration of its strengths and limitations. Considering its strengths first, this study represents one of

the first attempts at a quantitative synthesis of the relationship between ACEs and all types of EF in adulthood. In doing so, it has been able to draw some more empirically based conclusions about this relationship than prior narrative summaries of this field of research (though it also acknowledges the recent publication by Rahapsari and Levita (2024) of meta-analytic review of ACE and cognitive control relationship). Furthermore, it also builds on the review conducted by Lund et al. (2022) by rating the quality of the studies included in the review, which was notably missing previously.

4.3.2. Limitations

There was a great deal of variability across the studies in terms of how they assessed and reported EF. For example, some studies administered various EF measures and provided an overall (or composite) EF score (Aas et al., 2011; Ehrlich et al., 2023; Harris et al., 2021; Sideli et al., 2014), some administered multiple EF measures and reported these separately (Chakrabarty et al., 2020; Daly et al., 2017; Gould et al., 2012; Kalpidou et al., 2022; Mark & Poltavski, 2023; Maxfield et al., 2023; Peterfalvi et al., 2019; Rivera-Vélez et al., 2014; Tinajero et al., 2020), while others only administered and reported on one EF measure (Aas et al., 2012; Kalia & Knauft, 2020; Kalia et al., 2021; Marshall et al., 2016; Rogerson et al., 2022). These issues are consistent with those identified elsewhere (Porter et al., 2015) in respect of the characteristics of neuropsychological tests, and highlight how neuropsychological tests for EF may involve a number of EF processes not specific to an individual EF sub-domain, nor in some cases are they distinctly a measure of EF.

Moreover, review of the studies included in this paper highlighted disparities in conceptualization of EF, which varied from the definition provided earlier in this work. This generated some difficulties in attempting to code EF measure subdomains, though this issue was mitigated in part by consulting colleagues in a neuropsychology service. It also presented some difficulties in terms of establishing coherent and consistent outcomes across studies, as there were even some cases wherein different studies had utilized the same EF measure and reported the outcome differently. For instance, in the case of sources which utilized the BRIEF-A (Roth et al., 2005) to measure EF, three sources (Daly et al., 2017; Guss et al., 2020; Tinajero et al., 2020) reported only the Global Executive Composite score, while the others (Kalla et al., 2022; Schroeder & Kelley, 2008) reported the Behavioral Regulation and Metacognition Index scores. Consistent with the choices made by some of the authors of the studies identified in the review, this review made the decision in some instances to combine multiple EF outcomes on the basis of the data being representative of the same EF subgroup and/or multiple outcomes of a single measurement tool. In doing so, it aimed to increase the independence of the effect sizes by reporting fewer effect sizes per sample. Nonetheless, there was a distinct non-independence within the effect sizes included in this review. To address this, the reported sample sizes (N) were adjusted when calculating the SE to reweight the ES and so not inflate the total sample size.

Further limitations of this review potentially also include the search criteria, which was modelled on that used by Lund and colleagues (2022). One notable source which was not identified in the review was by Letkiewicz et al. (2021), seemingly not captured by the search terms utilized. It is possible that theoretical ambiguity around

the term ‘executive function,’ as has been highlighted above, may contribute to some of the difficulties in capturing sources which explore the concept. This review was also not able to extend moderator analyses to all subdomains of EF, or indeed to psychopathology subgroup owing to there being an insufficient number of studies per subgroup ($k < 10$). Finally, the inter-rater quality assessment was only able to be completed on a proportion of the sources identified in the review (48%), and thus completing full inter-rater quality assessment would be preferable.

4.4. Clinical and theoretical implications

Notwithstanding the above limitations of this review, it has some relevant clinical and theoretical implications for this field of research.

The overall effect of ACEs on EF was found to be small and significant with EF measure type, EF domain, and gender being identified as moderators of this relationship. This identification of EF measure type as a moderator is suggestive that future reviews should analyse studies which employ self-report measures to quantify the ACE-EF relationship separately to those which use performance-based measures. The findings also suggest that, consistent with previous recommendations (Goodman et al., 2019; Majer et al., 2010), future research exploring the relationship between ACEs and EF would benefit from focusing on case-control designs to disentangle the complex interactions of mental health, EF and childhood adversity. Future research would also benefit from developing a consensus on which measures have the most robust construct validity in assessing EF, as the variability of measures used across the studies included in this review

suggest either issues in resource and access, or in consensus on best tools to use. Consistency in reporting outcomes would help in future endeavors to quantitatively synthesize this field of research, as omissions in data accounted for many studies being excluded from the present review, despite attempts at follow-up with corresponding authors.

4.5. Conclusions

This review represents the first attempt at a quantitative synthesis of research exploring the relationship between adverse childhood experiences and executive functioning. As such, its findings should be regarded as preliminary, rather than exhaustive, and should be interpreted with caution. It has found that across the studies included in the review, a small and significant effect was found for the ACE-EF relationship. Type of EF measure utilized, EF domain assessed, and gender were significant moderators of this relationship.

It raises important questions about directions for future research in this field, including consideration of moderators in the ACE-EF relationship, and highlights the need for continued synthesis of this expanding area of research. Owing to inconsistent conceptualizations of executive functioning, it may be more valuable to build upon previous reviews which have focused on EF subdomains, than it would be to attempt to synthesize the data related to ACEs and overall EF. It will also be important to consider the nature of executive function measures (whether performance-based or self-report) in future analyses, as the findings here indicate it would be beneficial to look at these differing methods separately. This may help

account for the significant heterogeneity observed across the studies included in the present review, and therefore allow for more robust findings.

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6.0. Appendices

6.1. Appendix 1- Search Strategy

Boolean keywords/search terms for Medline, Embase and Psyclinfo:

Age of exposure

"early life" OR "adolescent" OR "child" OR "infant" OR "youth"

AND

Adverse childhood experiences

"advers*" OR "trauma" OR "abus*" OR "maltreat*" OR "neglect" OR "household dysfunction" OR "parent separat*" OR "divorce" OR "parent* mental" OR "maternal mental" OR "maternal psych*" OR "mother mental*" OR "mother psych*" OR "paternal mental*" OR "paternal psych*" OR "domestic abuse" OR "parent* alcohol" OR "parent* addiction" OR "maternal substance" OR "maternal addiction" OR "maternal alcohol" OR "paternal substance" OR "paternal addiction" OR "paternal alcohol" OR "parent* incarcerat*" OR "mother incarcerat*" OR "maternal incarcerat*" OR "father incarcerat*" OR "paternal incarcerat*"

AND

Executive functioning

"executive function*" OR "executive dysfunction*"

Subsequent limits were applied to searches, including:

- a date of publication limit from 2019 to current

- English language limit

Search terms for SCOPUS:

((TITLE-ABS-KEY ("early life" OR "adolescent" OR "child*" OR "infant" OR "youth")) AND (TITLE-ABS-KEY ("advers*" OR "trauma*" OR "abus*" OR "maltreat*" OR "neglect" OR "household dysfunction" OR "parent separat*" OR "divorce" OR "parent* mental" OR "maternal mental" OR "maternal psych*" OR "mother mental*" OR "mother psych*" OR "paternal mental*" OR "paternal psych*" OR "domestic abuse" OR "parent* substance" OR "parent* alcohol" OR "parent* addiction" OR "maternal substance" OR "maternal addiction" OR "maternal alcohol" OR "paternal substance" OR "paternal addiction" OR "paternal alcohol" OR "parent* incarcerat*" OR "mother incarcerat*" OR "maternal incarcerat*" OR "father incarcerat*" OR "paternal incarcerat*"))) AND (TITLE-ABS-KEY ("executive function*" OR "executive dysfunction*")) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT TO (LANGUAGE , "English"))

Search terms for Web of Science:

(ALL= (“early life” or "adolescent" or "child" or "infant" or "youth")) AND (ALL= “advers*” or “trauma*” or “abus*” or “maltreat*” or “neglect” or “household dysfunction” or “parent separat*” or “divorce” or “parent* mental” or “maternal mental” or “maternal psych*” or “mother mental*” or “mother psych*” or “paternal mental*” or “paternal psych*” or "domestic abuse" or “parent* substance” or “parent* alcohol” or “parent* addiction” or “maternal substance” or “maternal

addiction” or “maternal alcohol” or “paternal substance” or “paternal addiction” or “paternal alcohol” or “parent* incarcerat*” or “mother incarcerat*” or “maternal incarcerat*” or “father incarcerat*” or “paternal incarcerat*”)) AND (ALL= (“executive function*” or “executive dysfunction*”)) AND (English (Languages)) AND (Index date 2019-06-01 to 2023-07-06)

6.2. Appendix 2- Table demonstrating conversion of outcome data into r

Table 6. Extracted data and their conversion to r/pbr

Study	EF measure	Domain	+ / -	Non- ACE group		ACE group		t-test	pbr	r
				Mean score	SD	Mean score	SD			
Aas et al. (2011; Control)	TMT-B/L-NS	COMP	+	-0.03	0.7	0.02	0.6	0.450	0.039	
Aas et al (2011; Psychosis)	TMT-B/L-NS	COMP	+	-0.89	1.5	-1.12	1.4	-0.852	-0.073	
Aas et al. (2012)	VFT	VF	+	38.89	11.23	36.7	11.28	-1.822	-0.092	
Chakrabarty et al. (2020; Control)	CPT	CC	-	104.16	12.87	106.26	13.19	0.665	0.066	
Chakrabarty et al. (2020; MDD)	CPT	CC	-	105.16	12.08	100.43	12.52	-2.601	-0.190	
Chakrabarty et al. (2020; Control)	SDC	PS	+	116.61	20.96	108.95	21.06	-1.512	-0.150	
Chakrabarty et al. (2020; MDD)	SDC	PS	+	111.15	19.29	105.06	19.23	-2.138	-0.157	
Chakrabarty et al. (2020; Control)	STROOP/SAT	CF	-	103.45	16.32	102.6	15.85	-0.221	-0.022	
Chakrabarty et al. (2020; MDD)	STROOP/SAT	CF	-	100.47	16.07	96.7	18.93	-1.454	-0.107	
Cheng et al. (2020)	MCCB	PS	+	32.75	14.71	25.71	10.87	-1.609	-0.262	
	MCCB	R	+	31.81	4.83	27.67	4.39	-2.686	-0.413	
	MCCB	WM	+	34.19	8.59	31.95	5.45	-0.912	-0.152	
D'Amico et al. (2022)	BTACT	COMP	+							-0.07
Daly et al. (2017)	TMT	CF	+	11.32	1.74	11.22	2.05	-0.275	-0.026	
Daly et al. (2017)	BRIEF-A	COMP	-	50.05	9.68	57.2	10.12	3.727	-0.338	
Daly et al. (2017)	TOWER	R	+	10.66	2.23	10.52	2.25	-0.321	-0.031	
Daly et al. (2017)	STROOP	RI	+	11.84	1.98	11.24	2.36	-1.441	-0.137	
Daly et al. (2017)	VFT	VF	+	13.2	2.86	12.31	2.77	-1.619	-0.154	
Ehrlich et al. (2023)	TMT-A/TMT-B/SDC/STROOP/PG-NG/VFT	COMP	-	0.082	0.662	-0.109	0.678	-2.814	-0.139	
Gould et al. (2012)	CANTAB IED	CF	+	8.69	0.74	8.33	0.98	-1.994	-0.205	
Gould et al. (2012)	CANTAB DMS	R	+	36.97	2.69	35.12	4.98	-2.326	-0.237	
Gould et al. (2012)	CANTAB AGN	RI	-	4.58	2.68	5.66	4.78	1.396	-0.145	
Gould et al. (2012)	CANTAB SWM	WM	-	15.57	16.12	26.69	18.07	3.047	-0.304	
Guo et al. (2022; Controls)	DS-B/STROOP/TMT-B/VFT	COMP	+	0.11	0.71	-0.14	0.7	-2.104	-0.175	

Guo et al. (2022; MDD)	DS-B/STROOP/TMT-B/VFT	COMP	+	-0.43	0.5	-0.69	0.67	-2.747	-0.218	
Guss et al. (2020)	BRIEF-A	RI	-							-0.33
Harris et al. (2021)	WCST/STROOP	COMP	+							0.07
Kalia & Knauft (2020)	CFI	CF	+							-0.235
Kalia et al. (2021)	WCST	CF	+							-0.08
Kalla et al. (2022)	BRIEF-A	RI	-	39.56	7.44	47.35	12.05	3.607	-0.366	
Kalla et al. (2022)	BRIEF-A	WM	-	52.77	11.78	62.23	14.04	3.385	-0.346	
Kalpidou et al. (2022)	CPT	CC	+							0.100
Kalpidou et al. (2022)	FT	RI	-							-0.020
Mark & Poldavski (2023)	CPT	CC	-	1.06	1.21	1.26	1.14	0.777	-0.085	
Mark & Poldavski (2023)	WCST	CF	+	34.84	2.35	34.2	2.6	-1.168	-0.128	
Mark & Poldavski (2023)	OSPAN	WM	-	2.95	1.75	2.17	2.07	-1.834	-0.198	
Marshall et al. (2016)	PG-NG	RI	+							-0.16
Maxfield et al. (2023)	TMT-A	CF	-	34.02	15.67	39.04	20.41	3.952	-0.138	
Maxfield et al. (2023)	MR	R	+	15.45	5.67	13.22	6.07	-5.368	-0.186	
Peterfalvi et al. (2019)	CPT	CC	-	12.10	5.64	16.00	8.19	1.797	-0.273	
Peterfalvi et al. (2019)	WCST	CF	+	72.00	180.00	67.00	13.50	-0.127	-0.020	
Rivera-Velez et al. (2014)	CT-B	CF	-	85.58	19.38	92.08	12.41	-0.979	-0.204	
Rivera-Velez et al. (2014)	SDC	PS	+	9.75	3.36	11.5	2.43	-1.462	-0.298	
Rivera-Velez et al. (2014)	PA	R	+	14.08	5.63	16.08	1.98	-1.161	-0.240	
Rivera-Velez et al. (2014)	DS-B	WM	+	-0.11	1.16	0.3	0.7	-1.048	-0.218	
Rogerson et al. (2022)	DEX	COMP	-							-0.21
Schroeder & Kelley (2008)	BRIEF-A	RI	-	61.21	14.95	64.39	13.86	1.706	-0.103	
Schroeder & Kelley (2008)	BRIEF-A	WM	-	46.07	10.55	49.53	11.75	2.314	-0.139	
Sideli et al. (2014; Psychosis)	TMT-B/DS/SS	COMP	+	-0.78	1.09	-0.64	1.02	-0.652	-0.057	
Sideli et al. (2014; Controls)	TMT-B/DS/SS	COMP	+	0.15	0.73	-0.37	0.87	3.063	0.266	
Tinajero et al. (2019)	DFT/VFT/L-NS	CC	+	-0.38	1.7	0.33	1.9	1.742	0.195	
Tinajero et al. (2019)	BRIEF-A	COMP	-	4.5	2.4	6.73	3.8	3.191	-0.342	
Tinajero et al. (2019)	STROOP/TMT/CPT	RI	+	0.25	1.4	-0.32	1.6	-1.681	-0.188	
Wong et al. (2022)	ADEXI	RI	-	13.44	3.59	13.65	3.44	0.335	-0.030	
Wong et al. (2022)	ADEXI	WM	-	22.22	6.29	21.86	6.15	-0.325	0.029	

Table 7. Outcome data by study

Author	EF measure	Outcome(s) reported
Aas et al. (2011)	TMT-B/L-NS	Converted standardized z scores based on mean and SD for each test averaged by study authors
Aas et al. (2012)	D-KEFS VFT	Raw scores for verbal fluency and letter fluency averaged together by study authors
Chakrabarty et al. (2020)	CPT	Not described by authors, but data from omissions (missed targets), commissions (incorrect responses to non-targets), perseverations (random, repetitive, or anticipatory responses) likely averaged
Chakrabarty et al. (2020)	SDC	Not described by authors, but likely raw score (number of correct symbols in time limit)
Chakrabarty et al. (2020)	STROOP/SAT	Not described by authors, but Stroop commission errors and Shifting Attention Task correct reaction time likely averaged
Cheng et al. (2020)	MCCB PS	Subtest t scores
	MCCB R	Subtest t scores
	MCCB WM	Subtest t scores
D'Amico et al. (2022)	BTACT	EF score calculated by study authors by summing z-scores for working memory, verbal fluency, inductive reasoning, processing speed and attention shifting/correlation coefficient
Daly et al. (2017)	D-KEFS TMT 1-5	Scaled scores summed and averaged by present author
Daly et al. (2017)	BRIEF-A Global Executive Composite	Overall score
Daly et al. (2017)	D-KEFS TOWER	Overall achievement scaled score
Daly et al. (2017)	D-KEFS Colour-Word (STROOP)	Condition 3 scaled score
Daly et al. (2017)	D-KEFS VFT	Condition 3 scaled score
Ehrlich et al. (2023)	TMT-A and B/SDC/STROOP/PG-NG/VFT	Not described by authors, but 'processing speed with influence resolution' likely sum and average of 5 subtest scores
Gould et al. (2012)	CANTAB IED	Stages complete
Gould et al. (2012)	CANTAB DMS	Total correct
Gould et al. (2012)	CANTAB AGN	Omissions positive, commissions positive, omissions negative and total omissions neutral summed and averaged by present author
Gould et al. (2012)	CANTAB SWM	Total errors
Guo et al. (2022)	DS-B/STROOP/TMT-B/VFT	Sum of the standardized z-scores of each subtest
Guss et al. (2020)	BRIEF-A Behavioural Regulation Index	Subtest t score/correlation coefficient
Harris et al. (2021)	WCST/STROOP	WCST perseverance errors and Stroop completion time scaled scores/correlation coefficient
Kalia & Knauft (2020)	CFI	Total 'alternatives' raw score/correlation coefficient
Kalia et al. (2021)	WCST	Total correct/correlation coefficient
Kalla et al. (2022)	BRIEF-A Behavioural Regulation Index	T score

Kalla et al. (2022)	BRIEF-A Metacognition Index	T score
Kalpidou et al. (2022)	CPT	Accuracy scores/correlation coefficient
Kalpidou et al. (2022)	FT	Flanker test score/correlation coefficient
Mark & Poldavski (2023)	CPT	Part 1 omission error count
Mark & Poldavski (2023)	WCST	Total correct
Mark & Poldavski (2023)	OSPAN	Math accuracy errors
Marshall et al. (2016)	PG-NG	Mean inhibitory control accuracy/correlation coefficient
Maxfield et al. (2023)	TMT-A	Seconds to complete task
Maxfield et al. (2023)	MR	Total correct
Peterfalvi et al. (2019)	CPT	Commissions scores
Peterfalvi et al. (2019)	WCST	Total correct
Rivera-Velez et al. (2014)	CT-B	Raw scores
Rivera-Velez et al. (2014)	SDC	Raw scores
Rivera-Velez et al. (2014)	PA	Raw scores
Rivera-Velez et al. (2014)	DS-B	Raw scores
Rogerson et al. (2022)	DEX	Total overall score/correlation coefficient
Schroeder & Kelley (2008)	BRIEF-A Behavioural Regulation Index	T score
Schroeder & Kelley (2008)	BRIEF-A Metacognition Index	T score
Sideli et al. (2014)	TMT-B/DS/SS	Raw scores transformed into standardized z-scores by study authors
Tinajero et al. (2019)	DFT/VFT/L-NS	Scaled scores summed and averaged by study authors
Tinajero et al. (2019)	BRIEF-A Global Executive Composite	Overall t score
Tinajero et al. (2019)	STROOP/TMT/CPT	Scaled scores summed and averaged by study authors
Wong et al. (2022)	ADEXI Inhibition	Raw subscale score
Wong et al. (2022)	ADEXI Working Memory	Raw subscale score

Empirical paper

Cognitive disengagement syndrome, daily functioning, intolerance of uncertainty, executive functioning, and worry: A mediation and moderation model

Total Word Count: 7861
(Excluding title page, table of contents, abstract, table notes and titles, figure titles, and appendices)
Word Limit: 8000

Doctorate in Clinical Psychology

200750952

Emma Welsh

Supervisor: Professor Mark Freeston, Newcastle University

This thesis is submitted as partial fulfilment of the degree of Doctorate in Clinical Psychology

I declare that this assignment is my own work and I have correctly acknowledged the work of others. The assignment is in accordance with University and School guidance on good

0.0. Abstract

Background

Growing interest in cognitive disengagement syndrome (CDS) as a distinct set of symptoms from ADHD has prompted research exploring its impact on functional abilities, mental health and cognitive functioning. These broadly point to CDS negatively impacting these domains, though it remains scarcely considered in clinical practice. This study aimed to expand the understanding of CDS by considering its association with daily functioning, executive functioning (EF), intolerance of uncertainty (IU), and worry. It hypothesized CDS symptoms would adversely impact on daily functioning, and that this would be mediated by IU and moderated by EF. It further hypothesized CDS would predict greater levels of worry, mediated by IU and daily functioning, also moderated by EF.

Method

This cross-sectional study utilized self-report measures of CDS (ACI), daily functioning (IWPQ-A), IU (IUS-R), worry (PWSQ-3), and executive function (ADEXI). The main analysis included adult participants (N = 399, Age range: 18 – 79). An exploratory factor analysis was conducted on the IWPQ-A to establish its factor structure. The study tested the main hypothesis using Hayes model 5, and the final hypothesis with Hayes model 84.

Results

The findings suggest a direct CDS-daily functioning relationship, and established this is moderated by EF. IU was not found to be a mediator of this relationship, though IU was found to mediate the relationship between CDS and worry, as was daily functioning.

Conclusion

Alongside the key findings, this study provides further evidence for CDS operating independently from ADHD, and discusses the implications for clinical practice and for future research.

Word count: 250

1.0. Introduction

Cognitive disengagement syndrome (CDS; previously known as sluggish cognitive tempo) is a set of symptoms characterized by spacing out, excessive mind-wandering, drowsiness, hypoactivity, fogginess, and mental confusion (Becker et al., 2023). Research in this area has been driven by interest in the dimensionality of attention-deficit hyperactivity disorder (ADHD), and notably with distinguishing between CDS and ADHD-inattention (ADHD-IN) symptoms (Fredrick & Becker, 2023). Evidence suggests that whilst CDS symptoms are distinct from ADHD-IN symptoms, they appear to be strongly related to each other (Becker et al., 2013, 2016, 2023). Most convincingly, a meta-analysis (k = 23) conducted by Becker and colleagues (2016) utilizing more than 19,000 cases provided strong evidence for discriminative validity of CDS from ADHD-IN symptoms.

Preliminary research in this area suggests CDS may also contribute to a range of other functional impairments and psychopathologies, including peer withdrawal (Fredrick & Becker, 2022; Rondon et al., 2020), increased depression and anxiety symptoms (Becker et al., 2020; Smith et al., 2020; Willcutt et al., 2014), and impaired neuropsychological functioning (Barkley et al., 2022). Whilst promising, this developing field of research is dominated by studies exploring child, adolescent and student populations, with scope to extend understanding of CDS within adult populations. Becker (2021) also points to a dearth of CDS research conducted out-with the United States, South Korea, Spain, and Turkey, highlighting the importance of expanding research to include other countries and cultures. This paper will address these gaps and consider how worry, intolerance of uncertainty, daily functioning and cognitive functioning interact with CDS.

1.1. CDS and daily functioning

The literature suggests CDS can result in changes to daily functioning. For example, Barkley (2012) reported CDS is associated with impairments in home life and parenting, friendships and romantic relationships, managing finances, health maintenance and occupational functioning. Wood et al. (2020) similarly sought to establish if CDS behaviours were associated with a unique functional impairment profile after accounting for lifestyle variables (sleep, substance use and physical health) in college students. They found higher levels of CDS were associated with functional impairment, procrastination, health issues, worse time management, GPA scores, and levels of sleep (Wood et al., 2020). Meta-analytic data is consistent with these findings, with significant correlations found between CDS and impairments in academic (r = 0.45, N = 2,089, k = 3, 95%CI [0.19, 0.72]), global (r = 0.52, N = 1,499, k = 3, 95%CI [0.33, 0.67]) and social (r = 0.37, N = 2,390, k = 3, 95%CI [0.12, 0.56]) functioning (Becker et al., 2016).

1.2. CDS and mental health

CDS may also impact mental health. Bahmani et al.'s (2025) recent study, for example, examined the relationship between CDS and mental health in a sample of young adult students (N = 246). The authors found CDS scores were positively associated with higher anxiety (r = 0.74), stress (r = 0.75), depression (r = 0.77) and insomnia (r = 0.69) scores. Further, each mental health domain (anxiety, insomnia, stress and depression), was found to be independently associated with CDS. Becker et al. (2018) similarly found that in a group of college students (N = 1,704), CDS was strongly associated with anxiety (r =

0.52) and depression (r = 0.53). Albeit the strengths of correlation were weaker than those found by Bahmani et al. (2025), Becker and colleagues also measured suicidal behaviours, finding this to be moderately correlated with CDS (r = 0.37; 2018). Beyond student samples, Yucens et al. (2024) established among psychiatric outpatients (N = 274) aged 18 – 64 years, that CDS showed stronger first-order and unique associations with depression, stress, anxiety, and sleep issues when compared with ADHD-IN.

The potential overlap of CDS and depression has also been addressed in the literature, given their similarities. By using exploratory structural equation modelling with a sample of children (N = 124), Becker et al. (2015) established the construct of CDS (as rated by children) was distinct from child-rated anxiety and depression. Smith and colleagues (2019) also established (via confirmatory factor analysis) that while CDS and depression were strongly associated with one another, they form two distinct constructs. Smith et al. (2020) provide one of a few longitudinal studies in this area, exploring whether CDS symptoms in children aged 6-17 years would predict depression in adulthood. They measured the constructs of ADHD, CDS, and depression utilizing a structured interview with children and adult caregivers in the first wave, and then individually with the young adults in the second wave. The authors found CDS in childhood and adolescence was associated concurrently and predictively with depression in adulthood (β = 0.26, 95% CI [0.15, 0.37], $p < 0.001$), and interestingly that depression in adulthood was predicted to a greater degree by childhood and adolescent CDS than depression symptoms (β = 0.13, 95% CI [0.08, 0.18], $p < 0.001$).

1.3. Intolerance of uncertainty and worry

Despite prior research exploring the impact of CDS on mental health, much of the focus has been centred on depressive symptoms, as opposed to those of anxiety and worry. Intolerance of uncertainty (IU) has been defined as an "incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information" (Carleton, 2016, p.13). Accordingly, IU has been identified as a risk factor in the development and maintenance of anxiety disorders (Carleton, 2012; Gentes & Ruscio, 2011; Ren et al., 2021). McEvoy and colleagues' (2019) meta-analysis (N = 52,402, k = 181) found the strength of association between generalized anxiety disorder (GAD) symptoms and IU was significantly greater than with other psychopathologies (obsessive compulsive disorder, depression, social anxiety, eating disorders, and panic/agoraphobia).

In considering the mechanisms through which IU interacts with anxiety, Freeston and colleagues (1994) proposed worry represents an attempt to control anxiety and fear of future events, and that IU leads to negative problem orientation (Clarke et al., 2016) and over-identification of potential problems (Freeston et al., 1994). This negative problem orientation risks an avoidant response style developing, which can perpetuate the process of worrying. Flores et al. (2018) highlight individuals who exhibit high levels of IU may be particularly vulnerable to engaging in excessive avoidance behaviours, in attempts to enhance the perception of control and make uncertain situations more predicable. Relatedly, it is well documented anxiety disorders cause impairment in occupational, academic, social, and family functioning throughout the lifespan (Leon et

al., 1995; McKnight et al., 2016; Miller & McGuire, 2023), meaning IU is also likely to be contributing to a range of difficulties in daily functioning. Initial data from a network analysis (Brown et al., 2023) suggests IU and worry are linked to both ADHD and CDS, leading the authors to propose that processing the world differently (according to presence of CDS and/or ADHD) might indeed make the world a more uncertain place, and thus contribute to increased distress and functional impairment.

1.4. CDS and cognitive functioning

Given the nature of CDS symptoms and how they relate to daily functioning and mental health, researchers have also explored the association between CDS and neuropsychological functioning (Wood et al., 2017; Creque & Willcutt, 2021; Barkley et al., 2022). Some of these findings have been mixed (Bauermeister et al., 2012; Wahlstedt & Bohlin, 2010), while others have found significant relationships between CDS and neuropsychological functioning (Barkley, 2012; Becker & Langberg, 2014; Skirbekk et al., 2011; Willcutt et al., 2014). Jarrett and colleagues (2017) highlighted the impact of neuropsychological test type, indicating in their study with college students that elevated CDS symptoms were predictive of executive functioning (EF) deficits in self-report measures, but not on laboratory tasks of EF.

EFs are higher-level cognitive processes essential for navigating the demands of daily life, which help to process multiple streams of information, plan and problem-solve (Jurado & Rosselli, 2007; Snyder et al., 2015). Wood et al. (2017) explored the effect of CDS on functional impairment and EF in a college sample (N = 458), utilizing self-report

measures. Approximately 13% of their sample had elevated CDS scores. Notably, Wood et al. (2017) found that CDS symptoms accounted for the most unique variance in functional impairment and EF issues when compared to symptoms of anxiety, depression and ADHD. The authors also found that with or without elevated levels of ADHD symptoms, students who had high CDS scores exhibited significantly more EF issues and functional impairment than controls (p <.001 for both). The phenomenon of how EF interacts with CDS therefore clearly warrants further exploration.

1.5. Rationale, aims and hypotheses

The evidence suggests CDS may have an adverse impact on neuropsychological functioning, specifically on EF (Wood et al., 2017; Barkley et al., 2022). Prior research also points to CDS directly impacting the daily functioning of individuals in various life domains (Barkley, 2012; Becker, 2016; Wood et al., 2017). Concurrently, preliminary research with adults exhibiting ADHD and CDS symptoms suggests they experience elevated levels of IU (Brown et al., 2023). Given the above definition of IU as being an aversive response to perceived absence of sufficient information (Carleton, 2016), and that CDS may perpetuate the propensity to miss information, there remains potential for IU to be a phenomenon mediating the functional abilities of individuals with CDS.

The preliminary aim of this study is therefore to conceptually replicate the study completed by Wood et al. (2017), to establish if the results are comparable using different measures of EF, CDS, anxiety and depression symptoms, functional impairment, and ADHD symptoms. We hypothesize higher levels of CDS symptoms will predict greater issues with EF and daily functioning.

The main aim of this study is to extend the current understanding of CDS, towards considering what role, if any, IU has on the functional impairment observed in individuals with elevated CDS symptomology. The primary hypothesis of this study is that incidence of CDS symptoms and behaviours will adversely impact on daily functioning, and this relationship will be mediated by IU and moderated by EF (see Figure 1).

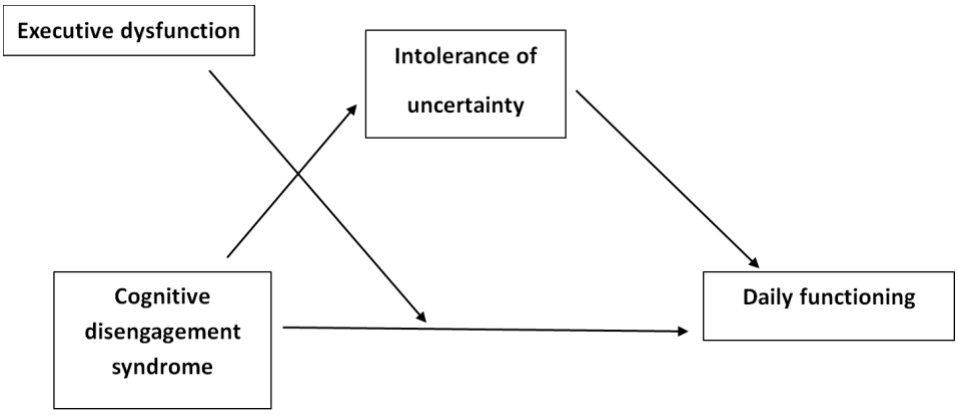

Figure 1: Illustration of hypothesized moderated mediation model for primary hypothesis

This study also aims to establish how the above findings relate to distress, and thus ascertain their clinical relevance. Specifically, it considers whether CDS is associated with worry, and the extent to which IU, daily functioning and EF influence this relationship. It hypothesizes CDS will lead to higher levels of worry, and this relationship will be mediated by both IU and daily functioning, and moderated by EF (see Figure 2).

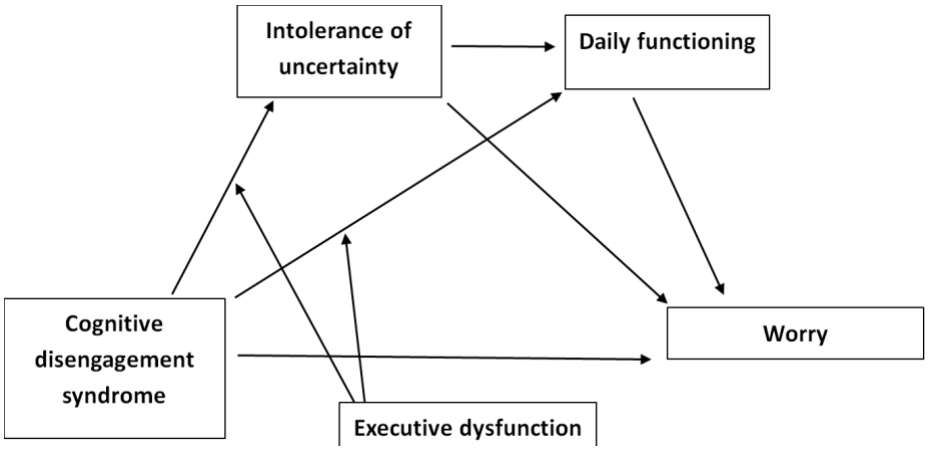

Figure 2: Illustration of hypothesized serial mediation model for third hypothesis

2.0. Methodology

2.1. Design

This project involves retrospective analysis of cross-sectional data.

2.2. Participants

2.2.1. Sample

Participants were recruited as part of a prior research project from the Newcastle University network and via social media between 19th February and 1st May 2024. Respondents were required to be at least 18 years to be eligible to participate.

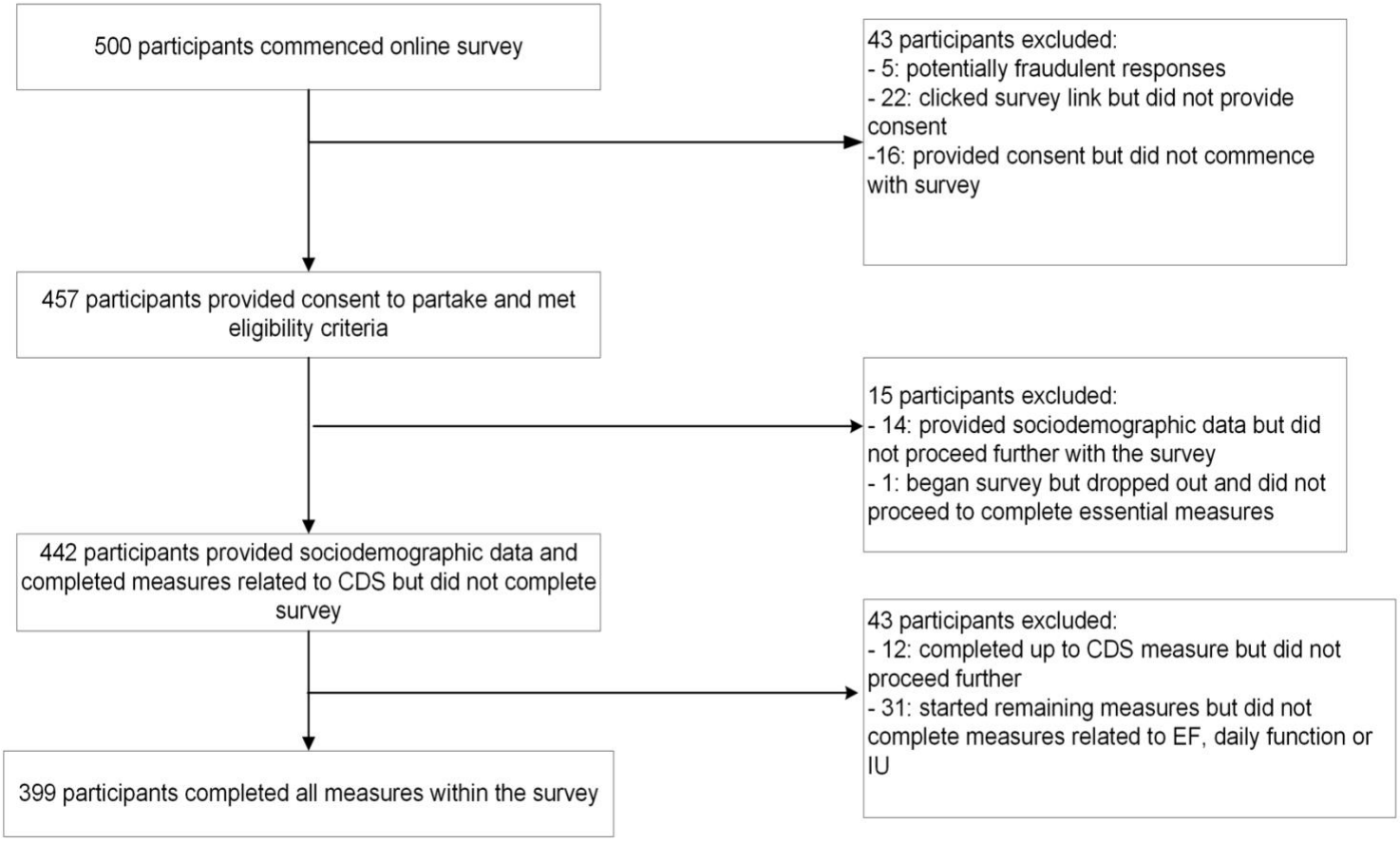

Figure 3. Participant recruitment flow chart

In total, 500 partial, potentially fraudulent, and completed survey responses were collected via Qualtrics software. Figure 3 illustrates the flow of participants. The final sample included in the main analysis comprised of 399 adult participants from a community-dwelling non-clinical population (*Range*: 18 - 79 years, *M* = 30.22, *SD* = 15.10).

2.2.2 Sample size considerations

This study utilized Monte Carlo power analysis for indirect effects (Schoemann et al., 2017) as a means of conducting a priori power calculations. Figure 2 demonstrates the

mediation model used to explore the CDS → IU → Worry pathway. Based on data from Becker and colleagues (2016; global impairment), the correlation *(r)* for the c' path (CDS → daily functioning) is assumed to be 0.5. In respect of the a' path (CDS → IU), research completed by Brown et al. (2023) suggests the correlation between CDS and IU is 0.46. Finally, the correlation for the b' path (IU → daily functioning) is assumed to be 0.4, based on recent research reporting on IU and functional impairment (Kelso and Gros, 2024). Monte Carlo power analysis for indirect effects therefore indicates power of 0.8 would be achieved with 151 participants (α = .05; Schoemann et al., 2017).

2.4. Measures

2.4.1. CDS

The Adult Concentration Inventory (ACI; Becker et al., 2018) was developed following the completion of Becker and colleagues' meta-analysis (2016) differentiating CDS from ADHD-IN. The ACI includes the 13 items identified in this meta-analysis, and three additional items relating to mental confusion. Items are rated on a 5-point scale, from 0, *none,* to 4, *severe difficulty*. The ACI also contains an 8-item measure of the extent to which CDS symptoms are pervasive in various areas of a respondent's life (e.g. relationships, work, parenting etc). The ACI has been established as having good external and structural validity for measuring CDS behaviours in adults (Fredrick et al., 2022).

2.4.2. Executive function

The Adult Executive Functioning Inventory self-report version (ADEXI; Holst & Thorell, 2018) was utilized to assess EF. The ADEXI has 14 items with two subscales for inhibition and working memory, and has been shown to have high internal reliability (α= 0.91 for full scale score). Relatedly, the scale has convergent validity when compared against neuropsychological tests assessing inhibition (D-KEFS Colour-Word Interference) and working memory (WAIS-IV Digit Span and Number-Letter Sequencing) in both clinical and non-clinical samples (Holst & Thorell, 2018). Each item is rated on a 5-point scale, from 1, *definitely not true*, to 5, *definitely true*. Scores are summed for the working memory and inhibition subdomains, though a total full-scale score is also provided.

2.4.3. Intolerance of uncertainty

IU was measured with the Intolerance of Uncertainty Scale-Revised (IUS-R; Walker et al., 2010; Freeston et al., 2015). This version of the IUS-12 (Carleton et al., 2007) uses simpler language, and measures the extent to which individuals are predisposed to distress in response to uncertainty, the future, and ambiguous stimuli. It contains 12 items, rated on a 5-point scale, from 1, *not characteristic of me,* to 5, *entirely characteristic of me*. It is a valid and reliable measure of IU, demonstrating good internal consistency within the general adult population (Cronbach's α = .93, for total score).

2.4.4. Worry

The Penn-State Worry Questionnaire – 3 (PSWQ-3; Berle et al., 2011) was utilized to assess pathological worry in the sample. It has 3 items rated on a 5-point scale from 0,

not at all typical of me, to 5, *very typical of me.* Topper et al. (2014) reported the PSWQ-3 has high specificity (.88 – .90) and sensitivity (.90 – .92) for identifying worry and rumination. Wilson et al. (2025) provide evidence this abbreviated version of the PSWQ has psychometric properties relatively comparable to the original version, and suggest a cut-off score of ≥ 7 for caseness.

2.4.5. Daily functioning

An adapted version of the Individual Work Performance Questionnaire (IWPQ-A; Koopmans et al., 2013) was utilized to measure daily functioning. The adaptations expanded the utility of this tool from being a work-based measure, to generalizable across academic and personal settings (thus not excluding individuals currently not in work). Exploratory analysis on a previous sample (N = 335; Manoj, 2023), revealed the three factors identified from interpretation of scree plot and factor loadings replicated the original factors: *contextual performance*, *counterproductive behaviour*, and *task performance*. Further information about this factor analysis can be found in Appendix 1. It contains 18 items, each rated on 5-point scale, from 0, *seldom*, to 4, *always*. Total score is derived from adding together responses, with reverse scores for items 14- 18. In contrast to the above measures, higher scores on the IWPQ-A indicate better functioning.

2.4.6. Additional measures

Owing to previous evidence that mood and prevalence of ADHD also impacts daily functioning, information was collected on these variables.

The Generalized Anxiety Disorder 2-item scale (GAD-2; Kroenke et al., 2007) and the Patient Health Questionnaire 2-item scale (PHQ-2; Kroenke et al., 2003) were used to screen for symptoms of anxiety and depression, respectively. A score of ≥ 3 points is the cut-off for caseness with these measures (Kroenke, 2001; Spitzer, 2006).

The Adult ADHD Self-report Scale (ASRS; Kessler et al., 2005) was used to measure ADHD symptomology. This 18-item self-report questionnaire has good validity and reliability in community and clinical samples (Fuller-Killgore et al., 2013). The first 9-items screen for ADHD-IN, while the remaining 9-items screen for ADHD-Hyperactivity, and respondents meet the threshold for caseness upon scoring ≥ 3 items 1 - 3, and ≥ 4 on items 4 – 6 (Kessler et al., 2005).

Demographic information regarding age, gender, ethnicity, educational attainment, and employment status were also collected via a demographic questionnaire.

2.5. Procedure

Participants were presented with an information sheet and informed consent forms at start of survey. They were advised participation was entirely voluntary and that they had the right to withdraw at any stage without penalty. Participants were signposted to support organizations at the start, throughout and end of the survey, in case they experienced any distress during its completion. Participants who provided informed consent and met the inclusion criteria were directed to complete the survey in full.

2.5.1. Determining clinical levels of symptoms

Participants were identified as having a symptom of ADHD or CDS if they rated the symptom as occurring “sometimes”, “often” or “very often” on ASRS items 1 -3, and “often” or “very often” across the ACI and ASRS items 4 - 6.

In respect of ADHD, participants were required to have a symptom count of 4 or more on ASRS items 1 – 6 to be identified as having clinical levels of ADHD symptoms, utilizing the threshold recommended by Kessler et al. (2005). As there are no widely established thresholds for the ACI, this paper was informed by previous studies using alternate methods of measuring CDS (Barkley, 2013; Wood et al., 2017), where a symptom count of five is utilized for caseness. A count of five or more CDS symptoms on the ACI was used in conjunction with symptoms being rated as causing either “moderate” or “severe” difficulties in two or more areas of their life to establish participants with clinical levels of CDS symptoms.

2.5.2. Identification of high symptom groups

Symptom scores from the ASRS and ACI were used to create four groups; clinical levels of ADHD symptoms (ADHD; n = 47), clinical levels of CDS symptoms (CDS; n = 40), clinical levels of ADHD and CDS symptoms (ADHD + CDS; n = 93) and those who scored below cut-off on both measures, herein referred to as controls (n = 219).

2.6. Analytic strategy

The preliminary hypothesis will be tested by utilizing chi square and correlation analyses, to explore the relationships between CDS symptom scores, functional impairment, ADHD symptoms, executive functioning scores, anxiety, and depression. The above categorisation of participants into four groups (ADHD, CDS, ADHD + CDS, and Controls) will be used for chi-square analysis of differences between groups.

The main hypotheses will be tested utilizing mediation analysis, with Hayes PROCESS macro for SPSS (Hayes, 2018). The first model (Hayes model 5; Figure 1) utilizes total ACI score as the independent variable, IUS-R total score as a predictor variable, and IWPQ-A total score as the dependant variable. Total ADEXI scores were included as a moderator on the c' path. The second serial mediation model retains ACI score as the independent variable, IUS-R score as first mediator, IWPQ-A score as second mediator, PSWQ-3 as the dependent variable and ADEXI total score as a moderator on the a1 and a2 paths (Hayes model 84; Figure 2).

2.7. Ethical considerations

Full ethical approval was obtained for the study from the Newcastle University Faculty of Medical Science Research Ethics Committee (REF: 39494/2023). The main ethical consideration in this project relates to the researcher adhering to open and transparent research principles, according to the data being archival in nature. The researcher therefore only had sight of data set demographics prior to the approval of the protocol

(17-01-2025), after which full access was granted to the data set. The data had at this point received minimal pretreatment to ensure data quality (see Freeston, 2024).

3.0. Results

3.1. Descriptive statistics

As observed in Table 1, over three-quarters of the sample identified as cis-female and less than a quarter as cis-male. The mean age across the sample was between 30 and 31 years. Most participants identified their ethnicity as white (86%).

Table 1. Participant demographics

		Complete data (N = 399)
Age *M* (SD)		30.22 (15.1) Range: 18 – 79
	Total	396
Gender N (%)		
	Agender	1 (0.3%)
	Cis-gender female	313 (78.4%)
	Cis-gender male	78 (19.5%)
	Genderqueer	1 (0.3%)
	Gender fluid	1 (0.3%)
	Non-binary	4 (1%)
	Self-describe	1 (0.3%)
	Total	399
Ethnicity N (%)		
	Asian/Asian British	20 (5%)
	Black/African/Caribbean/Black British	2 (0.5%)
	Mixed/multiple ethnic groups	8 (2%)
	Other ethnic group	20 (5%)

	White: English/Welsh/Scottish/Northern Irish	349 (87.5%)
	Total	399
Educational attainment N (%)		
	Further education/college (A-levels/BTEC)	223 (55.9%)
	Other	6 (1.5%)
	PhD	8 (2%)
	Postgraduate degree (Masters)	46 (11.5%)
	Prefer not to say	2 (0.5%)
	Secondary school (GCSE)	15 (3.8%)
	Undergraduate degree	99 (24.8%)
	Total	399
Occupational status N (%)		
	Employed	157 (39.3%)
	Full-time parent or carer	1 (0.3%)
	Prefer not to say	1 (0.3%)
	Retired	14 (3.5%)
	Self-employed	13 (3.3%)
	Self-describe	3 (0.8%)
	Student	197 (49.4%)
	Unemployed	13 (3.3%)
	Total	399
Mental health diagnoses N (%)		
	Anxiety	29 (7.3%)
	Bipolar disorder	3 (0.8%)
	Depression	30 (7.5%)
	Eating disorder	0
	Obsessive compulsive disorder	2 (0.5%)
	Panic disorder	3 (0.8%)
	Personality disorder	4 (1%)
	Phobia	3 (0.8%)
	Post-traumatic stress disorder	6 (1.5%)
	Total	80

Meeting clinical cut-off N (%)		
	Anxiety	137 (34.3%)
	Depression	91 (22.8%)
	Worry	256 (64.2%)

3.2. Exploratory analysis of measures utilized in study

3.2.1. Factor analysis of the Individual Work Performance Questionnaire- Adapted (Koopmans et al., 2013)

As the IWPQ-A represents an adapted measure, an exploratory factor analysis was conducted with the present sample to explore the factor structure of the 18-items scale. The analysis was conducted on the full sample (N = 399), as no data was missing. Principal Axis Factoring was used for extraction with oblique rotation (oblimin). The Kaiser-Meyer-Olkin (KMO) measure confirmed sampling adequacy for analysis, with the high KMO value (.899) indicating good strength of association between variables. Relatedly, Bartlett's test of sphericity was significant (χ^2 [153] = 4509.72, $p < .001$), which suggests a substantial correlation in the data and the suitability of data for the factor analysis.

Initial inspection of eigenvalues and the scree plot indicated three factors. Only factor loadings of .32 and above were retained (see Table 2), according to the recommendations of Tabachnick and Fidell (2014). The first factor (6 items; *contextual performance*) was robust, with an eigenvalue of 7.30, explaining 40.54% of variance in the data. The second factor (7 items; *counterproductive behaviours*) had an eigenvalue of 2.76 and explained 15.33% of variance. The third factor (5 items; *task performance*)

had an eigenvalue of 1.75, explaining 9.70% of the variance. The only difference was item 6, which in the original IWPQ measure (Koopmans et al., 2013) is found in the *contextual performance* subscale, here it loaded on the *task performance* factor. Interestingly, in prior factor analysis of the adapted measure (Manoj, 2023), item 6 loaded on both the *contextual* (.438) and *task performance* (.376) subscales. According to present findings, in all subsequent analyses the IWPQ-A subscale *task performance* will contain items 1-6, the *contextual performance* subscale will contain items 7-13, and the *counterproductive behaviours* subscale will contain items 14-18.

Table 2. Factor loadings, dimensions and communality of IWPQ-A

Item Number	Items	Factor Loadings			Communality
		1	2	3	
Task Performance					
1	I was able to plan my tasks so that I finished it on time.			.828	.599
2	I kept in mind the task results I needed to achieve.			.819	.602
3	I was able to distinguish main issues from side issues.			.729	.625
4	I was able to carry out the task well with minimal time and effort.			.616	.515
5	I planned my task optimally.			.714	.605

6	On my own initiative, I started new tasks when my old tasks were completed.			.579	.533
Contextual Performance					
7	I took on challenging tasks when these were available.	.738			.738
8	I worked on keeping my task related knowledge up to date.	.626			.639
9	I worked on keeping my task related skills up to date.	.667			.667
10	I came up with creative solutions for new problems.	.710			.586
11	I took on extra responsibilities.	.855			.664
12	I continually sought new challenges in my work.	.957			.759
13	I actively participated with my colleagues and other members.	.532			.337
Counterproductive behaviours					
14	I complained about unimportant issues related to my task.		.690		.459
15	I made problems related to a task bigger than they were.		.773		.654
16	I focused on the negative aspects of a situation related to my task instead of the positive aspects.		.701		.638
17	I talked to colleagues about the negative aspects of my responsibilities.		.694		.462

18	I talked to people outside of the organization about the negative aspects of my work	.738	.532

Note: Extraction method was Principal Axis Factoring, with Oblimin rotation which used Kaiser Normalization; Factor 1 = Contextual Performance; Factor 2 = Counterproductive behaviour; Factor 3 = Task Performance.

Correlational analysis revealed that in respect of the subscales, *task* and *contextual performance* were moderately correlated ($r = .608$, $p < .001$), though there were weak correlations between *counterproductive behaviours* and both *task* ($r = .257$, $p < .001$) and *contextual performance* ($r = .237$, $p < .001$) subscales.

3.2.2. Tests of normality

Table 3 below presents the means, standard deviations, and zero-order correlations for all measures of interest. The Skewness and kurtosis values indicated a broadly normal distribution. With the exception of the ADEXI Inhibition subscale (α = 0.72), all other Cronbach's α scores were above 0.80, indicating high internal consistency (Shrout, 1998).

Table 3. Cronbach's Alpha, Mean, Standard Deviation, Skewness, and Kurtosis for included scales and subscales

Scale	Subscales	Items	A	M (SD)	Skew	Kurtosis
ACI Total		16	.936	19.35 (10.06)	.543	-.087
IWPQ-A Total		18	.905	39.05 (12.75)	.138	-.350
	Task performance	6	.886	13.09 (5.44)		
	Contextual performance	7	.912	12.65 (42.91)		

	Counterproductive behaviours	5	.847	13.31 (4.50)		
ADEXI Total		14	.910	37.61 (10.69)	.329	-.183
	Working memory	9	.908	23.96 (7.55)		
	Inhibition	5	.719	13.65 (3.96)		
ASRS Total		18	.918	50.73 (12.89)	.423	.052
	Inhibition	9	.870	26.32 (7.05)		
	Hyperactivity	9	.852	24.46 (6.70)		
IUS-R Total		12	.922	28.92 (10.20)	.553	-.252
PSWQ-3		3	.931	8.42 (3.71)	.267	-1.018
GAD-2		2	.892	2.16 (1.84)	.636	-.543
PHQ-2		2	.856	1.72 (1.63)	.893	.185

Note: ACI = Adult Concentration Inventory; IWPQ-A = Individual Work Performance Questionnaire-Adapted version; ADEXI = Adult Executive Functioning Inventory; ASRS = Adult ADHD Self-Report Scale; IUS-R = Intolerance of Uncertainty Scale- Revised; PSWQ-3 = Penn State Worry Questionnaire-3; GAD-2 = Generalized Anxiety Disorder- 2; PHQ-2 = Patient Health Questionnaire- 2.

3.3. Relationships between variables

3.3.1. Hypothesis 1: Higher prevalence of CDS symptoms will predict greater issues with EF and daily functioning

The means and standard deviations of both predictor and outcome variables by each group (ADHD, CDS, ADHD + CDS, and Controls), with chi-square and contrasts are presented in Table 4. A Kruskal-Wallis H test was run to determine if there were differences in ADHD, CDS, anxiety, depression, worry, IU, EF and daily functioning scores between the four groups of participants. Visual inspection of the boxplots for each outcome variable indicated the distribution of scores was similar for each group. Median scores were significantly different between groups for depression ($X^2(3)$ =

115.019, p <.001), anxiety (X^2(3) = 101.975, p <.001), worry (X^2(3) = 84.985, p <.001), CDS (X^2(3) = 204.717, p <.001), ADHD-H (X^2(3) = 141.801, p <.001), ADHD-I (X^2(3) = 236.790, p <.001), daily functioning (X^2(3) = 97.057, p <.001), EF (X^2(3) = 173.787, p <.001), and IU (X^2(3) = 71.051, p <.001).

Table 4. Means and standard deviations of predictor and outcome variables by symptom group

	Group						
	1. Control n = 219 *M* (*SD*)	**2. CDS n = 40** *M* (*SD*)	**3. ADHD n = 47** *M* (*SD*)	**4. ADHD + CDS n = 93** *M* (*SD*)	X^2	*p*	Contrasts
Depression	1.05 (1.15)	2.83 (1.82)	1.21 (1.08)	3.07 (1.65)	115.02	<.001	1, 3 < 2, 4
Anxiety	1.38 (1.47)	3.20 (1.76)	2.19 (1.47)	3.54 (1.84)	101.98	<.001	1 < 2, 3, 4; 3 < 2, 4
Worry	6.95 (3.16)	10.03 (3.58)	8.74 (3.61)	11.01 (3.30)	84.99	<.001	1 < 2, 3, 4; 3 < 4
CDS	13.70 (6.54)	25.63 (6.20)	17.72 (7.87)	30.78 (7.93)	204.72	<.001	1 < 2, 3, 4; 2 < 4; 3 < 2, 4
ADHD-H	21.25 (4.81)	24.00 (5.23)	26.40 (5.66)	31.29 (6.21)	141.80	<.001	1 < 2, 3, 4; 2, 3 < 4
ADHD-I	22.02 (4.79)	25.43 (3.36)	30.06 (3.88)	34.92 (4.65)	236.79	<.001	1 < 2, 3, 4; 2 < 3, 4; 3 < 4
Daily functioning	44.37(11.41)	35.23 (9.50)	37.64 (11.93)	28.87 (10.29)	97.06	<.001	1 > 2, 3, 4; 2, 3 > 4
EF	31.92 (8.03)	39.65 (8.36)	39.26 (7.34)	49.28 (8.19)	173.79	<.001	1 < 2, 3, 4; 2, 3 < 4
IU	25.33 (7.89)	34.38 (10.80)	28.19 (10.93)	35.40 (10.37)	71.05	<.001	1, 3 < 2, 4

Note: ADHD-I = ADHD-Inattention total score (ASRS items 1-9); ADHD-H = ADHD Hyperactivity total score (ASRS items 10-18); CDS = Total score (ACI); Anxiety = Total score (GAD-2); Depression = Total score (PHQ-2); Daily functioning = Total score (IWPQ-A); EF = Total score (ADEXI); Worry = Total score (PSWQ-3); IU = Total score (IUS-R); Chi square and contrasts = Results of Kruskal-Wallis non-parametric chi-square tests. Group contrasts from Mann Whitney tests are shown for significant results.

Initial pairwise comparisons were performed using Dunn's (1964) procedure with Bonferroni correction for multiple comparisons. Adjusted *p*-values are presented. This post hoc analysis revealed significant differences in EF scores between the Control (*Median* = 32.00) and CDS (*Median* = 39.00) groups ($p < .001$). Daily functioning scores were compared in this way, also indicating significant differences in daily functioning scores between the Control (*Median* = 43.00) and CDS (*Median*= 35.50) groups ($p < .001$).

Figure 4 visually represents the distribution of CDS and ADHD scores by high symptom groups and controls. We observe that as CDS symptom scores increase, so too do ADHD total scores. Exploratory analysis revealed when compared to controls, the CDS group were 8.13 times more likely to meet caseness for anxiety (GAD-2; OR= 8.130, 95%CI [3.92, 16.95]), and 10.53 times more likely to meet caseness for depression (PHQ-2; OR= 10.526, 95%CI [4.83, 22.73]).

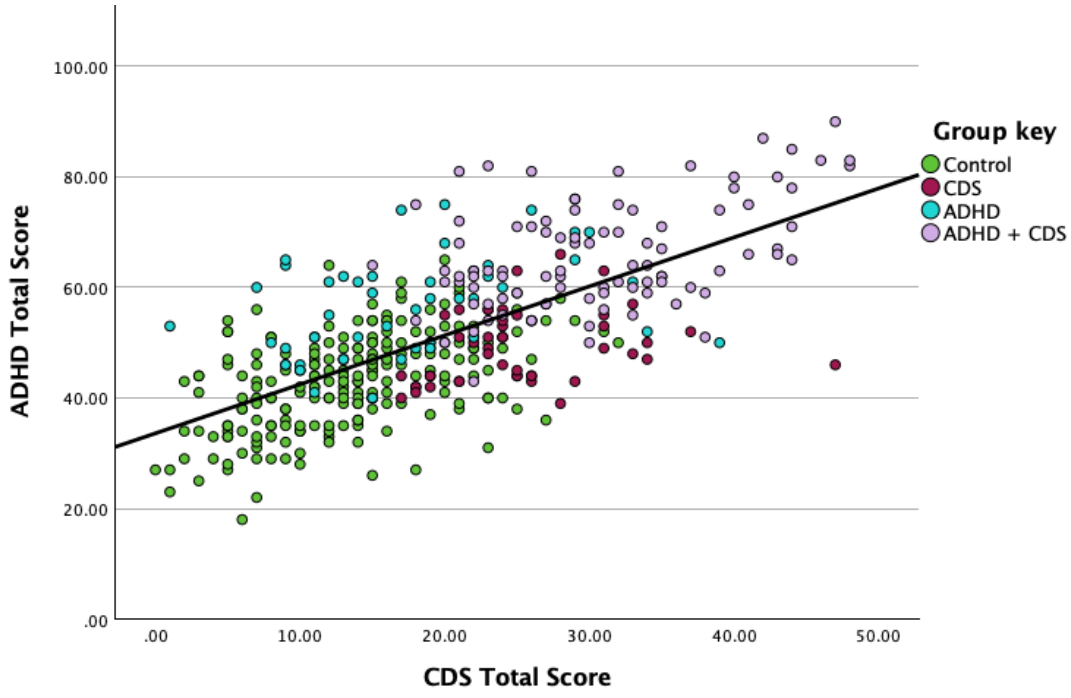

Figure 4. Scatterplot demonstrating ADHD and CDS scores by symptom groups

3.3.1.1. Group comparisons of daily functioning

A Kruskal-Wallis H Test was utilized to compare groups in respect of daily functioning subdomains. Statistically significant differences were found across the four groups for task performance ($X^2(3) = 113.492$, $p < .001$), contextual performance ($X^2(3) = 33.243$, $p < .001$), and counterproductive behaviours ($X^2(3) = 51.552$, $p < .001$). Mean scores across groups can be found below in Table 5.

Mann-Whitney U tests revealed that in respect of task performance, the CDS group ($U = 3119.00$, $p = .004$), ADHD group ($U = 2899.00$, $p < .001$), and ADHD + CDS group ($U = 2983.00$, $p < .001$), differed significantly from controls. The CDS group had significantly higher levels of task performance than the ADHD ($U = 654.50$, $p = .015$), and the ADHD

+ CDS group, (U = 682.50, p < .001). The ADHD also had significantly higher levels of task performance than the ADHD + CDS group (U = 1303.50, p < .001). For contextual performance, only the CDS group differed significantly from controls (U = 2991.00, p = 001). In respect of counterproductive behaviours, the CDS group (U = 2509.50, p < .001), ADHD group (U = 4058.50, p = .022), and the ADHD + CDS group (U = 5505.50, p < .001) all differed significantly from the control group. The ADHD group also demonstrated significantly higher levels of daily functioning than the ADHD + CDS group (U = 1554.50, p = .005)

3.3.1.2. Group comparisons of executive dysfunction

The Kruskal-Wallis H test was also used to compare groups on EF subdomains. Statistically significant differences were found across the four groups for working memory ($X^2(3) = 164.175$, p <.001), and inhibition ($X^2(3) = 124.248$, p <.001). Mean scores across groups can also be seen in Table 6.

Mann-Whitney U tests indicated that for working memory (WM) performance, the CDS group (U = 2393.50, p <.001), ADHD group (U = 2948.50 p < .001), and ADHD + CDS group (U = 1332.00, p <.001) all demonstrated significantly higher levels of impairment than controls. The CDS group also differed significantly from the ADHD + CDS group (U = 807.50, p <.001) on WM scores, with greater impairment noted in the latter group. The ADHD group also demonstrated significantly lower levels of WM impairment than the ADHD + CDS group (U = 816.00, p <.001). For the inhibition subscale, the CDS (U = 2530.00, p <.001), ADHD (U = 2726.50, p <.001), and ADHD + CDS groups (U =

2698.00, p <.001), all differed significantly from controls. The CDS (U = 984.50, p < .001) and ADHD (U = 1176.50, p <.001) groups also differed significantly from the ADHD + CDS group on inhibition scores, with the ADHD + CDS group demonstrating the greatest impairment.

To further explore the relationship between key variables of interest, correlation analyses were conducted. Table 6 provides a summary of the correlations between study variables. A strong negative correlation was found between CDS and daily functioning, r = -.571. A strong positive correlation was found between CDS and EF issues, r = .747. More generally, there were also moderate to strong correlations on all measures of distress (anxiety, depression and worry) and those of neurodivergence (EF, ADHD, and CDS).

Table 5. Means and standard deviations of executive function domain scores and daily functioning subscale scores by symptom groups

	Group						
	1. Control n = 219	**2. CDS n = 40**	**3. ADHD n = 47**	**4. ADHD + CDS n = 93**			
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	X^2	*p*	Contrasts
EF domains							
Working memory	20.08 (5.63)	25.35 (6.55)	24.85 (5.90)	32.03 (5.73)	164.18	<.001	1 < 2, 3, 4; 2, 3 < 4
Inhibition	11.84 (3.35)	14.30 (2.93)	14.40 (2.80)	17.25 (3.51)	124.25	<.001	1 < 2, 3, 4; 2, 3 < 4
Daily functioning							
Task performance	15.40 (4.98)	13.23 (3.37)	11.57 (4.54)	8.33 (4.17)	113.49	<.001	1 > 2, 3, 4; 2 > 3, 4; 3 > 4
Contextual performance	14.25 (6.37)	10.63 (6.08)	12.81 (6.64)	9.69 (5.91)	33.24	<.001	1 > 2, 4; 3 > 4
Counterproductive behaviours	14.72 (3.85)	11.38 (4.56)	13.26 (4.08)	10.85 (4.77)	51.55	<.001	1 > 2, 3, 4; 3 > 4

Note: Working memory = WM subscale total score (ADEXI); Inhibition = Inhibition subscale total score (ADEXI); Task performance = Total score (items 1-6, IWPQ-A); Contextual performance = Total score (items 7-13, IWPQ-A); Counterproductive behaviours = Total score (items 14-18, IWPQ-A). Group contrasts from Mann Whitney tests are shown for significant results, where Group 1 = Control, Group 2 = CDS, Group 3 = ADHD, and Group 4 = ADHD + CDS.

Table 6. Zero order correlations between study variables

	Variable								
	1	2	3	4	5	6	7	8	9
1. Depression	-								
2. Anxiety	.652	-							
3. Worry	.520	.791	-						
4. CDS	.586	.587	.541	-					
5. ADHD-H	.439	.414	.416	.587	-				
6. ADHD-I	.461	.471	.431	.712	.769	-			
7. Daily functioning	-.434	-.419	-.426	-.571	-.329	-.525	-		
8. EF issues	.436	.444	.439	.747	.708	.766	-.499	-	
9. IU	.415	.534	.555	.456	.404	.415	-.305	.410	-

Note: All correlations reported represent Pearson's r coefficients significant at p <.001. For all variables, pairwise n = 397

3.4. Mediation and moderation analyses

The data was first reviewed to ensure it met the assumptions of multiple regression (see Appendix 2 for evidence).

3.4.1. Hypothesis 2: IU mediates relationship between CDS and daily functioning

To test the primary hypothesis of this study, the mediation model was tested first by controlling for age and gender, and then tested again for specificity of the effects by controlling for ADHD and mood (PHQ-2, GAD-2 and PSWQ-3). The results of this analysis showed the direct effect of CDS symptomology on daily functioning was significant when controlling for age and gender (*B* = -.571, SE = .059, 95% CI [-.688, -.455], *p* <.001), with greater ACI scores predicting lower IWPQ scores. The total indirect effect of CDS symptomology on daily functioning through the mediator IU was, however, not significant (*B* = -.017, SE = .024, 95% CI [-.063, -.030]). The overall model accounted for 38.60% of the variance observed in IWPQ-A scores.

When controlling for ADHD and mood as well as age and gender, the direct effect of CDS symptomology on daily functioning remained significant (*B* = -.368, SE = .081, 95% CI [-.528, -.209], *p* <.001). The total indirect effect of CDS symptomology on daily functioning through the mediator IU remained non-significant (*B* = -.002, SE = .006, 95% CI [-.009, -.017]). The overall model accounted for 41.13% of the variance observed in IWPQ-A scores. These results can be found in Table 7 and Figure 5 below. Overall in this analysis, IU was not found to mediate the relationship between CDS and daily functioning.

Table 7. CDS, IU, EF and daily functioning: A mediation model

Model Pathway	*B*	SE	LLCI	ULCI	p
	IU				
Total	**-.588**	**.054**	**-.695**	**-.481**	**<.001**
Direct	**-.571**	**.059**	**-.688**	**-.446**	**<.001**
Indirect	-.017	.024	-.063	.030	
Covariates					
Age	**.209**	**.036**	**.138**	**.281**	**<.001**
Cis-gender woman	4.292	3.829	-3.236	11.819	.263
Cis-gender man	5.490	3.980	-2.334	13.314	.166
	IU with ADHD and mood covariates				
Total	**-.366**	**.081**	**-.525**	**-.207**	**<.001**
Direct	**-.368**	**.081**	**-.528**	**-.209**	**<.001**
Indirect	.002	.006	-.009	.018	
Covariates					
Age	**.206**	**.037**	**.134**	**.278**	**<.001**
Cis-gender woman	3.568	3.797	-3.897	11.033	.348
Cis-gender man	4.628	3.962	-3.161	12.417	.243
ADHD	-.094	.055	-.202	.013	.086
Depression	**-1.231**	**.428**	**-2.072**	**-.390**	**.004**
Anxiety	.436	.507	-.561	1.432	.390
Worry	-.342	.229	-.791	.108	.136

Note: LLCI = Lower limit confidence interval; ULCI = Upper limit confidence interval; Bootstrap sample size = 5000; Custom seed = 1678; Significant results in bold.

3.4.2. Hypothesis 2: Executive functioning is a moderator of relationship between CDS, IU and daily functioning

To test the second part of the primary hypothesis, moderation analyses were conducted using age, gender, ADHD and mood as covariates (see Figure 5). The results of the moderation analysis revealed that total EF scores have a significant impact on the direct effect between CDS and daily functioning (*B* = .009, SE = .004, 95% CI [.001, .017], *p* = .034). The moderation model accounted for 42.19% of the variance observed in daily functioning scores. Interestingly, when EF subscales were entered separately in the model, only the working memory domain had a significant effect on the direct relationship between CDS and daily functioning (*B* = .014, SE =

.006, 95% CI [.003, .025], p = .014). The impact of the inhibition subdomain was not significant (p = .132).

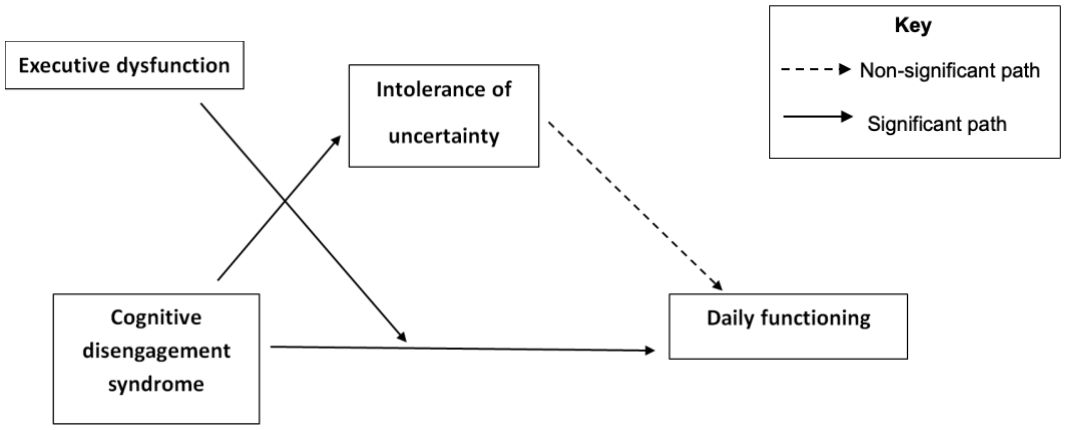

Figure 5: CDS and daily functioning with IU mediating and EF moderating c' path

To facilitate the interpretation of the moderating effect of total EF on the association between CDS and daily functioning, a line graph of scores for each variable at the mean, mean +1SD and mean -1SD was created. Figure 6 demonstrates that as EF scores worsen, the negative effect of CDS on daily functioning becomes less pronounced.

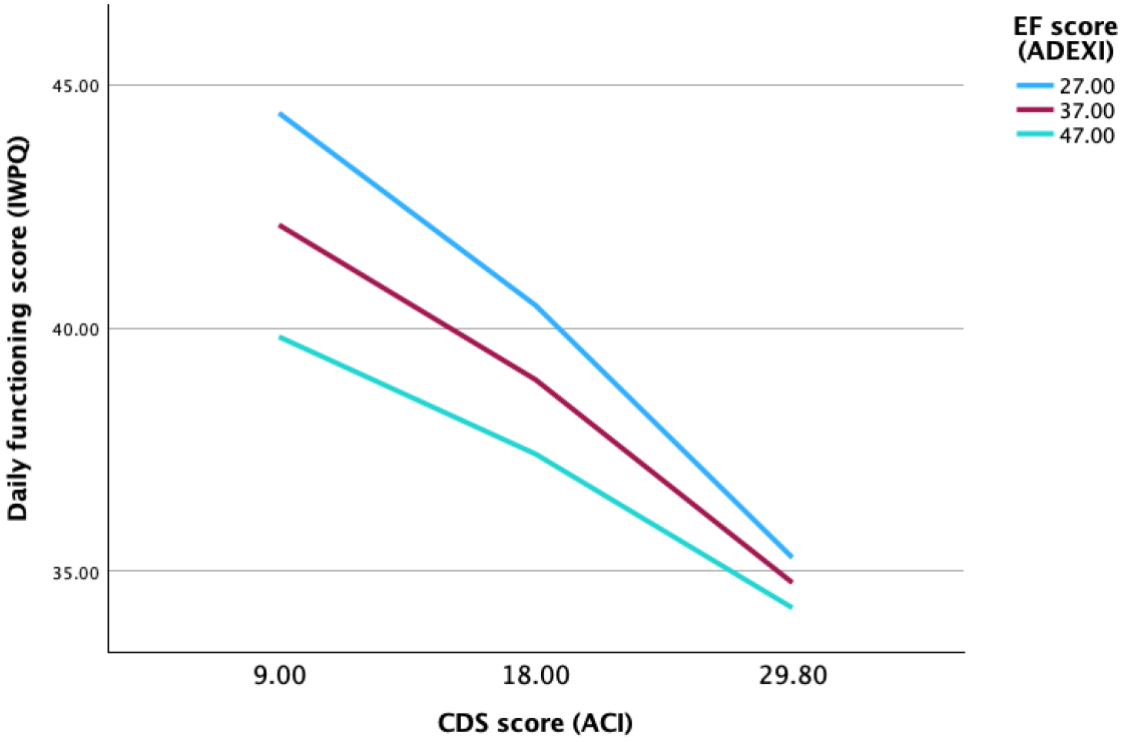

Figure 6. Graph demonstrating moderating effect of EF on direct relationship between CDS and daily functioning

3.4.3. Hypothesis 3: CDS will lead to higher levels of worry, mediated by both intolerance of uncertainty and daily functioning, and moderated by EF

To test the final hypothesis, a serial moderated mediation was conducted. Table 8 presents the results of this analysis, which indicates the direct effect of CDS on worry is significant, with higher ACI scores predicting higher PSWQ-3 scores. The model accounted for 44.66% of variance in worry scores.

Table 8. CDS, IU, EF, worry and daily functioning: A serial mediation model

Model Pathway	*B*	SE	LLCI	ULCI	P
	CDS and Worry				
Total	**.174**	**.016**	**.142**	**.207**	**<.001**
Direct	**.098**	**.018**	**.061**	**.134**	**<.001**
Indirect					
Total Indirect	**.076**	**.013**	**.051**	**.104**	

ACI → IUS-R → PSWQ-3	**.056**	**.010**	**.038**	**.078**	
ACI → IWPQ-A → PSWQ-3	**.019**	**.009**	**.003**	**.038**	
ACI → IUS-R → IWPQ → PSWQ-3	.001	.001	-.001	.002	
Covariates					
Age	**-.022**	**.0106**	**-.043**	**-.002**	**.036**
Cis-gender woman	-.703	1.073	-2.813	1.407	.513
Cis-gender man	-1.435	1.117	-3.632	.761	.199
Index of moderated mediation with EF	Index	SE	LLCI	ULCI	
ACI → IUS-R → PSWQ-3	-.0004	.0006	-.0016	.0006	
ACI → IWPQ- A→ PSWQ-3	-.0003	.0002	-.0007	.0000	
ACI → IUS-R → IWPQ-A → PSWQ-3	-.000003	.000012	-.000029	.000023	

Note: LLCI = Lower limit confidence interval; ULCI = Upper limit confidence interval; ACI = Adult Concentration Inventory; IUS-R = Intolerance of Uncertainty Scale- Revised; IWPQ-A = Individual Work Performance Questionnaire- Adapted; PSWQ-3 = Penn State Worry Questionnaire- 3; Bootstrap sample size = 5000; Custom seed = 1678; Significant effects in bold.

The analyses also indicate that the relationship between CDS and worry is significantly mediated by both IU (*B* = .056 SE = .010, 95% CI [.038, .078]) and daily functioning (*B* = .019, SE = .009, 95% CI [.003, .038]), though not significantly on the serial d' path (*B* = .000, SE = .001, 95% CI [-.001, .002]). These results are pictorially represented in Figure 7.

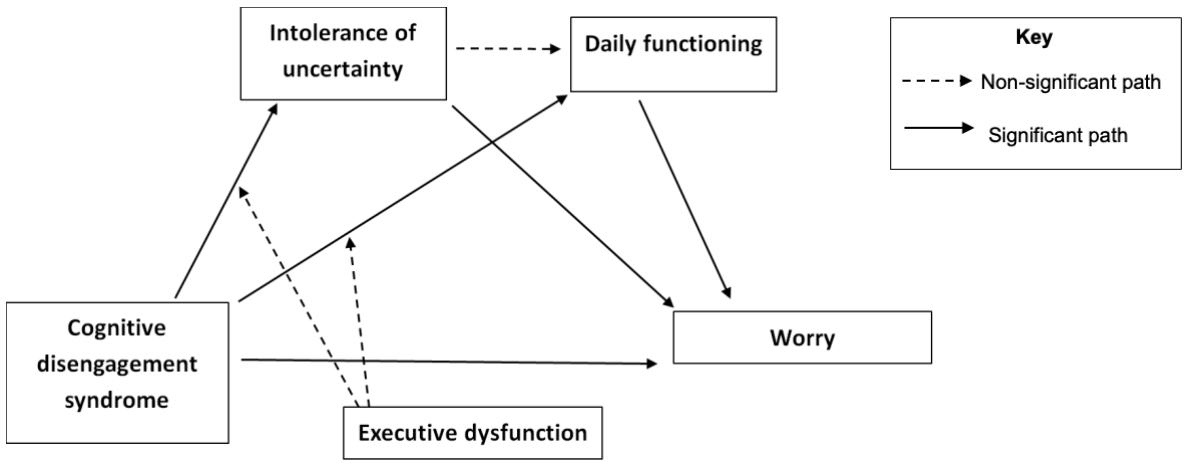

Figure 7: CDS on worry with daily functioning and IU mediating, with EF moderating a1 and a2 paths

4.0. Discussion

This study adds to growing research exploring CDS within adult populations. It proposed three distinct hypotheses, which will now each be considered.

4.1. CDS symptoms, daily and executive functioning

The first hypothesis stated that higher prevalence of CDS symptoms would predict greater issues with EF and daily functioning. Direct comparisons of groups indicated a significant difference in EF and daily functioning scores between the CDS and control groups. Daily functioning was significantly poorer, and EF issues significantly more pronounced in the CDS group when compared to controls. The same trend was observed in comparisons of groups across the daily functioning and EF subdomains. Moreover, the mediation analyses indicated the direct path between CDS and daily functioning was significant, when accounting for age, gender, ADHD, and mood. This is consistent with the findings of prior research with children, students and adults (Barkley, 2013; Jarrett et al., 2017; Wood et al., 2017; Becker et al., 2016). Correlation coefficients across this study and Wood et al. (2017) are comparable, with EF issues representing the construct with the strongest correlation to CDS (r = 0.75 and r = 0.77, respectively), and strong correlations noted too for daily functioning/impairment (r = -0.57 and r = 0.65, respectively).

4.2. The mediating role of intolerance of uncertainty

The second hypothesis stated that IU would mediate the relationship between CDS and daily functioning. When controlling for age, gender, ADHD and mood, IU was not found to be a significant mediator in the relationship between CDS and daily

functioning. While Kruskal-Wallis test results suggested those in the CDS group demonstrated significantly greater levels of IU than those in control group, this was not found to influence daily functioning outcomes. Nonetheless, the finding that CDS contributed to higher levels of IU is consistent with prior research (Brown et al., 2023).

4.3. The moderating role of executive function

The second hypothesis also posited EF would moderate the relationship between CDS and daily functioning, which was tested using moderation analysis. This study has demonstrated that when accounting for age, gender, mood and ADHD, EF is a significant moderator on the relationship between CDS and daily functioning. Moreover, it demonstrated only the working memory subdomain of EF (as measured by the ADEXI) had a significant effect on this direct relationship.

4.4. CDS and worry

The final hypothesis stated CDS would have a direct effect on levels of worry, mediated by daily functioning and intolerance of uncertainty, and moderated by EF. The findings of the moderated serial mediation model suggest CDS has a significant effect on levels of worry, and that this relationship is separately (though not serially) mediated by IU and daily functioning. EF was not found to be a moderator in this model. CDS therefore does appear to predict greater levels of distress in respect of worry symptoms, which contributes to the evidence base regarding CDS and mental health (Bahmani et al., 2025; Becker et al., 2018; Smith et al., 2020).

4.5. Limitations

These findings should be considered in light of its limitations. First, despite the causal model implied by the mediation analysis, the utilization of cross-sectional data in this study does not allow for conclusions to be drawn in respect of the casual relationship between variables. Future studies could address this by adopting longitudinal (Bernad et al., 2016; Smith et al., 2020) or interventional (Adler et al., 2021; Wiggs et al., 2024) approaches to studying CDS, providing insight into how factors of interest are related and change over time.

A second limitation is the reliance on self-report measures to quantify CDS, daily functioning, and EF. Future studies would benefit from utilizing performance-based measures of EF such as the Delis-Kaplan Executive Functioning System (Delis et al., 2001). Incorporating informant scores may be another alternative, such as the ADEXI informant version (Holst & Thorell, 2018). In respect of the measures utilized for CDS and ADHD (ACI and ASRS), it is acknowledged these are screening tools only and not diagnostic in nature. Additionally, the ACI does not have widely accepted cut-off scores, so categorizing scores as indicating ‘clinical levels’ of symptoms for preliminary aims involved consultation of similar measures and generalizing this to the ACI. It is also important to acknowledge that reliability and validity of the IWPQ-A (Koopmans et al., 2013) is relatively unknown. However, the factor structure has been demonstrated as being comparable to the original measure (Manoj, 2023), and tests of reliability suggested it has high internal consistency.

The final limitation is that the role of other potentially relevant factors influencing the reported levels of CDS have not been considered. Gathering information about

daytime sleepiness (Langberg et al., 2014), physical health, nutrition, medication, and substance misuse, for example, would support our understanding of CDS in future research and establish if CDS symptoms could be better explained by lifestyle choices or biological vulnerabilities.

4.6. Theoretical implications

Prior research has found that CDS symptoms can occur separately from symptoms of ADHD in adults and children (Barkley et al., 2012; Barkley et al., 2013; Wood et al., 2017). The current findings are consistent with this, given almost one third (30.1%) of all participants with elevated levels of CDS symptoms did not exhibit clinical levels of ADHD. Despite this, CDS was found to correlate most highly with ADHD-IN, suggestive that while they are clearly similar constructs, they do operate separately.

As previously highlighted, a cut-off score to identify clinically significant levels of CDS symptoms utilizing the ACI (Becker et al., 2018) has not yet been established. The merits of developing cut-off scores include increased standardization across the field of research, and potentially more efficient clinical decision-making, with greater diagnostic clarity through incorporation into diagnostic guidelines (e.g. *DSM-IV-TR* or *ICD-10*). However, as CDS is a construct which remains in its relative infancy in terms of our understanding of its boundaries and relationship to other constructs, it may perhaps be more prudent at present to conceptualize it dimensionally (e.g. on a continuum). This is in-keeping with the wider field of neurodivergence, where there is a tendency towards conceptualizing conditions on a spectrum (e.g. Foetal Alcohol Spectrum Disorder and Autism Spectrum Disorder).

4.7. Clinical implications

The results suggest that screening for symptoms of CDS within clinical settings may be beneficial. Approximately one third of all participants in this sample identified as exhibiting high levels of CDS symptoms which were impacting at least two areas of their life. In a clinical setting, the direct path found in this study between CDS and worry suggests that targeting either mediator in the model (IU or daily functioning), could be an effective means to reduce worry. Psychological interventions for IU with the most robust evidence base are cognitive-behavioural oriented with emphasis on behavioural experiments and 'making friends with uncertainty' (Dugas et al., 2003; Dugas et al., 2022; Ladouceur et al., 2000; Mofrad et al., 2020; Wilson et al., 2023).

Unfortunately, the developing evidence base for CDS interventions has predominantly focussed on individuals with diagnoses of ADHD with co-occurring CDS symptoms, exploring the effectiveness of medication (Adler et al., 2021), mindfulness-based practices (Wiggs et al., 2025), and psychoeducation (Gaur & Pallanti, 2020). Preliminary evidence presented by Gaur and Pallanti (2020), for example, suggests that adults with ADHD who self-report issues with EF and CDS see functional improvements from an intervention which incorporates medication initiation and psychoeducation. While not necessarily directly applicable to the subset of individuals identified in this study who presented with CDS symptoms independent of ADHD, this evidence does raise questions about the effectiveness of a psychoeducational intervention for addressing CDS, where functional improvements could potentially impact on levels of worry, if the CDS→ Daily functioning→ Worry mediation pathway holds in clinical practice. Consistent with the suggestions of Diamond and Ling (2016) around interventions to improve EFs,

targeting physical health through encouraging individuals to engage in more physical exercise (Etnier et al., 2006; Prakash et al., 2015), addressing sleep hygiene (Bernier et al., 2013; Sen & Tai, 2023), reducing stress (Liston et al., 2009) and increasing social connectedness (Cacioppo & Patrick, 2008; Ybarra et al., 2011), may all have secondary benefits of reducing the impact of CDS. Clearly, intervention studies with individuals who present with CDS symptoms independent of ADHD would be beneficial for advancing understanding of the construct and its clinical implications.

4.8. Conclusions

The results of this study add to a growing evidence base regarding the relationship between CDS, daily functioning, EF, and worry, utilizing self-report measures with a community-dwelling adult population. It has identified a direct relationship between CDS and daily functioning, and established this is moderated by levels of EF. IU was not found to be a mediator of this relationship, though IU was found to mediate the relationship between CDS and worry, as was daily functioning. It bolsters previous claims CDS operates independently from ADHD and depression, and discusses the implications for clinical practice and future research.

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6.0. Appendices

6.1. Appendix 1: A priori IWPQ-A Factor Analysis (Manoj, 2023)

The IWPQ measure was adapted to generalise to performance in activities of everyday living. To explore the factor structure in present sample, an exploratory factor analysis, on the 18 items, with oblimin rotation and principal axis factoring was performed.

The KMO index measure of sampling adequacy score of .900 and Bartlett's test of sphericity ($\chi 2(153) = 3964.212$, $p < .000$) indicated the correlation matrix was suitable for factor analysis. The item communalities ranged between .475 to .728, indicating variance between the factors.

As shown in Table 9, three factors were derived from interpreting the scree plot and factor loadings. The item loadings were between .223 to .876. There were 13 items above .7, four above .5, one above .3. The factors were labelled consistently with the original measure of Individual Work Performance Questionnaire (Koopmans et al., 2012). Factor 1 comprised of eight items and was labelled *'Contextual Performance'*. Factor 2 comprised of five items and was labelled '*Counterproductive Behaviour'*. Factor 3 comprised of five items and was labelled *'Task Performance'*. The overall scale demonstrated a good internal consistency α of .886 (Table 2). Contextual Performance had an excellent internal consistency (α = .917). Further, Task Performance (α = .880) and Counterproductive Behaviour (α = .844) had a good internal consistency respectively. Overall, these analyses on the version adapted for

this study to multiple contexts suggest the three-factor structure of the original performance measure in the work setting only.

Table 9. Factor Loading and Extraction Communality of Items in Adapted Individual Work Performance Questionnaire

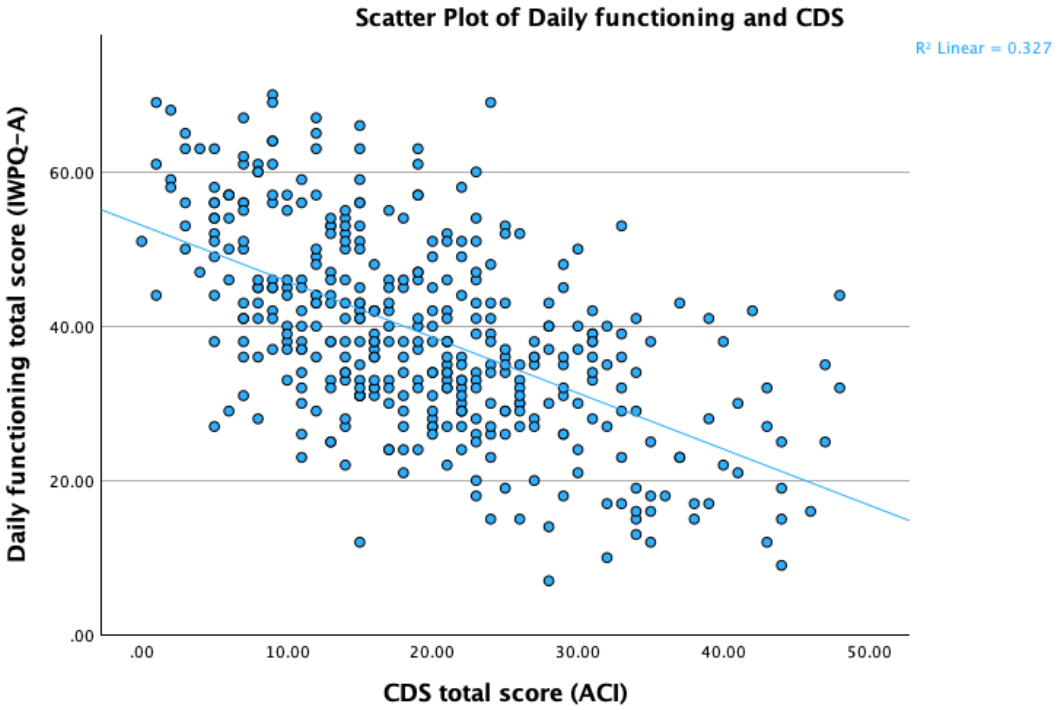
Item Number	Items	Factor Loadings			Communality
		1	2	3	
	I continually sought new challenges in my work.	.876			.654
	I took on extra responsibilities.	.805			.564
	I worked on keeping my task related skills up to date.	.754			.719
	I worked on keeping my task related knowledge up to date.	.748			.728
	I came up with creative solutions for new problems.	.743			.568
	I took on challenging tasks when these were available.	.728			.633
	I actively participated with my colleagues and other members.	.596			.475
	On my own initiative, I started new tasks when my old tasks were completed.	.438		.376	.550
	I talked to people outside of the organisation about the negative aspects of my work		.670		.451

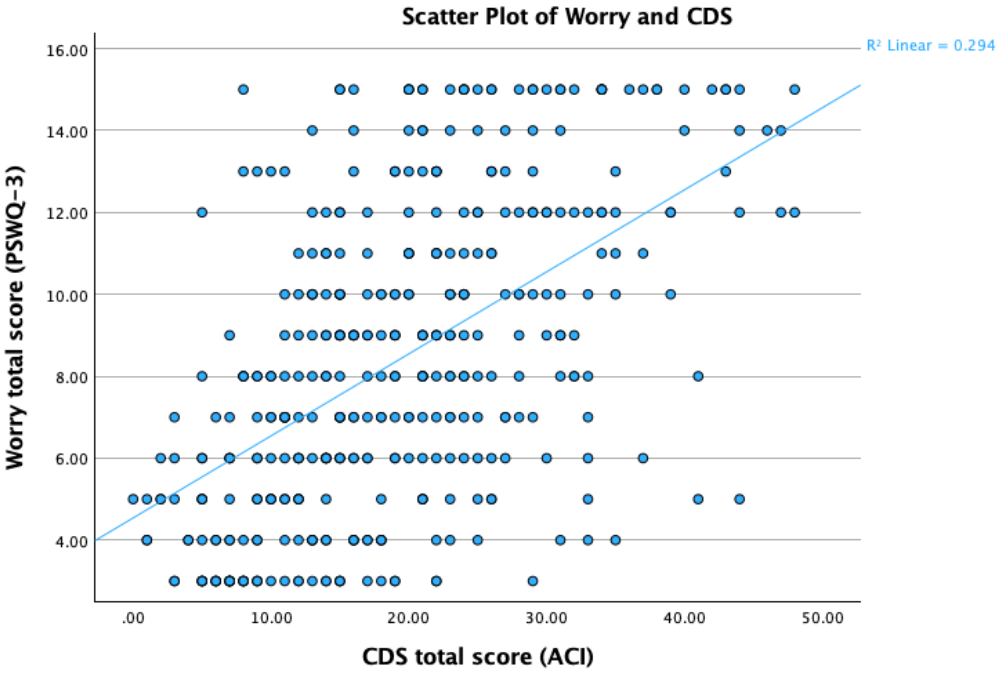
I complained about unimportant issues related to my task.		.726		.533
I made problems related to a task bigger than they were.		.752		.586
I talked to colleagues about the negative aspects of my responsibilities.		.756		.569
I focused on the negative aspects of a situation related to my task instead of the positive aspects.		.759		.588
I was able to plan my tasks so that I finished it on time.			.864	.650
I kept in mind the task results I needed to achieve.			.785	.615
I was able to distinguish main issues from side issues.			.723	.598
I planned my task optimally.			.696	.622
I was able to carry out the task well with minimal time and effort.	.223		.560	.526

Note. The extraction method was principal axis factoring with an oblimin rotation. Factor 1 = Contextual Performance, Factor 2 = Counterproductive Behaviour and Factor 2 = Task Performance.

6.2. Appendix 2- Evidence of meeting assumptions of multiple regression

Assumption 1: The relationship between the IVs and DVs is linear.
This can be observed clearly in the scatterplots below



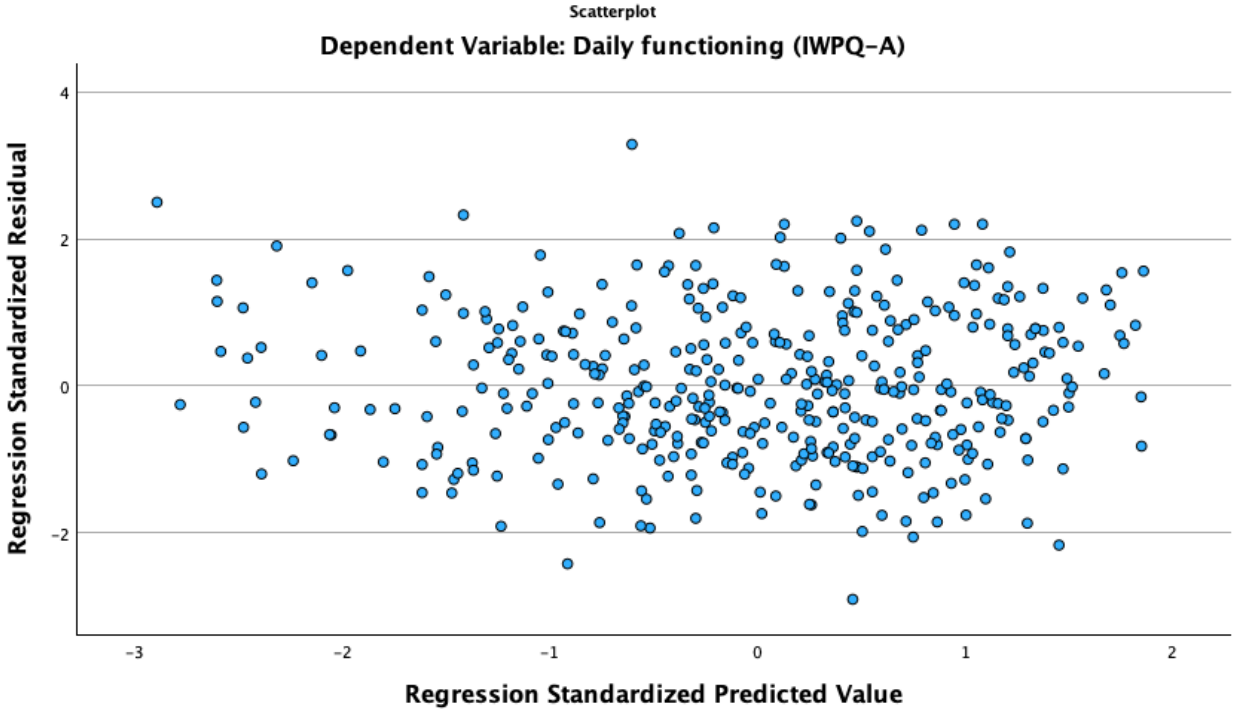


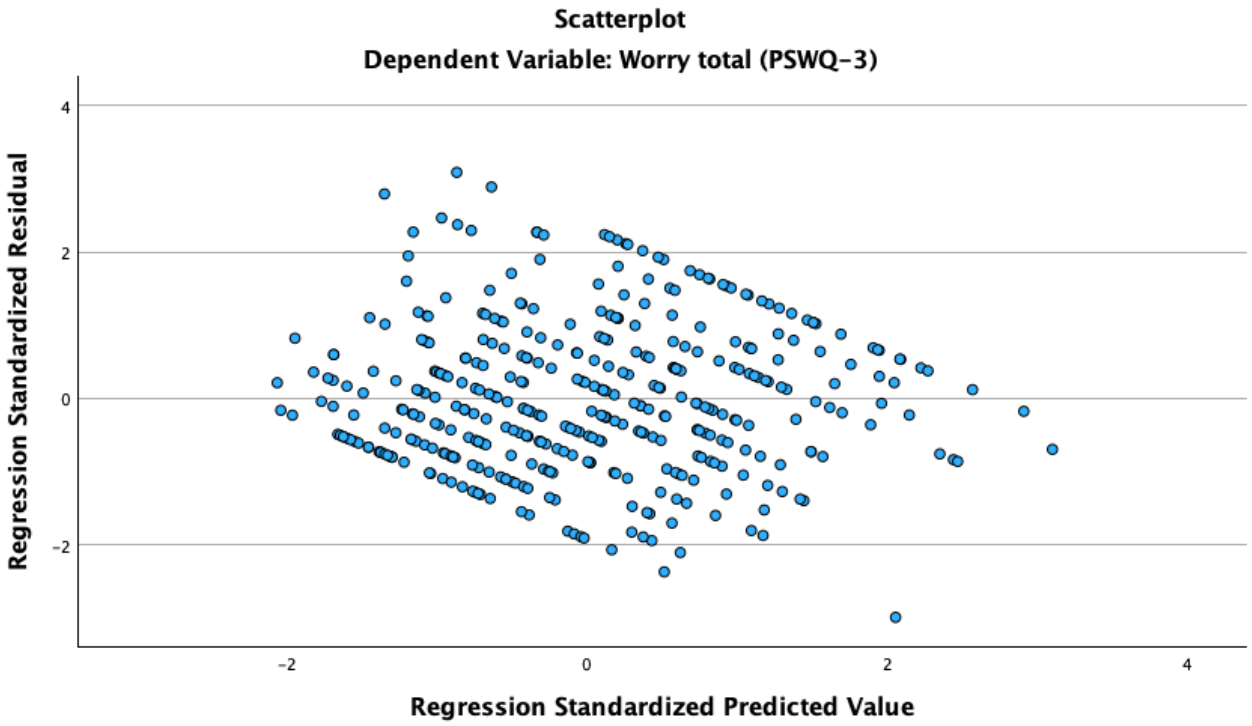
Assumption 2: There is no multicollinearity in data.

On reviewing collinearity statistics, VIF scores were well below 10, and tolerance scores above 0.2 (.792 and 1.263, respectively for CDS and daily functioning model; VIF = 1.709,1.268, 1.492, and tolerance =.585, .789, .670 in worry model). This is indicative the second assumption has been met.

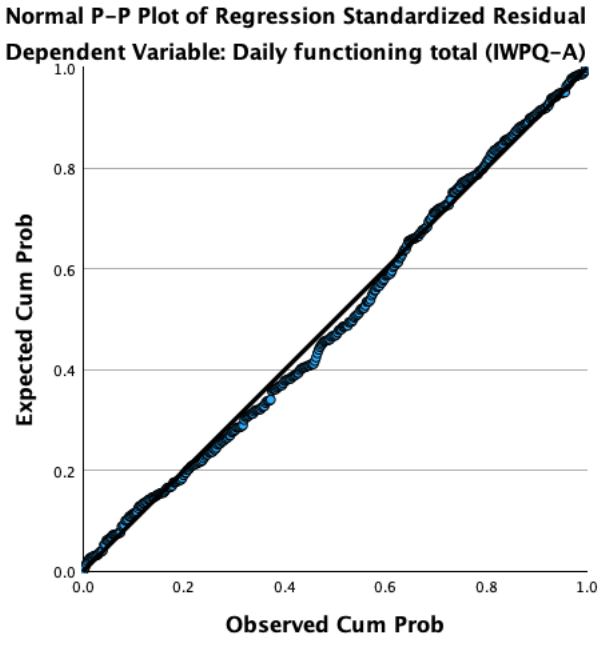
Assumption 3: The values of the residuals are independent.
The Durbin-Watson statistic showed this assumption has been met, as obtained value was close to 2 (Durbin-Watson = 1.949 in CDS and daily functioning model; Durbin-Watson = 1.926 in worry model).

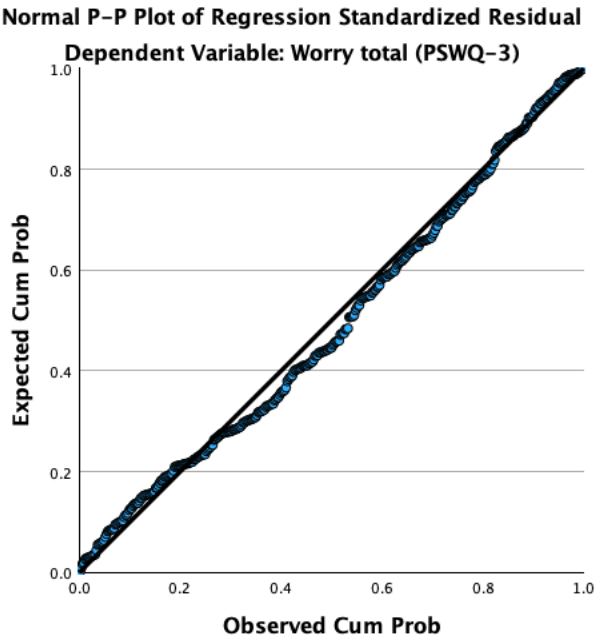
Assumption 4: The variance of the residuals is constant.
As can be observed below, the plots of standardized residuals v standardized predicted values shows no obvious signs of funneling. This suggests the assumption of homoscedasticity has been met.





Assumption 5: The values of the residuals are normally distributed.
The P-P plot for the model suggested the assumption of normality of the residuals has been met, as evidence below.





Assumption 6: There are no influential cases biasing model.
All Cook's Distance values were below 1, suggesting no individual cases were unduly influencing either model.

6.3. Appendix 3- Research project sign off sheet

NEWCASTLE UNIVERSITY
DOCTORATE IN CLINICAL PSYCHOLOGY

Research Course: Sign off sheet for Research Projects

	Please tick if it does not apply	Please tick if completed. If not ticked, please provide an explanation	**Trainee name:** **Emma Welsh** **Project title: Cognitive disengagement syndrome, daily functioning, intolerance of uncertainty, executive functioning, and worry: A mediation and moderation model** *Please add date for each action Please provide brief comment as necessary.*
In line with participant consent, raw and electronic data where consent has been subsequently withdrawn has been dealt with appropriately (e.g. removed) and communicated in writing to the supervisor with responsibility for data keeping.	X	☐	Date completed: Archival data
In line with participant consent, where permission to use data in future studies has been asked for and not been granted, this has been appropriately identified in data bases (e.g. properly labelled) and communicated in writing/document to the supervisor with responsibility for data keeping.	X	☐	Date completed: Archival data
In line with your approved data management plan/ethical approval, the informed consent forms and contact details are a) securely stored in a separate place from any other data, or b) securely destroyed, as the case may be.	X X	☐ ☐	Date completed: Archival data
In line with your approved data management plan/ethical approval, IDs or codes linking personal data to other data have been securely destroyed.	X	☐	Date completed: Archival data
In line with your approved data management plan/ethical approval, recruitment logs and other documents containing personally identifiable information have been securely destroyed.	X	☐	Date completed: Archival data

In line with your approved data management plan/ethical/HRA/sponsors approval, the raw data (e.g. questionnaires, test sheets, data collection logs) have been a) pseudonymized, b) properly labelled and c) appropriate arrangements for their storage have been made; d) indications for date of destruction are clearly indicated	X X X X	☐ ☐ ☐ ☐ ☐	Date completed: Archival data

	Please tick if it does not apply	Please tick if completed. If not ticked, please provide	*Please add date for each action* *Please provide brief comment as necessary.* :
Any concerns about participants, adverse effects, follow-up with participants due to distress, concerns raised by participants, disagreements/ incidents that could lead to participant complaint, etc., have been discussed with supervisors, suitably recorded in an appropriate manner, addressed (if required), and signalled (if necessary) to the appropriate ethics and governance frameworks, including the Course and the sponsors. Any correspondence about these matters has either been archived (and pseudon/anonymized if necessary) or destroyed as appropriate Please seek guidance about what is appropriate.	X X X	☐ ☐ ☐	Date completed:
Participants have been debriefed as laid out in Ethics approval.	X	☐	Date completed:
Participants have received a lay summary of the results of the study if requested or originally announced.	X	☐	Date completed:
Gatekeepers and others facilitating access to participants have been thanked and, wherever relevant, sent a copy of the lay summary.	X	☐	Date completed:
Participants and/or institutions, groups, organizations that have facilitated access have received the announced	X	☐	Date completed:

vouchers/course credits/reimbursements and/or the prize draw has been completed.			
Contact details for gatekeepers have been provided to supervisors.	X	☐	Date completed:
All study advertisements have been removed from websites or other postings.	X	☐	Date completed:

	Please tick if it does not apply	Please tick if completed. If not ticked, please provide	*Please add date for each action* *Please provide brief comment as necessary.*
Note: At least one final report should be completed for each project. *As a minimum a final report should indicate a) title, b) number, c) statements to the effect that study has been completed, no/some adverse incidents were noted, all obligations toward participants and gatekeepers have been completed, and all data and study materials have been securely destroyed/archived according to the data management plan, d) contact person (normally supervisor) for any further correspondence about the study.* *Some organizations have specific reporting requirements – see their websites/information.* ***If no final report has been submitted, please indicate clearly why not.***			
NHS Ethics Committee has received, as required, progress and final reports about the study.	X	☐	Date completed: Name of person contacted:
University Ethics Committee has received, as required, a final report about the study.	x	☐	Date completed: Name of person contacted:
Other approving body or Ethics Committee (e.g. charitable organization) has received a final report about the study.	X	☐	Date completed: Name of person contacted:
Relevant R & D Departments or other sponsoring organizations have received a final report about the study.	X	☐	Date completed: Name of person contacted:
HRA site file has been completed and archived according to sponsoring organizations wishes.	X	☐	Date completed: Name of person contacted:

	Please tick if it does not apply	Please tick if completed. If not ticked, please provide an explanation	*Please add date for each action* *Please provide brief comment as necessary.*
All project related costs have been appropriately been dealt with and outstanding financial issues with the Course, supervisors, or funders have been resolved (e.g. copy costs, travel expenses, vouchers, materials, etc.).	X	☐	Date completed:
Doctorate Director informed that all project related expenses have been claimed Employer's representative that all project related expenses have been claimed	X X	☐ ☐	Date completed: Date completed:
Funding bodies have received any required progress and final reports about the study.	X	☐	Date completed:
Any test materials (including unused recording sheets if purchased), manuals, programs, software belonging to the Course, supervisors, University or other sources or purchased for the study have been returned to the appropriate organization/person.	X	☐	Date completed:
Any equipment (including recording devices, storage media, mobile phones, sim cards, credit, software, books, manuals, etc.) that belongs to the Course, supervisors, University or other sources or purchased for the study have been returned to the appropriate organization/person. *(add additional items as needed)*	X	☐	Item: Returned to: Date returned: Item: Returned to: Date returned:
If literature review has been registered on PROSPERO or other data base, status has been updated including closing it down if there is no intention to publish. Note who holds registration (trainee or supervisor)	☐	X	Review Registration Number: CRD42023360245 Status: Complete Who holds registration? Emma Welsh Updated on: 07 July 2025

	Please tick if it does not apply	Please tick if completed. If not ticked, please provide an explanation	*Please add date for each action* *Please provide brief comment as necessary.*
All correspondence concerning the study (e-mails, .pdfs or image files, or paper documents that have been scanned) has been handed over to the supervisors in either/both hard media and/or as an electronically transferred zip file. This includes approvals (peer, ethics, funding agencies), extensions to approvals, amendments, registrations, letters of support or permission, etc.	X	☐	Date completed:
All study materials in electronic form have been handed over to the supervisors in either/both hard media (CD/DVD; flash drive) and/or as an electronically transferred zip file. This includes: project proposals, ethics applications, requests for amendments, protocols, invitation/ recruitment materials, information sheets, consent forms, questionnaires, tasks and induction materials developed for the study including those on various platforms (e.g. E-Prime, Matlab, Qualtrics, apps, etc.), SOPS, debriefing materials, etc.	X	☐ X	Date completed: Project proposal (LR) sent in email 25.06.2021 Project proposal (EP v.2.0) sent in email 10/01/2025
Final copies of the electronically saved raw data, transformed data, and syntax files been handed over to the supervisors in either/both hard media and/or as an electronically transferred zip file.	X ☐	☐ X	Date completed: 08/07/2025
Final electronic copies of thesis as well as the project presentation power point have been sent to supervisors.	☐	X	Date completed: 08/07/2025
If appropriate, data has been archived (along with all meta-data) in NU's Data Repository.	X	☐	Date completed:
Other: Please specify	X	☐	Date completed:

Emma Welsh **08 July 2025**

Signature *Date*

Updated By M. H. Freeston, June 2021.