PAY ATTENTION! A COMPARATIVE ANALYSIS OF PSYCHOLOGICAL ASSESSMENTS AND NEUROLOGICAL MECHANISMS FOR ADHD WITHIN A PEDIATRIC POPULATION

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This dissertation, by Kristen Newberry, has
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ABSTRACT

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This study evaluated the predictiveness of the WISC-V, NEPSY-II, CPT-3, and CATA when compared to each other in a sample of 272 children aged 8–16. Archival data was analyzed using binary and multinomial logistic regression models to assess concurrent validity of specific subtests and indexes. Participants were grouped by ADHD subtype (inattentive, combined/hyperactive, or no diagnosis), with gender and executive functioning measures included in the models. Findings indicated that lower Cognitive Proficiency Index (CPI) and executive functioning scores (e.g., Animal Sorting, Response Set) predicted any ADHD diagnosis compared to the no diagnosis group, whereas higher CATA scores predicted lower Inattentive and Combined/Hyperactive ADHD diagnoses. These results support using NEPSY-II, CATA, and CPT-3 for targeted, efficient ADHD assessments over traditional tools like the WISC-V. Streamlining batteries could improve diagnostic accuracy, reduce testing time, and enhance accessibility, particularly for underserved populations. This dissertation is available in open access at AURA (https://aura.antioch.edu) and OhioLINK ETD Center (https://etd.ohiolink.edu).

Keywords: ADHD, executive functioning, neuropsychological assessment, pediatrics

Dedication

This project honors all psychologists dedicated to enhancing the psychological assessment process, with a focus on cultural inclusivity, fairness, and ensuring equal access to mental health care for all.

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CHAPTER I: INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most diagnosed neurodevelopmental conditions in the United States in pediatric populations affecting 8.4% of children between 2 and 17 years of age (Yang et al., 2022). Up to 50% of referrals to child mental health clinics are for the assessment and treatment of ADHD (McGee et al., 2000). From the year of 1997 to 2016, the estimated prevalence of diagnosed ADHD in US children and adolescents increased from 6.1% in 1997–1998 to 10.2% in 2015–2016, which is almost a 50% increase over a span of 18 years (Xu et al., 2018).

With ADHD diagnosis on the rise, it is imperative to consider which psychological assessment tools and their subtests are the most predictive of ADHD. Thus, this study aims to examine the criterion (specifically, concurrent) validity of some of the most popular psychological assessments for diagnosing ADHD. Specifically, this study will examine the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V); A Neuropsychological Assessment, Second Edition (NEPSY–II); Conners Continuous Performance Test, Third Edition (Conners CPT-3); and Conners Continuous Auditory Test of Attention (CATA). In this study, a few specific scores (e.g., subtests and indexes) will be examined. Within the WISC-V, the General Ability Index (GAI) and Cognitive Proficiency Index (CPI) will be examined to see if the difference between the two is statistically significant in relation to an ADHD diagnosis. The Visual Spatial Index (VSI) will also be examined to see if this index is a strength in individuals diagnosed with ADHD. The Working Memory Index (WMI) and Processing Speed Index (PSI) will also be examined in detail.

Within the NEPSY-II, Animal Sorting, Auditory Attention, Response Set, Inhibition, and Word Generation will be evaluated; and Semantic versus Initial Letter conditions of the Word

Generation subtest will be examined in more detail. Lastly, the CPT-3 and CATA will be evaluated to see which assessment is most predictive of ADHD. The goal of this study is to help determine which tests and scores best predict ADHD, and the specific subtype of ADHD.

There is an abundance of research that has been done with children diagnosed with ADHD on how the WISC-V, NEPSY-II, CPT-3, and CATA individually might predict diagnosis. There is currently a gap in the literature about comparing these tests to one another, and determining which test is most predictive of ADHD in pediatric populations. This study will compare all the tests to each other to see which is the most predictive of ADHD and highlight the specific areas among the tests (e.g., executive functioning).

Thus, this study aims to show which assessment and ADHD-related areas clinicians should use to aid in assessing for any ADHD diagnosis, to help streamline the process of assessment not only for the clinician but also for the children being assessed.

CHAPTER II: LITERATURE REVIEW

Attention-Deficit/Hyperactivity Disorder

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders among children, with diagnostic prevalence varying from 3 to 20% (Schwarz & Cohen, 2013). In 2013, an estimated 6.4 million children ages 4 through 17 received an ADHD diagnosis at some point in their lives, a 16% increase from 2007 and a 53% rise in the past decade (Schwarz & Cohen, 2013).

An ADHD diagnosis is determined by the presence of pervasive; developmentally excessive; and impairing levels of hyperactivity, inattention, and impulsivity (Sayal et al., 2018). Children aged 4 years or older who exhibit poor attention, distractibility, hyperactivity, impulsivity, difficulties in academic performance, or behavioral challenges at home or school may meet the criteria for ADHD and might benefit from a neuropsychological evaluation (Felt et al., 2014).

The *Diagnostic and Statistical Manual of Mental Disorders* (5th ed., text revision; DSM-5-TR; American Psychiatric Association [APA], 2022) requires the presence of a sufficient number of core symptoms and functional impairment to meet criteria with three subtypes: Predominately Inattentive Presentation, Predominately Hyperactive-Impulsive Presentation, and Combined Presentation.

The term “executive function” refers to higher-order cognitive processes that underlie self-regulation and goal directed behavior. This includes working memory, response inhibition, set shifting, abstraction, planning, organization, fluency, and certain aspects of attention (Doyle, 2006, p. 21). The executive functions are believed to be in the frontal lobes of the brain which serve the purpose of maintaining an appropriate problem-solving set for attainment of a future goal (Berlin et al., 2004). To date, inhibitory control has been the most widely discussed core deficit in ADHD, with many studies supporting weakness on clinical and experimental measures of inhibition in individuals with ADHD versus non-ADHD controls.

Neuropsychological findings have suggested that the behavioral symptoms such as inattention and hyperactivity, result from an underlying deficit in response inhibition, delay aversion, and executive functioning (Krain & Castellanos, 2006). These hypothesized psychological findings are presumed to be linked to dysfunction of frontal–striatal–cerebellar circuits (Krain & Castellanos, 2006). Much attention has been paid to the neural circuits connecting the prefrontal cortex and the basal ganglia, which likely modulate response inhibition. The cerebellum, which has traditionally been viewed as a motor coordination center, has also been shown to be closely linked to non-motor regions of the cerebral cortex and to play a role in executive functions such as cognitive planning (Krain & Castellanos, 2006).

Working memory has been defined as the ability to hold an event in mind to use it to control a response, and it includes both a verbal and a non-verbal part (Berlin et al., 2004). Working memory represents another aspect of executive functioning that is of significant interest to ADHD researchers due to neuro-imaging studies showing that working memory tasks activate fronto-striatal and cerebellar regions. Although results of individual studies are varied, meta-analyses suggest lower working memory ability in those with ADHD (Doyle, 2006). Children with ADHD also tend to perform more poorly on verbal working memory tasks such as digit span, which is a task where the subject must repeat increasingly longer sequences of digits (Doyle, 2006). To corroborate this claim, this study aims to evaluate how the assessment of working memory and other related executive functioning skills could predict a possible ADHD diagnosis. Based on these factors, the assessments and subtests selected for this study evaluate these behavioral and neurological symptoms such as attention, working memory, impulsivity, processing speed, and distractibility.

Sex Differences in ADHD

While ADHD has historically been considered to occur primarily in males, a more recent meta-analysis and critical review of published research literature found no differences in girls and boys on impulsivity, academic performance, social functioning, fine motor skills, parental education, or parental depression (Bauermeister et al., 2007; Gaub & Carlson, 1997). Some of the contradictory results may be associated with differential referral practices for boys and girls that can be related to different impairment or severity levels of treated populations. Unexplored interactions of gender with ADHD subtypes may also explain contradictory findings. This generalization may be limited by the fact that girls with ADHD are underrepresented in these settings (Bauermeister et al., 2007).

Recent literature has highlighted that in children, male to female diagnosis ratio is approximately 4:1, with females more often diagnosed with ADHD later in life and less frequently prescribed medication compared to males (Martin, 2024). Females are more likely to exhibit symptoms of ADHD Predominately Inattentive Presentation more than the Predominately Hyperactive-Impulsive Presentation or Combined Presentation types of ADHD (Martin, 2024). Their symptoms may, therefore, be less noticeable and disruptive to others leading to those symptoms going unrecognized by family or teachers (Martin, 2024). In this study, when data is being analyzed it will be important to include gender in the regression model as it could potentially be a confounding variable as we look at the predictive validity of these assessments in relation to ADHD.

ADHD Neurodiversity

ADHD is conceptualized as a discrete, categorical, neurodevelopmental disorder which originates in early development and is normally assumed to be the result of underlying brain dysfunction (Sonuga-Barke & Thapar, 2021). From one viewpoint, these definitions serve as essential clarifications for clinical practice and ensure that we base our approach on research advancements spanning the past 40 years. In contrast, some argue that we require alternative perspectives. For instance, one proposal suggested replacing the concept of disorder, which is rooted in dysfunction, with that of neurodiversity instead (Sonuga-Barke & Thapar, 2021). Research has indicated that ADHD does not fit neatly into a discrete category but instead exists as a dimension within the population, making it difficult to clearly distinguish individuals with this condition from those without it. Independent of evidence-based challenges, there has emerged an ideologically driven proposition to fundamentally rethink our understanding of ADHD. This neurodiversity perspective aligns closely with other human rights movements in its advocacy for equality among all individuals. The term *neurodiversity* has been embraced by many individuals, but its interpretation can vary significantly. Some individuals have raised doubts or rejected the idea that ADHD is solely caused by brain dysfunction that inherently leads to impairment (Sonuga-Barke & Thapar, 2021). From the standpoint of neurodiversity, these conditions are viewed as variations in brain structure and function resulting in distinct ways of thinking and behaving that differ from the majority in society. Any impairment experienced by neurodiverse people is not considered an inherent part of a disorder but rather arises due to a mismatch between their cognitive and behavioral patterns and the neurotypical perspectives that shape their environments.

With ADHD on the rise in the pediatric population (Xu et al., 2018), there is more of a need for psychological assessment batteries to diagnose ADHD. Due to those with ADHD having trouble with attentiveness and impulse control, especially in younger kids, there is a need to consolidate the time spent testing to help maintain integrity of the results obtained. Because ADHD has so many different aspects to it and how it could be tested, there is not a standard battery for assessing ADHD. For this reason, rating scales are often used in assessing ADHD as they are often cost-effective and valuable because clinicians can obtain a large amount of data quickly, including presence and severity of symptoms. In addition to aiding in diagnosis, rating scales are also useful for measuring response to treatment. However, the limitations of rating scales are that they require familiarity with the person's behavior to be reliable; and some self-report scales may have questionable reliability (Murphy & Adler, 2004).

Social Media and ADHD

In the pediatric population, social media such as TikTok has had a huge influence on the increase of ADHD referrals for psychological assessments (Foster & Ellis, 2024). TikTok is a social networking app with 1.7 billion users, roughly a quarter of that being individuals between the ages of 10 and19 years old. News stories have circulated since creation of the app in 2021 that self-diagnosing has been a problem. Research beginning in 2022 found that self-diagnosis of ADHD was very significant after engagement with TikTok (Foster & Ellis, 2024). Due to the rise of social media use and self-diagnosis, especially in the pediatric population, there is an even higher need for objective, cognitive, and behavioral measures rather than relying on self-report scales alone.

Using a more precise approach that includes assessments that are most predictive of ADHD in children as well as using questionnaires and rating scales to aid in a diagnosis could help with shortening testing times as well as being able to confidently rely on the assessments given. It is important to study this variable because even though there has been research done on this topic, this disorder is rising quickly in the pediatric population, and it will be important to research which assessment can help most effectively predict ADHD in children compared to other tests in the field.

Insurance and Assessment

More frequently, psychologists report that assessment is neither authorized nor reimbursed by third-party payers even when it is indicated for ethical clinical practice and sound risk management (Eisman et al., 2000). These payers often argue that diagnostic interviews are sufficient for many, if not most, of the conditions previously evaluated using psychological assessment. Psychologists have countered that the application of diagnostic interviews as the only basis for such decisions as differential diagnoses, treatment options, and disability determinations can potentially lead to situational and examiner effects that limit reliability and validity (Eisman et al., 2000). Distressed children and adults often are not dependable reporters during a clinical interview because of their limited verbal skills, defensiveness, deceptiveness, or lack of insight into their own behavior.

Psychologists are professionally compelled to conduct as comprehensive of an assessment as possible but are barred from doing so because of insurance reasons. The dilemma is that they are guided by ethics, standards of care, and federal laws, such as the Americans with Disabilities Act, to do the fullest job possible yet fear the loss of provider network membership if they challenge the insurers policies for longer testing time (Eisman et al., 2000). There is a huge need to be able to have a shorter assessment battery psychologists can confidently rely on, not only for the client's comfort but also to be able to have insurance cover the cost for clients who might not be able to afford assessments out of pocket.

Common Assessments for ADHD

Neuropsychological tests play a crucial role in diagnosing ADHD, assessing various cognitive functions through targeted subtests.

Wechsler Intelligence Scale for Children, Fifth Edition

The Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V; Lynne Beal, 2004) is among the most widely used tests to assess the cognitive abilities of children aged 6 to 16 years which can be used to inform a range of educational decisions in children including eligibility for special services, underperformance in the classroom, and the diagnosis of several developmental disorders that are relevant in the context of school, including ADHD. The WISC-V is based on the Cattell-Horn-Carroll model (CHC-model) of cognitive abilities, which is the most encompassing taxonomy of cognitive abilities (McGrew, 2009) and can provide information relevant to understanding an individual's intellectual functioning and needs for treatment.

The five index scores consisting of Verbal Comprehension Index (VCI), Visual Spatial Index (VSI), Fluid Reasoning Index (FRI), Working Memory Index (WMI), and Processing Speed Index (PSI) along with the Full-Scale Intelligence Quotient (FSIQ) are recognized as the basis for clinical interpretation of the WISC-V (Bremner et al., 2011). The WISC-V has a test-retest reliability coefficient of 0.92 for the FSIQ and average reliability coefficients of 0.88–0.93 for primary index scores (Wechsler, 2014). A study published in the *Journal of Attention Disorders* in 2018 found that several subtests of the WISC-V were significantly related to symptoms of inattention and hyperactivity-impulsivity in a sample of children with ADHD.

Specifically, the subtests measuring working memory, processing speed, and visual-spatial ability were most strongly negatively correlated with ADHD symptoms (Kramer et al., 2018). The GAI and CPI will be examined as well as the VSI, WMI, and PSI.

General Ability Index

The General Ability Index (GAI) and Cognitive Proficiency Index (CPI) are two additional composite scores that may have potential clinical relevance in the assessment of and treatment planning for children referred for ADHD (Bremner et al., 2011). The GAI is an ancillary index score that provides an estimate of general intelligence that is less impacted by working memory and processing speed relative to the FSIQ consisting of subtests from the VCI, VSI, and FRI domains. The GAI was first developed for use with the WISC–III to offer additional flexibility in the assessment of cognitive abilities (Lenhard & Daseking, 2022). The goal was to establish an index that is less sensitive to the influence of working memory and processing speed. Because children with ADHD have a hard time with processing speed, it is expected that their GAI score would be higher than their CPI score.

Cognitive Proficiency Index

The Cognitive Proficiency Index (CPI) is a counterpart to the GAI and combines all the primary subtests of the WISC that measure either working memory or processing speed. The abilities measured in this index are also aspects of executive functioning (Lenhard & Daseking, 2022). The CPI is included in this study due to it being able to measure attentional control, and to evaluate if there is a significant difference between the GAI and CPI for children with ADHD. The CPI is most informative when interpreted as part of a comprehensive evaluation. A clinician may choose to evaluate the GAI-CPI pairwise comparison, as this may provide additional interpretive information regarding the possible impact of cognitive processing on ability (Wechsler, 2014).

The importance of reporting the CPI alongside the GAI has been emphasized to best capture the differential function between general reasoning abilities and components of intelligence that allow for the quick learning and efficient problem solving that enhance one's general reasoning abilities (Logue et al., 2015). Logue et al. (2015) conducted a study to examine the criterion validity of the CPI compared to other measures. The CPI correlated most effectively with measures of attention and processing speed such as the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) Attention (magnitude of $r = 0.77$) suggested that the CPI is superior to the RBANS Attention Index in differentiating between clinical and non-clinical groups when measuring attention and executive functioning. These findings provide support for convergent validity and criterion-related concurrent validity for the CPI.

Visual Spatial Index

The Visual Spatial Index (VSI) is derived from two subtests. Block Design (BD) and Visual Puzzles (VP; Wechsler, 2014) and measures one's ability to evaluate visual details and understand visual spatial relationships to construct geometric designs from a model. This skill requires visual spatial reasoning, integration of part-whole relationships, attentiveness to visual detail, and visual-motor integration. High scores in this area indicate a well-developed capacity to apply spatial reasoning and analyze visual details.

Using meta-analytic techniques, researchers have examined the idea that children with ADHD have poorer visual spatial abilities. They concluded that the environment affects visual-spatial abilities in terms of sustained attention on tasks and also found that the VSI could be a strength in certain environments. The overall finding though was that visual spatial abilities were a consistent deficit in the ADHD group (Ortega et al., 2013).

Working Memory Index

The Working Memory Index (WMI) measures one's ability to register, maintain, and manipulate visual and auditory information in conscious awareness, which requires attention and concentration, as well as visual and auditory discrimination (Wechsler, 2014). Working memory is an important factor of executive functioning, and therefore will be assessed using the WMI of the WISC-V.

There are two subtests that make up the WMI, Digit Span and Picture Span. The subtest Digit Span requires clients to listen to sequences of numbers read aloud and recall them in the same order, reverse order, and ascending order. Picture Span (PS) requires clients to memorize one or more pictures presented on a stimulus page and then identify the correct pictures (in sequential order, if possible) from options on a response page.

Research has identified working memory as one of the most impaired domains in individuals with ADHD when compared to healthy controls (Cockcroft & Alloway, 2012; Mayes & Calhoun, 2007; Moura et al., 2019; Theiling & Petermann, 2016). One meta-analytic study suggested that up to 80% of children with ADHD have a WM deficit (Kasper et al., 2012). They also found that fewer females in the ADHD group led to larger effect sizes, reflecting gender differences in WM performance.

In the current study, the WMI will be examined in children with and without ADHD and will be compared with other assessments to better understand the effect that working memory has on executive functioning in children.

Processing Speed Index

The Processing Speed Index (PSI) measures speed and accuracy of one's visual identification, decision making, and decision implementation (Wechsler, 2014). The PSI is made up of two different timed subtests. Symbol Search (SS) requires individuals to scan a group of symbols and indicate if the target symbol is present, and Coding requires the individual to use a key to copy symbols that corresponded with numbers. Literature has shown that processing speed difficulties among youth with ADHD appear strongly associated with several clinical and functional correlates including weaker academic skills, poorer adaptive skills, increased self-reported anxiety, and overestimates of social competence (Cook et al., 2018). This index will be examined in relation to an ADHD diagnosis in a pediatric population, as literature has shown this index to be negatively affected in those with ADHD.

A Neuropsychological Assessment, Second Edition

A Neuropsychological Assessment, Second Edition (NEPSY-II) is a multi-domain neuropsychological battery test designed to provide a comprehensive neuropsychological assessment of children aged 3–16 years (Faedda et al., 2019). The NEPSY-II is one of the only pediatric neuropsychological tools available for comparing performance across subtests using contemporary data on co-normed subtests. It is also the only battery for children conceptualized as a true flexible battery with normative data collected in a manner to reduce order effects (Brooks et al., 2009). Interrater reliability for the NEPSY-II was calculated as the percentage of agreement between trained scorers in evaluating the NEPSY-II protocol. Agreement rates ranged from 93% to 99% with Word Generation at the lowest level (93%) and Memory for Names at the highest level (99%; Davis & Matthews, 2010). Test-retest scores show generally adequate stability across time for all age groups. Pearson product moment coefficients (*r*) ranged from .21

to .91 across all age groups measured. Concurrent validity of intellectual functioning was assessed using the Wechsler Intelligence Scale for Children–Fourth Edition (Wechsler, 2003), Differential Abilities Scales–Second Edition (Elliott, 2007), and Wechsler Nonverbal Scale of Ability (Massa & Rivera, 2009). Correlations between these instruments suggest that the NEPSY-II is sufficiently predictive of cognitive performance in both verbal and nonverbal applications. The data suggests that NEPSY-II scores have good discriminative validity across a variety of disability conditions (Davis & Matthews, 2010). Several subtests of the NEPSY-II were significantly related to symptoms of inattention and hyperactivity-impulsivity in a sample of children with ADHD. Specifically, the subtests measuring attention and executive functioning were most strongly correlated with ADHD symptoms (Mahone et al., 2002).

Children with ADHD can be impaired in specific cognitive and executive functions, in working memory, inhibition, cognitive flexibility and verbal memory. The NEPSY Second Edition (NEPSY–II) assessment is a revision of the NEPSY (Korkman et al., 1998), a comprehensive instrument designed to assess neuropsychological development in preschool and school-age children (Korkman et al., 2007). The three subtests that will be examined in this assessment is Auditory Attention (AA), Response Set (RS), and Word Generation (WG).

Animal Sorting

Animal Sorting (AS) assesses one’s ability to formulate basic concepts, transform these into action, and to set shift from one concept to another, showing planning and cognitive flexibility. Children with ADHD tend to score lower in this area as cognitive flexibility and planning are main areas of executive functioning (Henry & Bettenay, 2010).

Auditory Attention

Auditory Attention (AA) is designed to assess selective and sustained auditory attention (Korkman et al., 2007). When presented with auditory stimuli, children with ADHD experience more profound working memory deficits compared to unaffected children leading to consequences in auditory perception, such as lowering the ability to detect and process speech in background noise (Abdo et al., 2010). Research has shown that those with ADHD often have specific auditory symptoms and perform worse in auditory processing compared to children without ADHD (Pickens et al., 2019).

Response Set

Response Set (RS) is designed to assess the ability to shift and maintain a new and complex set, involving both inhibition of previously learned responses and correctly responding to matching or contrasting stimuli (Korkman et al., 2007). Executive functions can be described as having three larger variables, mental set-shifting ('shifting'), information updating and monitoring in working memory, and inhibition of prepotent responses ('inhibition'), that are moderately correlated with one another, but separable (Uddin, 2021). The term 'flexibility' describes the aspect of executive function that is typically associated with mental set shifting or being able to adapt to new rules and cues. Although children with ADHD may exhibit flexibility deficits, the nature and severity of these issues can differ (Uddin, 2021).

Inhibition

Inhibition (IN) is a timed subtest that evaluates an ability to inhibit automatic responses in favor of novel responses, and the ability to switch between response types (Korkman et al., 2007). Current research has shown that children with ADHD experience more severe deficits in inhibition, working memory, and planning compared to their counter parts with no ADHD diagnosis (Benallie et al., 2021). Inhibition deficits can refer to the loss of both cognitive and behavior control. Comparison research has shown that there are differences in inhibition between ADHD and non-ADHD controls, however there were no differences found between the three subtypes of ADHD in relation to inhibition (Rahmi & Wimbarti, 2018).

Word Generation

Word Generation (WG) is designed to assess verbal productivity through the ability to generate words within specific semantic and initial letter categories. The child is given a semantic or initial letter category and asked to produce as many words as possible in 60 seconds (Korkman et al., 2007). Research suggests that phonological processing difficulties may be related to reading and writing challenges in children with ADHD, due to deficits in phonological awareness and operational memory (Goncalves-Guedim et al., 2017). Results obtained in the assessment of phonological awareness have revealed that students with ADHD had lower performance rates than those without ADHD, especially regarding phonemes (Goncalves-Guedim et al., 2017).

The Conners Continuous Performance Test, Third Edition

The Conners Continuous Performance Test, Third Edition (CPT-3) measures attention-related problems in individuals aged eight years and older by requiring subjects to maintain vigilance and react to the presence (or absence) of a specific stimulus within a set of distracters presented continuously. Children with ADHD have been shown to have impaired sustained attention and slow visual processing (McAvinue et al., 2015), and the CPT-3 can aid in the assessment of ADHD and other neurological conditions related to attention (McGee et al., 2000; Wang et al., 2021).

The CPT-3 is an extensively used tool for assessing deficits of visual attention and for assessing attention and inhibitory control in both children and adults (Conners, 2004). Studies demonstrated that patients with ADHD exhibit performance deficits on the CPT-3, especially in the number of omission and commission errors (Ord et al., 2020). The CPT-3 includes a validity indicator based on administration timing variability insufficient hits for computing scores, and/or omission errors greater than 25% (Ord et al., 2020). Research has found that the CPT-3 has moderate criterion validity for ADHD, in that performance was significantly associated with symptoms of inattention and hyperactivity-impulsivity in a sample of children with ADHD. CPT-3 has a high specificity and moderate sensitivity for identifying ADHD (Riccio et al., 2002).

Conners Continuous Auditory Test of Attention

The Conners' Continuous Auditory Test of Attention (CATA) assesses auditory processing and attention-related problems aimed at helping to identify symptoms of inattention in children with ADHD (Rassovsky & Alfassi, 2018). CATA also has a high specificity and moderate sensitivity for helping to identify ADHD (Wasserman & Wasserman, 2012). There is a belief from current research that, intuitively, auditory measures more closely resemble the attentional demands of a typical classroom, that is, have stronger ecological validity (Lehman et al., 2006). It is, therefore, expected that they would better predict ADHD. Research has shown that children with ADHD underperformed healthy controls on all CPT-3 and CATA indexes, except Response Style and Hit Reaction Time. The CPT-3, CATA, and CPT-3 plus CATA all significantly differentiate ADHD patients and controls (Wang et al., 2021). While these assessments are currently useful for diagnosing ADHD, further research is needed to determine their effectiveness compared to other psychological assessments and if they are the most accurate predictors of ADHD.

The effectiveness of using these assessments to diagnose ADHD has been researched, but there is very limited research on how these assessments compare to each other in terms of prediction of ADHD in a pediatric population. There is also limited research on which specific neurological domain of ADHD (represented by the subtests or indexes within these assessments) best predicts ADHD. Thus, the purpose of this research is to help answer these questions and determine if there is a better way to streamline the assessment process.

CHAPTER III: METHOD

This project used an online database of quantitative data from completed psychoeducational evaluations that assessed ADHD in a pediatric population. This project is archival by design and did not include any participant identifying information.

Participants

Two hundred seventy-two participant files were selected from a secured report database of Dr. Justin Hampton, PhD, who is employed at Western Washington Medical Group. He is a licensed clinical psychologist in the state of Washington and completes assessments for a pediatric population. Demographic information such as gender and age were collected. Inclusion criteria for participants included (a) the participant has received an official DSM-V ADHD diagnosis or no ADHD diagnosis, (b) the participant was administered all assessments and subtests included in the study, and (c) the participant is between the ages of 8 and 16 years old.

Materials

Several standardized scores were collected from participants who met inclusion criteria for the study. These scores were collected from assessments including the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V), A Developmental Neuropsychological Assessment, Second Edition (NEPSY–II), the Conners Continuous Performance Test, Third Edition (CPT-3), and the Conners Continuous Auditory Test of Attention (CATA).

Data Collection

After obtaining written consent from Dr. Hampton to have access to his online encrypted database (see Appendix), gender, age, comorbidity, and standard scores of all participants that met inclusion criteria were collected and organized in an Excel spreadsheet. The Excel spreadsheet was password protected and stored in a password protected file as well as laptop that only the researcher had access to. Participants were grouped based on diagnosis type, with the four groups being (1) Predominately Inattentive Presentation, (2) Predominately Hyperactive-Impulsive Presentation, (3) Combined Presentation, and (4) No ADHD diagnosis.

Prior to beginning the project, Antioch University's Institutional Review Board (IRB) approved the application for this research project to take place. This study analyzed data from Dr. Hampton's assessment reports dating back to 2018. Binary and multinomial forward stepwise logistic regression analyses were used to evaluate each hypothesis. First, descriptive data was collected. Second, a bivariate correlation table was made to compare each assessment to one another. Third, ANOVA was used to assess a difference in diagnosis type for each assessment. Demographic information was also described, and data analysis was performed using Microsoft Excel and SPSS.

CHAPTER IV: RESULTS

Demographics

Participants included 272 children between the ages of 8 and 16 years old. As seen in Table 4.1, the average age was 10.7 and two-thirds of the sample were 11 or younger. The vast majority (94.9%) had previous medical or psychological diagnosis before ADHD testing was conducted, and most children (88.2%) were diagnosed by Dr. Hampton with a type of ADHD. Only one participant (0.4% of the sample) had a hyperactive diagnosis, and for purposes of analysis, this was collapsed into the combined (both inattentive and hyperactive) diagnosis group. Similarly, due to small sizes, the “other” group for gender was collapsed into the female group. These participants were collapsed into other groups and not deleted due to the researcher wanting to maintain preservation of all data. By including small groups into larger ones, the aim was to increase statistical power and maintain an ethical responsibility to represent all participants and not marginalize any experiences. It was originally planned to perform analyses for the research questions adjusting for comorbidities, however given the lack of variability (nearly everyone in the sample had comorbidities), it was not included in analyses.

Table 4.1

Sample Demographics

Demographic	*n*	%
Age (*M* = 10.7, *SD* = 2.0)		
8 years	48	17.6
9 years	42	15.4
10 years	44	16.2
11 years	46	16.9
12 years	43	15.8
13 years	27	9.9
14 years	11	4
15 years	6	2.2
16 years	5	1.8
Gender		
Male	115	42.3
Female	151	55.5
Other	6	2.2
Comorbid Diagnosis		
None	14	5.1
Comorbidity	258	94.9
ADHD Diagnosis		
Inattentive	129	47.4
Hyperactive	1	0.4
Combined	110	40.4
No ADHD	32	11.8

Note. n = 272.

Descriptive Statistics

Descriptive statistics of all executive functioning and diagnosis likelihood scales are shown in Table 4.2. Auditory Attention and Response Set Total Correct had a large frequency of scores of 1, indicating many participants scored the minimum value on these subtests. The rest of the scales were roughly normally distributed, and as seen, no scales had skews greater than 0.5. Using the boxplot definition of outliers, there were some outliers which would be expected given the sample of 272, but none were extreme outliers. The sample's mean scores fall within an "average" range on all scales except for CPI and Response Set Total Correct, which were in the "low average" range.

Table 4.2

Descriptive Statistics of Executive Functioning Scales

Executive functioning scale	Mean	Median	SD	Skew (SE=.15)	Min	Max
General Ability Index	101.78	103	12.97	-0.27	61	136
Cognitive Proficiency Index	89.60	89	13.99	-0.03	42	122
Visual Spatial Index	102.04	102	12.82	0.03	67	138
Working Memory Index	90.54	91	13.69	0.31	51	132
Processing Speed Index	91.72	92	14.44	-0.13	49	132
Inhibition Naming - Completion time	8.10	8	2.90	0.09	1	17
Inhibition - Completion time	8.53	8.5	2.99	0.07	1	17
Switching - Completion time	8.90	9	3.14	-0.10	1	18
Animal Sorting - Correct sorts	8.72	9	3.33	0.03	1	18
Auditory Attention - Total correct	8.03	8	3.38	-0.34	1	13
Response Set - Total Correct	7.91	8	3.80	-0.22	1	16
Word Generation - Initial	8.43	8	2.91	0.39	1	18
Word Generation - Semantic	11.75	12	3.03	-0.05	1	19
CPT3 Attn D/O Likelihood	3.69	4	1.09	-0.19	2	5
CATA Attn D/O Likelihood	3.06	3	0.81	-0.11	1	5

Bivariate Descriptive Statistics

Pearson bivariate correlations of each assessment are shown in Table 4.3. Subtests that are combined to form the Visual Spatial Index, Working Memory Index, and Processing Speed also make up the General Ability Index and Cognitive Proficiency Index, and this shared content contributes to their large correlations. Because of this overlap, it is noted that the GAI and CPI scores will be assessed in analyses separately from the Visual Spatial Index, Working Memory Index, and Processing Speed Index scores in the research question analysis section. GAI and CPI have a large, positive correlation with each other, while the Visual Spatial Index, Working Memory Index, and Processing Speed Index had medium correlations with each other. Correlations within the NEPSY-II scales ranged from small to large, and all scales across both WISC-V and NEPSY-II were positively correlated with each other. Most scales were negatively correlated with the CPT-3 and CATA (scales that measure the likelihood of an ADHD diagnosis), indicating that better executive functioning scores on most of the WISC-V and NEPSY-II scales correspond to lower scores on those ADHD-specific scales. Gender (male column) was coded with females/other as the reference group and males as the indicator group, and thus if the value is < 1, there is a higher likelihood of the reference group or second variable. The point biserial correlations indicate that males score significantly lower than females/other on Switching Completion Time and significantly higher on Word Generation-Initial letter, but otherwise did not differ on other scales.

Table 4.3

Correlations of Executive Functioning Scales, Diagnosis Likelihood, and Gender

	WISC 5					NEPSY									
									9	10	11	12	13	14	15
WISC 5															
1. General Ability Index															
2. Cognitive Proficiency Index	.628**														
3. Visual Spatial Index	.785**	.507**													
4. Working Memory Index	.574**	.831**	.410**												
5. Processing Speed Index	.501**	.858**	.458**	.441**											
NEPSY															
6. Inhibition Naming - Completion time	.387**	.491**	.284**	.352**	.476**										
7. Inhibition - Completion time	.444**	.475**	.373**	.362**	.448**	.647**									
8. Switching - Completion time	.333**	.365**	.273**	.232**	.377**	.600**	.669**								
9. Animal Sorting - Correct sorts	.402**	.387**	.326**	.391**	.287**	.186**	.220**	.112†							
10. Auditory Attention - Total correct	.291**	.378**	.198**	.363**	.278**	.268**	.209**	.193**	.288**						
11. Response Set - Total Correct	.344**	.450**	.233**	.369**	.385**	.319**	.284**	.232**	.270**	.475**					
12. Word Generation - Initial	.417**	.441**	.256**	.368**	.384**	.328**	.323**	.261**	.155*	.302**	.397**				
13. Word Generation - Semantic	.453**	.486**	.300**	.404**	.416**	.270**	.218**	.291**	.348**	.342**	.297**	.499**			
14. CPT3 Attn D/O Likelihood	-.193**	-.219**	-.107	-.282**	-.088	-.117†	-.109	-.131*	-.233**	-.312**	-.298**	-.257**	-.271**		
15. CATA Attn D/O Likelihood	-.215**	-.228**	-.117†	-.271**	-.106	-.225**	-.129*	-.156**	-.121*	-.265**	-.272**	-.211**	-.199**	.422**	
16. Male	.019	.089	-.035	.083	.071	.008	-.075	-.132*	.061	.087	.073	.142*	.017	.042	.045
Note. †$p < .07$, *$p < .05$, **$p < .01$; $n = 272$															

ADHD Diagnosis Group Differences in Executive Functioning (via the CPT-3, CATA, NEPSY and WISC)

To explore bivariate relationships of each executive functioning scale and diagnosis likelihood scale to the ADHD diagnosis group separately, a series of one-way ANOVAs were run. As seen in Table 4.4, the three groups did not differ in their scores on Processing Speed. However, the no ADHD diagnosis group scored significantly higher on all other executive functioning scales and significantly lower on diagnosis likelihood scores (CPT-3 and CATA) than the Inattentive diagnosis group, as seen in Table 4.4. The no ADHD group did not significantly differ from the Combined/Hyperactive group on three assessments (specifically, Inhibition Naming, Inhibition Completion Time, and Switching Completion Time), but the no ADHD diagnosis group did score significantly lower than the Combined/Hyperactive diagnosis group on the diagnosis likelihood scores and significantly higher on the nine other executive functioning scales examined. The Inattentive and Combined/Hyperactive diagnosis groups did not significantly differ on diagnosis likelihood scores, nor did they differ on most scales, with two exceptions: The Combined/Hyperactive group scored significantly higher than the Inattentive group on Inhibition Completion time and Switching Completion time. *Thus, except for the PSI, all other assessments and subscales within them predicted differences between no ADHD and any ADHD diagnosis on their own, while only two, inhibition completion time and switching completion time, distinguished the two ADHD types.* The present research focused on finding the best combination to predict differences in diagnoses when considering all assessments together.

Table 4.4

Executive Functioning by ADHD Diagnosis

	One way ANOVA			Means (SD) by Diagnosis Group				Post hoc *p*-values		
				Inattentive	Combined/ Hyperactive	No ADHD				
	F(2, 269)	*p*	*η2*	Mean (SD)	Mean (SD)	Mean (SD)	Post hoc test	Inattentive vs No ADHD	Combined/ Hyperactive vs No ADHD	Inattentive vs Combined/ Hyperactive
General Ability Index	6.43	.002	.05	100.2 (13.4)	101.5 (12.7)	109.2 (9.4)	T-HSD	.001	.009	.687
Cognitive Proficiency Index	9.19	<.001	.06	87.1 (14.4)	89.9 (13.6)	98.6 (9.4)	T-HSD	<.001	.004	.274
Visual Spatial Index	4.53	.012	.03	100.8 (13.0)	101.7 (13.1)	108.3 (9.2)	T-HSD	.009	.028	.838
Working Memory Index	14.69	<.001	.10	88.2 (13.5)	90.0 (12.9)	102.1 (11.5)	T-HSD	<.001	<.001	.548
Processing Speed Index	3.01	.051	.02	89.6 (15.7)	93.0 (14.0)	95.7 (8.0)	NA			
Inhibition Naming - Completion time	3.30	.038	.02	7.8 (2.9)	8.1 (2.9)	9.3 (2.5)	T-HSD	.029	.093	.780
Inhibition - Completion time	5.77	.004	.04	7.9 (2.8)	8.9 (3.2)	9.6 (2.4)	T-HSD	.012	.487	.026
Switching - Completion time	6.22	.002	.04	8.2 (3.2)	9.4 (3.2)	9.8 (2.2)	T-HSD	.025	.812	.007
Animal Sorting - Correct sorts	12.39	<.001	.08	8.7 (3.3)	8.0 (3.1)	11.2 (2.8)	T-HSD	<.001	<.001	.239
Auditory Attention - Total correct	5.25	.006	.04	7.9 (3.4)	7.6 (3.5)	9.8 (2.2)	G-H	.001	<.001	.792
Response Set - Total Correct	12.57	<.001	.09	7.6 (3.8)	7.4 (3.8)	10.9 (2.4)	G-H	<.001	<.001	.919
Word Generation - Initial	8.65	<.001	.06	7.9 (2.8)	8.6 (2.8)	10.2 (3.0)	T-HSD	<.001	.017	.125
Word Generation - Semantic	4.92	.008	.04	11.4 (3.0)	11.7 (2.9)	13.3 (2.9)	T-HSD	.005	.030	.689
CPT3 Attn D/O Likelihood	24.57	<.001	.15	3.7 (.9)	4.0 (1.1)	2.6 (1.0)	T-HSD	<.001	<.001	.210
CATA Attn D/O Likelihood	24.76	<.001	.16	3.1 (.8)	3.3 (.8)	2.2 (.4)	G-H	<.001	<.001	.246

Note. Post hoc test selection was based on Levene's test for homogeneity of variance. Not significant Levene's test led to Tukey's HSD (T-HSD), while a significant Levene's test led to Games-Howell (G-H). Post hoc tests were not applicable (NA) for Processing Speed Index as it did not have a significant ANOVA.

Assumption Testing

To predict diagnosis group from many predictors, logistic regression was used. Assumptions for the use of logistic regression models were tested. Initially, to manage the issue of multicollinearity, particularly the GAI and CPI contain subscales that overlaps with the other WISC-V scales—those two indexes were not combined in analyses with the other scales and were instead assessed in separate analyses. Specifically, GAI and CPI as predictors of diagnosis are assessed as research question 1, while the remaining executive functioning measures and the likelihood of diagnosis measures as predictors of diagnosis are assessed in research question 2. This approach was used to prevent inaccurate estimates of regression coefficients and inflated standard errors, which are common problems in the presence of multicollinearity.

To address the assumption of linearity of the log odds (logit) for the logistic regression models, the Box-Tidwell procedure was utilized. This involves adding an interaction term between each continuous predictor and its natural logarithm to the model. The presence of statistically significant interactions indicates a violation of the linearity assumption. In the initial analysis, significant interactions were observed for some scales. Following graphical analyses of these relationships, there were some observed non-linear patterns with the Cognitive Proficiency Index and CPT-3. To address these, both scales were mean-centered, and quadratic (squared) terms were included in the model. These modifications helped create a more robust analysis by fully addressing the assumptions underlying logistic regressions. Mean-centering provides more interpretable lower-order terms (representing the relationship at the mean). Further, the minimum or maximum of the curve is calculated to describe where the relationship changes direction using the original log odds slopes (or natural log of the odds ratios) rather than the odds ratios displayed in the tables (Cohen et al., 2003).

Research Questions

The current study addresses which executive functioning and diagnosis likelihood scales are most predictive of ADHD in a pediatric population, when controlling for gender. This research question will be assessed in terms of predicting any ADHD diagnosis (versus no diagnosis) using a binary logistic regression, and separately in terms of predicting no diagnosis versus an Inattentive ADHD diagnosis versus a Combined/Hyperactive diagnosis using a multinomial logistic regression. Gender was always entered in the model, and then forward stepwise procedures were utilized to select which executive functioning assessments and diagnosis likelihood scales predicted an ADHD diagnosis. As previously noted, due to their overlapping content, one set of models were run with CPI and GAI (research question 1), and separate models were run for the rest of the executive functioning assessment scales and the diagnosis likelihood scales (research question 2).

Research Question 1: Binary Logistic Regression (ADHD vs. No ADHD for CPI & GAI)

The first model was a binary logistic regression with gender as a predictor and CPI and GAI available as forward stepwise predictors of any ADHD diagnosis. As seen in Table 4.5, the squared term for CPI was significant (and thus the non-squared CPI term in the model represents the lower order effect at the mean of CPI, and it was also significant), and it represents a somewhat complicated relationship. Specifically, starting at low CPI scores, as CPI increases, the odds of an ADHD diagnosis decrease, including significantly decreasing for those with average levels of CPI. The change in direction of the relationship occurs at a CPI score 12.3 points above the mean, at which point increasing CPI predicts in the direction of increasing odds of an ADHD diagnosis. Gender did not predict any difference in any ADHD diagnosis, and GAI would not significantly improve prediction of any ADHD diagnosis and was not entered in the model.

Table 4.5

Binary Logistic Regression Predicting Any ADHD Diagnosis

Predictors	*OR*	*95% CI OR*		*p*
Male	0.73	0.33	1.58	.418
Cognitive Proficiency Index	0.88	0.83	0.95	<.001
Cognitive Proficiency Index squared	1.01	1.00	1.01	.008
Model fit	$\chi 2(3) = 26.15$, p <.001			
Cox & Snell R2	.092			
Nagelkerke R2	.178			
Note. Cognitive Proficiency Index was mean centered.				

Research Question 1: Multinomial Logistic Regression (ADHD Diagnosis Type vs. No ADHD for CPI & GAI)

A multinomial regression analysis was run to examine CPI and GAI available as forward stepwise predictors of the three diagnosis types, adjusting for gender. Table 4.6 displays the odds ratios with no diagnosis as the reference group for the first two sets of columns, and an additional analysis was run to compare the Combined/Hyperactive group to the Inattentive as the reference group. As seen, males were significantly more likely to receive an Inattentive than a Combined/Hyperactive diagnosis, and there was a significant gender difference for males when comparing combined/hyperactive diagnosis to no diagnosis. There was no significant quadratic effect of CPI in predicting a Combined/Hyperactive versus an Inattentive diagnosis, but there was a significant quadratic effect of CPI predicting a Combined/Hyperactive versus no diagnosis and for predicting an Inattentive versus no diagnosis.

Similar to the binary logistic regression, starting at low scores of CPI, increasing CPI was associated with significantly decreasing odds of an Inattentive diagnosis (vs. no diagnosis) and significantly decreasing odds of Combined/Hyperactive diagnosis (vs. no diagnosis), including at mean levels of CPI for both comparisons. This relationship changed directions and CPI was predicting in the direction of increasing odds of these diagnoses versus no diagnoses at higher levels of CPI. Specifically, the direction change occurred at CPI level of 13.1 and 14.25 above the mean for the Inattentive versus no diagnosis and Combined/Hyperactive versus no diagnosis comparisons, respectively.

Table 4.6

Multinomial Regression Predicting ADHD Diagnoses

	Inattentive vs No Diagnosis				Combined/Hyperactive vs No Diagnosis				Combined/Hyperactive vs Inattentive			
Predictors	*OR*	*95% CI OR*		*p*	*OR*	*95% CI OR*		*p*	*OR*	*95% CI OR*		*p*
Male	1.15	0.51	2.62	.733	0.44	0.19	1.02	.055	0.384	0.223	0.66	<.001
Cognitive Proficiency Index	0.88	0.82	0.94	<.001	0.89	0.83	0.96	.001	1.017	0.998	1.037	.077
Cognitive Proficiency Index squared	1.01	1.00	1.01	.006	1.00	1.00	1.01	.012	1	0.999	1.001	.466
Model fit	$\chi 2(6) = 41.43$, *p* <.001											
Cox & Snell R2	.141											
Nagelkerke R2	.165											

Note. Cognitive Proficiency Index was mean centered.

Research Question 2: Binary Regression Analysis (ADHD vs. No ADHD excluding CPI & GAI)

As shown in Table 4.7, a binary logistic regression was run with all other executive functioning assessments (excluding the GAI and CPI scores) and diagnosis likelihood scales available as forward stepwise predictors of any diagnosis, adjusting for gender. Gender did not predict any difference in any ADHD diagnosis, but greater scores on both Animal Sorting and Response Set-Total Correct predicted significantly lower odds of any ADHD diagnosis, while greater scores on the CATA predicted significantly higher odds of any ADHD diagnosis. The squared term for CPT-3 was significant (and thus the other CPT-3 term in the model represents the lower order effect at the mean of CPT-3), and it represents a somewhat complicated relationship. Specifically, starting at low levels of CPT-3, as CPT-3 increases, the odds of an ADHD diagnosis increase, but there was no significant relationship at the mean of CPT-3. The change in direction of this relationship occurred at a CPT-3 score just .028 above the mean, at which point greater CPT-3 predicted in the direction of decreasing odds of an ADHD diagnosis.

Table 4.7

Binary Logistic Regression

Predictors	*OR*	*95% CI OR*		*p*
Male	0.74	0.25	2.18	.588
Animal Sorting – Correct Sorts	0.72	0.60	0.87	<.001
Response Set – Total Correct	0.83	0.69	1.00	.044
CPT3	1.07	0.61	1.87	.821
CPT3 squared	0.32	0.17	0.58	<.001
CATA	7.40	2.82	19.46	<.001
Model fit	$\chi2(6) = 104.93$, *p* <.001			
Cox & Snell R2	.320			
Nagelkerke R2	.621			

Note. CPT3 was mean centered.

Research Question 2: Multinomial Regression Analysis (ADHD Diagnosis Type vs. No ADHD excluding CPI & GAI)

A multinomial logistic regression model was run with all executive functioning assessments such as VSI, WMI, PSI, and NEPSY-II subtests (excluding the GAI and CPI scores) and diagnosis likelihood scales available as forward stepwise predictors of the three diagnosis types, adjusting for gender. Table 4.8 displays the odds ratios with no diagnosis as the reference group for the first two sets of columns, and an additional analysis was run to compare the Combined/Hyperactive group to Inattentive as the reference group.

Males were significantly more likely to have an Inattentive vs. a Combined/Hyperactive diagnosis, but there were no gender differences in either diagnosis type compared to no diagnosis. Greater scores on Switching-Completion Time and on Word Generation-Initial predicted significantly higher odds of a Combined/Hyperactive vs. Inattentive diagnosis but did not predict any differences in either diagnosis type compared to no diagnosis.

Greater scores on Animal Sorting predicted significantly higher odds of Inattentive vs. no diagnosis and significantly higher odds of Combined/Hyperactive vs. no diagnosis but did not predict any significant differences between the Combined/Hyperactive vs. Inattentive diagnoses. Similarly, CATA predicted significantly lower odds of Inattentive vs. no diagnosis and significantly lower odds of Combined/Hyperactive vs. no diagnosis but did not predict any differences between the Combined/Hyperactive vs. Inattentive diagnoses. There was a significant quadratic effect of CPT-3 in distinguishing each diagnosis group, but like prior analyses, the quadratic effects represent somewhat complicated relationships. Specifically, starting at low levels of CPT-3, increasing CPT-3 was associated with increasing odds of an Inattentive diagnosis (vs. no diagnosis), increasing odds of a Combined/Hyperactive diagnosis (vs. no diagnosis), and increasing odds of an Inattentive diagnosis (vs. Combined/Hyperactive diagnosis), but none of these relationships were significant at mean levels of CPT-3.

These relationships changed directions, and CPT-3 was predicting in the direction of decreasing odds of each diagnosis comparison near average levels of CPT-3 (specifically, the maximum points were at .003 above the mean of CPT-3 for Inattentive vs. no diagnosis, .17 above the mean for Combined/Hyperactive vs. no diagnosis, and -.32 below the mean for Inattentive vs. Combined/Hyperactive).

Table 4.8

Multinomial Logistic Regression

	Inattentive vs No Diagnosis				Combined/Hyperactive vs No Diagnosis				Combined/Hyperactive vs Inattentive			
Predictors	*OR*	*95% CI OR*		*p*	*OR*	*95% CI OR*		*p*	*OR*	*95% CI OR*		*p*
Male	1.12	0.35	3.54	.852	0.35	0.11	1.15	.083	0.317	0.174	0.577	<.001
Switching - Completion Time	0.96	0.78	1.18	.678	1.08	0.88	1.33	.482	1.126	1.024	1.239	.015
Animal Sorting - Correct Sorts	0.73	0.60	0.89	.002	0.68	0.56	0.83	<.001	0.937	0.858	1.023	.144
Word Generation - Initial	0.88	0.72	1.08	.225	1.02	0.84	1.25	.818	1.159	1.039	1.293	.008
CPT3	1.01	0.56	1.82	.980	1.34	0.74	2.43	.334	1.33	0.985	1.795	.063
CPT3 squared	0.28	0.15	0.51	<.001	0.43	0.23	0.80	.007	1.561	1.146	2.127	.005
CATA	6.88	2.61	18.10	<.001	9.34	3.48	25.05	<.001	1.358	0.91	2.025	.134
Model fit	$\chi 2(14) = 144.17$, $p < .001$											
Cox & Snell R2	.411											
Nagelkerke R2	.480											
Note. CPT3 was mean centered.												

CHAPTER V: DISCUSSION

The present study aimed to examine the neuropsychological profiles of children aged 8 to 16 with various ADHD diagnoses and compare them to those without ADHD. By assessing executive functioning and likelihood of diagnosis through several neuropsychological assessments, the goal was to identify key differences and predictive factors, specifically with predicting any diagnosis and differentiating between type of ADHD diagnosis when controlling for gender. This chapter discusses the implications of the findings, limitations of the study, and recommendations for future research.

Demographic Characteristics

Out of the sample of 272 participants, most had a comorbid diagnosis, and the majority were diagnosed with ADHD, primarily the inattentive presentation. A key characteristic of the sample is the high prevalence of comorbid diagnoses, with almost all the participants having either a previous or concurrent comorbid diagnosis, highlighting the complex clinical presentation of the sample. Among the ADHD group, only one participant presented solely with a hyperactive diagnosis, which shows the possible diagnosis frequency being less than other ADHD diagnosis types.

Participants who identified in the "other" gender category were collapsed into the female group due to the small sample size. This modification was implemented to maintain sufficient statistical power and to prevent overgeneralization based on a limited number of observations in this group. Importantly, adjustments were made solely based on gender and not on comorbidities. This decision was made due to the high rate of comorbid conditions present in the sample, which would have limited the ability to examine comorbidity as a separate variable effectively. Therefore, gender remained the primary variable of interest for adjustment, given the variability within the sample. Overall, these adjustments provide a clearer analysis while acknowledging the inherent complexities in studying children with ADHD and high comorbidity rates. This discussion illustrates both the methodological choices and the practical limitations encountered in managing small subgroup sizes and the implications of these decisions for interpreting the findings.

Correlations Among Assessments

Pearson correlations demonstrated that most executive functioning scales were positively correlated, suggesting that deficits in one area often co-occur with difficulties in others. The negative correlations between executive functioning scores and ADHD likelihood scales (CPT-3 and CATA) reinforce the notion that better cognitive performance is associated with a lower likelihood of ADHD. Interestingly, males scored significantly lower on Switching Completion time but higher on Word Generation-Initial letter compared to females/other, indicating some gender-specific differences in executive functioning. These results highlight the need for further research into gender-sensitive approaches in ADHD assessment and intervention.

Executive Functioning and ADHD

Children with ADHD, particularly the inattentive and combined types, exhibited significant challenges in executive functioning compared to the non-ADHD group. Notably, the Cognitive Proficiency Index (CPI) and Working Memory Index (WMI) were lower in ADHD groups, indicating difficulties in cognitive processes and memory. This finding is consistent with previous studies highlighting the role of executive dysfunction in ADHD (Kasper et al., 2012). The lack of significant differences in Processing Speed Index among the groups suggests that while ADHD impacts various cognitive domains, processing speed may not be as heavily affected. Since the PSI did not show significant differences, the WMI is likely a more accurate reflection of cognitive abilities than CPI, as CPI incorporates elements of processing speed. This aligns with previous studies showing the importance of the WMI in assessing those with ADHD (Cockcroft & Alloway, 2012; Mayes & Calhoun, 2007; Moura et al., 2019; Theiling & Petermann, 2016). From this research, while the WMI is a significant predictor of ADHD on its own, it is not as predictive as the NEPSY-II and CPT measures. Out of all indexes of the WISC-V, the WMI is the most statistically significant followed by the CPI and GAI as overall predictors of ADHD.

The VSI was found to be predictive of ADHD on its own like the other WISC-V indexes, but when compared to the other assessments it was not as predictive or found to be a relative strength as previously hypothesized. This research aligns with the findings from previous studies suggesting that the VSI is lower in those with ADHD compared to those with no ADHD (Ortega, 2013).

Research Question 1: Binary Logistic Regression (ADHD vs. No ADHD for CPI & GAI)

Research question 1 aimed to answer whether the CPI or GAI were predictive in aiding any ADHD diagnosis, and if the CPI or GAI were predictive of a certain diagnosis type. It was found that the CPI was a significant predictor of any ADHD diagnosis. As CPI scores increased, the likelihood of an ADHD diagnosis decreased, illustrating the inverse relationship between cognitive proficiency and ADHD symptomatology. The quadratic nature of this relationship further indicates that at higher levels of cognitive proficiency, the protective effect diminishes, reflecting the complexity of ADHD diagnosis. While the GAI was found to be predictive on its own, when entered into the stepwise regression compared to the CPI it was not found to be as predictive of ADHD compared to those without ADHD.

Research Question 1: Multinomial Logistic Regression (ADHD Diagnosis Type vs. No ADHD for CPI & GAI)

In terms of gender, the multinomial regression uncovered that males were found to be significantly more likely to receive an Inattentive diagnosis rather than a Combined/Hyperactive diagnosis. Interestingly, males were more likely to receive a Combined/Hyperactive diagnosis compared to the no diagnosis group. The CPI was also found to be more predictive than the GAI when assessing predictiveness of ADHD diagnosis type. CPI did not help differentiate between ADHD types (Combined/Hyperactive vs. Inattentive), but it did help in distinguishing children with ADHD (either type) from children with no diagnosis at all.

These findings of the GAI being affected in those with ADHD is inconsistent with previous literature suggesting that GAI remains unaffected due to not including processing speed and working memory in this index (Lenhard & Daseking, 2022). In individuals with ADHD, GAI was found to be impacted due to weaknesses in working memory and processing speed, which could potentially be contributing to difficulties in sustaining attention, organizing literary information, and efficiently processing complex tasks. Given that CPI is notably lower in individuals with ADHD, it suggests that deficits in these cognitive domains may also be influencing GAI, rather than GAI remaining unaffected. Individuals with ADHD may still show reductions in GAI due to broader executive functioning challenges that affect reasoning and problem-solving abilities.

Research Question 2: Binary Regression Analysis (ADHD vs. No ADHD excluding CPI & GAI)

The findings from the binary logistic regression analysis for research question 2 provide important insights into the relationship between various assessment measures and the likelihood of receiving an ADHD diagnosis. No significant differences were observed in the likelihood of an ADHD diagnosis based on gender. Both Animal Sorting and Response Set - Total Correct were associated with significantly lower odds of an ADHD diagnosis. These findings suggest that better performance on these measures, which likely tap into executive functioning and cognitive flexibility, may serve as protective factors against an ADHD diagnosis. Impaired performance in these domains has often been associated with ADHD, highlighting the importance of these measures in distinguishing individuals with and without the ADHD.

It was also found that higher scores on the CATA were associated with increased odds of an ADHD diagnosis. This result is consistent with previous findings indicating that auditory attentional difficulties, as measured by the CATA, are prominent in individuals with ADHD (Wasserman & Wasserman, 2012). The relationship between CPT-3 scores and ADHD diagnosis were more nuanced. At lower levels of CPT-3 performance, increasing scores were associated with higher odds of an ADHD diagnosis. However, the direction of the relationship reversed at a certain level with greater scores predicting decreased odds of an ADHD diagnosis. This relationship suggests that while moderate impairments on the CPT-3 may be associated with ADHD, more extreme scores could reflect other underlying factors not specific to ADHD, highlighting the complexity of attentional performance profiles in diagnostic contexts.

The assessments that remained significant in the final model when looking at any diagnosis compared to no diagnosis included Gender, Animal Sorting, Response Set - Total Correct, CPT-3, CPT-3 Squared, and CATA. The inclusion of these variables shows the complicated nature of ADHD, where a combination of cognitive, behavioral, and attentional factors all contributes to diagnostic outcomes.

Research Question 2: Multinomial Regression Analysis (ADHD Diagnosis Type vs. No ADHD excluding CPI & GAI)

This analysis explored the predictive relationships between gender and various cognitive and attentional assessments (excluding GAI and CPI scores) for three ADHD diagnosis types: Inattentive, Combined/Hyperactive, and no diagnosis. Gender emerged as a significant predictor when distinguishing between ADHD subtypes. Males were more likely to receive an Inattentive diagnosis compared to a Combined/Hyperactive diagnosis.

Switching completion time significantly predicted higher odds of a Combined/Hyperactive diagnosis compared to an Inattentive diagnosis. However, this measure did not differentiate individuals with ADHD (either subtype) from those with no diagnosis. This suggests that cognitive flexibility and task-switching speed may play a more prominent role in distinguishing ADHD subtypes than in identifying ADHD itself. These results are inconsistent with the idea from previous research, suggesting that there are no differences between the three subtypes of ADHD in relation to inhibition (Rahmi & Wimbarti, 2018). Results show that inhibition completion time and switching completion time, measuring processing speed and cognitive flexibility, were able to distinguish the two ADHD types.

Performance on the Word Generation - Initial task similarly predicted higher odds of a Combined/Hyperactive diagnosis compared to an Inattentive diagnosis but showed no significant differences when either ADHD subtype was compared to the no-diagnosis group. This finding indicates that tasks requiring rapid verbal production may differentiate ADHD subtypes, with potentially stronger links to hyperactive/impulsive traits.

Animal Sorting performance was a significant predictor in comparisons involving both ADHD subtypes and no diagnosis. Higher scores predicted greater odds of an Inattentive diagnosis compared to no diagnosis, as well as a Combined/Hyperactive diagnosis compared to no diagnosis. However, it did not distinguish between the two ADHD subtypes. This suggests that Animal Sorting is broadly sensitive to ADHD-related cognitive deficits but lacks specificity in differentiating ADHD subtypes.

CATA scores were associated with significantly lower odds of both ADHD subtypes (Inattentive and Combined/Hyperactive) compared to no diagnosis. However, CATA performance did not differentiate between the two ADHD subtypes. This finding may reflect that lower CATA scores, indicative of better auditory attention, are characteristic of individuals without ADHD, while ADHD subtypes show similar levels of auditory attention deficits. The relationship between CPT-3 scores and ADHD diagnosis was complex and non-linear. At lower levels of CPT-3 performance, increasing scores were associated with higher odds of an Inattentive diagnosis compared to no diagnosis, a Combined/Hyperactive diagnosis compared to no diagnosis, and an Inattentive diagnosis compared to a Combined/Hyperactive diagnosis. These findings could suggest that moderate performance deficits on the CPT-3 may be most indicative of ADHD, while extreme scores might reflect other factors not specific to ADHD.

Variables included in the final model incorporated Gender, Switching Completion Time, Animal Sorting - Correct Sorts, Word Generation – Initial, CPT-3, CPT-3 Squared, and CATA. Interestingly, the WISC-V seemed to not be as predictive of ADHD when compared to other assessments, as the CPT-3, CATA, or NEPSY-II subtests in any of the models. This finding could have future implications for psychologists in that while the WISC-V is predictive of ADHD, if there is an opportunity to use the NEPSY-II, CATA, or CPT-3 in a shortened battery, it might produce better outcomes. This research finding is partially consistent with previous research because past research shows all these assessments can add to aiding an ADHD diagnosis (Becker et al., 2021) but has not shown which assessment to be most predictive.

Implications for Practice

The findings of this study emphasize the critical role of specific neuropsychological assessments in diagnosing ADHD and understanding its impact on executive functioning. Clinicians should consider incorporating specific assessment batteries when evaluating ADHD and differentiating between diagnosis types.

Battery for ADHD diagnosis

For predicting any ADHD diagnosis compared to no diagnosis, key assessments should include Gender, Animal Sorting, Response Set - Total Correct, CPT-3, and CATA. Additionally, when using the WISC-V, the best predictors were the Working Memory Index (WMI) and Cognitive Proficiency Index (CPI) as opposed to the GAI, suggesting that selecting specific subtests accordingly can help optimize assessment time and costs.

Battery for Identifying ADHD (Inattentive & Combined/Hyperactive vs. no ADHD)

When identifying whether someone has ADHD or not, the WISC-V indexes were not predictive, indicating they may not be necessary if the goal is to determine whether someone has ADHD. For inattentive ADHD versus no diagnosis, significant predictors that clinicians might consider using include Animal Sorting - Total Correct and CATA. Similarly, for combined/hyperactive ADHD versus no diagnosis, Animal Sorting - Correct Sorts and CATA were key indicators, showing that Animal Sorting-Total Correct and CATA were able to predict type of ADHD diagnosis from control samples.

Battery for Combined/Hyperactive vs. Inattentive

When differentiating between combined/hyperactive ADHD and inattentive ADHD, notable predictors that clinicians might consider using include Switching Completion Time, Animal Sorting - Correct Sorts, and Word Generation - Initial. It is also noteworthy that Gender was also a significant factor (with males being more likely to be diagnosed with inattentive type), These findings highlight the importance of selecting targeted measures based on the specific diagnostic question.

These results can help with effectiveness of diagnosis as well as specified psychoeducation and recommendations for families. Additionally, the predictive value of the WMI suggests that enhancing cognitive proficiency in working memory tasks might be a beneficial focus for interventions aimed at reducing ADHD symptoms.

Overall, the NEPSY subtests such as Animal Sorting and Response Set - Total Correct, in addition to the CPT-3 and CATA could be helpful in determining whether someone has ADHD and, if they do have it, then Animal Sorting - Correct Sorts and CATA could be helpful in determining which subtype.

Limitations

Some of the limitations of this study include that the sample was characterized by a high rate of comorbid conditions and a predominance of Inattentive ADHD diagnoses. This may limit the generalizability of the results to broader populations with different ADHD subtype distributions or lower comorbidity rates. Given the high number of participants with comorbid diagnoses—such as anxiety, depression, specific learning disorders, or autism—these co-occurring conditions may contribute to executive dysfunction. This complicates the ability to generalize findings specifically to children undergoing evaluation for a first-time ADHD diagnosis without any comorbidities. While this represents a limitation in terms of reduced internal validity (i.e., the absence of an ADHD-only group), it also enhances external validity, as ADHD in real-world settings is frequently accompanied by comorbid conditions.

Results could also include more participants with a Hyperactive/Impulsive ADHD diagnosis possibly from other samples so that assessments could be entered into the model with all diagnosis types. This limitation may reduce the ability to generalize findings to this subgroup, which could have distinct cognitive and behavioral profiles that differ from the Inattentive or Combined subtypes. Other considerations include that all data was collected from the same group practice, all diagnosis were based on one clinician's findings, and all the clients in this sample are only representative of the Pacific Northwest.

Recommendations for Future Research

Future research could include more diverse samples, possibly from multiple databases and psychologists that can help enhance the variability seen in clinical and community populations. Another direction is to include more gender diversity. As were there were not many participants who identified as a gender other than male or female, including a more diverse range of gender identities in future research would provide a more comprehensive understanding of ADHD across populations. Including a larger sample of kinds of neuropsychological assessments to be compared to ADHD diagnosis types in the future could also enhance and target more specific batteries for ADHD in a pediatric population. Future research could also examine what children with only an ADHD diagnosis—having no comorbidities—would look like, to assess whether other diagnoses are affecting how predictive these assessments can be in diagnosing ADHD, thereby improving internal validity and informing the external validity of the findings across more complex clinical presentations.

Another area that this study could expand upon is adding more statistical analysis, such as examining standardized betas or partial correlations, to examine a rank order of which predictors are most to least predictive within the regression models. This could help with creating a battery that informs clinicians about which assessments and subtests are predictive for ADHD but also which are most predictive. Lastly, this study could also be replicated on an adult population with adult specific assessments that are most used in assessing ADHD.

Conclusion

The study contributes to the understanding of ADHD’s neuropsychological mechanisms, highlighting significant executive functioning deficits and the predictive value of the Working Memory Index, NEPSY-II subtests such as Animal Sorting-Total Correct and Inhibition, and CPT-3/CATA assessments. Assessments found to predict an ADHD diagnosis included Gender, Animal Sorting, Response Set - Total Correct, CPT-3, and CATA. Additionally, when using the WISC-V, the best predictors were the Working Memory Index (WMI) and Cognitive Proficiency Index (CPI) as opposed to the GAI. When looking to assess for specific diagnostic types, for inattentive ADHD versus no diagnosis, significant predictors that clinicians might consider using include Animal Sorting - Total Correct and CATA. Similarly, for combined/hyperactive ADHD versus no diagnosis, Animal Sorting - Correct Sorts and CATA were key indicators, showing that Animal Sorting-Total Correct and CATA were able to predict type of ADHD diagnosis from control samples. Lastly, when predicting between the inattentive and combined/hyperactive diagnosis, gender (with males being more likely to be diagnosed with inattentive type), Switching Completion Time, Animal Sorting - Correct Sorts, and Word Generation – Initial are all assessments that should be used.

By integrating these findings of specific batteries depending on referral question into clinical practice, psychologists can improve diagnostic accuracy and develop targeted interventions to support children with ADHD in achieving better cognitive and functional outcomes. This approach also helps with streamlining testing batteries for children, making assessments more efficient and improving accessibility for lower-income populations by aligning with insurance requirements and reducing overall costs associated with this process.

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APPENDIX: GRANTED PERMISSION LETTER

Based on my review of the proposed research by Kristen Newberry, I give permission for her to conduct the study entitled Pay Attention! Determining Which Psychological Assessment is Most Predictive of ADHD within a Pediatric Population within the Western Washington Medical Group clinic. As part of this study, I authorize the researcher to collect data from my client database for information such as diagnosis, age, gender, ethnicity, and assessment scores. All information will be de-identified, and no direct contact between the researcher and the clients will be involved. I understand that my responsibilities include providing access to client reports from a database on OneDrive, and I understand that the research will include reviewing and collecting de-identified data from this database. This authorization covers the time period of January 20th, 2024 to January 1st, 2025.

Both parties acknowledge that original data resulting from this research will be the sole property of the researcher, and that the researcher will maintain exclusive rights to the publication of the research findings. Both parties will maintain the right to the dissemination of research findings and will agree to acknowledge the contributions of each other in any publications or presentations resulting from the research project, if desired. I confirm that I am authorized to approve research in this setting. I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the research team without permission from the AUS IRB.

Sincerely,

Justin Hampton

Justin Hampton, PhD
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Western Washington Medical Group Department of Psychology