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Processing Speed in Girls with and without ADHD: Association with Longitudinal Outcomes in Symptoms and Academic Achievement



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# Processing Speed in Girls with and without ADHD: Association with Longitudinal Outcomes in Symptoms and Academic Achievement

By

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Abstract

Processing Speed in Girls with and without ADHD: Association with Longitudinal Outcomes in Symptoms and Academic Achievement

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Theoretical models of ADHD often implicate executive function difficulties, particularly inhibitory control, as underlying ADHD symptoms. However, this theory has been challenged by studies showing that only a portion of children with ADHD have deficits in executive function. Processing speed has been suggested as a cognitive endophenotype of ADHD due to shared genetic and neurobiological etiologies with relevant symptom patterns. Indeed, children with ADHD often demonstrate slower processing speed than comparison children. It may be that “lower order” cognitive deficits in processes such as processing speed are crucial with respect to the long-term impairments of children with ADHD.

The purpose of the present investigation was to examine (1) processing speed differences between ADHD presentations, (2) the relation between processing speed and ADHD symptomatology, (3) the relation between processing speed and academic achievement, and (4) the relation between processing speed and adult educational and occupational outcomes in a sample of girls with ADHD and their typically developing counterparts.

The present study comprises secondary data analysis from 228 participants in a longitudinal investigation of females with and without ADHD (i.e., combined or inattentive presentations). Girls participating in the original study were between the ages of six and 12 years and participated in summer enrichment programs. In addition to the original data collection, three follow-up studies were conducted at five-year, 10-year, and 16-year follow-up intervals, with excellent subject retention, during which participants, caregivers, and teachers completed evaluations, including objective tests of academic performance.

In conclusion, findings from the present study demonstrate an association between processing speed and concurrent inattentiveness in girls with ADHD. These findings also demonstrated a long-lasting association between slow processing speed in childhood and poor math performance from childhood through adulthood regardless of diagnostic status. Aside from the association with inattentiveness, slow processing speed does not seem to put girls with ADHD at particular risk for poor academic outcomes through childhood, adolescence, or adulthood. This may be attributable to sex differences in processing speed, such that females

tend to have faster processing speeds than males. Indeed, this may be a protective factor of sorts for girls with ADHD. This may also mean that girls may benefit from targeted intervention in deficits other than processing speed. However, it was found that for all girls, regardless of diagnostic status, slow childhood processing speed predicts poor math performance through childhood, adolescence, and adulthood.

# Processing Speed in Girls with and without ADHD: Association with Longitudinal Outcomes in Symptoms and Academic Achievement

Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by symptoms of inattention and/or hyperactivity-impulsivity. Approximately 5% of children and 2.5% of adults are estimated to have ADHD, worldwide, which has been associated with reduced academic attainment and school achievement in childhood and poorer occupational performance in adulthood (APA, 2013).

The three presentations of ADHD include the predominantly inattentive presentation (ADHD-I), the predominantly hyperactive/impulsive (ADHD-HI) presentation, and the combined (ADHD-C) presentation, characterized by both inattentive and hyperactive/impulsive symptoms (APA, 2013). A diagnosis of ADHD, according to the DSM, is based on behavioral symptoms such as having difficulty sustaining attention in tasks, struggling to sit still for extended periods of time, or challenges in waiting for turns (APA, 2013). Theoretical models of ADHD often implicate executive function difficulties, particularly inhibitory control, as causal forces underlying ADHD symptoms (e.g., Barkley, 1997). However, this theory has been challenged by studies showing that only a portion of children with ADHD have deficits in executive function (Nigg et al., 2005). Additionally, it has been argued that even when children with ADHD perform poorly on inhibitory control tasks, core information processing deficits and impairments in basic information accumulation processes may explain a variety of symptoms of ADHD (Van De Voorde, Roeyers, Verté, & Wiersema, 2010; Salum et al., 2014).

Processing speed is the cognitive capacity to process information and generate an appropriate response within constrained time limits (Weiler, Bernstein, Bellinger, & Waber, 2000). The overwhelming majority of studies comparing processing speed between children with ADHD and typically developing children have demonstrated a pattern in which children with ADHD have significantly slower processing speed (Arnett, Pennington, Willcutt, DeFries, & Olson, 2015; Jacobson et al., 2011; Tillman, Bohlin, Sørensen, & Lundervold, 2009; Lewandowski, Lovett, Parolin, Gordon, & Codding, 2007; Shanahan et al., 2006). This pattern has been replicated in Spain (Moreno-García, Delgado-Pardo, & Roldán-Blasco, 2015), New Zealand (Rucklidge, 2006), and Italy and Germany (Graham et al., 2013).

## Measurement of Processing Speed

Various measures of processing speed exist in the literature and fall into different categories of tasks (e.g., trail making tasks, continuous performance tasks, forced-choice reaction time tasks, rapid naming tasks) and have varying demands in addition to information processing (e.g., visuomotor integration, linguistic abilities, motor speed).

**Wechsler intelligence tests.** The most common measures of processing speed in the literature come from the Wechsler intelligence tests (e.g., Wechsler Intelligence Scale for Children) (Jacobson et al., 2011). Wechsler intelligence tests include subtests and composite scores measuring various cognitive functions. They are standardized for individuals from 2.5 to 90 years of age. Specific to processing speed, Coding and Symbol Search subtest scores yield the Processing Speed Index composite score. The Coding subtest involves using a key to copy symbols; the Symbol Search subtest involves scanning search groups to determine whether target symbols are present. Subtest scores are based on the number of correct responses within a specified time limit. Researchers often use the Processing Speed Index composite score or the individual subtest scores as variables within their studies.

**Rapid naming tests.** Rapid naming tests require individuals to quickly identify and name a series of familiar objects, letters, or digits. These tests often include two types of conditions: single-dimension and dual-dimension. Single-dimension conditions require an individual to identify one category at a time (e.g., name the color of stimuli in a series) and are often used as a measure of processing speed. Dual-dimension conditions involve the identification of two categories and thus tap into executive functions such as set-shifting or inhibition. Therefore, only the single-dimension conditions areused as measures of processing speed. Examples of single-dimension rapid naming tests include A Quick Test of Cognitive Speed (AQT) (Nielsen & Wiig, 2011a; Nielsen & Wiig, 2011b), Rapid Automatized Naming (RAN) (Bidwell, Willcutt, DeFries, & Pennington, 2007; Denckla & Rudel, 1974; Shanahan et al., 2006), Contingency Naming Test (Poon & Ho, 2014), and the Stoop Color and Word Test (Poon & Ho, 2014; Biederman et al., 2008; Shanahan et al., 2006).

## Processing Speed Differences between ADHD Presentations

Differential processing speed performance based on both ADHD presentations and ADHD symptom dimensions has been demonstrated in the literature. Specifically, slow processing speed performance has been implicated in children with the predominantly inattentive presentation of ADHD. Studies have shown that children with ADHD-I are particularly vulnerable to processing speed weaknesses compared to children with ADHD-C (Hellwig-Brida, Daseking, Petermann, & Goldbeck, 2010; Mayes, Calhoun, Chase, Mink, & Stagg, 2009; Yang et al., 2013) and children with ADHD-HI (Hellwig-Brida et al., 2010). Additionally, children's processing speed performance has predicted ADHD-I diagnostic status with 69% accuracy (Mayes et al., 2009). In adults, symptoms of hyperactivity-impulsivity have been associated with *faster* processing speed (Nigg et al., 2005) whereas symptoms of inattentiveness have been associated with *slower* processing speed (Hunt, Bienstock, & Qiang, 2012; Nigg et al., 2005). However, relations between processing speed and ADHD symptom dimensions have not been examined in *children* with ADHD.

There have been conflicting arguments about subtype/presentation differentiation in ADHD (Schweitzer, Hanford, & Medoff, 2006). Some researchers suggest that individuals with ADHD-C and ADHD-I should demonstrate similar weaknesses in processing speed as they share symptoms of inattentiveness in common. However, others have argued ADHD-I is a distinct disorder from ADHD-C and ADHD-HI, citing the notion that ADHD-C and ADHD-HI are both characterized by deficits in inhibition whereas ADHD-I inattentiveness results from noninhibitory mechanisms (see Schweitzer et al., 2006). Given characteristic differences in impulsivity and inattentiveness, it would seem reasonable that individuals with ADHD-I would show a distinct cognitive profile from individuals with ADHD-C or ADHD-H.

## Relative Weakness in Processing Speed

Some investigations reveal that individuals with ADHD may not have below-average processing speed per se but instead have a relative weakness in processing speed compared to other neuropsychological functions. Indeed, two studies have demonstrated that children and adolescents with ADHD and subthreshold ADHD show relative weakness in processing speed (Ek, Westerlund, & Fernell, 2013) or show low-average processing speed (DeBono et al., 2012). In a sample of children with ADHD, Mayes and Calhoun (2007) compared WISC-III and WISC-IV indexes and found that Processing Speed Index (PSI) scores were the lowest index scores for almost all children with ADHD—in other words, that PSI was a relative weakness.

Thaler, Bello, and Etcoff (2013) conducted a hierarchical cluster analysis using data from 189 children with a diagnosis of ADHD-I or ADHD-C to examine differences in WISC-IV profiles. The cluster analyses revealed five distinct WISC-IV profiles, two in which PSI was particularly low: Reduced PSI and Below Average WMI/PSI. The Reduced PSI cluster (PSI $M$ = 90.3) had a comparative weakness in processing speed relative to other cognitive indices, whereas the Below Average WMI/PSI cluster (PSI $M$ = 77.1) had low average or below average scores on all WISC-IV indices. Thus, the Reduced PSI cluster represented children with ADHD who displayed a relative weakness in processing speed, whereas the Below Average WMI/PSI cluster reflected children with poorer WISC-IV index scores overall. Thaler and colleagues (2013) found that children with the Reduced PSI profile had significantly higher ratings of inattentiveness and incidence of ADHD-I than other cluster profiles. These findings support the notion that relative weakness in processing speed is likely to characterize individuals with a diagnosis of ADHD-I, even if processing speed is not below average in an absolute sense (Thaler et al., 2013). Thus, in the current study, I will analyze for relative weakness in processing speed compared to other domains of cognitive functioning, in addition to "absolute" processing speed indicators per se.

## Trajectory of Processing Speed Performance

In normative samples, raw scores of processing speed increase quadratically during childhood and adolescence (Kail & Ferrer, 2007) and thereafter demonstrate minimal change in adulthood (Jacobson et al., 2004; Wiig, Nielsen, & Jacobson, 2007). In a cross-sectional sample of 2,182 adults (aged 47-54) in Australia, Das, Cherbuin, Anstey, and Easteal (2015) found that ADHD symptoms were negatively associated with processing speed, supporting the notion that cognitive deficits associated with ADHD persist well into adulthood. However, cognitive impairments associated with ADHD are subject to age-related decline (Das et al., 2015). Thus, the degree to which ADHD symptoms and age-related decline independently influence processing speed in adulthood remains unknown.

## Sex Differences

Sex differences in ADHD diagnosis have been well established in the literature, with males more likely to receive a diagnosis than females through childhood and adolescence (Arnett et al., 2015). Likewise, several recent studies have revealed that males with ADHD demonstrate significantly slower processing speed than females with ADHD (Arnett et al., 2015; Tillman et al., 2009; Rucklidge & Tannock, 2001). In a study of children and adolescents with ADHD, Arnett and colleagues (2015) sought to determine whether neuropsychological endophenotypes mediated the relationship between ADHD symptom severity and sex. They found that processing speed, along with working memory and inhibition, partially mediated sex differences in inattention, hyperactivity/impulsivity, and total ADHD symptom severity. These results suggest that neuropsychological endophenotypes like processing speed may partially explain sex differences in ADHD symptomatology.

**Etiology**

Neurobiological and genetic studies have provided evidence suggesting that ADHD symptoms and processing speed deficits share common etiology.

Processing speed has been suggested as a candidate cognitive endophenotype of ADHD, as certain genes associated with ADHD symptoms have also been associated with processing speed performance (Wood et al., 2010). In a systematic review of studies examining the relation between neuropsychological abilities and putative susceptibility genes for ADHD, Kebir, Tabbane, Sengupta, and Joober (2009) reported that processing speed is compromised in carriers of the 7-repeat allele of dopamine receptor 4 (DRD4), even though overall evidence is mixed. As cited in a review paper by Kebir and Joober (2011) examining studies that examine associations between genes and neuropsychological traits in ADHD, Waldman (2005) found that in a sample of 137 children with ADHD and their siblings, children carrying two copies of the 7-R allele demonstrated longer response times on the Trails A, indicating slower processing speed.

Twin studies have supported the high heritability of processing speed performance. Indeed, heritability estimates for processing speed range from 75% to 90% in such studies (Luciano et al., 2001). In one relevant investigation, Bidwell, Willcutt, DeFries, and Pennington (2007) examined processing speed within a sample of dizygotic twin pairs. Twin pairs were grouped into those in which one co-twin met criteria for ADHD and a control group in which neither co-twin met criteria for ADHD. Unaffected co-twins of youth with ADHD were significantly more impaired in processing speed than control twins, even when adjusting statistically for subclinical symptoms of ADHD, suggesting that processing speed is a heritable phenotype sharing genetic variance with ADHD (Bidwell et al., 2007).

Neurobiological evidence suggests a common association with white matter abnormalities between ADHD (van Ewijk et al., 2012) and slow processing speed (Konrad & Eickhoiff, 2010). White matter consists of neurons with myelinated axons through which neural impulses travel quickly to send signals to other neurons  (Brydges, Ozolnieks, & Roberts, 2015). This myelination insulates the axon, thereby increasing the speed of nerve signal transmission. It has been implicated in speed of information processing (Brenhouse & Andersen, 2011). ADHD is also associated with total white matter volume reductions as well as volume reductions in specific brain structures, including the corpus callosum and the cerebellum (van Ewijk et al., 2012).

**Processing Speed and Academic Achievement**

ADHD is associated with lowered academic attainment and school performance in childhood (APA, 2013) and beyond (Owens, Zalecki, Gillette, & Hinshaw, 2017). The relation between processing speed and academic achievement has largely focused on cross-sectional investigations of samples of children with ADHD and comorbid reading disorder. Indeed, the relations between ADHD symptoms, processing speed, and academic achievement are rarely studied in the absence of reading disorder, which is the focus of the present study.

McGrath and colleagues (2011) noted that literature has shown that processing speed weaknesses are shared neuropsychological deficits in both children with ADHD and children with reading disorder, as corroborated by a meta-analysis conducted by Willcutt and colleagues (2008). Thus, McGrath and colleagues (2011) tested this multiple deficit model to determine if such shared deficits were responsible for the comorbidity between ADHD and reading disorder. In a sample of 614 children and adolescents, they found that, among other shared neuropsychological deficits in children with ADHD and reading disorder (i.e., naming speed, verbal working memory), only processing speed—and particularly symbolic processing speed—significantly predicted both inattention and low performance on reading. When processing speed was included as a covariate, the relation between ADHD and reading disorder was no longer significant. Thus McGrath and colleagues (2011) suggest that processing speed may explain the comorbidity between ADHD (specifically inattention symptoms) and reading disorder. Indeed, a recent study found that the genetic association between ADHD and reading disorder was accounted for by processing speed performance (Willcutt et al., 2010).

In a series of twin analyses using data from 244 monozygotic twin pairs (i.e., twins sharing all of their genes) and 213 same-sex dizygotic twin pairs (i.e., twins who share about half of their genes on average), Willcutt and colleagues (2010) found that genetic influences that lead to slow processing speed primarily accounted for comorbidity between ADHD and reading disorder. In phenotypic analyses, Willcutt and colleagues (2010) found that processing speed was the only cognitive ability to predict both ADHD and reading disorder.

In addition, and importantly, symptoms of ADHD, in the absence of reading disorder, have been associated with poorer academic achievement and outcomes. Indeed, academic problems are characteristic of ADHD (APA, 2013). Beyond concurrent associations between symptoms of ADHD and academic achievement deficits, this relation has been demonstrated longitudinally such that early ADHD symptoms are associated with later reduced academic achievement. In a study of 192 children with ADHD, it was shown that ADHD symptoms in the sixth grade were negatively associated with academic achievement longitudinally (Scholtens, Rydell, & Yang-Wallentin, 2013). Still, it is possible that cognitive and executive function problems mediate ADHD symptom-academic achievement associations.

One study conducted by Mayes and Calhoun (2007) did investigate correlations between WISC-III index scores and WIAT academic achievement scores in a sample of children with ADHD (76% with a learning disability). They found that WISC FSIQ was the strongest predictor of academic achievement. Correlation coefficients between WISC-III PSI and WIAT academic achievement scores in Basic/Word Reading ($r$ = .34), Reading Comprehension ($r$ = .39), Numerical Operations ($r$ = .43), and Written Expression ($r$ = .43) were moderate (Mayes & Calhoun, 2007). However, there is a dearth of literature on the relation between early processing speed and longitudinal academic outcomes in the context of ADHD, particularly when it is not accompanied by reading disorder.

**0** Rapid naming test performance has specifically been implicated in predicting reading ability and is in widespread use as a diagnostic tool for reading disorders (Bowers, 1995). It is presently unknown whether the relation between rapid naming and reading ability is due to commonalities in orthographic processing (i.e., the use of the visual system to encode and retrieve words) or phonological processing (i.e., the use of phonemes, or sounds/units of a language, to encode and retrieve words) (Arnell et al., 2009). Furthermore, it is suggested that working memory is responsible, in part, for rapid-naming performance (Arnell et al., 2009).

Overall, given that ADHD is a prevalent childhood disorder that often persists into adulthood (APA, 2013), studying processing speed, a cognitive endophenotype greatly implicated in ADHD (Wood et al., 2010), is needed. The influences of childhood processing speed weaknesses on later outcomes such as ADHD symptoms and academic achievement have yet to be examined. Processing speed is often examined only as a variable of peripheral interest, yet studies suggest that the neurobiological and genetic abnormalities implicated in processing speed weaknesses are the very abnormalities implicated in ADHD (Wood et al., 2010; van Ewijk et al., 2012; Konrad & Eickhoiff, 2010). It may well be that early deficits in processing speed are more important than ADHD symptoms per se—or than other executive functions—in predicting important outcomes.

## Hypotheses

### Objective I: Group Differences in Processing Speed Performance

**Hypothesis 1: Girls with ADHD will show slower processing speed than matched comparison girls.** Previous literature has consistently shown that children with ADHD (mainly boys, in past research) demonstrate significantly poorer processing speed performance than children without ADHD as well as differences between ADHD presentations, such that children with ADHD-I demonstrate slower processing speed than children with ADHD-C. The purpose of these analyses will be to attempt to replicate previous patterns of processing speed performance in a sample of girls with and without ADHD. I expect significant group differences to be consistent with previous literature such that (a) girls with ADHD will perform more poorly than comparison girls and (b) girls with ADHD-I will perform more poorly than girls with ADHD-C.

**Hypothesis 2: Girls with ADHD will show greater relative weakness in processing speed than matched comparison girls.** Studies of processing speed in children with ADHD often use a standard score on a continuous scale to reflect performance, as opposed to examining status of a specific weakness in processing speed compared to other cognitive abilities. Although previous literature has established significant differences between children with and without ADHD, as well as between ADHD subtypes/presentations, the degree to which children with ADHD demonstrate greater likelihood for a relative weakness in processing speed is less studied. Relative weakness will be determined by comparing WISC-III PSF scores to mean primary factor scores. The purpose of these analyses will be to determine whether there are group differences in relative weakness in processing speed in a sample of girls with and without ADHD. Because children with ADHD have shown poorer processing speed performance than comparison children and because children with ADHD-I have shown poorer processing speed performance than children with ADHD-C, I expect significant group differences such that (a) more girls with ADHD will have a relative weakness in processing speed than comparison girls and (b) more girls with ADHD-I will have a relative weakness in processing speed than girls with ADHD-C.

**Objective II: Relation between Processing Speed Performance and ADHD Symptoms**

**Hypothesis 3: Processing speed performance will be differentially associated with ADHD symptom dimensions.** Processing speed performance is typically examined between various ADHD presentations; however, there is heterogeneity of symptom count and severity within each presentation. A DSM-5 diagnosis of ADHD-I or ADHD-H requires the presence of six inattentive or hyperactive-impulsive symptoms respectively. Thus, it is possible that a child with six inattentive symptoms and five hyperactive-impulsive symptoms, for example, would be diagnosed with ADHD-I and not ADHD-C. Therefore, it is necessary to explore specific symptom dimensions in addition to diagnoses. The purpose of these analyses will be to determine whether processing speed performance is associated with inattentiveness and hyperactivity-impulsivity symptom count and severity within a sample of girls with ADHD. Because processing speed performance has previously been associated with ADHD symptom dimensions, I expect significant prediction effects such that processing speed will have a negative relation with both inattentiveness symptom count and severity, but a positive relationship with hyperactivity-impulsivity symptom count and severity. Because executive function performance has been shown to vary between girls with ADHD and comparison girls (Hinshaw, Carte, Sami, Treuting, & Zupan, 2002), baseline executive functioning, indexed chiefly through performance on the Rey-Osterrieth Complex Figure Test, will be included as a covariate. Baseline WISC-III factor scores (i.e., VCF, POF, FDF) will also be included as covariates for analyses in which PSF is the main predictor variable.

**Hypothesis 4: Childhood processing speed performance will predict ADHD symptoms in adolescence and adulthood.** It is presently unknown whether early processing speed predicts future ADHD symptomatology. The purpose of these analyses will be to determine whether childhood processing speed performance predicts (a) ADHD symptom count or severity at each follow-up assessment point and (b) trajectories of ADHD symptom count or severity from childhood through adulthood. Because processing speed has been cross-sectionally associated with ADHD symptomatology, I expect significant prediction effects, such that childhood processing speed will have (a) a negative relation with inattentiveness symptom count and severity in adolescence and adulthood, (b) a positive relation with hyperactivity-impulsivity in adolescence and adulthood, and (c) significant prediction effects on trajectories. Covariates will include baseline executive functioning (ROCF copy condition) and baseline ADHD symptoms (SNAP-IV). Baseline WISC-III factor scores (i.e., VCF, POF, FDF) will also be included as covariates for analyses in which PSF is the main predictor variable.

**Objective III: Relation between Processing Speed and Academic Achievement**

**Hypothesis 5: Processing speed performance will be associated with academic achievement.** The relation between processing speed performance and academic functioning has largely focused on comorbidities between ADHD and reading disorder. Clear implications for a common etiology and similar deficits exist between individuals with ADHD and reading disorder, yet it remains unclear whether processing speed performance predicts difficulties with reading in the absence of reading disorder and whether mathematics performance is associated with processing speed performance. The purpose of these analyses will be to determine whether processing speed performance is associated with academic achievement in reading and mathematics at baseline. I expect significant prediction effects such that processing speed will have (a) a positive relation with reading performance and (b) a positive relation with mathematics performance. Moderation effects of diagnostic group will also be tested to determine whether the relation between processing speed and academic performance varies based on diagnostic status, but due to the exploratory nature of these analyses, directionality is not predicted. However, it is possible that processing speed deficits will hinder academic performance for girls with ADHD to a greater extent than for comparison girls because of an interaction between symptoms of ADHD and slow processing speed. Baseline executive functioning (ROCF copy condition) will be included as a covariate. Baseline WISC-III factor scores (i.e., VCF, POF, FDF) will also be included as covariates for analyses in which PSF is the main predictor variable.

**Hypothesis 6: Childhood processing speed performance will predict academic achievement in adolescence and adulthood.** There is a dearth of literature on longitudinal academic outcomes of the effects of early processing speed weaknesses. The purpose of these analyses will be to determine whether childhood processing speed performance predicts (a) academic achievement in reading and mathematics performance at each follow-up assessment point and (b) trajectories of reading and mathematics performance from childhood through adulthood. I expect significant prediction effects such that childhood processing speed will have (a) a positive relation with reading performance in adolescence and adulthood, (b) mathematics performance in adolescence and adulthood, and (c) significant prediction effects on trajectories. Baseline executive functioning (ROCF copy condition) will be included as a covariate. Baseline WISC-III factor scores (i.e., VCF, POF, FDF) will also be included as covariates for analyses in which PSF is the main predictor variable.

# Method

## Participants

The current study will comprise secondary data analysis from 228 participants in a longitudinal investigation of females with and without ADHD, called the Berkeley Girls with ADHD Longitudinal Study (BGALS). This investigation appears to be the largest study of girls with ADHD, ascertained in childhood, worldwide. Participants were initially recruited from schools, pediatric practices, and the community to participate in summer enrichment programs. Participants were included in one of three groups: ADHD-C, ADHD-I, or comparison.

Inclusion criteria for the ADHD group required meeting sex-specific thresholds for the SNAP-IV as well as full DSM-IV criteria on the DISC-IV for either ADHD-C or ADHD-I. Inclusion criteria for the comparison group required not meeting DSM-IV criteria for ADHD based on either the SNAP-IV or the DISC-IV. Exclusion criteria for the comparison and ADHD groups included a WISC-III FSIQ less than 70, history of neurological damage, pervasive developmental disorder, psychosis, or presence of a medical condition preventing participation in the summer enrichment program (see Hinshaw, 2002, for details).

The original sample consisted of 228 girls (ADHD-C *n* = 93, ADHD-I *n* = 47, comparison *n* = 88). The ADHD and comparison samples were group-matched on age and ethnicity. Participants were between the ages of six and 12 years (*M* = 9.6, *SD* = 1.7). The sample was socioeconomically diverse, with family incomes ranging from public assistance to upper-middle class. The sample was also ethnically diverse (53% White, 27% African American, 11% Latina, 9% Asian American).

In addition to the original data collection (i.e., Wave 1), three follow-up studies were conducted (i.e., Waves 2, 3, and 4). At Wave 2 (i.e., five-year follow-up), 209 participants (92%) were assessed, between the ages of 11 and 18 years (*M* = 14.2). At Wave 3 (i.e., 10-year follow-up), 216 participants (95%) were assessed, were between the ages of 17 and 24 years (*M* = 19.6). At Wave 4, 211 participants (93%) were assessed, between the ages of 21 and 29 years (*M* = 25.6). The high retention rates reflect careful subject tracking, regular contacts with each participant and family, and the use of social media to follow some participants.

## Measures

### Diagnostic measures.

***Diagnostic Interview Schedule for Children – Parent version 4th Edition (DISC-IV; Shaffer, Fisher, Lucas, Dulvan, & Schwab-Stone, 2000).*** The DISC-IV is structured diagnostic instrument that was used in the original study for inclusion criteria for the ADHD-I and ADHD-C groups. The DISC-IV has demonstrated acceptable test-retest reliability (reliability coefficient for ADHD parent report = .79) (Shaffer et al., 2000). The ADHD section has also demonstrated acceptable internal consistency and concurrent validity (Rolon-Arroyo, Arnold, Harvey, & Marshall, 2016).

***Swanson, Nolan, and Pelham Teacher and Parent Rating Scale 4th Edition (SNAP-IV; Swanson, 1992).*** The SNAP-IV is an inventory used to measure ADHD symptoms in children and young adults. This measure includes a checklist of nine symptoms of ADHD-I and nine symptoms of ADHD-H based on the DSM-IV. The frequency of each symptom is rated on a dimensional 4-point scale from 0 (i.e., not at all) to 3 (i.e., very much). At Wave 1, the SNAP-IV was used for study inclusion. SNAP-IV parent ratings from Waves 1 through 3 will be used in the present study as outcome measures of ADHD symptoms. The fifth edition of the SNAP (SNAP-V) was administered at Wave 4 and was included in the present study as well. Scores are calculated both categorically for symptom count (i.e., presence or absence of symptoms, such that categorical symptom presence includes scores of 2 and 3 whereas absence includes scores of 0 and 1) and dimensionally for symptom severity (i.e., 4-point ratings). The SNAP-IV has demonstrated acceptable to excellent internal consistency, test-retest reliability, and validity (Swanson, 1992).

### Measures of processing speed.

***Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991).*** The WISC-III is a test of intellectual ability yielding a Full Scale IQ (FSIQ) from four factor scores: Verbal Comprehension Factor (VCF), Perceptual Organization Factor (POF), Freedom from Distractibility Factor (FDF), and Processing Speed Factor (PSF). Wave 1 FSIQ was used for study inclusion. Wave 1 PSF is used as a predictor variable. The PSF includes the core subtests of Coding and Symbol Search, which are also used as predictor variables separately. VCF, POF, and FDF scores are used as covariates for analyses in which PSF is a predictor variable.

***Relative weakness in processing speed.*** Relative weakness in processing speed occurs when an individual's processing speed performance is significantly lower than his or her performance in other cognitive abilities. Scores for this variable are determined using the ipsative approach described by Naglieri (1993). Following Naglieri's approach, the four WISC-III factor scores (VCF, POF, FDF, and PSF) are averaged and the PSF score is subtracted from the average factor score. The raw difference score (i.e., WISC-III average factor score minus WISC-III PSF score) will be compared to Naglieri's table of WISC-III factor difference scores required for significance (see Table 2 in Naglieri, 1993), and then each participant is grouped into an ordinal variable of three levels: (0) relative weakness, (1) neither relative weakness nor strength, (2) relative strength. Relative weakness in VCF, POF, and FDF is used as covariates for analyses in which relative weakness in PSF is a predictor variable.

***Rapid Automatized Naming Test (RAN; Denckla & Rudel, 1974).*** Respondents are presented with a sheet of paper with 50 repeated stimuli and are asked to vocally name those stimuli as quickly as possible. Two subtests of the RAN test used in the present study are RAN Objects and RAN Numbers. RAN Objects involves pictures of common items as stimuli (i.e., comb, umbrella, key, clock, and scissor). RAN Numbers includes digits as stimuli (i.e., digits 1 through 9). Both sets of stimuli represent learned information, requiring retrieval. The final performance variable used in the present study is an accuracy rate that incorporates both speed and accuracy. The accuracy rate is calculated by (1) summing the number of incorrect recognitions and the number of omissions, (2) subtracting that sum from the total number of stimuli, and (3) dividing that number by the completion time in seconds.

**Covariate.**

***Rey-Osterrieth Complex Figure Test (ROCF; Osterrieth, 1994).*** The ROCF is a task requiring an individual to copy and recall a complex figure and assesses multiple executive functions, including attention, planning, response inhibition, and organization. Because the copy condition of the ROCF was the only condition to differentiate the ADHD groups from the comparison group at Wave 1 (Sami, Carte, Hinshaw, & Zupan, 2003), it has been used as a primary measure of executive functioning in previous analyses of data from the same sample (Miller, Loya, & Hinshaw, 2013). Thus the ROCF copy condition is included as a covariate in analyses in the present study.

**Outcome measures.**

***Wechsler Individual Achievement Test (WIAT; Wechsler, 1992)***. The WIAT is a test of academic achievement. Specific scores from this test to be included in the present study are Basic Reading and Math Reasoning. Scores from Basic Reading and Math Reasoning from Waves 1 through 4 are used as outcome measures of academic achievement. The WIAT-I was used at Waves 1 and 2, and with some participants in Wave 3. The WIAT-II was used with some participants at Wave 3 and for all participants at Wave 4.

***Teacher's Report Form (TRF; Achenbach, 1991).*** The TRF is a questionnaire completed by teachers with various scales measuring student functioning. For the present study, the Academic Performance scale is used, with high scores reflecting good academic performance as rated by teachers. The TRF has demonstrated high test-retest reliability and good inter-rater reliability (Achenbach, 1991).

***Child Behavior Checklist (CBCL; Achenbach, 1991).*** The CBCL is a parent-report form measuring multiple areas of child functioning in mental health, social abilities, and educational problems. The School Problems scale is used in the present study. The CBCL has demonstrated excellent internal consistency, test-retest reliability, and validity (Achenbach, 1991).

***Highest education.*** Participant highest education level attained was collected via self-report at Wave 4 and cast into an ordinal variable with the following codes: (1) high school, (2) completed associate's level degree, (3) completed trade program or certificate program, (4) completed bachelor's level degree, (5) completed master's level degree or similar (i.e., two years post bachelor's degree education), and (6) completed doctoral level degree (i.e., at least three years post bachelor's degree education).

***Income.*** Participant monthly income was collected via self-report and included as a continuous variable in the present study.

## Procedure

At Wave 1, girls from the comparison and ADHD groups participated in summer enrichment programs. These were designed as day camps including classroom, art, drama, and outdoor activities. Classes of 25-26 girls (60% with ADHD, 40% comparison) were grouped by age and participated in activities together. Families of girls with a history of receiving stimulant medication were asked to have girls participate while unmedicated. Participants from Wave 1 were asked to participate in follow-up evaluations at Wave 2 (i.e., five-year follow-up), Wave 3 (i.e., 10-year follow-up), and Wave 4 (i.e., 16-year follow-up).

An extensive battery of neuropsychological testing was conducted at Wave 1 and key measures were repeated at follow-ups. Evaluations were performed while girls who were previously on medication were not receiving stimulant medication. Additionally, informant report measures were collected at Wave 1 and at follow-ups. Parents were asked to rate their daughters' behaviors off medication.

## Data Analytic Plan

All statistical analyses are conducted using SPSS 23 and STATA 13. In addition to analyzing descriptive statistics of the sample, a series of analyses is conducted to address each question. To determine collinearity of study variables, correlations are computed. To compare group differences in demographic, neuropsychological, ADHD symptomatology, academic achievement, and adult outcome variables, t-tests and Chi-square tests are used. Given that four measures of processing speed will be used to predict outcomes (i.e., WISC-III PSF, WISC-III PSF relative weakness, RAN Objects, and RAN Numbers), Bonferroni correction will be applied to control for familywise error and a p-value threshold of .0125 (i.e., desired alpha level of .05 divided by four predictors) will be used for post-hoc interpretation.

**Hypothesis 1: Girls with ADHD will show slower processing speed than matched comparison girls.** A series of ANOVAs were conducted to determine significance of group differences in processing speed performance at Wave 1. An ANOVA was conducted to determine group differences in processing speed. The independent variable is childhood diagnostic status (three levels: Comparison, ADHD-C, ADHD-I). The dependent variable is childhood processing speed; three separate analyses were conducted for different measures of childhood processing speed (i.e., WISC-III PSF, RAN Objects, and RAN Numbers). To determine specific group differences, planned comparisons following the Holm-Bonferroni method were conducted to compare (a) ADHD-I to comparison girls, (b) ADHD-C to comparison girls, and (c) ADHD-I to ADHD-C girls.

**Hypothesis 2: Girls with ADHD will show greater relative weakness in processing speed than matched comparison girls.** A Chi-square test was conducted to determine significance of association between childhood diagnostic status group (three levels: Comparison, ADHD-C, and ADHD-I) and childhood relative weakness in processing speed (categorical). Post-hoc testing via adjusted standardized residuals was conducted to compare (a) ADHD-I to comparison girls, (b) ADHD-C to comparison girls, and (c) ADHD-I to ADHD-C girls.

**Hypothesis 3: Processing speed performance will be associated with ADHD symptom dimensions.** A series of linear regression analyses was conducted to determine whether processing speed performance predicts ADHD symptomatology during childhood (i.e., Wave 1). The independent variable is processing speed performance; three separate analyses will be conducted for different measures of childhood processing speed (i.e., WISC-III PSF, RAN Objects, and RAN Numbers), plus an additional analysis for relative weakness in processing speed. The dependent variables are (a) inattentiveness symptom count, (b) inattentiveness symptom severity, (c) hyperactivity-impulsivity symptom count, and (d) hyperactivity-impulsivity symptom severity. To determine whether the relation between processing speed performance and ADHD symptomatology varies by diagnostic group, an additional step was added to the linear regression analyses to include diagnostic group by processing speed interaction terms.

**Hypothesis 4: Childhood processing speed performance will predict ADHD symptoms in adolescence and adulthood.** A series of linear regression analyses, similar to those in Hypothesis 3, was conducted to determine whether processing speed performance predicts ADHD symptomatology at each follow-up wave (i.e., Waves 2-4). Latent growth modeling was used to determine whether processing speed performance predicts different trajectories of ADHD symptomatology from childhood through adulthood. The independent variable was Wave 1 processing speed; three separate analyses were conducted for different measures of childhood processing speed (i.e., WISC-III PSF, RAN Objects, and RAN Numbers). The dependent variables were slopes of trajectories of Wave 1 through Wave 4 measures of (a) inattentiveness symptom severity and (d) hyperactivity-impulsivity symptom severity.

**Hypothesis 5: Processing speed performance will be associated with academic achievement.** A series of linear regression analyses was conducted to determine whether processing speed performance predicts academic achievement during childhood (i.e., Wave 1). The independent variable was processing speed performance, with separate analyses conducted for the three different measures of childhood processing speed (i.e., WISC-III PSF, RAN Objects, and RAN Numbers), along with relative weakness in processing speed. The dependent variables were (a) basic reading (WIAT Basic Reading) and (b) math reasoning (WIAT Math Reasoning). To determine whether the relation between processing speed performance and academic achievement varies by diagnostic group, an additional step was added to the linear regression analyses to include diagnostic group by processing speed interaction terms.

**Hypothesis 6: Childhood processing speed performance will predict academic achievement in adolescence and adulthood.** A series of linear regression analyses, similar to those in Hypothesis 5, were conducted to determine whether processing speed performance predicts academic achievement at each follow-up wave (i.e., Waves 2-4). Latent growth modeling was used to determine whether processing speed performance predicts different trajectories of academic achievement from childhood through adulthood. The independent variable was Wave 1 processing speed, with three separate analyses conducted for different measures of childhood processing speed (i.e., WISC-III PSF, RAN Objects, and RAN Numbers). The dependent variables were the slopes of trajectories of Wave 1 through Wave 4 measures of (a) basic reading (WIAT Basic Reading) and (b) math reasoning (WIAT Math Reasoning).

### Covariates

Executive function performance from the RCFT copy condition was used as a covariate in all linear regression analyses and latent growth curve modeling analyses. In analyses for which WISC-III PSF was used as a predictor variable, additional covariates included other WISC-III factor scores (i.e., VCF, POF, FDF). In analyses for which relative weakness in processing speed was used as a predictor variable, additional covariates included relative weakness in relative weakness in other WISC-III factors (i.e., VCF, POF, FDF). In analyses of dependent variables at follow-up time-points (i.e., Waves 2-4), baseline (i.e., Wave 1) values for the dependent variable were included as a covariate.

## Results

### Descriptive Statistics

**Sample demographic characteristics.** Tables 1a and 1b include sample demographic characteristics at Wave 1 (i.e., age, ethnicity, total gross annual household income, and maternal education). To determine whether there were significant differences between childhood diagnostic status groups, a series of t-tests were conducted. There were no significant differences in demographic factors between the comparison and ADHD groups. Similarly, there were no significant differences in demographic factors between the ADHD-C and ADHD-I subgroups. Chi-square tests of independence were performed to determine the relation between group/subgroup and ethnicity. This revealed a significant difference in ethnicity break-up between the ADHD and Comparison groups with a higher proportion of Asian American girls in the Comparison group than in the ADHD group (Table 1a).

**Processing speed predictors.** Group comparisons demonstrated significant differences between the Comparison and ADHD groups in most measures of processing speed; however, significant group differences did not exist for RAN Numbers. Group comparisons did not demonstrate significant differences between the ADHD-C and ADHD-I groups.

**Executive functioning.** Group comparisons demonstrated significant differences between the Comparison and ADHD groups in Wave 1 ROCF. Group comparisons also demonstrated significant differences between the ADHD-C and ADHD-I groups.

**ADHD symptoms.** Group comparisons demonstrated significant differences between the Comparison and ADHD groups in all measures of SNAP inattentiveness and hyperactivity-impulsivity at each wave. Group comparisons demonstrated significant differences between the ADHD-C groups and the ADHD-I groups in measures of SNAP hyperactivity-impulsivity at each wave, but significant group differences were not found for inattentiveness.

**Reading and mathematics.** Group comparisons demonstrated significant differences between the Comparison and ADHD groups in all measures of WIAT Basic Reading and Math Reasoning at each wave. Group comparisons did not demonstrate significant differences between the ADHD-C and ADHD-I groups.

**Academic problems.** Group comparisons demonstrated significant differences between the Comparison and ADHD groups in all measures of academic problems (i.e., Wave 1 TRF, Wave 2 TRF, Wave 2 CBCL) at each wave. Group comparisons demonstrated significant differences between the ADHD-C groups and the ADHD-I groups in Wave 1 TRF such that teachers reported poorer academic performance for girls in the ADHD-I group than in the ADHD-C group. No other group differences were found between ADHD-C and ADHD-I groups.

**Educational attainment and occupational earnings.** Group comparisons demonstrated significant differences between the Comparison and ADHD groups in Wave 4 monthly earnings such that participants with a childhood diagnosis of ADHD made significantly less monthly income ($M$ = $1447.46) than their counterparts in the Comparison group ($M$ = $2087.68). Group comparisons also demonstrated significant differences between the Comparison and ADHD groups in Wave 4 highest level of education attained such that participants with a childhood diagnosis of ADHD completed significantly less education than their counterparts in the Comparison group. Group comparisons did not demonstrate significant differences between the ADHD-C and ADHD-I groups.

Tables 2 through 5 provide primary variable means and group differences.

**Collinearity**

Table 6 provides correlations between primary study variables.

**WISC-III PSF subtests.** To determine the extent to which WISC-III Coding and WISC-III Symbol Search scores were associated with each other, a Pearson correlation analysis was performed. Scores from all participants in the study were included in this analysis. Coding and Symbol Search subtest scores were significantly and positively correlated, $r = .53$, $p < .001$.

**RAN Subtests.** To determine the extent to which RAN Objects and RAN Numbers scores were associated with each other, a Pearson correlation analysis was performed. Scores from all participants in the study were included in this analysis. RAN Objects and RAN Numbers scores were significantly and positively correlated, $r = .70$, $p < .001$.

**RAN and WISC-III PSF.** A Pearson correlation was performed to determine the extent to which RAN Objects and RAN Numbers scores were associated with WISC-III PSF. Scores from all participants in the study were included in this analysis. WISC-III PSF was not significantly correlated with either RAN Objects ($r = .08$) or RAN Numbers ($r = .07$) (Table 6).

**Parent and teacher ratings of ADHD symptoms.** At Wave 1, there was a significant correlation between parent and teacher ratings of the SNAP for inattentive symptom count ($r = .76$) and severity ($r = .79$) as well as hyperactive/impulsive symptom count ($r = .61$) and severity ($r = .66$) (Table 7a). A similar pattern of results was found for Wave 2 (Table 7b).

**Processing speed and ADHD symptoms.** To determine the extent to which processing speed and symptoms of ADHD were associated with each other, a series of Pearson correlation analyses were performed. Scores from all participants in the study were included in this analyses. Wave 1 WISC-III PSF was significantly and negatively correlated with each of the nine inattentive symptoms as measured by the SNAP (i.e., mean of parent and teacher ratings at Wave 1) (Table 8). Wave 1 WISC-III PSF was significantly and negatively correlated with three of the hyperactive/impulsive symptoms (i.e., #10 fidgeting, #11 leaving seat, #18 interrupting or intruding on others) as measured by the SNAP (i.e., mean of parent and teacher ratings at Wave 1) (Table 8).

**Relative weakness in processing speed and ADHD symptoms.** To determine the extent to which relative weakness in processing speed and symptoms of ADHD were associated with each other, a series of Pearson correlation analyses was performed. Scores from all participants in the study were included in this analysis. Wave 1 relative weakness in processing speed (continuous) was not significantly correlated with any of the inattentive symptoms as measured by the SNAP (i.e., mean of parent and teacher ratings at Wave 1) (Table 9). Wave 1 relative weakness in processing speed (continuous) was significantly and positively correlated with three of the hyperactive/impulsive symptoms (i.e., #12 running or climbing excessively, #13 difficulty playing quietly, #14 always “on the go”) as measured by the SNAP (i.e., mean of parent and teacher ratings at Wave 1) (Table 9).

## Group Differences in Predictors

**WISC-III PSF.** To determine whether there was a significant difference in WISC-III PSF between participant subgroups (three levels: Comparison, ADHD-I, ADHD-C) at Wave 1, an analysis of variance was performed. WISC-III PSF was significantly different between participant subgroups, $F(2, 222) = 7.75$, $p = .001$, $\eta 2 = .07$. Post hoc analyses using Bonferroni pairwise comparisons revealed significant pairwise differences between Comparison and ADHD-C subgroup participants ($p = .002$) and Comparison and ADHD-I subgroup participants ($p = .005$), but not between ADHD-I and ADHD-C subgroup participants.

**WISC-III Coding.** To determine whether there was a significant difference in WISC-III Coding subtest scores between participant subgroups (Comparison, ADHD-I, ADHD-C) at Wave 1, an analysis of variance was performed. WISC-III Coding was significantly different between participant subgroups, $F(2, 225) = 6.69$, $p = .002$, $\eta 2 = .06$. Post hoc analyses using Bonferroni pairwise comparisons revealed significant pairwise differences between Comparison and ADHD-C subgroup participants ($p = .007$) and Comparison and ADHD-I subgroup participants ($p = .007$), but not between ADHD-I and ADHD-C subgroup participants.

**WISC-III Symbol Search.** To determine whether there was a significant difference in WISC-III Symbol Search subtest scores between participant subgroups (Comparison, ADHD-I, ADHD-C) at Wave 1, an analysis of variance was performed. WISC-III Symbol Search was significantly different between participant subgroups, $F(2, 222) = 5.24$, $p = .006$, $\eta 2 = .05$. Post hoc analyses using Bonferroni pairwise comparisons revealed significant pairwise differences between Comparison and ADHD-C subgroup participants ($p = .013$) and Comparison and ADHD-I subgroup participants ($p = .034$), but not between ADHD-I and ADHD-C subgroup participants.

**Relative weakness in processing speed.** To determine whether there was a significant difference in WISC-III PSF relative weakness between participant subgroups (Comparison, ADHD-I, ADHD-C) at Wave 1, an analysis of variance was performed. WISC-III PSF relative weakness was not significantly different between participant subgroups, $\eta 2 = .01$.

**RAN Objects.** To determine whether there was a significant difference in Wave 1 RAN Objects accuracy rate between participant subgroups (three levels: Comparison, ADHD-I, ADHD-C), an analysis of variance was performed. Wave 1 RAN Objects was significantly different between participant subgroups, $F(2, 217) = 6.41$, $p = .002$, $\eta 2 = .06$. Post hoc analyses using Bonferroni pairwise comparisons revealed significant pairwise differences between Comparison and ADHD-C subgroup participants, $p = .001$. There were no significant differences when comparing Comparison and ADHD-I groups or ADHD-C and ADHD-I groups.

**RAN Numbers.** To determine whether there was a significant difference in Wave 1 RAN Numbers accuracy rate time between participant subgroups (three levels: Comparison, ADHD-I, ADHD-C), an analysis of variance was performed. Wave 1 RAN Numbers was not significantly different between participant subgroups, $\eta 2 = .02$.

## Processing Speed as a Predictor of Outcomes

**ADHD symptoms.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 WISC-III PSF) predicted symptom severity or symptom count for inattentiveness or hyperactivity-impulsivity (SNAP parent ratings) throughout childhood, adolescence, and young adulthood (Waves 1-4). Covariates included Wave 1 VCF, POF, FDF, and ROCF scores. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Wave 1 PSF marginally significantly predicted Wave 1 inattentiveness symptom severity such that higher Wave 1 PSF predicted lower Wave 1 inattentiveness symptom severity (Table 10). ADHD Group marginally significantly moderated the relation between Wave 1 PSF and Wave 1 inattentiveness symptom severity, such that Wave 1 PSF was positively associated with Wave 1 inattentiveness symptom severity for participants in the Comparison group whereas Wave 1 PSF was negatively associated with Wave 1 inattentiveness symptom severity for participants in the ADHD group (Figure 1). (2) ADHD Group marginally significantly moderated the relation between Wave 1 PSF and Wave 1 inattentiveness symptom count, such that Wave 1 PSF was positively associated with Wave 1 inattentiveness symptom count for participants in the Comparison group whereas Wave 1 PSF was negatively associated with Wave 1 inattentiveness symptom count for participants in the ADHD group (Figure 2; Table 11). (3) Group approached significantly moderating the relation between Wave 1 PSF and Wave 3 inattentiveness symptom count, such that Wave 1 PSF was negatively associated with Wave 3 inattentiveness symptom count for participants in the Comparison group whereas Wave 1 PSF was positively associated with Wave 3 inattentiveness symptom count for participants in the ADHD group (Figure 3; Table 11). No other associations (i.e., prediction or moderation) were significant.

**Reading and mathematics.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 WISC-III PSF) predicted academic achievement in reading or math (WIAT Basic Reading, Math Reasoning) throughout childhood, adolescence, and young adulthood (Waves 1-4). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. Wave 1 WISC-III PSF approached significantly predicting WIAT Math Reasoning scores at Wave 1 and significantly predicted performance at Waves 2-4. Significance was not found for basic reading across the four waves. Group was not a significant moderator of the predictive effects. (1) Wave 1 PSF approached significantly predicting Wave 1 math reasoning performance such that Wave 1 PSF predicted higher Wave 1 math reasoning performance (Table 12). (2) Wave 1 PSF significantly predicted Wave 2 math reasoning performance Wave 1 PSF predicted higher Wave 2 math reasoning performance and survived familywise error correction (Table 12). (3) Wave 1 PSF significantly predicted Wave 3 math reasoning performance such that 1 PSF predicted higher Wave 3 math reasoning performance and survived familywise error correction (Table 12). (4) Wave 1 PSF significantly predicted Wave 4 math reasoning performance such that Wave 1 PSF predicted higher Wave 4 math reasoning performance and survived familywise error correction (Table 12). No other associations (i.e., prediction or moderation) were significant.

**Academic problems.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 WISC-III PSF) predicted parent or teacher ratings of academic performance (Wave 1 TRF Academic, Wave 2 TRF Academic, Wave 2 CBCL School Scale). Covariates included Wave 1 VCF, POF, FDF, and ROCF scores. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Wave 2). Group (two levels: Comparison, ADHD) was included as a moderator. Group significantly moderated the relation between Wave 1 PSF and Wave 2 teacher report of academic performance, such that Wave 1 PSF was positively associated with Wave 2 teacher report of academic performance for participants in the Comparison group whereas Wave 1 PSF was negatively associated with Wave 2 teacher report of academic performance for participants in the ADHD group and survived familywise error correction (Figure 4; Table 13). No other associations (i.e., main effect or moderation) were significant.

**Educational attainment and occupational earnings.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 WISC-III PSF) predicted educational or occupational outcomes in young adulthood (Wave 4 highest level of education or Wave 4 work earnings). Covariates included Wave 1 VCF, POF, FDF, and ROCF scores. Group (two levels: Comparison, ADHD) was included as a moderator. Group approached significantly moderating the relation between Wave 1 PSF and Wave 4 monthly earnings such that Wave 1 PSF was negatively associated with Wave 4 monthly earnings for participants in the Comparison group whereas Wave 1 PSF was positively associated with Wave 4 monthly earnings for participants in the ADHD group (Figure 5; Table 14). No other associations (i.e., prediction or moderation) were significant.

**Processing Speed as a Predictor of Outcome Trajectories**

**Inattentiveness.** Latent growth curve modeling was conducted to determine the extent to which processing speed (PSF) predicted trajectories of inattentiveness symptom severity from childhood through adulthood (Waves 1-4). Childhood diagnostic status (two levels: Comparison or ADHD) was a significant predictor of inattentiveness symptom severity ($p < .001$), such that participants in the ADHD group had higher intercepts for inattentiveness symptom severity by 17.24 units (i.e., higher symptom severity) than their counterparts in the Comparison group. The estimated slope for the trajectory of inattentiveness symptom severity decreased from childhood through young adulthood. Figures 6a, 6b, 7a, and 7b show inattentiveness across time based on childhood diagnostic status. Childhood diagnostic status was a significant predictor of slope ($p < .001$) such that participants in the ADHD group demonstrated significantly steeper slopes (i.e., steeper decreases) in inattentiveness symptom severity over time (B = -3.34) than their counterparts in the Comparison group (B = -.15). Processing speed was not a significant predictor of the slopes of inattentiveness symptom severity trajectories when coavarying group, ROCF, VCF, POF, and FDF; however, a one-unit increase in processing speed resulted in a .01 unit increase in inattentiveness symptom severity.

**Hyperactivity-impulsivity.** Latent growth curve modeling was conducted to determine the extent to which processing speed (PSF) predicted trajectories of hyperactivity-impulsivity symptom severity from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of hyperactivity-impulsivity symptom severity ($p < .001$), such that participants in the ADHD group had higher intercepts for hyperactivity-impulsivity symptom severity by 12.26 units (i.e., higher symptom severity) than their counterparts in the Comparison group. The estimated slope for the trajectory of hyperactivity-impulsivity symptom severity decreased from childhood through young adulthood. Figures 8a, 8b, 9a, and 9b show hyperactivity-impulsivity across time based on childhood diagnostic status. Childhood diagnostic status was a significant predictor of slope ($p < .001$) such that participants in the ADHD group demonstrated significantly steeper slopes (i.e., steeper decreases) in hyperactivity-impulsivity symptom severity over time (B = -3.16) than their counterparts in the Comparison group (B = -.3). Processing speed was not a significant predictor of the slopes of hyperactivity-impulsivity symptom severity trajectories when covarying group, ROCF, VCF, POF, and FDF; however, a one unit increase in processing speed resulted in a .01 unit decrease in hyperactivity-impulsivity symptom severity.

**Reading.** Latent growth curve modeling was conducted to determine the extent to which processing speed (PSF) predicted trajectories of basic reading from childhood through adulthood (Waves 1-4). Childhood diagnostic status was not a significant predictor of basic reading intercepts; however, participants in the ADHD group had lower intercepts for basic reading by 1.44 units (i.e., poorer performance) than their counterparts in the Comparison group. The estimated slope for the trajectory of basic reading decreased from childhood through young adulthood. Figures 10a and 10b show basic reading performance across time based on childhood diagnostic status. Childhood diagnostic status was not a significant predictor of slopes. Processing speed was not a significant predictor of the slopes of basic reading trajectories when covarying group, ROCF, VCF, POF, and FDF; however, a one unit increase in processing speed resulted in a .02 unit decrease in basic reading.

**Mathematics.** Latent growth curve modeling was attempted to determine the extent to which processing speed (PSF) predicted trajectories of math reasoning from childhood through adulthood (Waves 1-4). Results could not be garnered because the model failed to reach convergence. Figures 11a and 11b show inattentiveness across time based on childhood diagnostic status.

## Relative Weakness in Processing Speed as a Predictor of Outcomes

**ADHD symptoms.** A series of linear regression analyses was performed to determine whether childhood relative weakness in processing speed (Wave 1 WISC-III PSF relative weakness) predicted symptom severity or symptom count for inattentiveness or hyperactivity-impulsivity (SNAP parent ratings) throughout childhood, adolescence, and young adulthood (Waves 1-4). Covariates included Wave 1 VCF relative weakness, POF relative weakness, FDF relative weakness, and ROCF scores. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Group significantly moderated the relation between Wave 1 PSF relative weakness and Wave 1 inattentiveness symptom severity such that Wave 1 PSF relative weakness was positively associated with Wave 1 inattentiveness symptom severity for participants in the Comparison group whereas Wave 1 PSF relative weakness was negatively associated with Wave 1 inattentiveness symptom severity for participants in the ADHD group, but did not survive familywise error correction (Figure 12; Table 15). (2) Group significantly moderated the relation between Wave 1 PSF relative weakness and Wave 1 inattentiveness symptom count such that Wave 1 PSF relative weakness was positively associated with Wave 1 inattentiveness symptom count for participants in the Comparison group whereas Wave 1 PSF relative weakness was negatively associated with Wave 1 inattentiveness symptom count for participants in the ADHD group, but did not survive familywise error correction (Figure 13; Table 16). No other associations (i.e., prediction or moderation) were significant.

**Reading and mathematics.** A series of linear regression analyses was performed to determine whether childhood relative weakness in processing speed (Wave 1 WISC-III PSF relative weakness) predicted academic achievement in reading or math (WIAT Basic Reading, Math Reasoning) throughout childhood, adolescence, and young adulthood (Waves 1-4). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Group approached significantly moderating the relation between Wave 1 PSF relative weakness and Wave 3 basic reading performance such that Wave 1 PSF relative weakness was positively associated with Wave 3 basic reading performance for participants in the Comparison group whereas Wave 1 PSF relative weakness was negatively associated with Wave 3 basic reading performance for participants in the ADHD group (Figure 14; Table 17). (2) Wave 1 PSF relative weakness significantly predicted Wave 2 math reasoning performance such that Wave 1 PSF relative weakness predicted higher Wave 2 math reasoning performance and survived familywise error correction (Table 18). (3) Wave 1 PSF relative weakness significantly predicted Wave 3 math reasoning performance such that Wave 1 PSF relative weakness predicted higher Wave 3 math reasoning performance and survived familywise error correction (Table 18). (4) Wave 1 PSF relative weakness significantly predicted Wave 4 math reasoning performance such that Wave 1 PSF relative weakness predicted higher Wave 4 math reasoning performance but did not survive familywise error correction (Table 18). No other associations (i.e., prediction or moderation) were significant.

**Academic problems.** A series of linear regression analyses was performed to determine whether childhood processing speed relative weakness (Wave 1 WISC-III PSF relative weakness) predicted parent or teacher ratings of academic performance (Wave 1 TRF Academic, Wave 2 TRF Academic, Wave 2 CBCL School Scale). Covariates included Wave 1 VCF relative weakness, POF relative weakness, FDF relative weakness, and ROCF scores. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Wave 2). Group (two levels: Comparison, ADHD) was included as a moderator. Wave 1 PSF relative weakness approached significantly predicting Wave 2 teacher report of academic performance such that as Wave 1 PSF relative weakness predicted worse Wave 2 teacher report of academic performance. Group significantly moderated the relation between Wave 1 PSF relative weakness and Wave 2 teacher report of academic performance such that Wave 1 PSF relative weakness was positively associated with Wave 2 teacher report of academic performance for participants in the Comparison group whereas Wave 1 PSF relative weakness was negatively associated with Wave 2 teacher report of academic performance for participants in the ADHD group but did not survive familywise error correction (Figure 15; Table 19). No other associations (i.e., prediction or moderation) were significant.

**Educational attainment and occupational earnings.** A series of linear regression analyses was performed to determine whether childhood processing speed relative weakness (Wave 1 WISC-III PSF relative weakness) predicted educational or occupational outcomes in young adulthood (Wave 4 highest level of education or Wave 4 work earnings). Covariates included Wave 1 VCF relative weakness, POF relative weakness, FDF relative weakness, and ROCF scores. Group (two levels: Comparison, ADHD) was included as a moderator. No associations (i.e., prediction or moderation) were significant.

## RAN Objects as a Predictor of Outcomes

**ADHD symptoms.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Objects) predicted symptom severity or symptom count for inattentiveness or hyperactivity-impulsivity (SNAP parent ratings) throughout childhood, adolescence, and young adulthood (Waves 1-4). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Wave 1 RAN Objects significantly predicted Wave 1 inattentiveness symptom severity such that Wave 1 RAN Objects predicted higher Wave 1 inattentiveness symptom severity but did not survive familywise error correction (Table 20). (2) Wave 1 RAN Objects approached significantly predicting Wave 3 inattentiveness symptom severity such that Wave 1 RAN Objects predicted higher Wave 3 inattentiveness symptom severity (Table 20). (3) Wave 1 RAN Objects approached significantly predicting Wave 1 inattentiveness symptom count such that Wave 1 RAN Objects predicted higher Wave 1 inattentiveness symptom count (Table 21). (4) Wave 1 RAN Objects significantly predicted Wave 3 hyperactivity-impulsivity symptom severity such that Wave 1 RAN Objects predicted higher Wave 3 hyperactivity-impulsivity symptom severity and survived familywise error correction (Table 22). (5) Wave 1 RAN Objects significantly predicted Wave 3 hyperactivity-impulsivity symptom count such that Wave 1 RAN Objects predicted higher Wave 3 hyperactivity-impulsivity symptom count and survived familywise error correction (Table 23). No other associations (i.e., prediction or moderation) were significant.

**Reading and mathematics.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Objects) predicted academic achievement in reading or math (WIAT Basic Reading, Math Reasoning) throughout childhood, adolescence, and young adulthood (Waves 1-4). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Wave 1 RAN Objects significantly predicted Wave 1 basic reading performance such that Wave 1 RAN Objects predicted better Wave 1 basic reading performance but did not survive familywise error correction (Table 24). (2) Wave 1 RAN Objects approached significantly predicting Wave 3 basic reading performance such that Wave 1 RAN Objects predicted better Wave 3 basic reading performance. (3) Wave 1 RAN Objects significantly predicted Wave 4 basic reading performance such that Wave 1 RAN Objects predicted better Wave 4 basic reading performance. Group approached significantly moderating the relationship between Wave 1 RAN Objects and Wave 4 basic reading performance such that Wave 1 RAN Objects was negatively associated with Wave 4 basic reading performance for participants in the Comparison group whereas Wave 1 RAN Objects was positively associated with Wave 4 basic reading performance for participants in the ADHD group (Figure 16; Table 24). No other associations (i.e., prediction or moderation) were significant.

**Academic problems.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Objects) predicted parent or teacher ratings of academic performance (Wave 1 TRF Academic, Wave 2 TRF Academic, Wave 2 CBCL School Scale). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Wave 2). Group (two levels: Comparison, ADHD) was included as a moderator. Wave 1 RAN Objects significantly predicted Wave 1 teacher report of academic performance such that Wave 1 RAN Objects predicted better Wave 1 teacher report of academic performance increased and survived familywise error correction (Table 25). No other associations (i.e., prediction or moderation) were significant.

**Educational attainment and occupational earnings.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Objects) predicted educational or occupational outcomes in young adulthood (Wave 4 highest level of education or Wave 4 work earnings). ROCF was included as a covariate. Group (two levels: Comparison, ADHD) was included as a moderator. No associations (i.e., prediction or moderation) were significant.

## RAN Objects as a Predictor of Outcome Trajectories

**Inattentiveness.** Latent growth curve modeling was conducted to determine the extent to which RAN Objects predicted trajectories of inattentiveness symptom severity from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of inattentiveness symptom severity ($p < .001$), such that participants in the ADHD group had higher intercepts for inattentiveness symptom severity by 17.29 units (i.e., higher symptom severity) than their counterparts in the Comparison group. The estimated slope for the trajectory of inattentiveness symptom severity decreased from childhood through young adulthood. Childhood diagnostic status was a significant predictor of slope ($p < .001$) such that participants in the ADHD group demonstrated significantly steeper slopes (i.e., steeper decreases) in inattentiveness symptom severity over time (B = -2.64) than their counterparts in the Comparison group (B = -.17). RAN Objects was not a significant predictor of the slopes of inattentiveness symptom severity trajectories when controlling for group and ROCF; however, a one unit increase in RAN Objects resulted in a .55 unit decrease in inattentiveness symptom severity.

**Hyperactivity-impulsivity.** Latent growth curve modeling was conducted to determine the extent to which RAN Objects predicted trajectories of hyperactivity-impulsivity symptom severity from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of hyperactivity-impulsivity symptom severity ($p < .001$), such that participants in the ADHD group had higher intercepts for hyperactivity-impulsivity symptom severity by 11.49 units (i.e., higher symptom severity) than their counterparts in the Comparison group. The estimated slope for the trajectory of hyperactivity-impulsivity symptom severity decreased from childhood through young adulthood. Childhood diagnostic status was a significant predictor of slope ($p < .001$) such that participants in the ADHD group demonstrated significantly steeper slopes (i.e., steeper decreases) in hyperactivity-impulsivity symptom severity over time (B = -3.06) than their counterparts in the Comparison group (B = -.49). RAN Objects was not a significant predictor of the slopes of hyperactivity-impulsivity symptom severity trajectories when controlling for group and ROCF; however, a one unit increase in RAN Objects resulted in a .60 unit increase in hyperactivity-impulsivity symptom severity.

**Reading.** Latent growth curve modeling was conducted to determine the extent to which RAN Objects predicted trajectories of basic reading from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of basic reading ($p < .001$), such that participants in the ADHD group had lower intercepts for basic reading by 8.10 units (i.e., poorer performance) than their counterparts in the Comparison group. The estimated slope for the trajectory of basic reading decreased from childhood through young adulthood. Childhood diagnostic status was not a significant predictor of slopes. RAN Objects was not a significant predictor of the slopes of basic reading trajectories when controlling for group and ROCF; however, a one unit increase in RAN Objects resulted in a 1.16 unit increase in basic reading.

**Mathematics.** Latent growth curve modeling was conducted to determine the extent to which RAN Objects predicted trajectories of math reasoning from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of math reasoning ($p < .001$), such that participants in the ADHD group had lower intercepts for math reasoning by 11.64 units (i.e., poorer performance) than their counterparts in the Comparison group. The estimated slope for the trajectory of math reasoning decreased from childhood through young adulthood. Childhood diagnostic status was not a significant predictor of slopes. RAN Objects was not a significant predictor of the slopes of math reasoning trajectories when controlling for group and ROCF; however, a one unit increase in RAN Objects resulted in a .43 unit increase in math reasoning.

**RAN Numbers as a Predictor of Outcomes**

**ADHD symptoms.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Numbers) predicted symptom severity or symptom count for inattentiveness or hyperactivity-impulsivity (SNAP parent ratings) throughout childhood, adolescence, and young adulthood (Waves 1-4). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Wave 1 RAN Numbers significantly predicted Wave 3 inattentiveness symptom severity such that Wave 1 RAN Numbers predicted higher Wave 3 inattentiveness symptom severity (Table 26). (2) Wave 1 RAN Numbers approached significantly predicting Wave 3 inattentiveness symptom count such that Wave 1 RAN Numbers predicted higher Wave 3 inattentiveness symptom count (Table 27). (3) Wave 1 RAN Numbers significantly predicted Wave 3 hyperactivity-impulsivity symptom severity such that Wave 1 RAN Numbers predicted greater Wave 3 hyperactivity-impulsivity symptom severity. Group significantly moderated the relationship between Wave 1 RAN Numbers and Wave 3 hyperactivity-impulsivity symptom severity such that Wave 1 RAN Numbers was less positively associated with Wave 3 hyperactivity-impulsivity symptom severity for participants in the Comparison group than for participants in the ADHD group (Figure 17; Table 28). (4) Wave 1 RAN Numbers significantly predicted Wave 3 hyperactivity-impulsivity symptom count such that Wave 1 RAN Numbers predicted higher Wave 3 hyperactivity-impulsivity symptom count increased. Group significantly moderated the relationship between Wave 1 RAN Numbers and Wave 3 hyperactivity-impulsivity symptom count such that Wave 1 RAN Numbers was less positively associated with Wave 3 hyperactivity-impulsivity symptom count for participants in the Comparison group than for participants in the ADHD group (Figure 18; Table 29). No other associations (i.e., prediction or moderation) were significant.

**Reading and mathematics.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Numbers) predicted academic achievement in reading or math (WIAT Basic Reading, Math Reasoning) throughout childhood, adolescence, and young adulthood (Waves 1-4). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Waves 2-4). Group (two levels: Comparison, ADHD) was included as a moderator. (1) Wave 1 RAN Numbers significantly predicted Wave 1 basic reading performance such that Wave 1 RAN Numbers predicted better Wave 1 basic reading performance and survived familywise error correction (Table 30). (2) Wave 1 RAN Numbers approached significantly predicting Wave 3 basic reading performance such that Wave 1 RAN Numbers predicted better Wave 3 basic reading performance (Table 30). (3) Wave 1 RAN Numbers significantly predicted Wave 4 basic reading performance such that Wave 1 RAN Numbers predicted better Wave 4 basic reading performance. Group significantly moderated the relation between Wave 1 RAN Numbers and Wave 4 basic reading performance such that Wave 1 RAN Numbers was negatively associated with Wave 4 basic reading performance for participants in the Comparison group whereas Wave 1 RAN Numbers was positively associated with Wave 4 basic reading performance for participants in the ADHD group, but did not survive familywise error correction (Figure 19; Table 30). (4) Wave 1 RAN Numbers significantly predicted Wave 4 math reasoning performance such that Wave 1 RAN Numbers predicted better Wave 4 math reasoning performance but did not survive familywise error correction (Table 31). No other associations (i.e., prediction or moderation) were significant.

**Academic problems.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Numbers) predicted parent or teacher ratings of academic performance (Wave 1 TRF Academic, Wave 2 TRF Academic, Wave 2 CBCL School Scale). ROCF was included as a covariate. Wave 1 values for the dependent variable were included as covariates for analyses for follow-up time-points (Wave 2). Group (two levels: Comparison, ADHD) was included as a moderator. Wave 1 RAN Numbers significantly predicted Wave 1 teacher report of academic performance such that Wave 1 RAN Numbers predicted lower Wave 1 teacher report of academic performance (Table 32). No other associations (i.e., prediction or moderation) were significant.

**Educational attainment and occupational earnings.** A series of linear regression analyses was performed to determine whether childhood processing speed (Wave 1 RAN Numbers) predicted educational or occupational outcomes in young adulthood (Wave 4 highest level of education or Wave 4 work earnings). ROCF was included as a covariate. Group (two levels: Comparison, ADHD) was included as a moderator. Wave 1 RAN Numbers approached significantly predicting Wave 4 highest education attained such that Wave 1 RAN Numbers predicted better Wave 4 highest education attained. Group approached significantly moderating the relationship between Wave 1 RAN Numbers and Wave 4 highest education attained such that Wave 1 RAN Numbers was more positively associated with Wave 4 highest education attained for participants in the Comparison group than for participants in the ADHD group and survived familywise error correction (Figure 20; Table 33). No other associations (i.e., prediction or moderation) were significant.

**RAN Numbers as a Predictor of Outcome Trajectories**

**Inattentiveness.** Latent growth curve modeling was conducted to determine the extent to which RAN Numbers predicted trajectories of inattentiveness symptom severity from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of inattentiveness symptom severity ($p < .001$), such that participants in the ADHD group had higher intercepts for inattentiveness symptom severity by 17.16 units (i.e., higher symptom severity) than their counterparts in the Comparison group. The estimated slope for the trajectory of inattentiveness symptom severity decreased from childhood through young adulthood. Childhood diagnostic status was a significant predictor of slope ($p < .001$) such that participants in the ADHD group demonstrated significantly steeper slopes (i.e., steeper decreases) in inattentiveness symptom severity over time (B = -3.33) than their counterparts in the Comparison group (B = -.19). RAN Numbers was not a significant predictor of the slopes of inattentiveness symptom severity trajectories when covarying group and ROCF; however, a one unit increase in RAN Numbers resulted in a .16 unit increase in inattentiveness symptom severity.

**Hyperactivity-impulsivity.** Latent growth curve modeling was conducted to determine the extent to which RAN Numbers predicted trajectories of hyperactivity-impulsivity symptom severity from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of hyperactivity-impulsivity symptom severity ($p < .001$), such that participants in the ADHD group had higher intercepts for hyperactivity-impulsivity symptom severity by 11.49 units (i.e., higher symptom severity) than their counterparts in the Comparison group. Childhood diagnostic status was a significant predictor of slope ($p < .001$) such that participants in the ADHD group demonstrated significantly steeper slopes (i.e., steeper decreases) in hyperactivity-impulsivity symptom severity over time (B = -3.07) than their counterparts in the Comparison group (B = -.48). RAN Numbers was not a significant predictor of the slopes of hyperactivity-impulsivity symptom severity trajectories when covarying group and ROCF; however, a one unit increase in RAN Numbers resulted in a .24 unit increase in hyperactivity-impulsivity symptom severity.

**Reading.** Latent growth curve modeling was conducted to determine the extent to which RAN Numbers predicted trajectories of basic reading from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of basic reading ($p < .001$), such that participants in the ADHD group had lower intercepts for basic reading by 8.45 units (i.e., poorer performance) than their counterparts in the Comparison group. The estimated slope for the trajectory of basic reading decreased from childhood through young adulthood. Childhood diagnostic status was not a significant predictor of slopes. RAN Numbers was not a significant predictor of the slopes of basic reading trajectories when covarying for group and ROCF; however, a one unit increase in RAN Numbers resulted in a .52 unit increase in basic reading.

**Mathematics.** Latent growth curve modeling was conducted to determine the extent to which RAN Numbers predicted trajectories of math reasoning from childhood through adulthood (Waves 1-4). Childhood diagnostic status was a significant predictor of math reasoning ($p < .001$), such that participants in the ADHD group had lower intercepts for math reasoning by 11.71 units (i.e., poorer performance) than their counterparts in the Comparison group. The estimated slope for the trajectory of math reasoning decreased from childhood through young adulthood. Childhood diagnostic status was not a significant predictor of slopes. Rapid automatized naming was not a significant predictor of the slopes of math reasoning trajectories when covarying group and ROCF; however, a one unit increase in rapid automatized naming resulted in a .65 unit increase in math reasoning.

## Discussion

The purpose of the present investigation was to examine (1) processing speed differences between ADHD presentations, (2) the relation between processing speed and ADHD symptom patterns, (3) the relation between processing speed and academic achievement, and (4) adult educational and occupational outcomes in a sample of girls with ADHD and their typically developing counterparts. Data from four waves across childhood, adolescence, and adulthood were used to study these relations both concurrently and longitudinally.

### Group Differences in Processing Speed

In the present study, WISC-III PSF was considered the primary measure of processing speed given its inclusion of unlearned, novel stimuli and widespread clinical use. RAN Objects and RAN Numbers were included as secondary measures of processing speed. Given the lack of strong correlation between WISC-III PSF and RAN performance found in the present study, it is likely that the two do not measure the same underlying construct. First, WISC-III PSF performance is dependent on motor speed, whereas RAN performance requires verbalization. Second, WISC-III PSF performance involves the processing of novel stimuli, whereas RAN performance involves processing of learned stimuli and thus is dependent upon information retrieval. Indeed, as evidenced by the study's findings, inattentiveness is associated with WISC-III PSF performance and not RAN performance. Given that WISC-III PSF performance was associated with inattentiveness and RAN performance was associated with basic reading performance, it may be warranted for clinicians to use each as a performance-based screener for ADHD and reading disorder, respectively.

As expected, girls with ADHD had significantly slower processing speed than girls in the Comparison group. This pattern was demonstrated through the main factor score for processing speed (WISC-III PSF) as well as the two individual subtests comprising this factor: Coding and Symbol Search.

Surprisingly, girls with the inattentive presentation did not demonstrate slower processing speed performance than girls with the combined presentation. This finding is inconsistent with many studies demonstrating slower processing speed performance in individuals with ADHD-I (Hellwig-Brida, Daseking, Petermann, & Goldbeck, 2010; Mayes, Calhoun, Chase, Mink, &

Stagg, 2009; Yang et al., 2013); however, these studies have included male participants in their samples. Previous literature suggests that slow processing speed is specifically associated with inattentiveness. Given that individuals with the combined presentation of ADHD also present with inattentiveness, it is reasonable to expect that they would have slow processing speed as well. Yet the inattentiveness that is presented in the combined presentation is thought to have a different source (i.e., response inhibition) than in those with the inattentive only presentation. Studies of sex differences in processing speed show that females tend to have faster processing speed than males (Arnett et al., 2015; Tillman et al., 2009; Rucklidge & Tannock, 2001). It may be that girls with ADHD-I do not suffer from slower processing speed than girls with ADHD-C because female sex is a protective factor. Additionally, the present sample has not demonstrated significant differences in neuropsychological functioning between girls in the ADHD-I and ADHD-C group (e.g., Hinshaw et al., 2002; 2007). Furthermore, this sample did not demonstrate significantly pronounced deficits in processing speed, with mean group WISC-III PSF scores in the average range (ADHD-C $M$ = 100.19, ADHD-I $M$ = 99.38).

This pattern of group differences was also replicated in RAN Objects accuracy rates. Here, pairwise comparisons revealed significant differences between the ADHD-C and Comparison groups only. Additionally, despite the substantial correlation between the two RAN subtests, no significant group differences were observed in RAN Numbers accuracy rates.

**Inattentiveness**

Unsurprisingly, faster processing speed was associated with lower inattentiveness at baseline. This finding is consistent with much literature demonstrating an association between processing speed and inattentiveness. Yet this pattern was different between girls with ADHD and their typically developing counterparts. Slow processing speed did not appear to be associated with inattentiveness in typically developing girls but it was in those with ADHD. This difference in patters may simply reflect the significant group differences in both processing speed and inattentiveness. Indeed, there may not have been enough range in either variable within the Comparison group to demonstrate an association. Regardless, this finding supports the notion that the association between slow processing speed and inattentiveness reflects a cognitive endophenotype unique to individuals with ADHD.

Childhood processing speed did not predict inattentiveness during adolescence or adulthood, nor did it predict trajectories of inattentiveness. This finding may be explained by longitudinal changes in processing speed over time. Processing speed performance follows a quadratic curve over time such that it becomes faster throughout childhood and adolescence (Kail & Ferrer, 2007). It may be that inattentiveness changes as a function of concurrent processing speed. If true, this could potentially explain some of the variance in changes in inattentiveness throughout development. In a sample of boys with ADHD, inattentive symptoms decreased throughout adolescence, although the authors point out this does not necessarily imply amelioration of functional impairment (Biederman, Mick, & Faraone, 2000). More recent research using data from the current sample of girls with ADHD demonstrated that presentation of ADHD (i.e., ADHD-I, ADHD-H, or ADHD-C) changed for many participants from childhood through adulthood (Owens, Zalecki, Gillette, & Hinshaw, 2017).

In the present study, the estimated slope for the trajectory of inattentiveness decreased from childhood through young adulthood for all participants. Childhood diagnostic status significantly predicted slopes of inattentiveness such that participants in the ADHD group demonstrated significantly steeper slopes than participants in the Comparison group. In other words, inattentiveness decreased with maturity more dramatically in participants with ADHD than their typically developed counterparts. Despite these greater decreases in symptom severity over time, women with a childhood diagnosis of ADHD still presented with greater inattentiveness than women without ADHD by young adulthood, with effect sizes of 1.98 at Wave 3 and 1.38 at Wave 4.

Relative weakness in processing speed was not associated with inattentiveness. This negative finding is interesting because there were also not group differences in relative weakness in processing speed between girls with ADHD and their typically developing counterparts. This finding further supports the notion that (a) processing speed and (b) relative weakness in processing speed are separate, but related, constructs with differing implications for testing, treatment, and outcomes.

RAN Objects accuracy rates were associated with baseline inattentiveness; however, better performance in accuracy rate was associated with more severe inattentiveness. This association held during adulthood for both RAN Objects and RAN Numbers. The direction of this finding is opposite that of results for processing speed in the present study. It is unexpected that better performance on a performance-based test demanding cognitive processing speed would be associated with poorer behavioral symptoms of inattentiveness. One explanation for this unexpected finding could be that RAN accuracy rate is not a valid measure of processing speed and may be tapping into another unidentified construct that is more associated with academic performance. Indeed, poorer performance in academic functioning could be related to many factors other than inattentiveness (e.g., intellectual disorder, learning disorder, anxiety). RAN tests are often used clinically to screen for reading disorders (Bowers, 1995), which may be a more valid use for the measure.

**Hyperactivity-Impulsivity**

Like inattentiveness, the estimated slope for the trajectory of hyperactivity-impulsivity decreased from childhood through young adulthood for all participants. This supports research that shows a strong decrease in hyperactivity-impulsivity as children mature (Fischer, Barkley, Fletcher, & Smallish, 1993; Hart et al. 1995). Childhood diagnostic status also significantly predicted slopes of hyperactivity-impulsivity in a patter similar to that of inattentiveness. Unlike inattentiveness, processing speed was not associated with hyperactivity-impulsivity at baseline.

**Reading**

Better RAN Objects and RAN Numbers accuracy rates were associated with better basic reading performance for all girls at baseline. This association held up for predictions of reading performance in adulthood as well; however, the pattern of association varied between women with and without ADHD. Specifically, childhood RAN Objects performance appeared to have a greater influence (i.e., greater magnitude of association) on basic reading performance in adulthood for women with ADHD than it did for their peers. It may be that the girls without ADHD developed compensatory skills and behaviors to accommodate for their reading difficulties over time. In contrast, the girls with ADHD may not have learned or developed such compensatory skills for coping with reading difficulties.

**Math**

The estimated slope for the trajectory of math reasoning decreased from childhood through young adulthood for all girls. Childhood diagnostic status was not a significant predictor of slopes. For all girls, childhood processing speed predicted math reasoning performance at each wave, such that faster processing speed was associated with better math performance. This finding suggests that childhood processing speed performance has long-lasting implications for math performance. Another explanation may be in the differences between the math and reading tests. Interestingly, the reading test is timed whereas the math test is untimed. It would be reasonable to expect that processing speed performance would have a significant effect on a timed rather than untimed test. But processing speed may be implicated in math reasoning performance due to the nature of the stimuli presented in the test. Specifically, the math test presents novel stimuli (i.e., new math problems) whereas the reading test presents learned stimuli (i.e., words that the respondent is likely to have encountered before taking the test). This distinction points to the importance of the distinction between processing speed and fluency, and how each is measured. Supporting this notion is the fact that RAN performance did not predict math performance until adulthood, when better childhood RAN Numbers performance did predict better math reasoning performance. It is unclear why this association would not exist until adulthood and is an area requiring further study.

**Academic Performance**

Teacher ratings of academic performance were collected during childhood and adolescence. During childhood, high RAN Objects and RAN Numbers accuracy rates were associated with poor academic performance. In contrast, during adolescence, slow processing speed and relative weakness in processing speed were both associated with poor academic performance. This inverse relationship between two sets of measures is unexplained and requires further investigation in the future, particularly given that numerous factors may be involved in academic performance (e.g., learning disorders, study skills, behavior difficulties) as well as a teacher’s perception of a child’s academic performance (e.g., stigmatization).

**Adult Income**

Girls with a childhood diagnosis of ADHD went on to make significantly less monthly income in adulthood ($M$ = $1447.46) than typically developing girls ($M$ = $2087.68). Childhood processing speed did not have a significant main effect on monthly income in adulthood, but , there was a nearly significant moderation effect for group, such that faster processing speed was associated with higher monthly income for girls with ADHD, whereas the opposite was true for typically developing women.

**Highest Education**

Girls with a childhood diagnosis of ADHD went on to complete significantly less education than girls in the typically developing group. Indeed, 53.4% of typically developing girls went on to earn a bachelor's level degree, whereas the same was true for only 16.4% of girls with a childhood diagnosis of ADHD. Childhood RAN Numbers performance approached significantly predicting highest level of education attained, such that better RAN Numbers performance was associated with higher levels of education attained. This pattern seemed to have even more of an effect for typically developing girls. A possible explanation, may be, again, that girls with ADHD were too taxed with managing their symptoms of ADHD to learn or practice compensatory skills for impaired performance.

**Limitations**

The present study is the first to date, to the knowledge of the author, to examine the longitudinal effects of early childhood processing speed on ADHD symptomatology and academic achievement in adulthood. Particular strengths of the study design allowed for such an endeavor. First, data were collected at four waves across critical developmental stages, including childhood, adolescence, and adulthood. Indeed, many of the participants followed since childhood are now have children of their own. Second, this study enjoyed a low attrition rate. Third, the sample was ethnically diverse. Finally, multiple measures of processing speed (i.e., WISC-III PSF, relative weakness in PSF, RAN Objects, and RAN Numbers) were collected.

Despite the numerous strengths of the study, there are limitations to these findings that must be considered.

First, processing speed was measured only during childhood (i.e., at Wave 1). Processing speed increases at a quadratic rate intra-individually from childhood through adolescence, and tends to level off in adulthood. Including processing speed measures across all four waves would allow for replication of longitudinal changes in processing speed as well as the ability to adjust for changes in processing speed when examining its relation with changes in ADHD symptomatology and academic achievement over time. It may also be helpful to examine whether processing speed predicts academic achievement more strongly at particular time-points, as there are key differences in academic demands across development.

Second, males were not included in the current study. As one of the largest longitudinal samples of girls with ADHD, BGALS data has been used in numerous studies to draw attention to important and unique vulnerabilities that girls with ADHD face (e.g., Guendelman et al., 2016). A primary remaining area for investigation is in the possible moderation by sex on ADHD presentation group differences. In other words, the present study demonstrated no significant differences in processing speed between girls with ADHD-I and girls with ADHD-C, but whether and why that same pattern appears in boys remains unanswered.

Third, diagnostic status of formal learning disorders was not collected for this sample. Given that reading and math achievement was studied in relation to processing speed, it is possible that the presence of a learning disorder may have confounded certain findings in the present study. An important next step in the evaluation of this sample's data is to include a post-hoc calculation of difference between actual and expected reading and math scores based on WISC-III FSIQ to determine likely presence of learning disorder, although even this attempt would not constitute a formal diagnosis.

**Implications**

The present study has demonstrated that children with ADHD present with slow processing speed, which is associated with symptoms of inattentiveness. Yet aside from its association with inattentiveness, slow processing speed does not seem to put girls with ADHD at particular risk for poor academic outcomes through childhood, adolescence, or adulthood. Part of the reason may relate to the stringent set of statistical covariates (i.e., executive functioning, verbal comprehension, working memory, and perceptual and organizational reasoning) applied in all predictive analyses. Given that processing speed may be implicated in other areas of neuropsychological functioning (e.g., working memory as in Ek, Westerlund, & Fernell, 2013 and Schweitzer, Hanford, & Medoff, 2006), it is likely that the complexity of the relation between processing speed and academic achievement necessitates further investigation. This finding may also be attributable to sex differences in processing speed, such that females tend to have faster processing speeds than males. Indeed, this faster speed may be a protective factor of sorts for girls with ADHD. Another implication is that girls may benefit from targeted intervention in deficits other than processing speed. Still, for all girls, regardless of diagnostic status, slow childhood processing speed predicts poor math performance through childhood, adolescence, and adulthood.

An important consideration is in differences between slow processing speed and a relative weakness in processing speed. The present study showed that slow processing speed is implicated in children with ADHD, but not a relative weakness in processing speed. Indeed, there was not a significant difference in the proportion of children in the ADHD or Comparison groups presenting with a relative weakness in processing speed. Additionally, relative weakness in processing speed was not associated with inattentiveness. Taken together, these findings imply that relative weakness in processing speed is not, in itself, a signifier of ADHD symptoms. Thus, when children's neuropsychological testing reveals a relative weakness in processing speed, clinicians should weigh the actual processing speed more heavily in considering neuropsychological functioning consistent with a diagnosis of ADHD. Finally, clinicians, families, and teachers may need to treat slow processing speed and relative weakness in processing speed differently. For example, children with slow processing speed may benefit from additional time on tests, instructions presented one step at a time, and additional time for decision-making. These same accommodations may not prove helpful, or warranted, for children with average yet relatively weak processing speed.

Relative weakness in WISC-III primary index scores was determined following Naglieri's (1993) ipsative method. This method is consistent with current Wechsler-based testing protocol. For the present edition of the WISC (i.e., WISC-V), strength or weakness in a factor score is determined by subtracting a comparison score from the index score in question and comparing the difference score to a critical value for significance (Wechsler, 2014). Comparison scores that can be used are either (a) FSIQ or (b) the mean primary index score (MIS) which is calculated by dividing the sum of the five index scores by five. Both the WISC-V FSIQ and the

MIS include the processing speed index score in the comparison score. Thus the method for determining relative weakness in WISC-III factor scores used in the present study is consistent with present (i.e., WISC-V) clinical practice standards. Yet it stands to reason that inclusion of processing speed in the mean factor score may confound comparisons of the two scores. Further investigation into this approach, which guides clinical practice, is necessary.

**Conclusion and Future Directions**

In conclusion, findings from the present study demonstrate an association between processing speed and concurrent inattentiveness in girls with ADHD. These findings also demonstrated a long-lasting association between slow processing speed in childhood and poor math performance from childhood through adulthood regardless of diagnostic status. Further investigation is required to answer remaining questions about the effects of processing speed on ADHD symptom patterns and academic achievement. Important next steps involve examining (a) sex differences in processing speed and its effect on ADHD symptomatology and academic achievement, (b) operational definitions and measures for processing speed, (c) longitudinal changes in processing speed concurrent to changes in ADHD symptomatology, and (d) processing speed as a predictor of remittance status for ADHD diagnosis.

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Table 1a

Sample demographic characteristics and group differences at Wave 1

| | **Comparison n = 88** | | **ADHD n = 140** | | **t-test** | **Cohen's *d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Age (years)** | 9.43 | 1.65 | 9.64 | 1.68 | -.89 (226) | .13 |
| **Ethnicity** | | | | | $\chi^2$ = 10.02* | |
| Caucasian | 46.6% | | 56.4% | | | |
| African American | 26.1% | | 27.9% | | | |
| Latina | 11.4% | | 10.7% | | | |
| Asian American | 15.9% | | 4.3% | | | |
| Native American | 0% | | .7% | | | |
| **Total Gross Annual Household Income** | | | | | 1.63 (221) | -.21 |
| < $10,000 | 2.3% | | 7.1% | | | |
| $10,000 to $20,000 | 5.7% | | 3.6% | | | |
| $20,000 to $30,000 | 5.7% | | 10.0% | | | |
| $30,000 to $40,000 | 6.8% | | 7.9% | | | |
| $40,000 to $50,000 | 6.8% | | 12.1% | | | |
| $50,000 to $60,000 | 13.6% | | 6.4% | | | |
| $60,000 to $70,000 | 11.4% | | 10.7% | | | |
| $70,000 to $75,000 | 6.8% | | 5.7% | | | |
| > $75,000 | 39.8% | | 33.6% | | | |
| **Maternal Education** | | | | | 1.67 (226) | -.22 |
| Some high school | 2.3% | | .7% | | | |
| High school graduate/GED | 2.3% | | 7.1% | | | |
| Some college | 31.8% | | 39.3% | | | |
| Bachelor's level degree | 28.4% | | 27.1% | | | |
| Advanced or professional degree | 35.2% | | 25.7% | | | |

* $p < .05$

A chi-square test of independence was performance to determine the relation between group and ethnicity.

Table 1b

Sample demographic characteristics and subgroup differences at Wave 1

| | **ADHD-C n = 93** | | **ADHD-I n = 47** | | **t-test** | **Cohen's *d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Age (years)** | 9.54 | 1.68 | 9.83 | 1.68 | -.98 (138) | .17 |
| **Ethnicity** | | | | | $\chi^2 = 4.42$ | |
| Caucasian | 55.9% | | 57.4% | | | |
| African American | 30.1% | | 23.4% | | | |
| Latina | 8.6% | | 14.9% | | | |
| Asian American | 5.4% | | 2.1% | | | |
| Native American | 0% | | 2.1% | | | |
| **Total Gross Annual Household Income** | | | | | -.69 (134) | .08 |
| < $10,000 | 4.3 | | 12.8 | | | |
| $10,000 to $20,000 | 5.4 | | 2.1 | | | |
| $20,000 to $30,000 | 14.0 | | 4.3 | | | |
| $30,000 to $40,000 | 9.7 | | 17.0 | | | |
| $40,000 to $50,000 | 9.7 | | 4.3 | | | |
| $50,000 to $60,000 | 7.5 | | 10.6 | | | |
| $60,000 to $70,000 | 10.8 | | 6.4 | | | |
| $70,000 to $75,000 | 5.4 | | 36.2 | | | |
| > $75,000 | 32.3 | | 12.8 | | | |
| **Maternal Education** | | | | | -.02 (138) | 0 |
| Some high school | 1.1% | | 0% | | | |
| High school graduate/GED | 6.5% | | 8.5% | | | |
| Some college | 39.8% | | 38.3% | | | |
| Bachelor's level degree | 26.9% | | 27.7% | | | |
| Advanced or professional degree | 25.8% | | 25.5% | | | |

None of the group comparisons were significant.
A chi-square test of independence was performance to determine the relation between group and ethnicity.

Table 2a

Group differences in predictors and covariates

| | Comparison | | ADHD | | t-test | Cohen's *d* |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Predictors** | | | | | | |
| W1 PSF | 108.10 | 14.34 | 99.91 | 15.78 | 3.94 (223)*** | -.54 |
| W1 Coding | 11.00 | 3.04 | | | 3.62 (226)*** | -5.12 |
| W1 Symbol Search | 11.74 | 3.40 | | | 3.24 (223)** | -4.88 |
| W1 PSF RW | .91 | .5 | 1.00 | .52 | -1.31 (220) | .18 |
| Weakness | 17.0% | | 12.9% | | | |
| Strength | 8.0% | | 12.9% | | | |
| W1 RAN Objects | .97 | .22 | .85 | .29 | 3.38 (218)** | -.47 |
| W1 RAN Numbers | 1.87 | .47 | 1.74 | .56 | 1,84 (219) | -.25 |
| **Covariates** | | | | | | |
| W1 ROCF | .22 | .15 | .35 | .19 | -5.46 (221)*** | .76 |
| W1 VCF | 113.74 | 13.31 | 101.34 | 14.44 | 6.47 (224)*** | -.89 |
| W1 POF | 108.90 | 14.26 | 100.54 | 14.45 | 4.28 (226)*** | -.58 |
| W1 FDF | 109.56 | 10.93 | 97.37 | 12.98 | 7.29 (223)*** | -1.02 |
| W1 VCF RW | 1.17 | .55 | 1.04 | .57 | 1.76 (220) | -.23 |
| W1 POF RW | 1.02 | .53 | 1.01 | .48 | .23 (220) | -.02 |
| W1 FDF RW | .99 | .47 | .93 | .41 | .93 (220) | -.14 |

RW = relative weakness

[a] indicates Levene's Test for Equality of Variances was significant at the .05 level and thus an adjustment to the degrees of freedom was conducted using the Welch-Satterhwaite method

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 2b

Subgroup differences in predictors and covariates

| | ADHD-C | | ADHD-I | | t-test | Cohen's ***d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Predictors** | | | | | | |
| W1 PSF | 100.19 | 16.12 | 99.38 | 15.28 | .28 (135) | -.05 |
| W1 Coding | 9.52 | 3.25 | 9.19 | 3.58 | .54 (138) | -.1 |
| W1 Symbol Search | 10.21 | 3.77 | 10.11 | 3.34 | .16 (135) | -.03 |
| W1 PSF RW | 1.01 | .51 | .98 | .53 | | -.06 |
| Weakness | 11.8% | | 14.9% | | | |
| Strength | 12.9% | | 12.8% | | | |
| W1 RAN Objects | .83 | .3 | .88 | .26 | -1.078 (133) | .18 |
| W1 RAN Numbers | 1.74 | .56 | 1.73 | .56 | .153 (134) | -.02 |
| **Covariates** | | | | | | |
| W1 ROCF | .38 | .19 | .30 | .17 | 2.23 (135)* | -.44 |
| W1 VCF | 100.60 | 13.33 | 102.79 | 16.47 | -.85 (137) | .15 |
| W1 POF | 100.74 | 14.8 | 100.13 | 13.9 | .24 (138) | -.04 |
| W1 FDF | 97.90 | 13.51 | 96.34 | 11.94 | .67 (136) | -.12 |
| W1 VCF RW | .99 | .56 | 1.13 | .56 | -1.37 (133) | .25 |
| W1 POF RW | 1.03 | .49 | .96 | .46 | .88 (133) | -.15 |
| W1 FDF RW | .97 | .39 | .87 | .45 | 1.21 (83[a]) | -.24 |

RW = relative weakness

[a] indicates Levene's Test for Equality of Variances was significant at the .05 level and thus an adjustment to the degrees of freedom was conducted using the Welch-Satterhwaite method

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3a

Group differences in ADHD symptoms

| | Comparison | | ADHD | | t-test | Cohen's ***d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Inattention Symptom Severity** | | | | | | |
| Wave 1 | 3.90 | 3.45 | 21.06 | 4.80 | -31.13 (218[a])*** | 4.11 |
| Wave 2 | 4.30 | 4.31 | 17.54 | 6.77 | -16.81 (196[a])*** | 2.33 |
| Wave 3 | 3.51 | 4.41 | 15.65 | 7.48 | -13.61 (174[a])*** | 1.98 |
| Wave 4 | 2.96 | 3.83 | 11.26 | 7.61 | -9.73 (165[a])*** | 1.38 |
| **Inattention Symptom Count** | | | | | | |
| Wave 1 | .36 | .94 | 7.55 | 1.90 | -37.73 (215[a])*** | 4.8 |
| Wave 2 | .66 | 1.54 | 6.02 | 3.14 | -15.95 (186[a])*** | 2.17 |
| Wave 3 | .68 | 1.65 | 5.33 | 3.37 | -12.23 (164[a])*** | 1.75 |
| Wave 4 | .47 | 1.33 | 3.38 | 3.19 | -8.50 (150[a])*** | 1.19 |
| **Hyperactivity-Impulsivity Symptom Severity** | | | | | | |
| Wave 1 | 2.33 | 2.66 | 15.96 | 6.68 | -21.16 (189[a])*** | 2.68 |
| Wave 2 | 1.05 | 1.99 | 9.42 | 6.83 | -12.68 (150[a])*** | 1.66 |
| Wave 3 | .93 | 1.75 | 7.91 | 6.59 | -10.34 (125[a])*** | 1.46 |
| Wave 4 | .96 | 1.55 | 6.07 | 6.50 | -7.69 (117[a])*** | 1.08 |
| **Hyperactivity-Impulsivity Symptom Count** | | | | | | |
| Wave 1 | .20 | .59 | 5.47 | 2.84 | -20.8 (150[a])*** | 2.57 |
| Wave 2 | .10 | .38 | 2.75 | 2.78 | -10.35 (127[a])*** | 1.34 |
| Wave 3 | .10 | .38 | 2.36 | 2.60 | -8.77 (111[a])*** | 1.22 |
| Wave 4 | .06 | .25 | 1.57 | 2.30 | -6.60 (105[a])*** | .92 |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3b

Subgroup differences in ADHD symptoms

| | **ADHD-C** | | **ADHD-I** | | **t-test** | **Cohen's *d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Inattention Symptom Severity** | | | | | | |
| Wave 1 | 20.77 | 5.06 | 21.62 | 4.24 | -.98 (137) | .18 |
| Wave 2 | 17.07 | 6.97 | 18.47 | 6.33 | -1.07 (119) | .21 |
| Wave 3 | 16.15 | 7.38 | 14.63 | 7.67 | .99 (105) | -.20 |
| Wave 4 | 12.04 | 7.66 | 9.78 | 7.4 | 1.47 (105) | -.30 |
| **Inattention Symptom Count** | | | | | | |
| Wave 1 | 7.48 | 2.09 | 7.70 | 1.47 | -.66 (137) | .12 |
| Wave 2 | 5.78 | 3.32 | 6.50 | 2.74 | -1.27 (92[a]) | .24 |
| Wave 3 | 5.46 | 3.41 | 5.06 | 3.32 | .58 (105) | -.12 |
| Wave 4 | 3.63 | 3.19 | 2.92 | 3.18 | 1.1 (105) | -.22 |
| **Hyperactivity-Impulsivity Symptom Severity** | | | | | | |
| Wave 1 | 18.82 | 5.39 | 10.09 | 5.04 | 8.99 (132)*** | -1.67 |
| Wave 2 | 10.73 | 7.45 | 6.77 | 4.36 | 3.67 (115[a])*** | -.65 |
| Wave 3 | 9.21 | 6.92 | 5.31 | 5.02 | 3.29 (90[a])** | -.65 |
| Wave 4 | 7.03 | 7.20 | 4.35 | 4.63 | 2.29 (99[a])* | -.44 |
| **Hyperactivity-Impulsivity Symptom Count** | | | | | | |
| Wave 1 | 6.67 | 2.32 | 3.02 | 2.16 | 8.72 (132)*** | -1.63 |
| Wave 2 | 3.25 | 3.09 | 1.75 | 1.6 | 3.51 (119[a])** | -.61 |
| Wave 3 | 2.83 | 2.79 | 1.43 | 1.88 | 3.04 (94[a])** | -.59 |
| Wave 4 | 1.92 | 2.51 | .95 | 1.75 | 2.32 (96[a])* | -.45 |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 4a

Group differences in academic achievement

| | **Comparison** | | **ADHD** | | **t-test** | **Cohen's *d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Basic Reading** | | | | | | |
| Wave 1 | 112.02 | 12.6 | 101.78 | 14.44 | 5.62 (203[a])*** | -.76 |
| Wave 2 | 107.73 | 8.81 | 98.00 | 11.99 | 6.89 (202[a])*** | -.92 |
| Wave 3 | 108.83 | 8.47 | 97.24 | 15.02 | 7.17 (206[a])*** | -.95 |
| Wave 4 | 105.33 | 8.37 | 92.90 | 15.12 | 7.56 (196[a])*** | -1.02 |
| **Math Reasoning** | | | | | | |
| Wave 1 | 109.13 | 13.77 | 97.52 | 14.26 | 6.04 (223)*** | -.83 |
| Wave 2 | 112.93 | 14.16 | 94.15 | 16.39 | 8.44 (202)*** | -1.23 |
| Wave 3 | 105.89 | 12.55 | 91.23 | 16.09 | 7.43 (204a)*** | -1.02 |
| Wave 4 | 101.93 | 15.75 | 85.20 | 17.25 | 7.09 (203)*** | -1.01 |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 4b

Subgroup differences in academic achievement

| | **ADHD-C** | | **ADHD-I** | | **t-test** | **Cohen's *d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| **Basic Reading** | | | | | | |
| Wave 1 | 102.12 | 14.62 | 101.13 | 14.21 | .38 (135) | -.07 |
| Wave 2 | 98.09 | 11.54 | 97.82 | 13.07 | .11 (121) | -.02 |
| Wave 3 | 97.25 | 14.67 | 97.22 | 15.91 | .01 (126) | -.00 |
| Wave 4 | 92.47 | 15.45 | 93.71 | 14.63 | -.43 (120) | .08 |
| **Math Reasoning** | | | | | | |
| Wave 1 | 97.32 | 14.18 | 97.89 | 14.56 | -.22 (135) | .04 |
| Wave 2 | 93.50 | 16.82 | 95.56 | 15.51 | -.65 (121) | .13 |
| Wave 3 | 91.31 | 16.30 | 91.02 | 15.83 | .1 (126) | -.02 |
| Wave 4 | 84.63 | 17.10 | 86.26 | 17.68 | -.49 (118) | .09 |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 5a

Group differences in outcomes

| | Comparison | | ADHD | | t-test | Cohen's ***d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| W1 TRF | 52.82 | 8.3 | 40.49 | 6.46 | 11.79 (150[a])*** | -1.66 |
| W2 TRF | 54.00 | 9.46 | 43.86 | 8.26 | 6.91 (150)*** | -1.14 |
| W2 CBCL | 47.65 | 8.22 | 34.89 | 7.65 | 11.21 (199)*** | -1.61 |
| W4 Monthly Income ($) | 2087.68 | 1895.80 | 1447.46 | 1715.49 | 2.48 (167[a])* | -.35 |
| **W4 Highest Education** | 3.15 | 1.36 | 1.93 | 1.31 | 6.55 (206)*** | -.91 |
| High School | 22.7% | | 52.9% | | | |
| AA | 6.8% | | 3.6% | | | |
| Completed trade/certificate program | 6.8% | | 12.1% | | | |
| BA/BS | 53.4% | | 16.4% | | | |
| MS | 6.8% | | 1.4% | | | |
| PhD, MD, Law, etc. | 0% | | 0% | | | |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 5b

Subgroup differences in outcomes

| | **ADHD-C** | | **ADHD-I** | | **t-test** | **Cohen's *d*** |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t (df)* | |
| W1 TRF | 41.26 | 6.78 | 38.96 | 5.52 | 2.14 (108[a])* | -.37 |
| W2 TRF | 43.75 | 8.23 | 44.06 | 8.43 | -.18 (94) | .04 |
| W2 CBCL | 35.31 | 7.65 | 33.97 | 7.68 | .90 (120) | -.17 |
| W4 Monthly Income ($) | 1470.09 | 1909.33 | 1404.37 | 1287.44 | .20 (120) | -.04 |
| **W4 Highest Education** | 1.88 | 1.26 | 2.02 | 1.41 | -.6 (121) | .10 |
| High School | 50.5% | | 57.4% | | | |
| AA | 4.3% | | 2.1% | | | |
| Completed trade/certificate program | 15.1% | | 6.4% | | | |
| BA/BS | 12.9% | | 23.4% | | | |
| MS | 1.1% | | 2.1% | | | |
| PhD, MD, Law, etc. | 0% | | 0% | | | |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 6

Correlations between scores on neuropsychological measures at Wave 1

| Measures | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. RAN Objects | -- | | | | | | | | | | | |
| 2. RAN Numbers | .70** | -- | | | | | | | | | | |
| 3. ROCF | -.4** | -.32** | -- | | | | | | | | | |
| 4. FSIQ | .15* | .06 | -.33** | -- | | | | | | | | |
| 5. PSF | .08 | .07 | -.16* | .57** | -- | | | | | | | |
| 6. VCF | .18** | .10 | -.23** | .88** | .38** | -- | | | | | | |
| 7. POF | .05 | -.05 | -.38** | .83** | .41** | .52** | -- | | | | | |
| 8. FDF | .29** | .25** | -.30** | .63** | .39** | .53** | .43** | -- | | | | |
| 9. PSF RW | -.04 | -.02 | .11 | -.16* | .56** | -.26** | -.18** | -.22** | -- | | | |
| 10. VCF RW | -.04 | -.1 | .05 | .25** | -.26** | .57** | -.05 | .01 | -.4** | -- | | |
| 11. POF RW | -.09 | -.16* | -.17* | .26** | -.05 | -.01 | .62** | -.09 | -.21** | -.12 | -- | |
| 12. FDF RW | .1 | .16 | .08 | -.26** | -.29** | -.22** | -.3** | .33** | -.19** | -.09 | -.25 | -- |

* $p < .05$, ** $p < .01$

Table 7a

Correlations between parent and teacher report of ADHD symptoms at Wave 1

| | | **Teacher** | | | |
|---|---|---|---|---|---|
| | | Inattentiveness Symptom Severity | Inattentiveness Symptom Count | Hyperactivity-Impulsivity Symptom Severity | Hyperactivity-Impulsivity Symptom Count |
| **Parent** | Inattentiveness Symptom Severity | .79*** | .76*** | .53*** | .49*** |
| | Inattentiveness Symptom Count | .78*** | .76*** | .55*** | .51*** |
| | Hyperactivity-Impulsivity Symptom Severity | .62*** | .60*** | .66*** | .61*** |
| | Hyperactivity-Impulsivity Symptom Count | .6*** | .58*** | .65*** | .61*** |

* $p$ < .05, ** $p$ < .01, *** $p$ < .001

Table 7b

Correlations between parent and teacher report of ADHD symptoms at Wave 2

| | | **Teacher** | | | |
|---|---|---|---|---|---|
| | | Inattentiveness Symptom Severity | Inattentiveness Symptom Count | Hyperactivity-Impulsivity Symptom Severity | Hyperactivity-Impulsivity Symptom Count |
| **Parent** | Inattentiveness Symptom Severity | .53*** | .48*** | .34*** | .31*** |
| | Inattentiveness Symptom Count | .54*** | .49*** | .36*** | .34*** |
| | Hyperactivity-Impulsivity Symptom Severity | .42*** | .42*** | .48*** | .42*** |
| | Hyperactivity-Impulsivity Symptom Count | .4*** | .40*** | .44*** | .4*** |

* $p$ < .05, ** $p$ < .01, *** $p$ < .001

Table 8

Correlations between Wave 1 WISC-III PSF and mean of parent and teacher report of ADHD symptoms at Wave 1

| **Symptom** | WISC-III PSF |
|---|---|
| Inattentive #1 | -.27** |
| Inattentive #2 | -.30** |
| Inattentive #3 | -.27** |
| Inattentive #4 | -.33** |
| Inattentive #5 | -.29** |
| Inattentive #6 | -.31** |
| Inattentive #7 | -.26** |
| Inattentive #8 | -.23** |
| Inattentive #9 | -.25** |
| Hyperactive/Impulsive #10 | -.22** |
| Hyperactive/Impulsive #11 | -.13* |
| Hyperactive/Impulsive #12 | 0.01 |
| Hyperactive/Impulsive #13 | -0.09 |
| Hyperactive/Impulsive #14 | -0.06 |
| Hyperactive/Impulsive #15 | -0.10 |
| Hyperactive/Impulsive #16 | -0.12 |
| Hyperactive/Impulsive #17 | -0.11 |
| Hyperactive/Impulsive #18 | -.13* |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 9

Correlations between Wave 1 WISC-III PSF relative weakness and mean of parent and teacher report of ADHD symptoms at Wave 1

| **Symptom** | WISC-III PSF Relative Weakness |
|---|---|
| Inattentive #1 | .10 |
| Inattentive #2 | .06 |
| Inattentive #3 | .04 |
| Inattentive #4 | .01 |
| Inattentive #5 | .04 |
| Inattentive #6 | .00 |
| Inattentive #7 | .01 |
| Inattentive #8 | .06 |
| Inattentive #9 | .01 |
| Hyperactive/Impulsive #10 | .06 |
| Hyperactive/Impulsive #11 | .09 |
| Hyperactive/Impulsive #12 | .13* |
| Hyperactive/Impulsive #13 | .13 |
| Hyperactive/Impulsive #14 | .18** |
| Hyperactive/Impulsive #15 | .09 |
| Hyperactive/Impulsive #16 | .1 |
| Hyperactive/Impulsive #17 | .1 |
| Hyperactive/Impulsive #18 | .07 |

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 10

Linear regression of Wave 1 WISC-III PSF and SNAP inattentiveness symptom severity

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | .894 | 153.967 | 208 | < .001 | .787 |
| | W1 ROCF | -.014 | | | | |
| | W1 VCF | .029 | | | | |
| | W1 POF | -.021 | | | | |
| | W1 FDF | -.005 | | | | |
| Step 2 | W1 PSF | -.068 | 3.478 | 207 | .064 | .004 |
| Step 3 | PSF x Group | -.385 | 2.795 | 206 | .096 | .003 |

Table 11

Linear regression of Wave 1 WISC-III PSF and SNAP inattentiveness symptom count

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | .907 | 197.696 | 208 | < .001 | .826 |
| | W1 ROCF | -.013 | | | | |
| | W1 VCF | .020 | | | | |
| | W1 POF | -.009 | | | | |
| | W1 FDF | -.024 | | | | |
| Step 2 | W1 PSF | -.046 | 1.916 | 207 | .168 | .002 |
| Step 3 | PSF x Group | -.370 | 3.135 | 206 | .078 | .003 |
| **Wave 3** | | | | | | |
| Step 1 | Group | .183 | 21.198 | 160 | < .001 | .443 |
| | W1 ROCF | .080 | | | | |
| | W1 VCF | .100 | | | | |
| | W1 POF | .009 | | | | |
| | W1 FDF | -.063 | | | | |
| | W1 Inattentiveness Symptom Count | .469 | | | | |
| Step 2 | W1 PSF | .003 | .002 | 159 | .966 | .000 |
| Step 3 | PSF x Group | .739 | 2.978 | 158 | .086 | .010 |

Table 12

Linear regression of Wave 1 WISC-III PSF and WIAT Math Reasoning

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | -.037 | 52.537 | 209 | < .001 | .557 |
| | W1 ROCF | .016 | | | | |
| | W1 VCF | .199 | | | | |
| | W1 POF | .255 | | | | |
| | W1 FDF | .435 | | | | |
| Step 2 | W1 PSF | .093 | 3.125 | 208 | .079 | .007 |
| **Wave 2** | | | | | | |
| Step 1 | Group | -.156 | 63.621 | 187 | < .001 | .671 |
| | W1 ROCF | -.033 | | | | |
| | W1 VCF | .132 | | | | |
| | W1 POF | .144 | | | | |
| | W1 FDF | .147 | | | | |
| | W1 WIAT Math Reasoning | .424 | | | | |
| Step 2 | W1 PSF | .133 | 7.571 | 186 | .007 | .013 |
| **Wave 3** | | | | | | |
| Step 1 | Group | -.086 | 45.474 | 194 | < .001 | .584 |
| | W1 ROCF | -.062 | | | | |
| | W1 VCF | .116 | | | | |
| | W1 POF | .110 | | | | |
| | W1 FDF | .148 | | | | |
| | W1 WIAT Math Reasoning | .438 | | | | |
| Step 2 | W1 PSF | .165 | 10.210 | 193 | .002 | .021 |
| **Wave 4** | | | | | | |
| Step 1 | Group | -.077 | 33.178 | 186 | < .001 | .517 |
| | W1 ROCF | -.129 | | | | |
| | W1 VCF | .073 | | | | |
| | W1 POF | .080 | | | | |
| | W1 FDF | .278 | | | | |
| | W1 WIAT Math Reasoning | .295 | | | | |
| Step 2 | W1 PSF | .154 | 7.082 | 185 | .008 | .018 |

Table 13

Linear regression of Wave 1 WISC-III PSF and TRF academic performance

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 2** | | | | | | |
| Step 1 | Group | -.284 | 10.702 | 137 | < .001 | .319 |
| | W1 ROCF | -.097 | | | | |
| | W1 VCF | .143 | | | | |
| | W1 POF | .103 | | | | |
| | W1 FDF | .076 | | | | |
| | W1 TRF | .084 | | | | |
| Step 2 | W1 PSF | -.100 | 1.464 | 136 | .228 | .007 |
| Step 3 | PSF x Group | -1.321 | 7.208 | 135 | .008 | .034 |

Table 14

Linear regression of Wave 1 WISC-III PSF and Wave 4 monthly earnings

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| Step 1 | Group | -.115 | 2.568 | 190 | .028 | .063 |
| | W1 ROCF | -.168 | | | | |
| | W1 VCF | .102 | | | | |
| | W1 POF | .001 | | | | |
| | W1 FDF | -.073 | | | | |
| Step 2 | W1 PSF | .028 | .121 | 189 | .729 | .001 |
| Step 3 | PSF x Group | .951 | 3.628 | 188 | .058 | .018 |

Table 15

Linear regression of Wave 1 WISC-III PSF relative weakness and SNAP inattentiveness symptom severity

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | .894 | 154.437 | 208 | < .001 | .788 |
| | W1 ROCF | -.008 | | | | |
| | W1 VCF RW | .024 | | | | |
| | W1 POF RW | .025 | | | | |
| | W1 FDF RW | .010 | | | | |
| Step 2 | W1 PSF RW | -.053 | 1.846 | 207 | .176 | .002 |
| Step 3 | PSF RW x Group | -.185 | 4.924 | 206 | .028 | .005 |

RW = relative weakness

Table 16

Linear regression of Wave 1 WISC-III PSF relative weakness and SNAP inattentiveness symptom count

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | .916 | 199.106 | 208 | < .001 | .827 |
| | W1 ROCF | -.008 | | | | |
| | W1 VCF RW | .032 | | | | |
| | W1 POF RW | .025 | | | | |
| | W1 FDF RW | .004 | | | | |
| Step 2 | W1 PSF RW | -.035 | .976 | 207 | .324 | .001 |
| Step 3 | PSF RW x Group | -.177 | 5.533 | 206 | .020 | .004 |

RW = relative weakness

Table 17

Linear regression of Wave 1 WISC-III PSF relative weakness and WIAT Basic Reading

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | -.156 | 31.196 | 194 | < .001 | .491 |
| | W1 ROCF | -.053 | | | | |
| | W1 VCF RW | .084 | | | | |
| | W1 POF RW | .006 | | | | |
| | W1 FDF RW | .003 | | | | |
| | W1 WIAT Basic Reading | .592 | | | | |
| Step 2 | W1 PSF RW | -.040 | .384 | 193 | .536 | .001 |
| Step 3 | PSF RW x Group | -.219 | 2.760 | 192 | .098 | .007 |

RW = relative weakness

Table 18

Linear regression of Wave 1 WISC-III PSF relative weakness and WIAT Math Reasoning

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 2** | | | | | | |
| Step 1 | Group | -.213 | 53.289 | 187 | < .001 | .631 |
| | W1 ROCF | -.069 | | | | |
| | W1 VCF RW | .063 | | | | |
| | W1 POF RW | .063 | | | | |
| | W1 FDF RW | .013 | | | | |
| | W1 WIAT Math Reasoning | .637 | | | | |
| Step 2 | W1 PSF RW | .156 | 8.626 | 186 | .004 | .016 |
| **Wave 3** | | | | | | |
| Step 1 | Group | -.142 | 39.684 | 194 | < .001 | .551 |
| | W1 ROCF | -.090 | | | | |
| | W1 VCF RW | .001 | | | | |
| | W1 POF RW | .053 | | | | |
| | W1 FDF RW | .022 | | | | |
| | W1 WIAT Math Reasoning | .630 | | | | |
| Step 2 | W1 PSF RW | .168 | 8.102 | 193 | .005 | .018 |
| **Wave 4** | | | | | | |
| Step 1 | Group | -.159 | 27.382 | 186 | < .001 | .469 |
| | W1 ROCF | -.159 | | | | |
| | W1 VCF RW | -.014 | | | | |
| | W1 POF RW | .034 | | | | |
| | W1 FDF RW | .075 | | | | |
| | W1 WIAT Math Reasoning | .521 | | | | |
| Step 2 | W1 PSF RW | .142 | 4.530 | 185 | .035 | .013 |

RW = relative weakness

Table 19

Linear regression of Wave 1 WISC-III PSF relative weakness and TRF academic performance

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 2** | | | | | | |
| Step 1 | Group | -.291 | 8.841 | 137 | < .001 | .279 |
| | W1 ROCF | -.132 | | | | |
| | W1 VCF RW | .043 | | | | |
| | W1 POF RW | .018 | | | | |
| | W1 FDF RW | -.008 | | | | |
| | W1 TRF | .235 | | | | |
| Step 2 | W1 PSF RW | -.147 | 2.949 | 136 | .088 | .015 |
| Step 3 | PSF RW x Group | -.435 | 5.180 | 135 | .024 | .026 |

RW = relative weakness

Table 20

Linear regression of Wave 1 RAN Objects and SNAP inattentiveness symptom severity

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | .898 | 397.975 | 211 | < .001 | .790 |
| | W1 ROCF | -.027 | | | | |
| Step 2 | W1 RAN Objects | .070 | 4.206 | 210 | .042 | .004 |
| **Wave 3** | | | | | | |
| Step 1 | Group | .225 | 57.961 | 163 | < .001 | .516 |
| | W1 ROCF | .109 | | | | |
| | W1 Inattentiveness Symptom Severity | .467 | | | | |
| Step 2 | W1 RAN Objects | .113 | 3.381 | 162 | .068 | .010 |

Table 21

Linear regression of Wave 1 RAN Objects and SNAP inattentiveness symptom count

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | .920 | 506.869 | 211 | < .001 | .828 |
| | W1 ROCF | -.032 | | | | |
| Step 2 | W1 RAN Objects | .052 | 2.765 | 210 | .098 | .002 |

Table 22

Linear regression of Wave 1 RAN Objects and SNAP hyperactivity-impulsivity symptom severity

| | | $\beta$ | $\Delta F$ | $df$ | $p$ | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | .141 | 36.873 | 156 | < .001 | .415 |
| | W1 ROCF | .088 | | | | |
| | W1 Hyperactivity-Impulsivity Symptom Severity | .486 | | | | |
| Step 2 | W1 RAN Objects | .187 | 7.757 | 155 | .006 | .028 |

Table 23

Linear regression of Wave 1 RAN Objects and SNAP hyperactivity-impulsivity symptom count

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | .119 | 24.734 | 156 | < .001 | .322 |
| | W1 ROCF | .109 | | | | |
| | W1 Hyperactivity-Impulsivity Symptom Count | .422 | | | | |
| Step 2 | W1 RAN Objects | .195 | 7.289 | 155 | .008 | .030 |

Table 24

Linear regression of Wave 1 RAN Objects and WIAT Basic Reading

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | -.318 | 14.276 | 212 | < .001 | .119 |
| | W1 ROCF | -.062 | | | | |
| Step 2 | W1 RAN Objects | .154 | 4.818 | 211 | .029 | .020 |
| **Wave 3** | | | | | | |
| Step 1 | Group | -.161 | 64.734 | 196 | < .001 | .498 |
| | W1 ROCF | -.075 | | | | |
| | W1 WIAT Basic Reading | .608 | | | | |
| Step 2 | W1 RAN Objects | .097 | 2.989 | 195 | .085 | .008 |
| **Wave 4** | | | | | | |
| Step 1 | Group | -.209 | 49.702 | 192 | < .001 | .437 |
| | W1 ROCF | -.048 | | | | |
| | W1 WIAT Basic Reading | .537 | | | | |
| Step 2 | W1 RAN Objects | .160 | 7.044 | 191 | .009 | .020 |
| Step 3 | RAN Objects x Group | .400 | 3.539 | 190 | .061 | .010 |

Table 25

Linear regression of Wave 1 RAN Objects and TRF academic performance

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | -.621 | 69.715 | 211 | < .001 | .398 |
| | W1 ROCF | -.028 | | | | |
| Step 2 | W1 RAN Objects | .137 | 5.621 | 210 | .019 | .016 |

Table 26

Linear regression of Wave 1 RAN Numbers and SNAP inattentiveness symptom severity

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | .219 | 59.140 | 164 | < .001 | .520 |
| | W1 ROCF | .108 | | | | |
| | W1 Inattentiveness Symptom Severity | .476 | | | | |
| Step 2 | W1 RAN Numbers | .131 | 4.910 | 163 | .028 | .014 |

Table 27

Linear regression of Wave 1 RAN Numbers and SNAP inattentiveness symptom count

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | .161 | 43.918 | 164 | < .001 | .445 |
| | W1 ROCF | .104 | | | | |
| | W1 Inattentiveness Symptom Count | .475 | | | | |
| Step 2 | W1 RAN Numbers | .107 | 2.802 | 163 | .096 | .009 |

Table 28

Linear regression of Wave 1 RAN Numbers and SNAP hyperactivity-impulsivity symptom severity

| | | $\beta$ | $\Delta F$ | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | .122 | 38.026 | 157 | < .001 | .421 |
| | W1 ROCF | .081 | | | | |
| | W1 Hyperactivity-Impulsivity Symptom Severity | .512 | | | | |
| Step 2 | W1 RAN Numbers | .190 | 8.272 | 156 | .005 | .029 |
| Step 3 | RAN Numbers x Group | .402 | 3.429 | 155 | .066 | .012 |

Table 29

Linear regression of Wave 1 RAN Numbers and SNAP hyperactivity-impulsivity symptom count

| | | $\beta$ | $\Delta F$ | $df$ | $p$ | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 3** | | | | | | |
| Step 1 | Group | .104 | 25.897 | 157 | < .001 | .331 |
| | W1 ROCF | .103 | | | | |
| | W1 Hyperactivity-Impulsivity Symptom Count | .446 | | | | |
| Step 2 | W1 RAN Numbers | .232 | 10.867 | 156 | .001 | .044 |
| Step 3 | RAN Numbers x Group | .405 | 3.049 | 155 | .083 | .012 |

Table 30

Linear regression of Wave 1 RAN Numbers and WIAT Basic Reading

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | -.321 | 14.641 | 213 | < .001 | .121 |
| | W1 ROCF | -.062 | | | | |
| Step 2 | W1 RAN Numbers | .250 | 14.391 | 212 | < .001 | .056 |
| **Wave 3** | | | | | | |
| Step 1 | Group | -.161 | 66.267 | 197 | < .001 | .502 |
| | W1 ROCF | -.073 | | | | |
| | W1 WIAT Basic Reading | .611 | | | | |
| Step 2 | W1 RAN Numbers | .095 | 2.973 | 196 | .086 | .007 |
| **Wave 4** | | | | | | |
| Step 1 | Group | -.209 | 51.196 | 193 | < .001 | .443 |
| | W1 ROCF | -.047 | | | | |
| | W1 WIAT Basic Reading | .542 | | | | |
| Step 2 | W1 RAN Numbers | .144 | 5.892 | 192 | .016 | .017 |
| Step 3 | RAN Numbers x Group | .427 | 4.488 | 191 | .035 | .012 |

Table 31

Linear regression of Wave 1 RAN Numbers and WIAT Math Reasoning

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 4** | | | | | | |
| Step 1 | Group | -.169 | 55.193 | 191 | < .001 | .464 |
| | W1 ROCF | -.171 | | | | |
| | W1 WIAT Math Reasoning | .516 | | | | |
| Step 2 | W1 RAN Numbers | .113 | 3.940 | 190 | .049 | .011 |

Table 32

Linear regression of Wave 1 RAN Numbers and Wave 4 highest education level attained

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| Step 1 | Group | -.391 | 23.656 | 197 | < .001 | .194 |
| | W1 ROCF | -.108 | | | | |
| Step 2 | W1 RAN Numbers | .123 | 3.174 | 196 | .076 | .013 |
| Step 3 | RAN Numbers x Group | -.432 | 3.134 | 195 | .078 | .013 |

Table 33

Linear regression of Wave 1 RAN Numbers and TRF academic performance

| | | *β* | *ΔF* | *df* | *p* | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Wave 1** | | | | | | |
| Step 1 | Group | -.622 | 70.437 | 212 | < .001 | .399 |
| | W1 ROCF | -.028 | | | | |
| Step 2 | W1 RAN Numbers | -.192 | 7.579 | 211 | .006 | .021 |

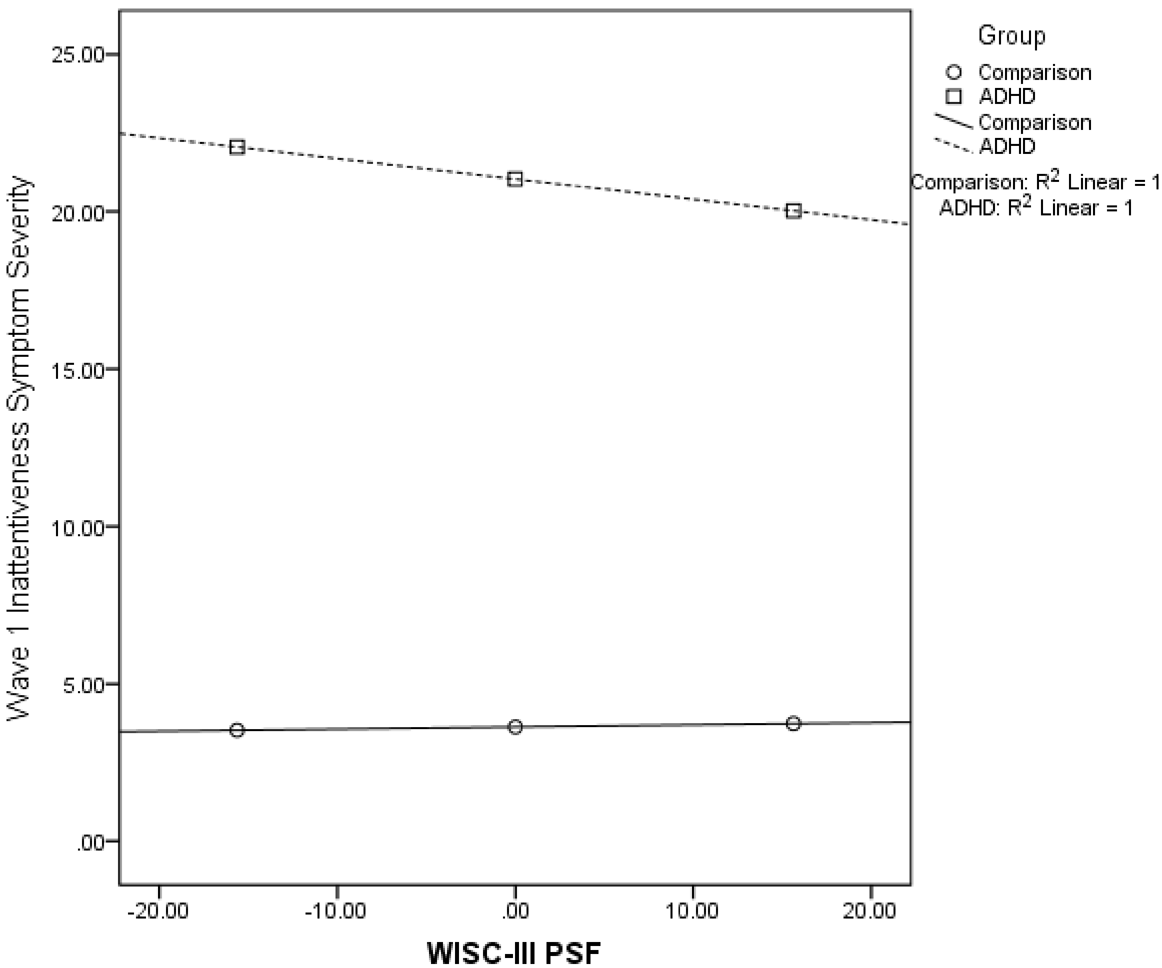


*Figure 1. Moderation effects of group on the relationship between WISC-III PSF and Wave 1 inattentiveness symptom severity.*

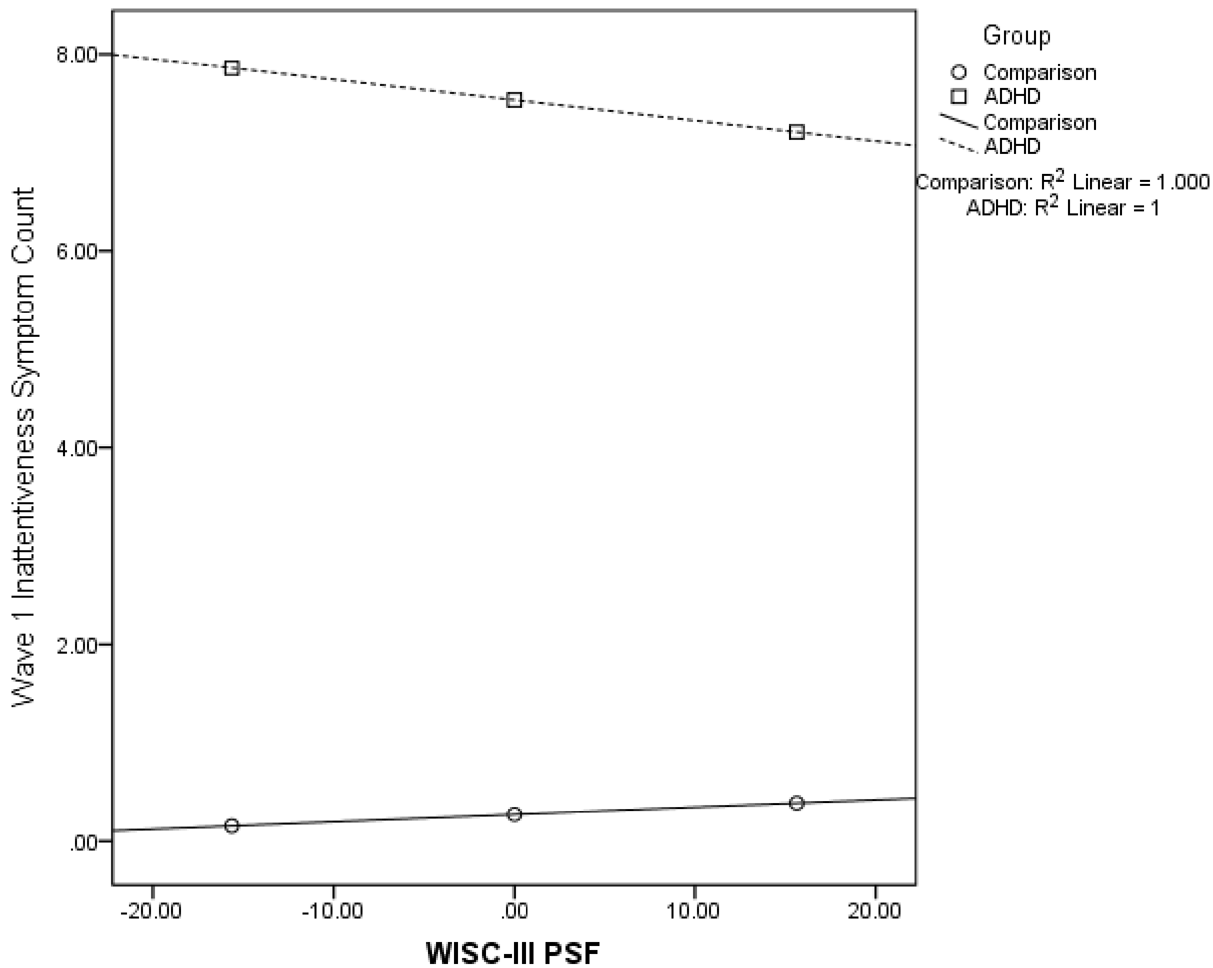


*Figure 2.* *Moderation effects of group on the relationship between WISC-III PSF and Wave 1 inattentiveness symptom count.*

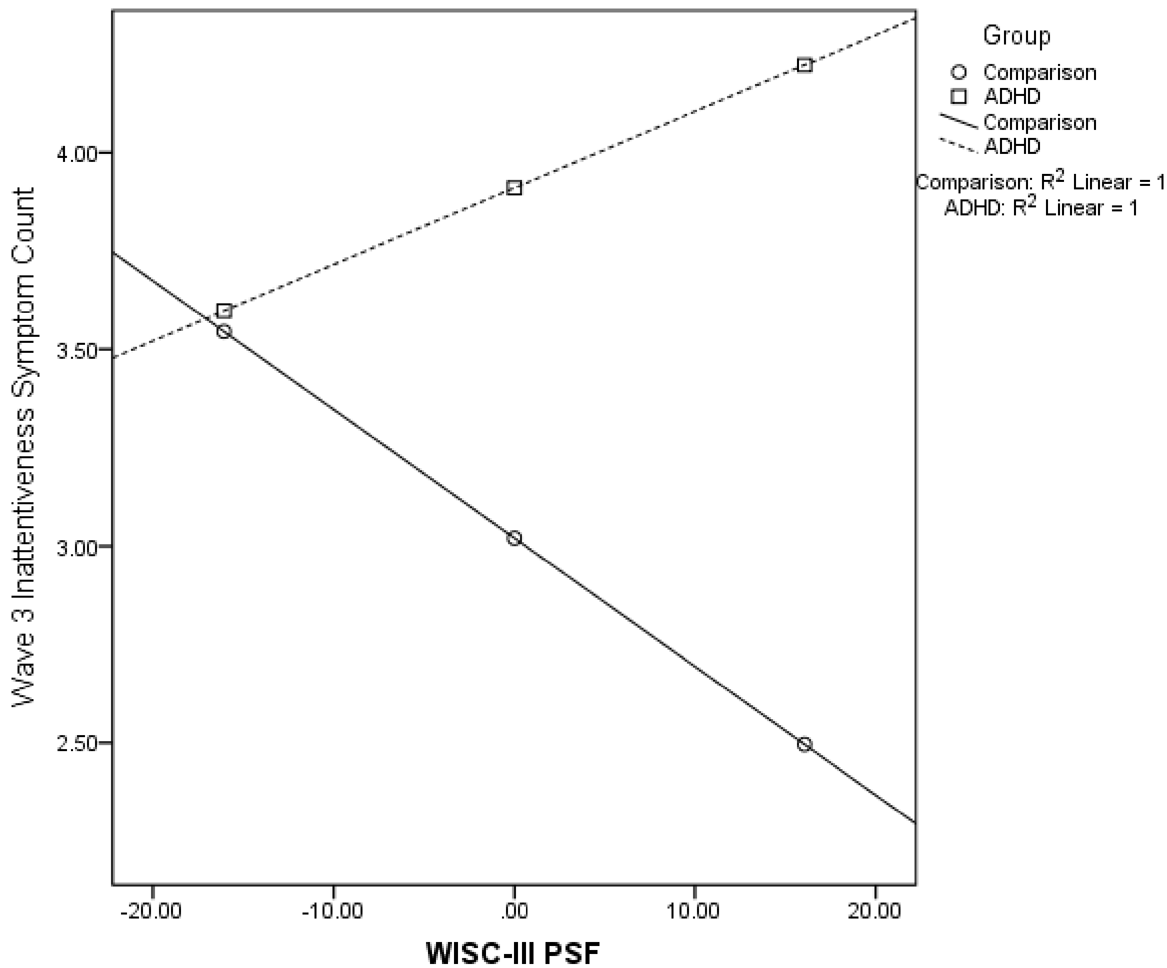


*Figure 3.* *Moderation effects of group on the relationship between WISC-III PSF and Wave 3 inattentiveness symptom severity.*

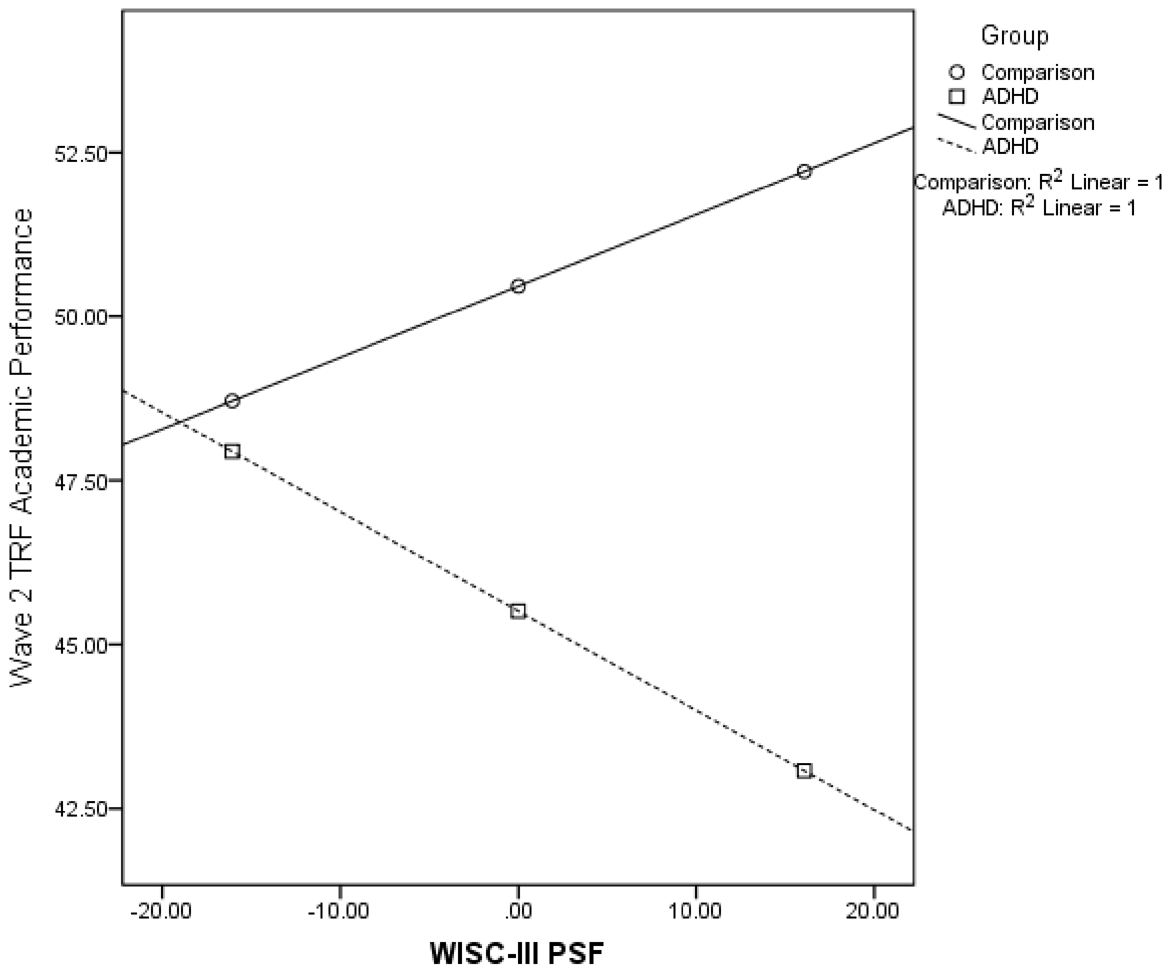


*Figure 4.* *Moderation effects of group on the relationship between WISC-III PSF and Wave 2 teacher report of academic performance.*

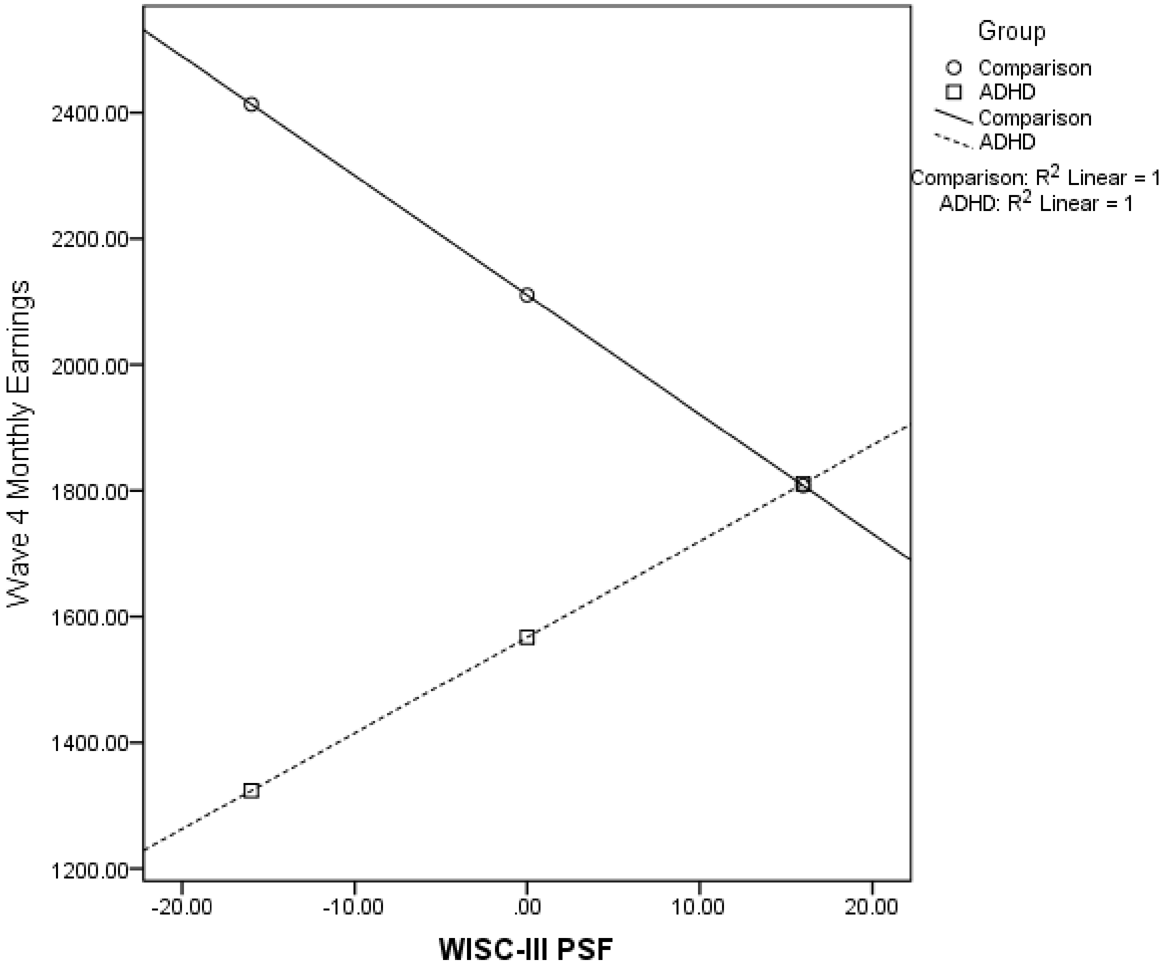


*Figure 5.* *Moderation effects of group on the relationship between WISC-III PSF and Wave 4 monthly earnings.*

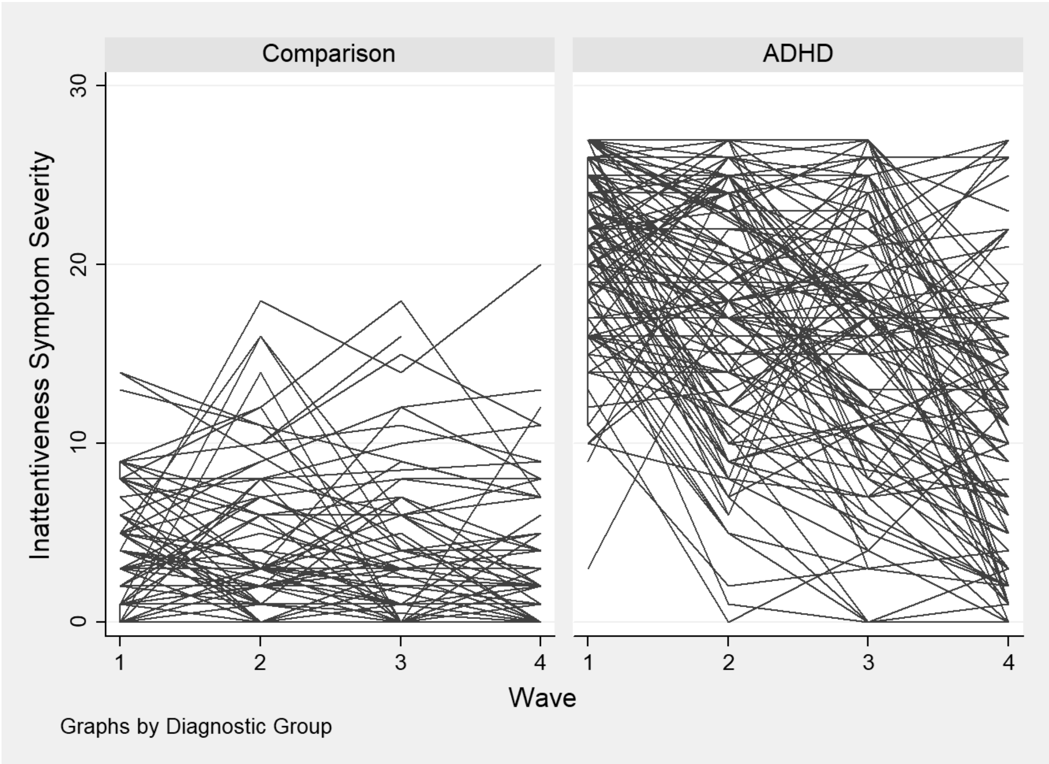


*Figure 6a. Trajectories of SNAP inattentiveness symptom severity by diagnostic group.*

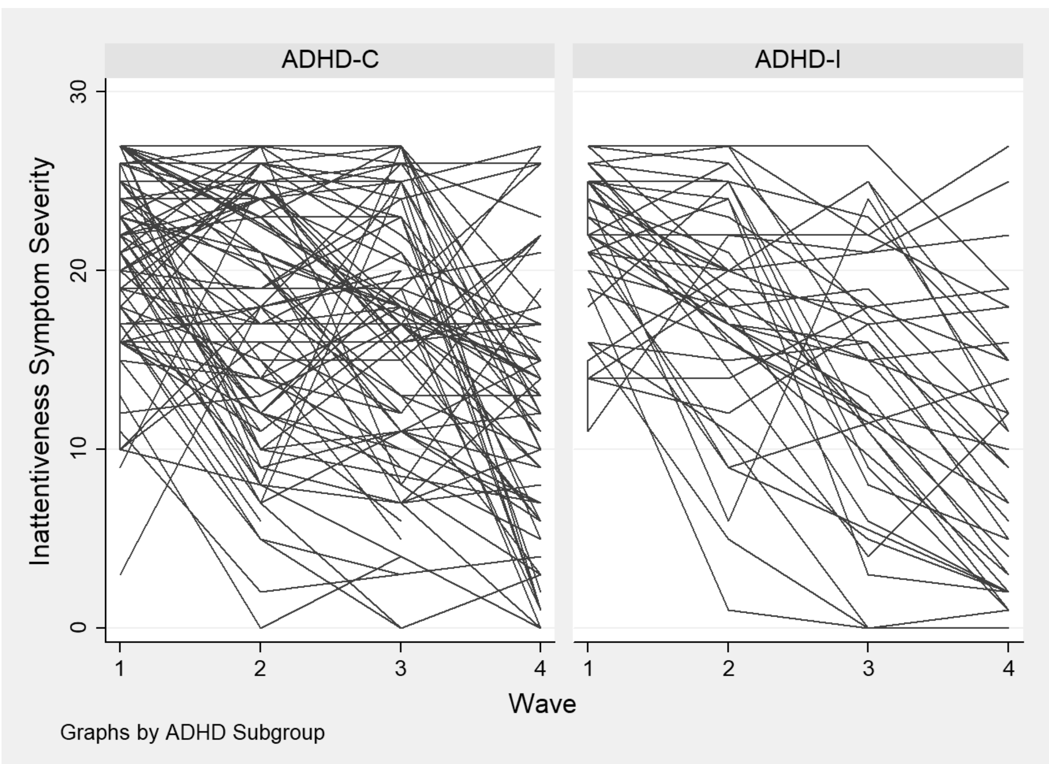


*Figure 6b. Trajectories of SNAP inattentiveness symptom severity by ADHD subgroup.*

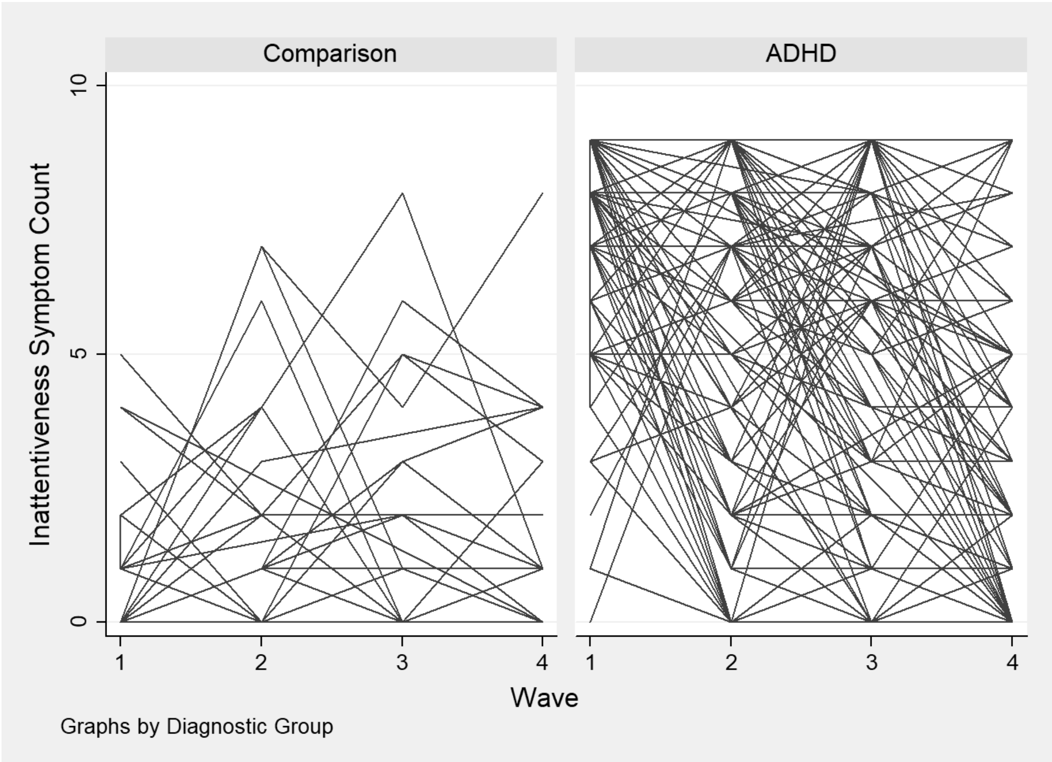


*Figure 7a. Trajectories of SNAP inattentiveness symptom count by diagnostic group.*

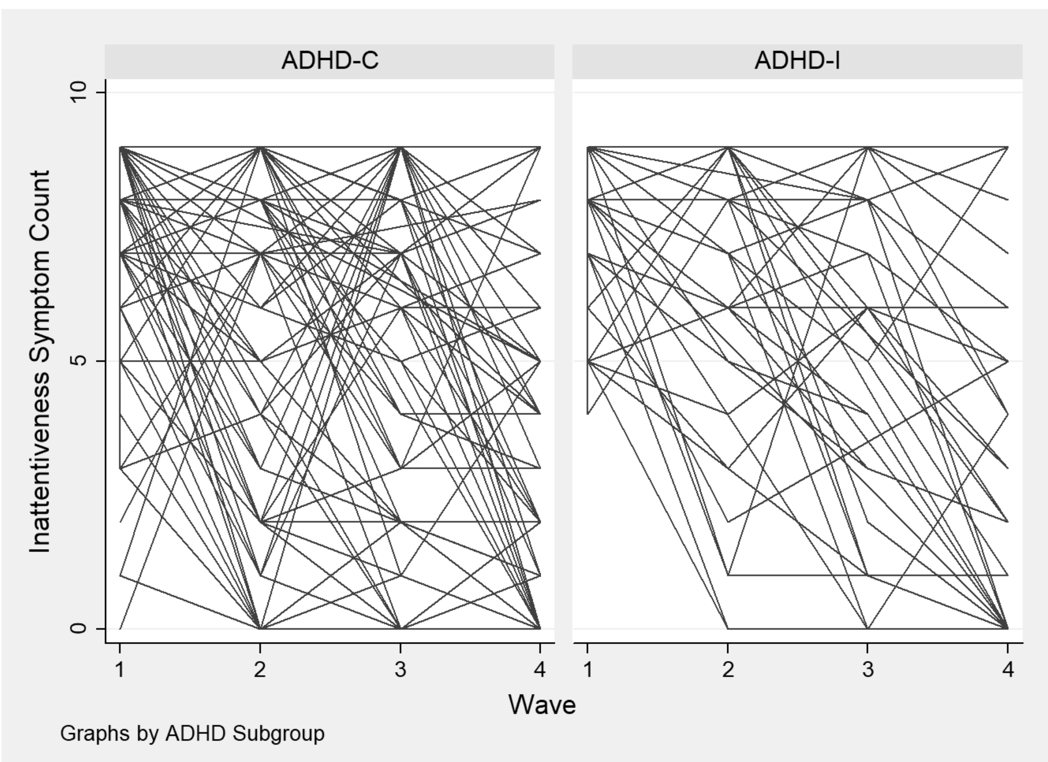


*Figure 7b. Trajectories of SNAP inattentiveness symptom count by ADHD subgroup.*

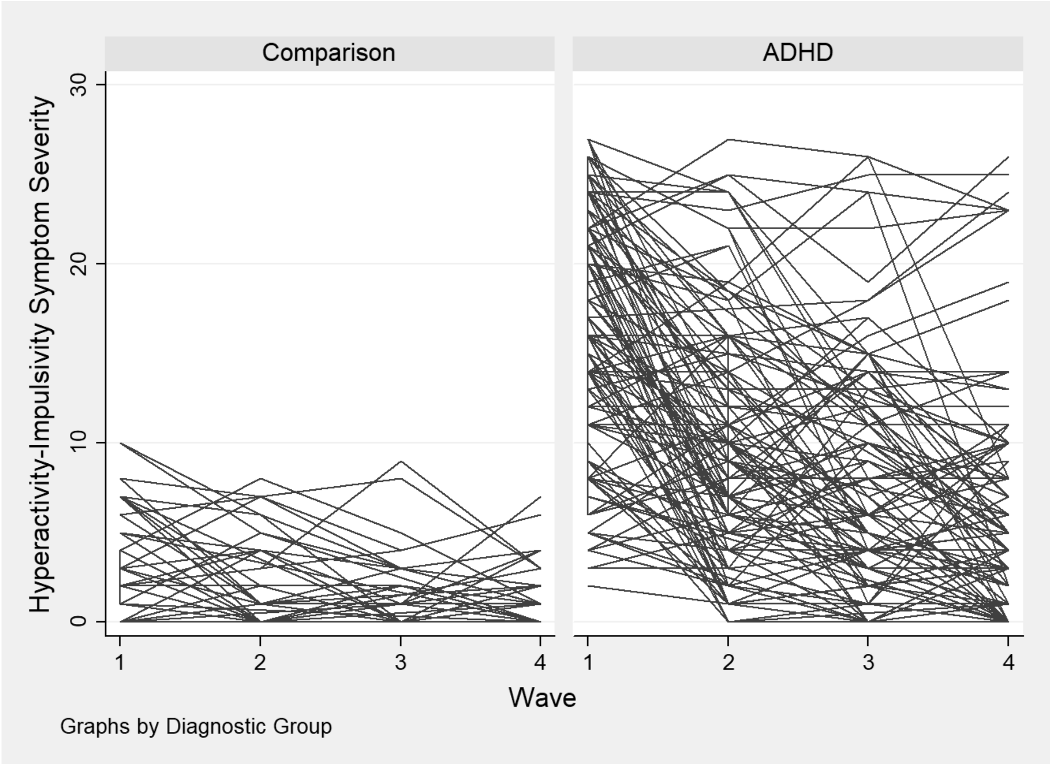


*Figure 8a.* *Trajectories of SNAP hyperactivity-impulsivity symptom severity by diagnostic group.*

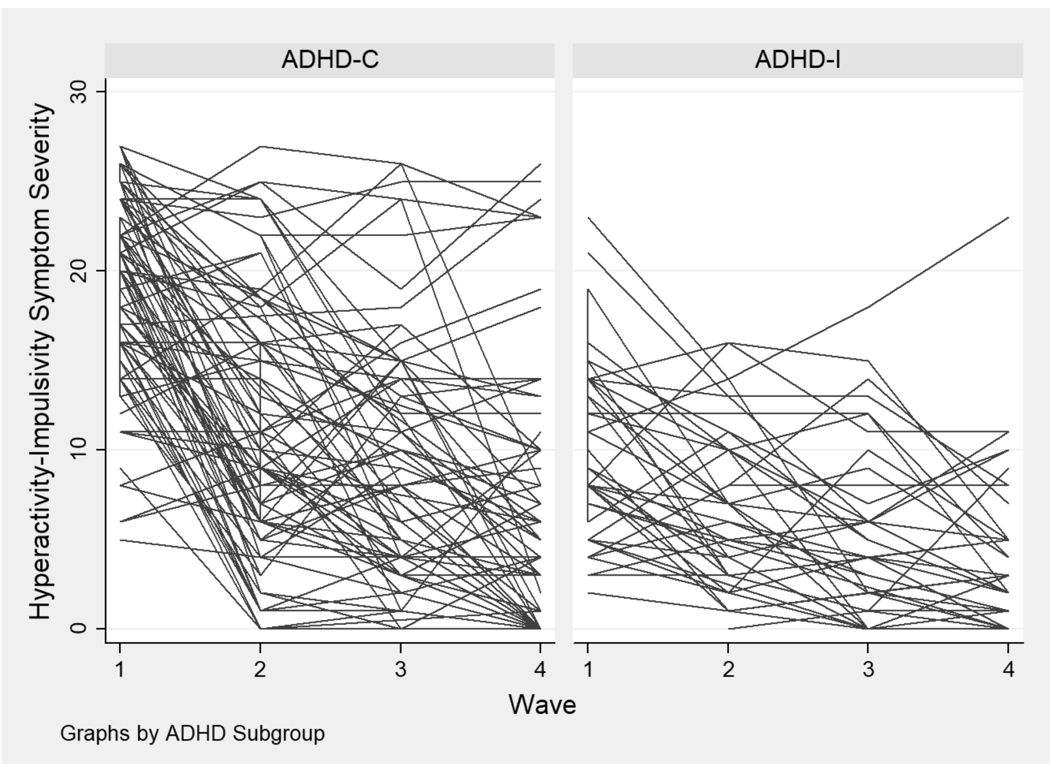


*Figure 8b.* *Trajectories of SNAP hyperactivity-impulsivity symptom severity by ADHD subgroup.*

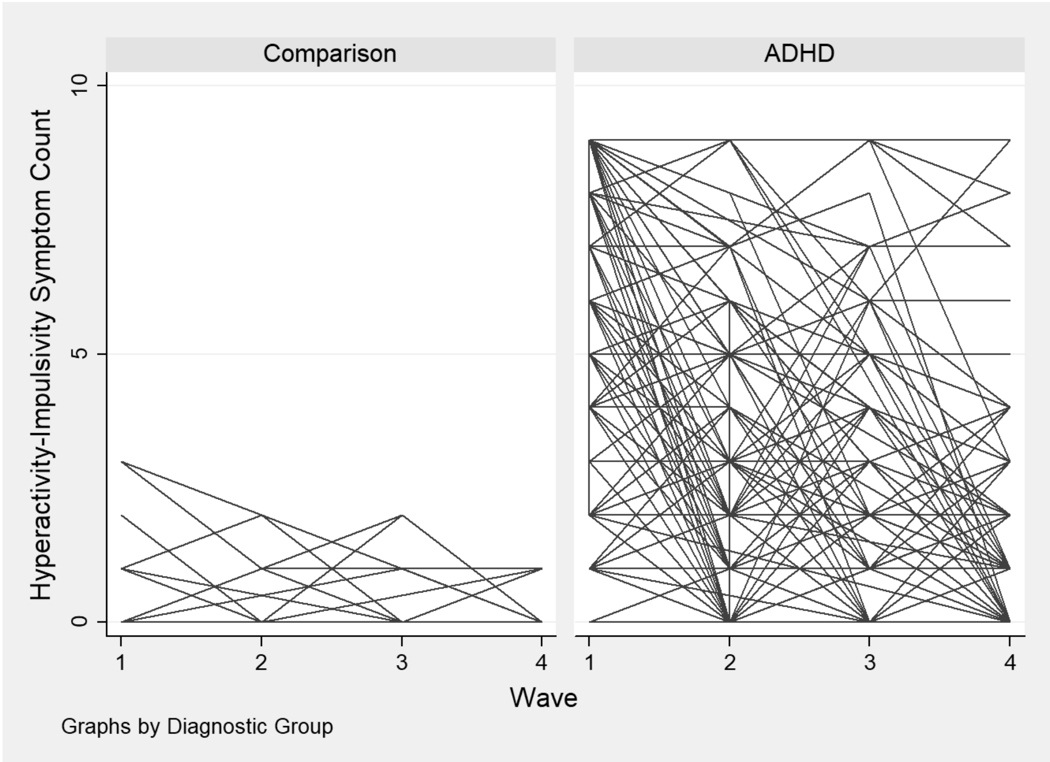


*Figure 9a.* *Trajectories of SNAP hyperactivity-impulsivity symptom count by diagnostic group.*

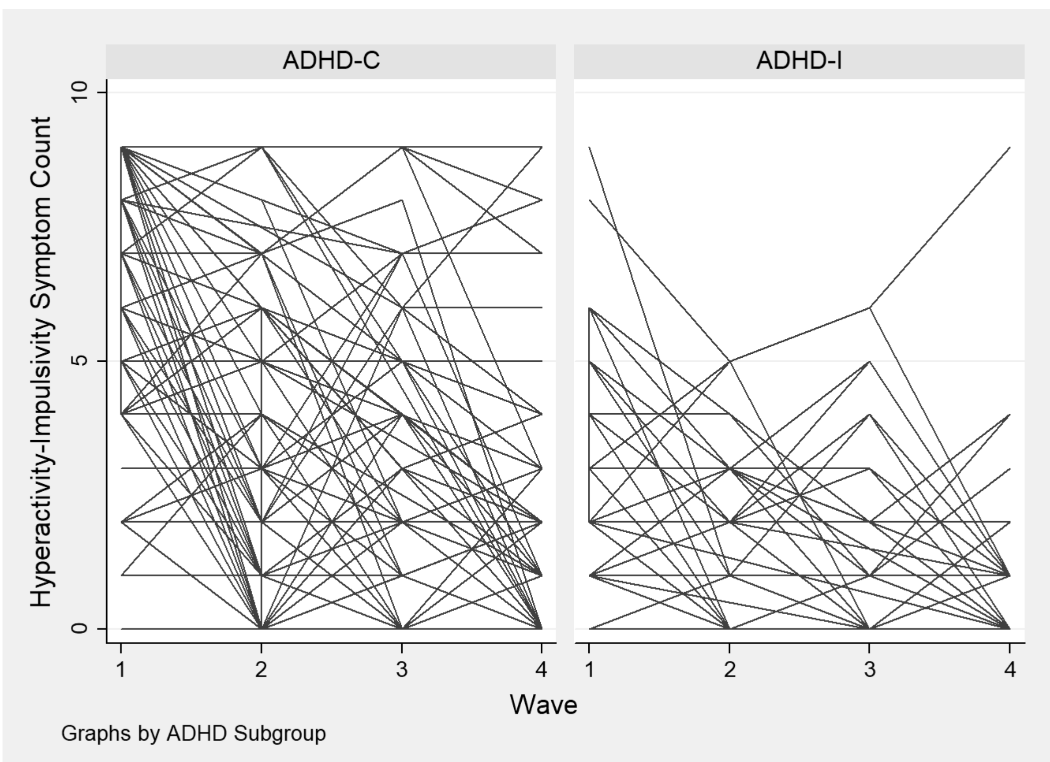


*Figure 9b.* *Trajectories of SNAP hyperactivity-impulsivity symptom count by ADHD subgroup.*

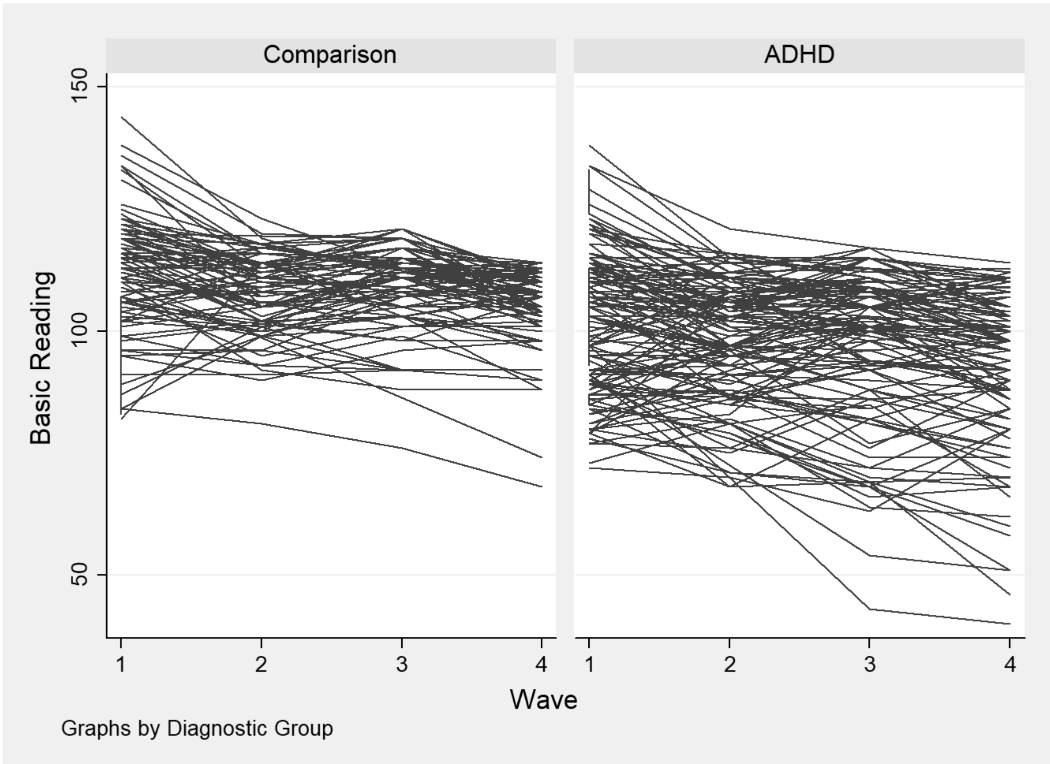


*Figure 10a. Trajectories of WIAT Basic Reading performance by diagnostic group.*

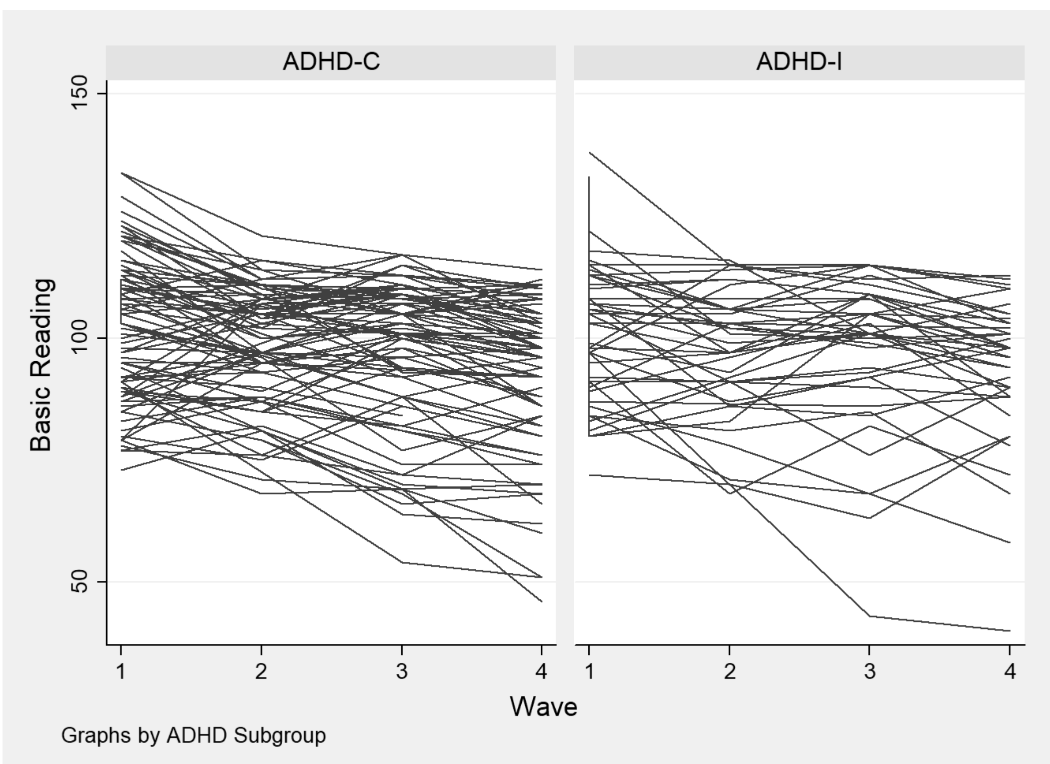


*Figure 10b. Trajectories of WIAT Basic Reading performance by ADHD subgroup.*

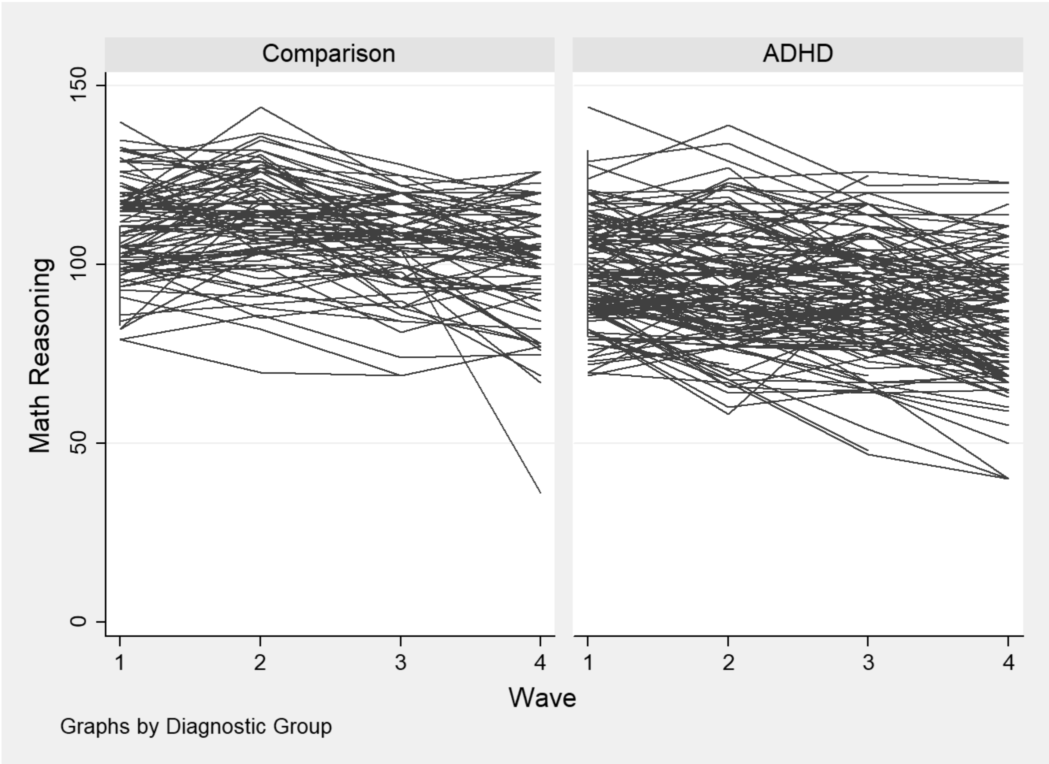


*Figure 11a. Trajectories of WIAT Math Reasoning performance by diagnostic group.*

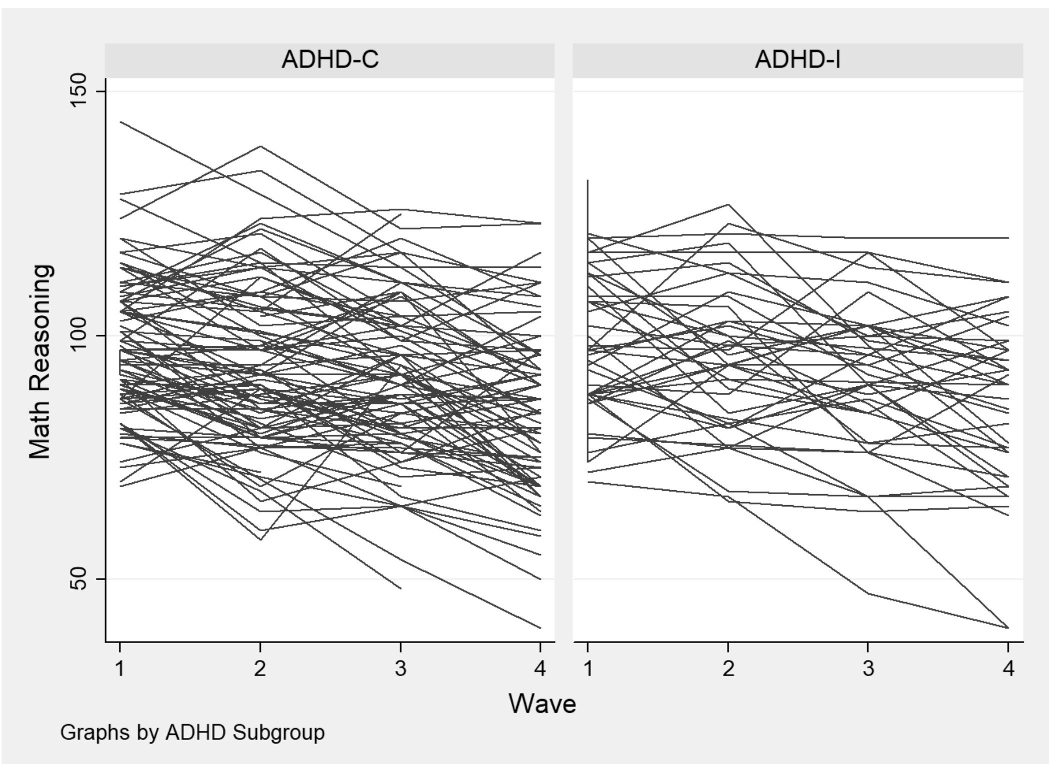


*Figure 11b. Trajectories of WIAT Math Reasoning performance by ADHD subgroup.*

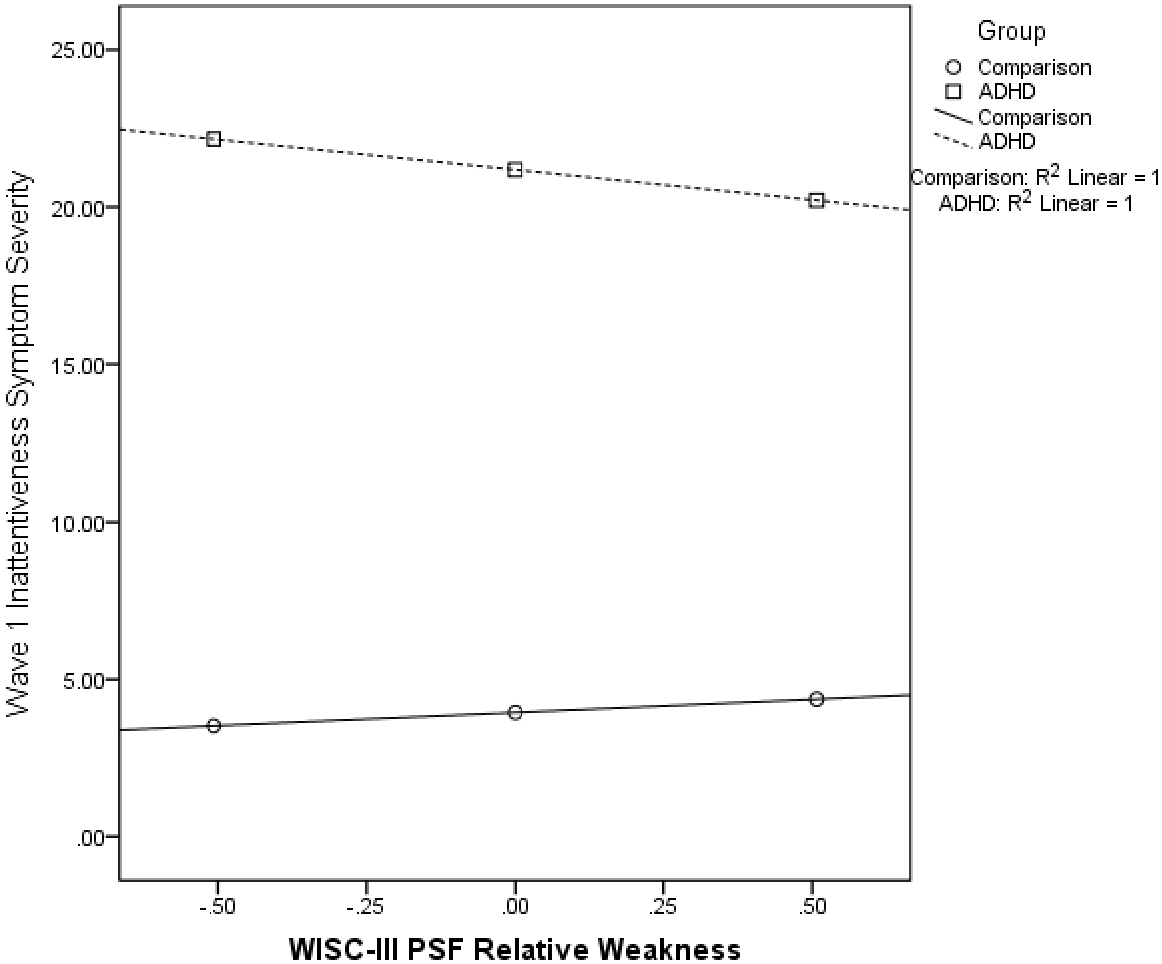


*Figure 12.* *Moderation effects of group on the relationship between WISC-III PSF relative weakness and Wave 1 inattentiveness symptom severity.*

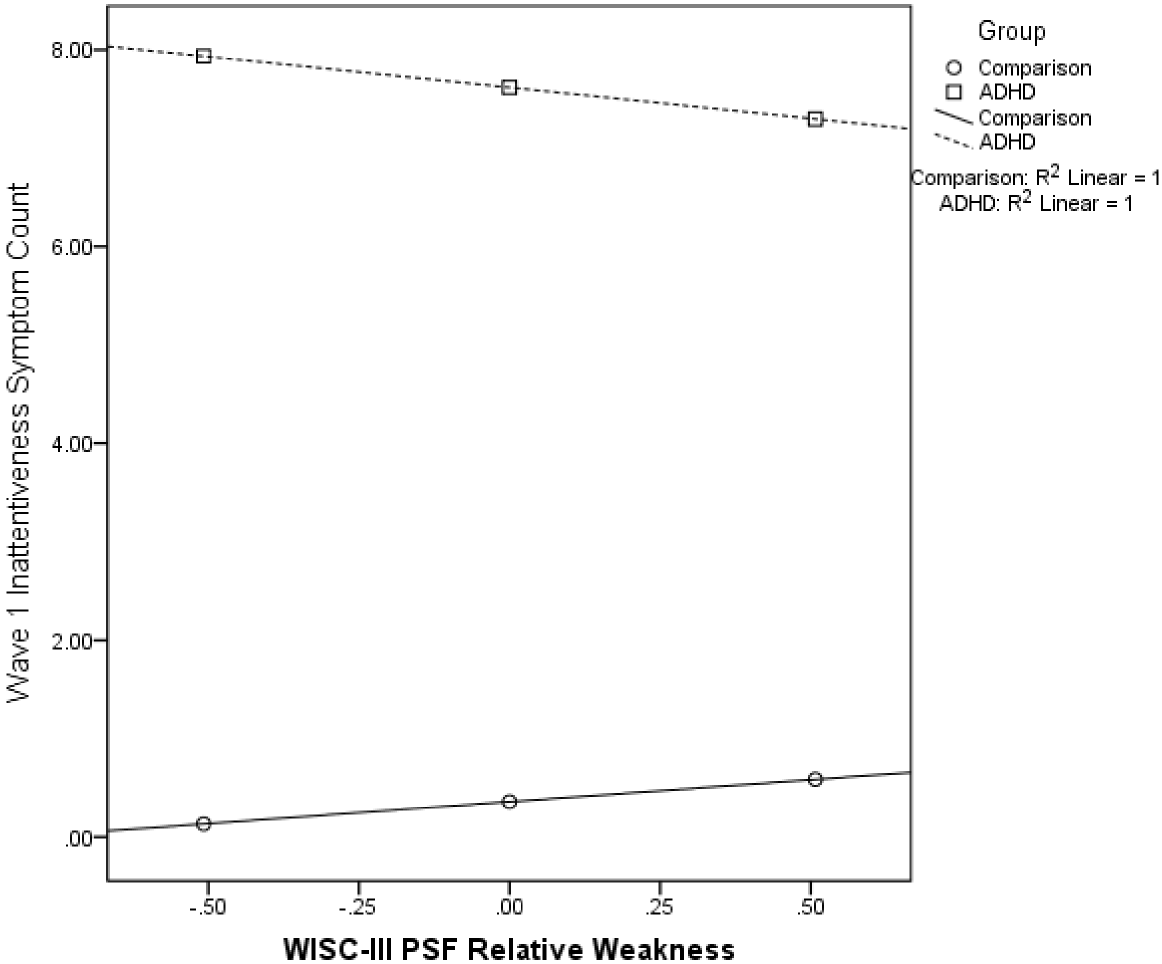


*Figure 13.* *Moderation effects of group on the relationship between WISC-III PSF relative weakness and Wave 1 inattentiveness symptom count.*

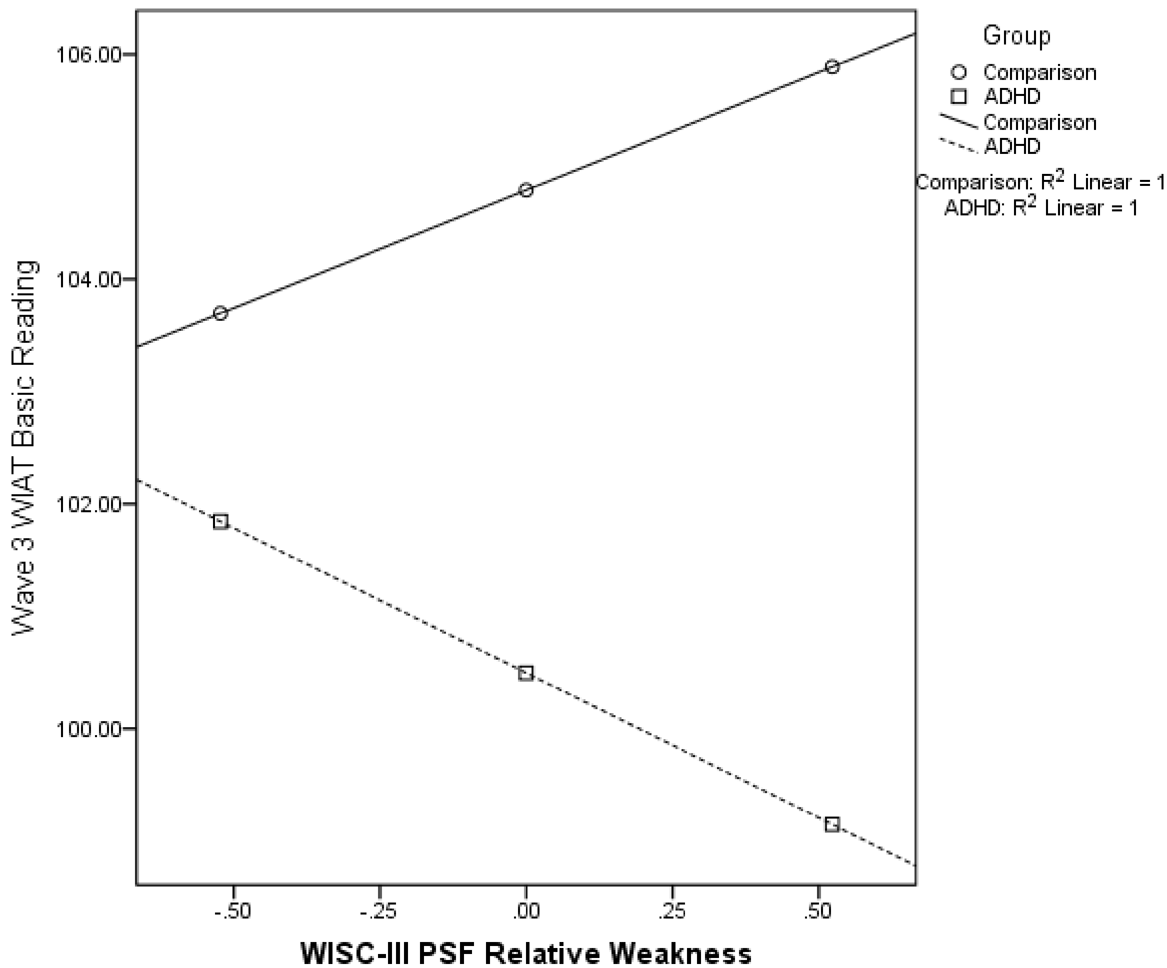


*Figure 14.* *Moderation effects of group on the relationship between WISC-III PSF relative weakness and Wave 3 basic reading performance.*

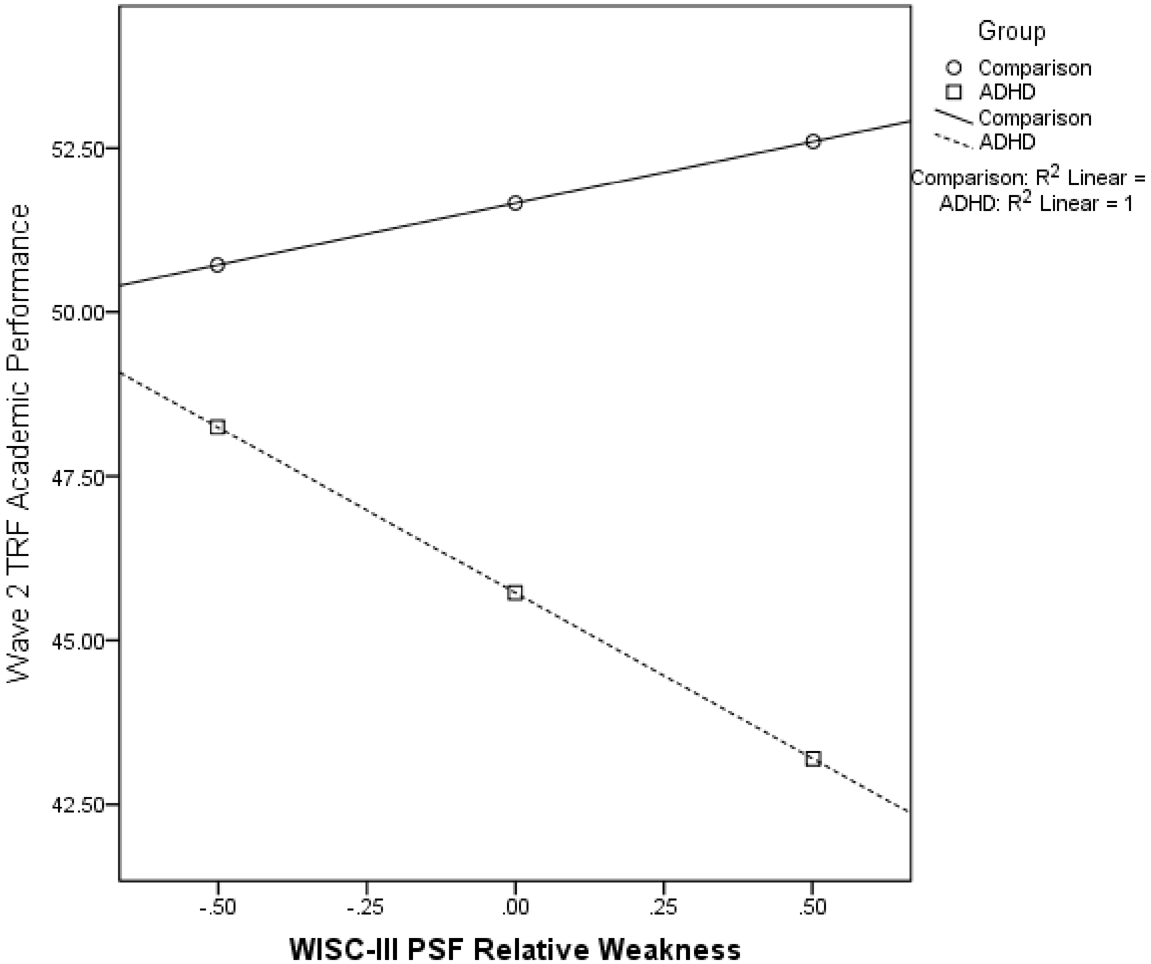


*Figure 15.* *Moderation effects of group on the relationship between WISC-III PSF relative weakness and Wave 2 teacher report of academic performance.*

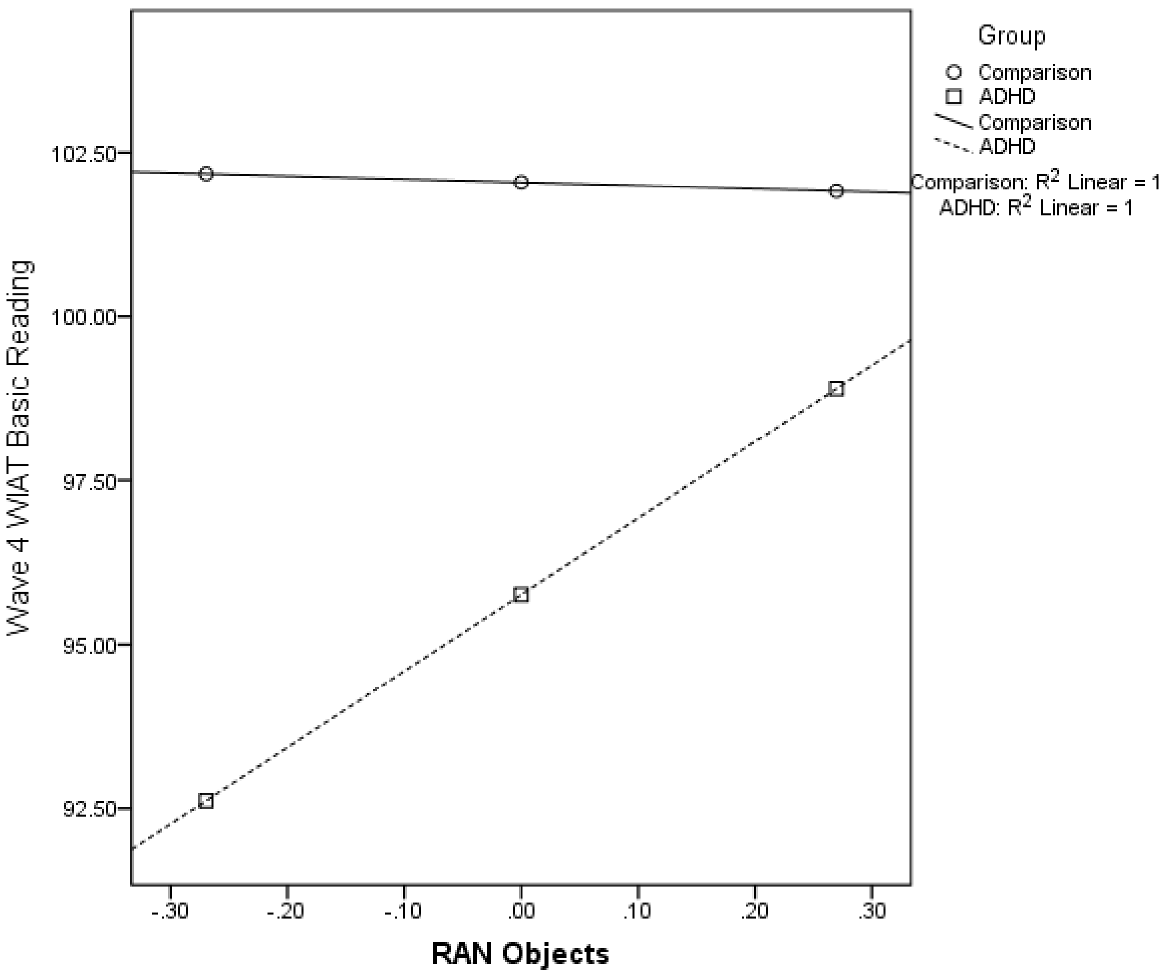


*Figure 16.* *Moderation effects of group on the relationship between RAN Objects accuracy rate and Wave 4 basic reading performance.*

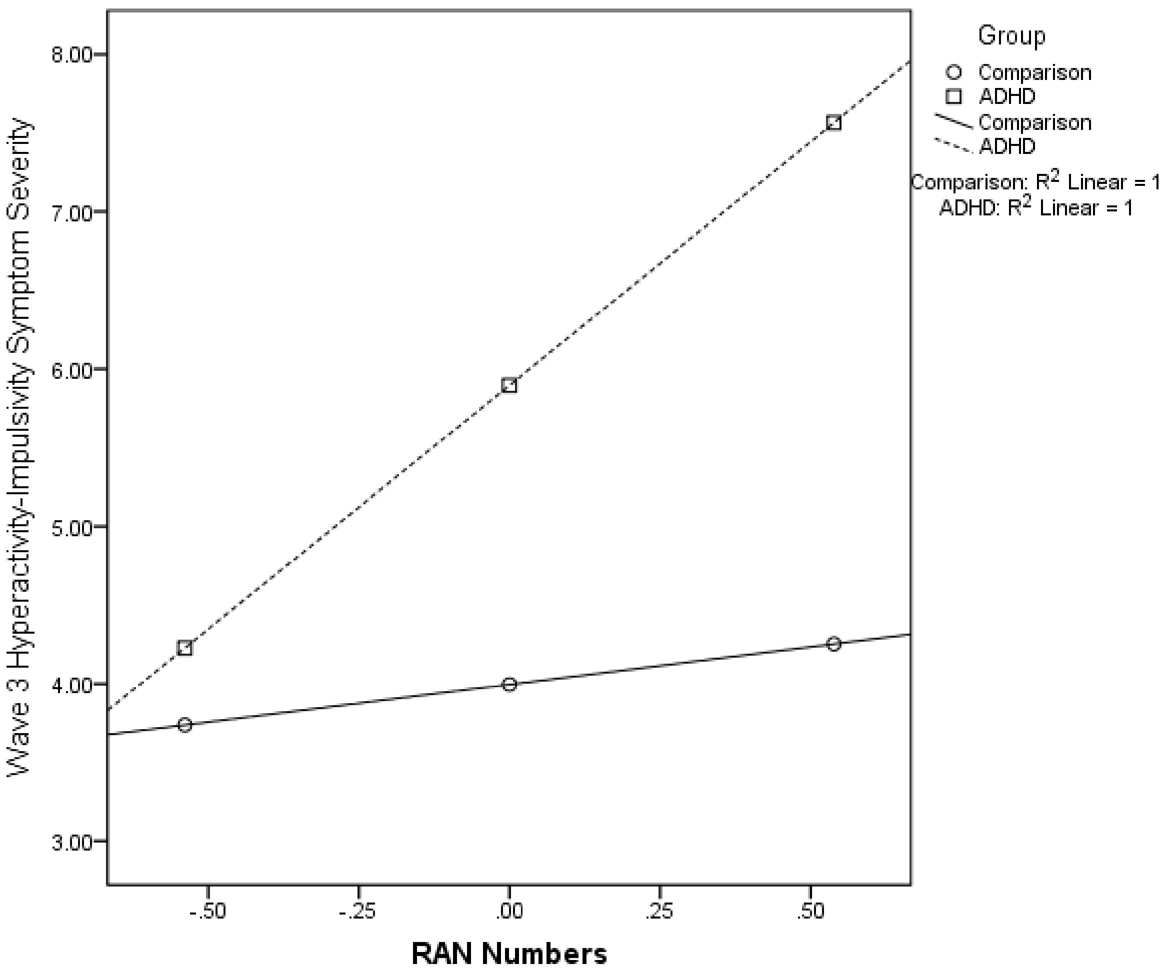


*Figure 17.* *Moderation effects of group on the relationship between RAN Numbers accuracy rate and Wave 3 hyperactivity-impulsivity symptom severity.*

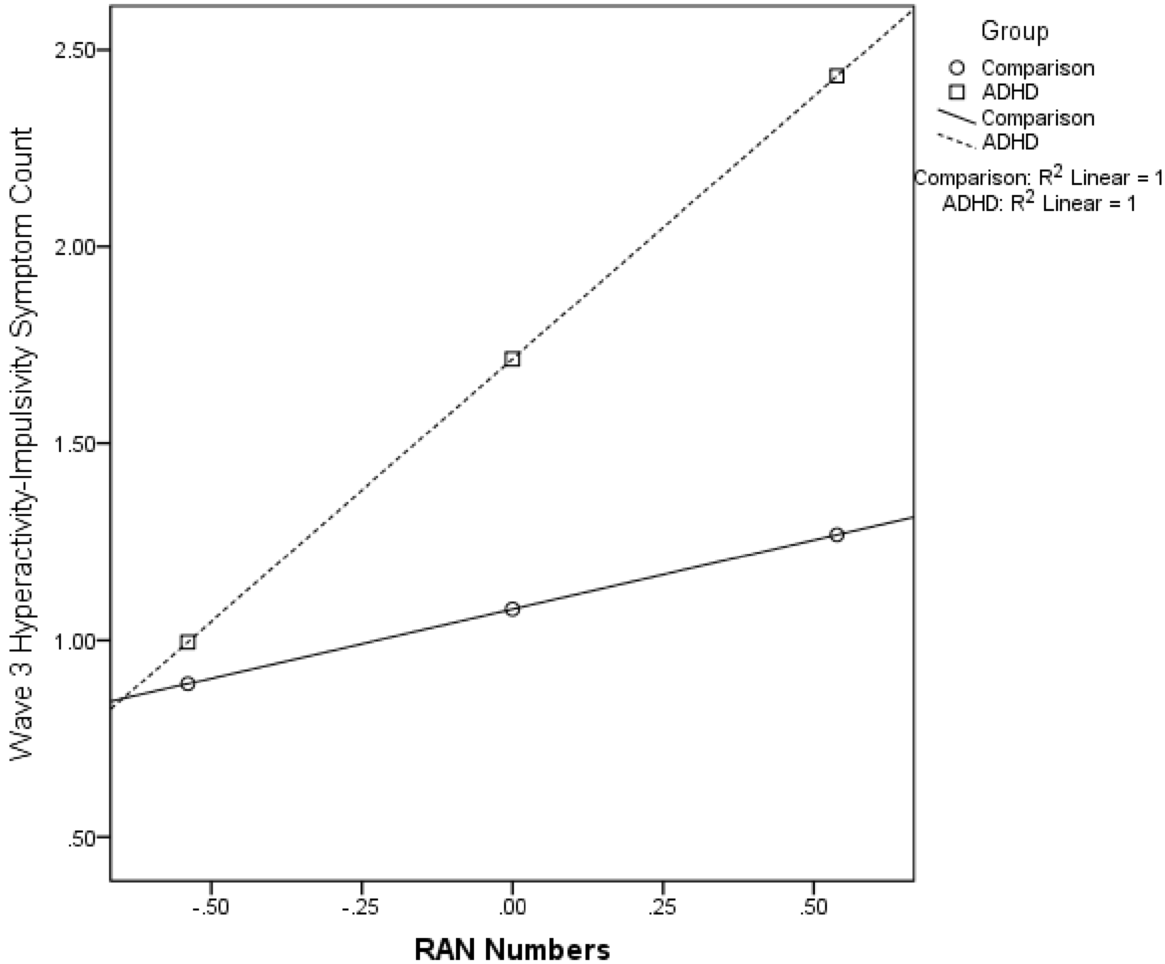


*Figure 18.* *Moderation effects of group on the relationship between RAN Numbers accuracy rate and Wave 3 hyperactivity-impulsivity symptom count.*

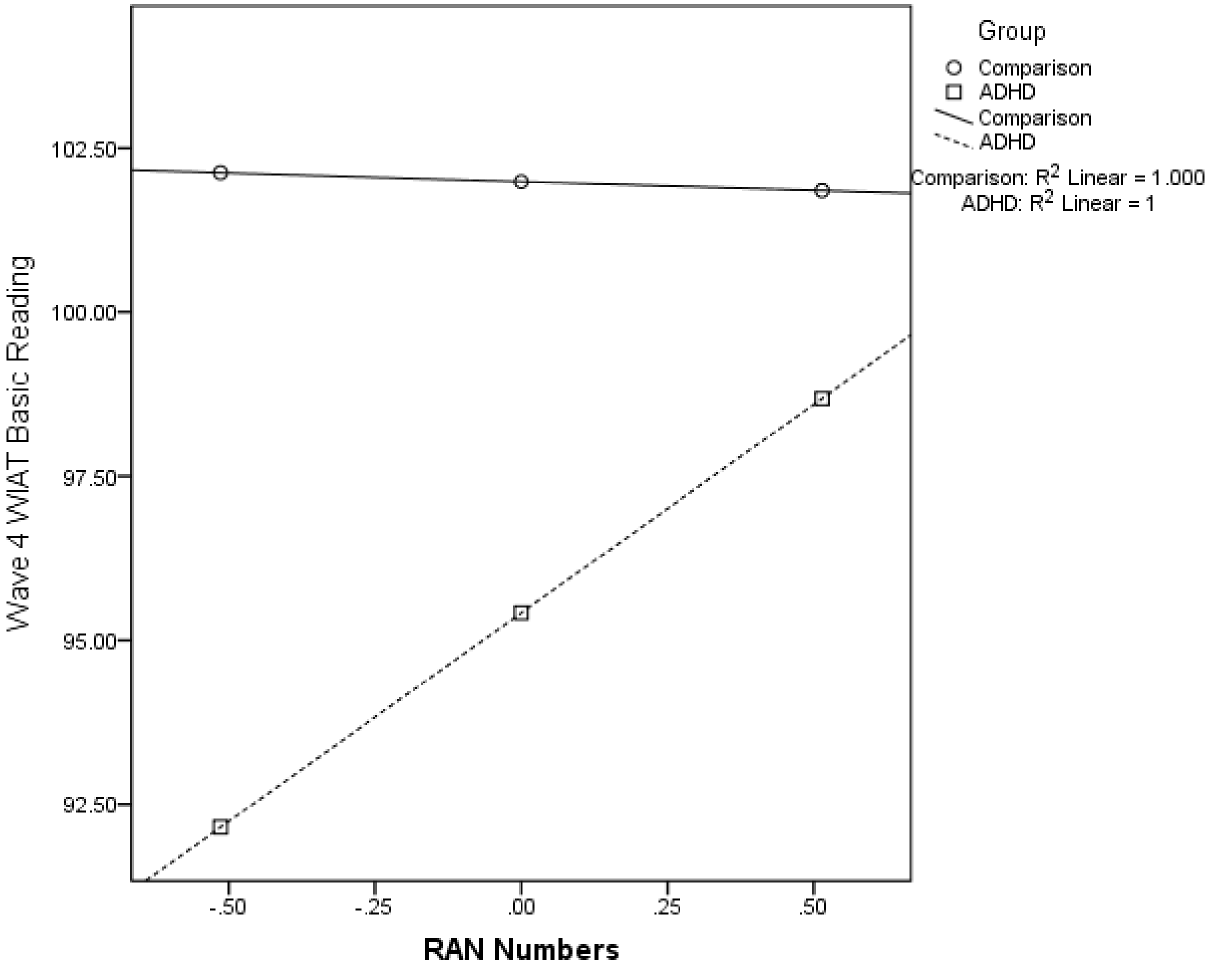


*Figure 19. Moderation effects of group on the relationship between RAN Numbers accuracy rate and Wave 4 basic reading performance.*

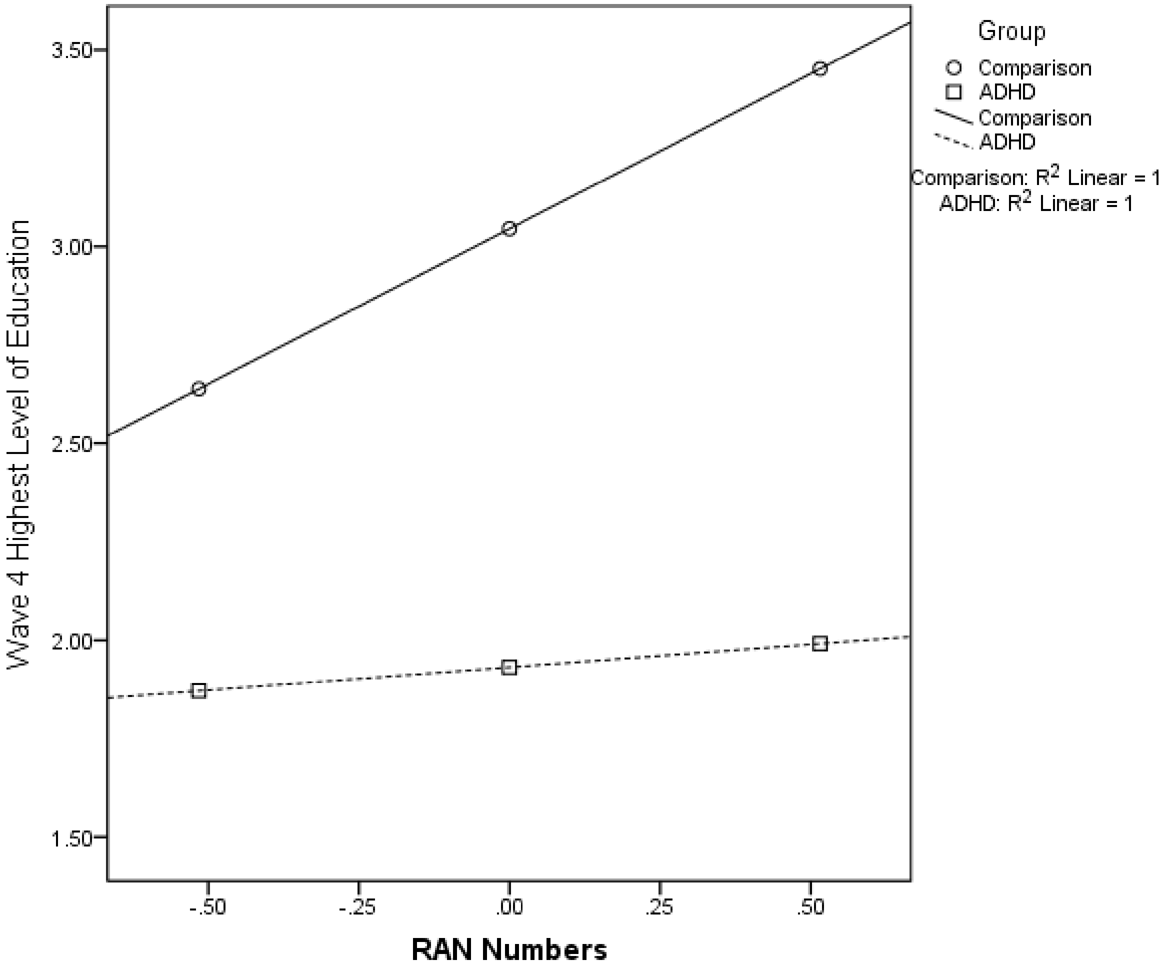


*Figure 20.* *Moderation effects of group on the relationship between RAN Numbers accuracy rate and Wave 4 highest level of education attained.*