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THE RELATIONSHIP BETWEEN ARTICULATION SPEED AND ACADEMIC ACHIEVEMENT IN CHILDREN WITH AND WITHOUT ATTENTION-DEFECIT/HYPERACTIVITY DISORDER

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ABSTRACT

Objective: Previous research has been conducted that looks at ADHD and how it affects both articulation speed and overall academic achievement, separately. However, the purpose of this study is to examine the relationship that articulation speed has on academic achievement for those with and without ADHD. **Methods:** A sample of 223 children, 70 with ADHD and 153 controls, were administered academic achievement tasks of reading, spelling, and math. The participants also performed an articulation speed task where they were asked to repeat a sequence of letters and/or numbers as quickly and as accurately as they could following an auditory start tone. **Results:** The participants with ADHD showed to have lower academic achievement scores in comparison to their control counterparts. Additionally, there were no significant group differences in overall articulation speed in regards to preparatory interval and speech rate. Although, both speech rate and preparatory interval were negatively correlated with math and reading while speech rate was uniquely correlated with spelling. **Conclusion**: The results suggest that because the articulation speed for those with ADHD were no longer/slower than for those without ADHD, it is not reasonable to infer that articulation speed affects academic achievement. However, the status of ADHD has a major effect on academic achievement, which could account for the relationship that has been identified by the results.

TABLE OF CONTENTS

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INTRODUCTION

Attention-Deficit/ Hyperactivity Disorder

Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized as a neurodevelopmental disorder according to the *Diagnostic Manual of Mental Disorders, 5th edition (DSM-V)* (American Psychiatric Association [APA], 2013). The neurodevelopmental disorders are those in which the start of the disorder occurs in the early stages of development. According to the DSM-V (APA, 2013), ADHD is defined as showing consistent signs of impulsivity, inattention, and hyperactivity that interfere with development that may result in disruptions in daily functioning.

There are two major dimensions in which ADHD is categorized: inattention and hyperactivity/impulsivity. According to the DSM-V, children with the "combined presentation" must display behaviors consistent with that of impulsivity as well as inattention for at least six months, and those behaviors must cause impairments to social as well as academic functioning. The second and third presentations are the "predominantly inattentive presentation" and "predominantly hyperactive/impulsive presentation", respectively.

A number of symptoms of the disorder are exhibited that specifically correspond to the inattention and hyperactivity presentations. These symptoms need to be consistently apparent in two or more major natural settings that a child engages within such as the home and the school environment (APA, 2013). It is necessary that multiple informants across several settings that associate with the child report what types of symptoms are evident in order to properly detect and diagnose the disorder (Felt, Biernmann, Christner, Kochhar, & Harrison, 2014). The parents and teacher of the child must recognize the behaviors associated with ADHD which can impair

functioning of the child. These behaviors can disrupt social, academic, and familial interactions. There is a list of symptoms presented by the DSM-V, for the presentations displayed within ADHD. In order to be diagnosed with ADHD for a specific presentation, a child must exhibit six or more symptoms from the list. However, if demonstrating the combined presentation, then the child must display six symptoms from both the inattentive and hyperactive/impulsive list (Biederman & Faraone, 2005).

The first set of symptoms or traits associated with the inattentive presentation of ADHD consists of behaviors associated with the inability to focus. The individual may be easily distracted, may struggle to stay on task for long periods of time, have difficulty staying organized, and may not listen to instructions or follow through with tasks or other activities (APA, 2013; Bokor & Anderson, 2014). These particular behaviors can hinder the individual's functioning in proper social and academic settings. The classification of hyperactivity includes symptoms that follow the notion of restless behaviors which can ensue the failure to keep still and therefore become squirmy. Impulsivity as a constituent of hyperactivity entails the concept of 'doing before thinking'. This would include being inconsiderate and act in frustration towards others, being impatient, and disclosing information that may be inappropriate to the situation (Bokor & Anderson, 2014). These symptoms and behaviors listed and explained by the DSM-V can help to reach and to determine an appropriate diagnosis.

Prevalence

ADHD is the most commonly diagnosed neurological disorder in children and about 5.4 million of the children in the United States have been diagnosed with ADHD which is an estimated 9.5% of US children (Feldman & Reiff, 2014). According to the Centers for Disease

Control and Prevention (CDC), as cited by Bokor & Anderson (2014), indicate that 13.2% of boys and 5.6% of girls from the ages of 4 to 17 are diagnosed with ADHD. According to Rucklidge (2010), boys are more likely to be diagnosed with ADHD and are represented by the ratio of 2:1, for boys and girls diagnosed, respectively. Eight to twelve percent of children in the world are diagnosed with ADHD (Biederman & Faraone, 2005). The behaviors associated with ADHD are usually apparent before the age of twelve (APA, 2013).

There are several groups of individuals in which ADHD is more common. According to Biederman & Faraone (2005), studies have shown that males, as discussed earlier, those of a lower socioeconomic status, and those who are younger in age are more likely to be diagnosed with ADHD. This particular disorder co-occurs with internalizing disorders such as anxiety and depression. It also occurs alongside externalizing problems such as disorderly behaviors and conduct issues, as well as problems with learning and language (Feldman et al., 2014). These externalizing and internalizing disorders can cause problems for an individual with ADHD in many different settings, specifically in a structured-academic setting.

Beyond childhood ADHD

Biederman & Faraone (2005) reported that the symptoms of ADHD in adolescence and early adulthood decrease for about half of the population; hence, most or all of the symptoms are non-existent. However, the other half either retain all or some of the symptoms associated with the disorder into adolescence and early adulthood. This source also claims that 25% of those who retain the symptoms will go on to develop another disorder such as antisocial personality disorder (Biederman & Faraone, 2005). This particular disorder can cause major issues in other aspects of life such as possible drug or alcohol dependence or even incarceration.

According to the DSM-V (2013), adults with ADHD exhibit a minor amount of symptomatic behaviors that include improper motor activity, while the behaviors of inattentiveness and impulsivity/hyperactivity remain prevalent. Adults with ADHD account for 2.5% of the population, which appears to be a disorder that is continuous throughout childhood and into adulthood. It also appears to be tied with lower academic success in childhood which can continue into adulthood due to its pattern of continuity throughout the lifespan. This can affect those in the work force or academia, unless treated appropriately (Loe & Fieldman, 2007).

Academic Achievement and ADHD

Children with ADHD demonstrate lower performance in writing, reading, and mathematics (Loe & Fieldman, 2007). Barry, Lyman, & Klinger (2002) performed a study that observed academic achievement with individuals with ADHD and those without. In this study, the male cohort displayed a lower academic achievement for reading compared to females in the study (Barry, Lyman, & Klinger, 2002). There were individuals in the ADHD group that were diagnosed with a learning disability, which is a comorbid disorder that is commonly associated with ADHD. There was not a great significance of difference in the scores of mathematics, writing, or the basic skills that were tested in the study. Although, the scores were lower compared to the counterparts who did not have ADHD.

There is also considerable evidence that claims individuals with ADHD end up having to repeat a grade because of their lack of proficiency in academics (Daley & Birchwood, 2010). There may appear to be several predictors of underachievement, according to Barry, Lyman, & Klinger (2002). Their research study has found that when measuring and accounting for academic achievement, executive functioning, which entails the ability to organize, problem

solve, and plan, is at the forefront of academic achievement. Executive functioning attends to cognition and control, as well as how attention is delegated. The study showed that those with ADHD had greater differences in their math scores compared to those without ADHD. Those who had a higher level of ADHD severity performed worse in each of the tests that were administered to both ADHD participants with a lesser severity and non-ADHD participants (Barry, Lyman, & Klinger 2007). According to Rodriquez and colleagues (2007), as cited by Daley & Birchwood (2010), the inattentive presentation displayed by an individual with ADHD exhibits a negative relationship to academic areas of mathematics, reading, and writing. As more inattentive behaviors are displayed, the worse one does in those particular academic areas.

Rabiner et al. (2004) suggested from their study that hyperactivity increases the inattentiveness that an individual exhibits which in return decreases the level of academic performance for someone with ADHD. The study also investigated the differences amongst several ethnicities such as African American, Hispanic, and Caucasian individuals. There were higher expectations for academic achievement in Caucasians than for both Hispanics and African Americans. The results of their study showed that African Americans are associated with higher inattentiveness. However, inattention affected a small proportion of those of Hispanic ethnicity, as illustrated by the study. There was also a significant difference in academic achievement between African Americans and Caucasians; Caucasians did have a greater academic achievement (Rabiner et al., 2004).

Overall, the academic achievement of those with ADHD was worse than those who do not have ADHD. It has been mentioned previously that ADHD is also comorbid with learning deficits, and so the inattentiveness as well as impulsivity components of ADHD negatively affect

academics. Barry, Lyamn, & Klinger (2007), found that the ADHD group did have lower IQ scores than the non-ADHD group. Again, they scored below average on the norm-referenced testing that was done in the academic areas of writing, reading, and mathematics. The norm-referenced test are distributed based upon the age as well as the grade level of the child so that the scores of the participants can be compared to their peers, nationally. There were several differences in the academic areas tested for those who were diagnosed with ADHD (Barry, Lyman, & Klinger, 2007). Here, they found that the control participants scored below the author's predicted estimation while the ADHD participants performed above prediction in both reading and math, but did score below prediction for writing. The predicted estimation score was created by the score of the individual's IQ in relation to academic achievement (Barry, Lyman, & Kilnger, 2007).

ADHD and Reaction Time

There have been numerous studies that have examined the differences in response and reaction times in populations of individuals with and without ADHD. According to Johnson, et al. (2007), reaction time (RT) variability can be due to the functioning of the frontal cortex and may reflect impairments when attending to tasks for an extended period of time. The cognitive mechanisms that underlie their performance have also been routinely identified. One particular study highlighted the motor pace as well as language deficits in a population of young boys with and without ADHD. In order to test verbal speed measures, the study used a "Rapid Automatized Naming" (RAN) task and a "Time To Do 20" task for measuring motor speed (Carte, E. T., Nigg, J. T., & Hinshaw, S. P., 1996). Their participants were asked to undergo the RAN task which involves naming sets of pictures or symbols in a fast-paced manner. According to Wolf,

Bailey, & Morris (1986) as cited by Carte, et al. (1996), another component of the RAN task, digit naming, is a good predictor of a reading disability. However, here they employed the picture and symbol naming, which is not related to reading disabilities. The other task of interest was the Time To Do 20 (TTD-20) task adapted by Denckla (1974). The participants were instructed to complete 20 repetitive motion movements as quickly and accurate as possible. Results of the RAN task found that the participants were slower in production of the names. As for the TTD-20 task, the authors found that both the arm and leg movements were slower as well. In these speeded tasks, it has been shown that the boys with ADHD have slower motor movements and verbal fluency (Carte et al., 1996).

Another study enlisted only-male participants for their study. Rosch, Dirlikov, & Mostofsky (2013) monitored the motor and cognitive manipulation and their relationship with the intra-subject variability in a finger sequencing task. Again, their findings have been concistent with many of the other studies that will be further discussed. The boys with ADHD were slower and exhibited more variability in regards to their reaction times compared to the boys without ADHD. Also, in the finger sequencing task, the ADHD subjects were more likely to be slower to improve their motor control even after they were able to practice several times (Rosch, et al., 2013). Karalunas, et al. (2014) explains that the ADHD subjects slower reaction times on some tasks could possibly be due to their impaired motor output and input organization.

One other particular study examined the relationship amongst performance of RT with ADHD subjects, family members of the ADHD individuals, and non-ADHD counterparts (Andreou, et al., 2007). These authors utilized The Fast Task which emphasized speed and

accuracy in response time to a stimulus. The authors found from their study that the ADHD counterparts had slower response times but there was a greater individual's variability in RTs.

There has been a mix of research findings, as explained by Epstein, et al. (2011), on RT variability in reference to the different presentations of ADHD. However, this study probed the possible contributions to the RT variability with those who have ADHD by presenting these participants with numerous neuropsychological tests. The authors discovered that the ADHD participants exhibited slower mean RTs for only the Go/No-Go task. Also, the ADHD population had a higher RT variability when presented with various event rates and incentives to enhance performance rate. There was really no moderation effect amongst performance and the ADHD presenations, intelligence, or other co-occuring presenations associated with ADHD (Epstein, et al., 2011).

Johnson, et al. (2007) conducted a study that looked at the RT variability of subjects with and without ADHD by utilizing a Sustained Attention to Responst Task. Johnson, et al. (2007) found that the ADHD subjects engaged in sequentially slower reaction times during the task. The ADHD participants also had a greater amount of errors during the task course. They theorized that the ADHD sample's poor performance and variance in their performance during the task could possibly reflect poor attention skills associated with the diagnosis of ADHD (Johnson, et al., 2007).

After assessing a meta-anyltic review of 319 studies, Kofler, et al. (2013) found that the participants with ADHD do not indicate a processing speed that is slower when including for reaction time variability. This study discovered that the ADHD participants were in fact "more variable but not slower" than the non-ADHD individuals. Also, this attribution appears to be

present because of a subdivision's atyipical slow response rather than a pervasive slow response by the enitre population. Essentially, some of the ADHD subjects present an extremely slow response which skews the report of intra-subject variability (Kofler, et al., 2013). Klein, et al. (2006) found that an increased intra-subject variability, thus the individual variability in subjects, could be a tpyical phenomena of the ADHD diagnosis. The authors also claim that there has been a multitude of studies that investigate the intra-subject variability or also known as the intra-reaction time variability. However, the studies fail to coincide and tend to yield different results (Klein, et al., 2006) which appears to be a consistent problem amongst the data on this subject.

Articulation Speed

It has been well established that children with ADHD are slower and more variable on speeded tasks than children without ADHD. However, because children with ADHD have fine motor problems, it is not clear whether the slow and variable performance is due to problems coordinating finger movements, and whether slow and variable performance would be found in non-motor tasks including measures of articulation speed.

Passolunghi & Siegel (2004) utilized several tasks and tests to determine working memory and articulation efficiency in a population of children with problems in mathematics. Articulation speed and fluency was determined by several tests. The first test involved speech rate. The participant had to read out four Italian words, two that were three syllables each and two that were four syllables each. The participants were instructed to repeat the words in an accurate and fast-paced manner until told to stop. There was also a counting speed task in which the participants were asked to count from 1 to 20 as fast as they could three consecutive times. Then, there was an item counting task in which the participant was instructed to look at cards

that had blue and yellow dots, then told to count the yellow dots by pointing to each one. The speed of each task was timed by using a stopwatch. There was a poor performance in the speed of those participants who were having difficulties with math compared to those who were performing as expected in math.

Therefore, processing speed and articulation speed could possibly be great predictors of academic performance and partially explain ADHD-related academic concerns. Working memory, which is associated with executive functioning, can greatly affect the proficiency of several areas of academics such as reading, writing, and mathematics.

Hypothesis 1: It is hypothesized that the sample of participants with ADHD will have slower articulation speeds than the control counterparts.

Hypothesis 2: It is hypothesized that children with ADHD will have lower academic achievement in reading, math, and spelling, than the control counterparts

Hypothesis 3: A negative correlation is predicted between the variables of articulation speed and academic achievement, in which slower speed of articulation will hence predict lower academic achievement when examining the combined groups then the groups, separately.

METHODS

Participants

This study involved the participation of 223 children between the ages of 8 and 12.There were 70 children in the control group (31 males: 39 females) and 153 children with ADHD (56 females: 97 male). Ethnicity of the sample were 10.8% African American/Non-Hispanic, 73.5% Caucasian/Non-Hispanic, 1.3% Asian, and 14.4% mixed race/ethnicity. This study recruited these participants from surrounding areas of State College, PA as well as Harrisburg, PA.

Screening/ Data Collection Procedure

In order to participate in the study, there were three phases in the screening process used to determine eligibility. The initial phase was a phone screen. This phone screen was conducted by a research assistant with either a parent or caregiver of the child. In this initial phase, basic demographic and health information in regards to the participant was collected. The participants were ineligible to participant if their parents reported them having been diagnosed with a neurologic impairments or if they had a sensorimotor impairment that prevented them from completing study tasks (e.g. deaf/blind). Participating children were asked to be off of their stimulant medications for 24 to 48 hours prior to and during the session.

Parents and teachers completed: the ADHD Rating Scale-IV, the Conner's Rating Scale-Revised (CRS-R), and the Behavior Assessment Scale for Children-Second Edition (BASC-2). The questionnaires are geared to measure the level of hyperactivity/impulsivity and attention symptoms presented by the participant.

The ADHD Rating Scale-IV is a checklist of Inattention and Hyperactivity-Impulsivity. This scale is a 4-point Likert scale that uses the answers of "never or rarely", "sometimes",

"often", and "very often". The Inattention score is calculated by adding the odd-numbered items while the Hyperactivity-Impulsivity scale is calculated by adding the even-numbered items (DuPaul, Power, Anastopoulos, & Reid, 1998).

The CRS-R (Conners, Sitarenios, Parker, & Epstein, 1993) is another commonly used measure to investigate behaviors associated with ADHD. It is available in the full and short-form. The short-form is given to the teachers while the long-form is provided to the parents. The long-form of this behavioral assessment includes the following indices: Cognitive Problems, Oppositional, Hyperactivity-Impulsivity, Anxious-Shy, Perfectionism, Social Problems, and Psychosomatic (Conners, Sitarenios, Parker, & Epstein, 1998).

The BASC-2 consists of 160 items and a 4-point Likert scale that assesses a broad range of behaviors including: externalizing problems, internalizing problems, school problems, behavioral symptoms, and adaptive behavior (Reynolds & Kamphaus, 2004).

In order for the participant to be screened as possibly ADHD, one parent and one teacher index related to ADHD must exceed the 85th percentile on the BASC, CRS-R, or ADHD Rating Scale-IV. The BASC and CRS-R's T-score must be greater than or equal to 61 and the ADHD Rating Scale-IV must indicate that the number of ADHD symptoms must be greater than or equal to three.

In order for a participant to be screened as a possible control, all the screen indices must be less than the 80th percentile which equates to a T-score of 58. Also, in regards to the ADHD Rating Scale-IV, the individuals must have less than or equal to two of hyperactive/impulsive and inattention symptoms. The participant must also have less than three total symptoms across

inattention or hyperactivity. In addition to the rating scale and the T-scores, controls also need to have the Teacher Academic Competence Standard Score (TACSS) less than 111.

During the first on-campus visit, children completed a battery of neuropsychological assessments that included the Wechsler Individual Test-Third Edition (WIAT-III) and the Wechsler Intelligence Scare for Children-IV (WISC-IV). Parents of participating children completed a structured diagnostic interview, the Diagnostic Interview Schedule for Children (DISC-IV) to determine final diagnostic status.

Consent and Compensation

Parents provided informed consent and children provided their assent prior to participation. Compensation included a gift card to the teachers for $10 after they completed the online questionnaires. Parents were given $100 gift card to target, and the child was given a small prize.

Articulation and Speed

Children were asked to repeat a sequence of letters and/or numbers as quickly and as accurately as they could following an auditory start tone. Digital vocal recordings were coded for preparatory interval which was calculated from the total time from the end of the tone to when the participant begins to speak and was divided by the number of items in the stimuli. They were also coded for speech rate which was calculated by the total time from the beginning speech until the end and was divided by the number of items presented in the stimuli.

Academic Achievement

Academic achievement was calculated by using three separate assessments from a composite of WIAT-2 and WIAT-3. These three assessments were Spelling, Numerical

Operations, and Word Reading. The Spelling assessment consists of a list of words in which the child participant must spell. Numerical Operations involves a set of math questions that the child must solve. Also, the Word Reading task is an assessment of words the child needs to speak out while the research assistant follows along.

RESULTS

Test of Hypothesis 1

Although children with ADHD were slightly slower in their speech rate than controls, the difference was not significant, F(1,221) F=1.47, p=.227, η^2=.007. There were also no significant group differences in preparatory interval, F(1,217) F=1.30, p=.255, η^2=.006, even though the speech rate was slightly longer for the ADHD participants in comparison to the control group. Means and standard deviations of performance can be found in Table 1.

Test of Hypothesis 2

Children with ADHD had lower IQ scores than the controls, F(1,221) F=14.74, p<.01, η2=.063. However, the scores were still in the normal range of IQ scores. Children with ADHD had a lower reading score than the controls, F(1,221) F=13.29, p<.001, η2=.057. Children with ADHD also had lower numerical operations scores than the controls, F(1,221) F=21.27, p<.001, η2=.088. Lastly, children with ADHD had lower spelling scores than the controls, F(1,175) F=7.45, p=.007, η2=.041. Group means and standard deviations of academic performance can be found in Table 1.

Test of Hypothesis 3

Among all children, speech rate was negatively correlated with numerical operations (r= -.16 and p= .015) and word reading (r= -.24 and p<.001). It was also negatively correlated with spelling (r= -.15 and p= .05). The preparatory interval rate was negatively correlated with numerical operations (r= -.23 and p= .001) and word reading (r= -.19 and p= .006). It was also negatively correlated with spelling but the correlation was not significant (r= -.12 and p= .13). The correlation values of the third hypothesis can be found in table 2.

For children with ADHD only, speech rate and preparatory interval were both negatively correlated with numerical operations (speech rate: r= -.19 and p= .017, preparatory interval: r= -.28 and p= .000) and word reading (speech rate: r= -.21 and p= .008, preparatory interval: r= -.21 and p=.008). Among controls only, speech rate and word reading were negatively correlated (r= -.29 and p= .017). No other significant correlations between speech rate/preparatory interval and academic achievement were found. This information can be found in table 3.

DISCUSSION

Summary

This research found that academic achievement and articulation speed were negatively correlated to one another, which was hypothesized earlier. Academic achievement was lower among children with ADHD, but there were no group differences in articulation speed or speech rate among children with and without ADHD. There has not been a high volume of research that examines articulation speed and how it may predict the academic achievement in children with ADHD. Therefore, this study is crucial to the first step of understanding the possible predictive relationship.

Hypothesis 1

This study expected to find that the participants with ADHD would have slower articulation speeds than the control participants. The results indicate that the participants with ADHD did not have slower articulation speed rates than that of the control participants. Although the means of both the preparatory interval and speech rate of the participants were slightly lower than the means of the participants with ADHD, the differences were not significant.

Previous research has found that articulation speed is not necessarily slower, but rather is more variable for those with ADHD (Kofler, et al., 2013). Passolunghi & Siegel (2004) found that those participants who they studied who experienced performance problems in math also had slower articulation speed than those who did not have problems with math. It is possible that the cognitive processes that deal with math may also affect speed rate and preparatory interval. There is literature that has found that working memory and executive functioning greatly

influence the cognitive processes behind articulation speed. Therefore, differences between these speech variables may not be evident because they are essentially affected by the same cognitive mechanisms.

Previous research has found that boys with ADHD experience poorer verbal fluency than those without ADHD (Carte et al., 1996). Children with ADHD also have more variable performance in their reaction times to certain tasks that looked for accuracy and quickness. ADHD participants may be subject to slower reaction times on certain tasks due to motor problems (Karalunas, et al., 2014). A probable explanation that those with ADHD were not found to have slower rates than the controls is because the analyses ran included both female and male participants, not just males. Further research could delve into the differences between male and female rates as well as achievement to investigate gender differences which may account for the proposed results. Also, there may be unseen differences between verbal fluency and motor skills that are affected by the status of ADHD in different ways.

Hypothesis 2

This study also expected to find that those with ADHD would perform more poorly on academic tasks such as math, spelling, and reading that were administered to them in the initial lab visits. The results indicated that the participants with ADHD did have significantly lower academic achievement scores than that of their control counterparts. The Full Scale IQ of the ADHD participants were also lower than that of the controls; however, the scores for both of the groups were well within the range of normal IQ.

Prior research and findings suggest that there may be several predictors of underachievement, including deficits in executive functioning. Executive functioning enables the

individual to take in information and then deal with that information in an appropriate manner, by organization, planning and problem solving (Barry, Lyman, & Klinger, 2002). Executive functioning entails the cognition and control that an individual maintains and how well that individual allocates their attention to that cognition and control. Although those who have ADHD are shown to have lower academic achievement scores in reading, math, and spelling (Loe & Fieldman, 2007), executive functioning, as a main proponent of working memory, greatly impacts performance in mathematics.

Hypothesis 3

Lastly, the research conducted predicted that there would be a negative correlational relationship between the overall articulation speed as well as academic achievement. With the exception of the relationship between speech rate and word reading in children with ADHD, the articulation speed variables were negatively correlated with all three of the academic achievement tasks. Separately, among children with ADHD, there was a negative correlation between preparatory interval and speech rate for both reading and math. However, when just examining the relationships with the control group, only speech rate and reading were significantly related to articulation speed.

The significant relationship between speech rate with mathematics among children with ADHD could be due to the executive functioning component of this cognitive process. The working memory and executive functioning involvement in mathematics has been examined. In regards to the reading task, one has to be able to recall learned words from their lexicon and then appropriately pronounce and articulate that word with accuracy and with verbal fluency, which had been tied to previous research. However, in terms of spelling and executive functioning, not

much research has been performed. With spelling, the lexicon, or the cognitive storage of words, and skills to organize the words does not involve verbal communication. Since spelling is mental and not a verbal task, that is what could have accounted for the significance in relationship with the variables involved. A mental task refers to a cognitive task while a verbal task is a task that requires one to articulate while performing the task. Also, the spelling task is done slowly so to achieve accuracy while word reading is a task that is done more quickly. As a result, the instructions for how to do the tasks may have affected the significance of the findings.

However, it is interesting that after the two groups of participants were separated to investigate the relationship between speech rate and reading, there were differences in the significance between the variables. The only significance found for the control participants were between word reading and speech rate. However, both of the articulation speed variables were significantly related to the word reading and numerical operation tasks. A possible explanation to this phenomenon is that the status of ADHD could have affected this relationship. Although the results indicate that academic achievement is not affected by articulation speed, the separation of groups show that the status of ADHD may be a stronger influence in this relationship. The speech rate tasks involve the individuals speaking out loud after recalling the digital recording prior to the beginning of the speech. The reading assessment involves reading out loud words on a laminated paper. Therefore, it almost seems logical to assume that the longer it takes for one to articulate can influence the lower performance in reading.

Limitations

There are many ways in which this research design could have been completed differently. One way would be to examine the mechanisms of executive functioning and working

memory as they may have affected the academic achievement and the ability to retain information and attend to it efficiently in a population of ADHD children. Although there has been a great deal of research on articulation speed, reaction time, and academic achievement, the studies have been primarily focused on the performance of academic achievement in terms of mathematics. Although it has been found that those with ADHD do suffer from a greater amount of underachievement in their academics, the specifics and the underpinnings for that underachievement has still yet to be examined more closely. However, executive functioning and the cognitive capacities do have a strong hold in the literature and research as possible factors to the low academic performance by the ADHD population.

One other issue that has arisen was that the sample of the population could have affected the results. It would have been interesting to see if the amount of participants change the data. Specifically, perhaps the articulation speed for those with ADHD would have been slower, and significant if there were more participants with ADHD in the study. Following this limitation would also be the lack of ethnic diversity that was involved in the study. In order to generalize and apply the results more appropriately, the ethnicity of the participants could have been more plentiful to do so. Lastly, because much of the research has been dedicated to the study of males with ADHD, gender differences should have been examined in this study to hopefully find other lingering results.

Also, it is extremely crucial to keep in mind that the means as well as the correlations presented should be interpreted properly so as to not infer causal relationships. Correlations do not tell us there is a causal relationship, but rather there is either a strong or weak relationship between two variables. It may be easy to confuse causation and correlation as being one in the

same, but a correlation does not result in causation. To add, statistical means can provide a great starting point to the overall trend of a certain population; however, they may not be generalizable to all individuals as there are certainly individual differences that can influence the results. As mentioned in other literature, many of the ADHD participants studied illustrated a great deal of variance in their speech, even though they were slower than the controls. Precautions must be taken to not apply this mean to all of the participants involved, because the different presentations of ADHD may influence articulation speed and academic achievement in a number of different ways. Therefore, studies where the different presentations of ADHD and how they influence a change in articulation speed and academic achievement could be examined.

Implications

As discussed, the results of this study need to be processed carefully to ensure that they are not generalized to all populations and that no causal relationships can be inferred from the data. More intricate and detailed research should be done to advance the literature and knowledge in this field.

However, there is a plentitude of literature that supports the claim that children with ADHD perform more poorly in academics than those children without ADHD. Although articulation speed did not show to be significantly slower for those with ADHD compared to those without ADHD, there was still a negative relationship between the status of ADHD and interactions of articulation speed variables and academic achievement scores. There is a relationship between these factors that claims: as the academic achievement performance declines, the longer it may take for an individual to start speaking (preparatory interval) and the longer it takes them to speak (speech rate). At first, it appears there is a relationship, but the

results tell us that articulation speed is not slower/longer than the control's articulation speed. Therefore, ADHD has the greatest impact on academic achievement.

So, in order to help children with ADHD and issues with academics, attention should be given to enhance the working memory and executive functioning of the child. Since there has been a great deal of research on the disruption of motor skills, but not for verbal skills for those with ADHD, this topic should be further investigated. With practice, the executive functioning and cognitive flexibility of working memory could be enriched.

Language and language processing is a very difficult mechanism to understand as well as to develop. There is no one part of the brain that is totally devoted to this area; although, it does take many parts of the brain to develop these skills. However, it may not be apparent, because of the results that were uncovered, that verbal fluency or articulation speed affects academic achievement. Therefore, status of ADHD may be a major proponent to this interaction of articulation speed and academic achievement. These findings are unique in that the disorder could perpetuate further problems in working memory and the frontal cortex that works with executive functioning.

Future Research

Although this study did find a negative correlational relationship between articulation speed and academic achievement, it is vital that more research is done to advance these findings and cultivate more intense and detailed literature in this subject. Even though it is not appropriate to claim that articulation speed can predict academic achievement, it is still important to note that a relationship does exist. Future research should examine and investigate the foundation of language and how it can affect achievement. Also, thinking and problem solving processes

should be more closely examined. There are many more ways in which this research could be carried out; however, only two will be discussed. How and why does the processing of articulation speed and motor skills differ? What other brain processing factors contribute to articulation speed that may also account for the contribution to academic achievement? These specific questions as well as similar topics that explore the influence of these factors including the different ADHD presentations and diverse ethnic backgrounds that may further influence the relationship should also be researched. To fully understand these processes and relationships, more complex analyses should be completed and evaluated, carefully and appropriately.

Conclusion

In conclusion, this study has helped to cultivate more to the pre-existing literature in regards to achievement and articulation speed to the ADHD population. Although it reiterates what has been found in other literature, it is still vital to the understanding of these two separate variables that affect the child ADHD population, especially in the school setting. This is because the findings do indicate that there is a significant relationship between articulation speed and academic achievement. The development of verbal fluency as well as executive functioning and working memory is crucial to understanding the relationship between the variables. Personnel who work with students who have ADHD in school settings are encouraged to improve the learning experiences for all children. So, in order to help them succeed these professionals should take into account these factors when promoting interventions for these individuals.

Appendix A

Tables

Table 1. One-way Analysis of Variance on ADHD and Control Groups of Academic Achievement and Articulation Speed Measures

	ADHD (n=153)		Control (n=70)		
Measure	***M***	***SD***	***M***	***SD***	***F***
WIAT WR	100.01	15.92	107.57	10.23	F(1,221) F=13.29, p<.001, η2=.057
WIAT NO	98.95	16.08	108.66	10.54	F(1,221) F=21.27, p<.001, η2=.088
WIAT SP	98.79	14.21	105.44	13.85	F(1,175) F=7.45, p=.007, η2=.041
Speech Rate	.36	.13	.34	.10	F(1,221) F=1.47, p=.227, η2=.007
Preparatory Interval	.09	.06	.08	.05	F(1,217) F=1.30, p=.255, η2=.006

Table 2. Pearson Correlations of WIAT Subtests and Speech Rate and Preparatory Interval for combined groups

Measure	Speech Rate	Preparatory Interval
1. WIAT WR	-.238**	-.185**
Sig. (2-tailed)	.000	.006
N	223	219
2. WIAT NO	-.163*	-.226**
Sig. (2-tailed)	.015	.001
N	223	219
3. WIAT SP	-.147*	-.116
Sig. (2-tailed)	.050	.126
N	177	175

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

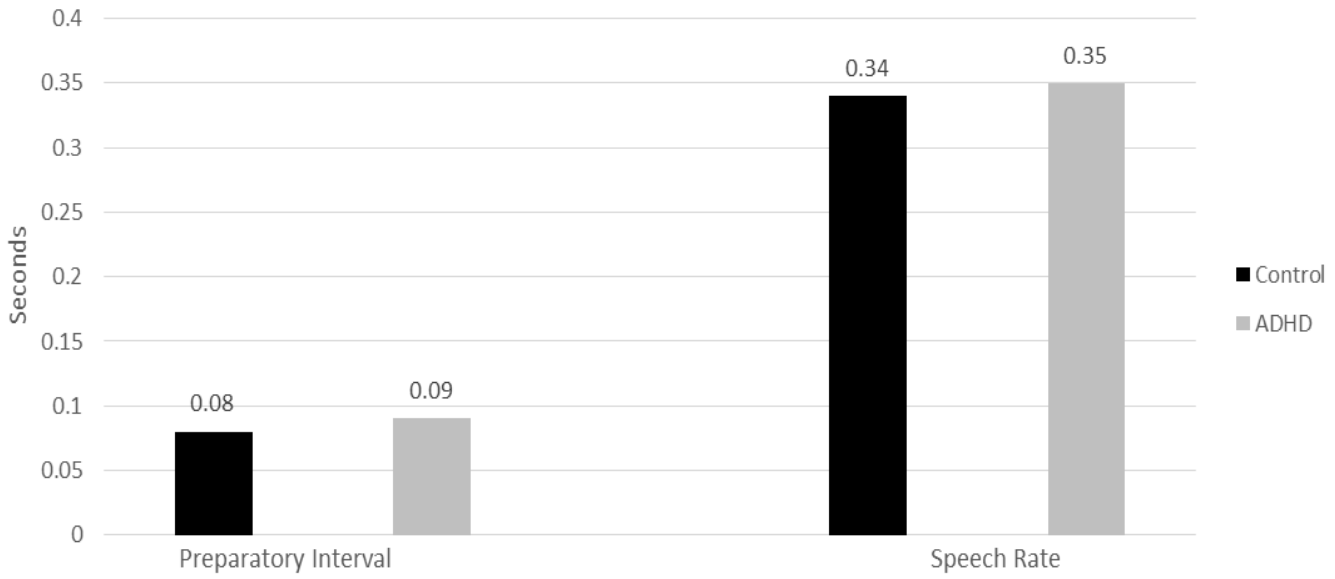
Table 3. Pearson Correlations of WIAT Subtests and Speech Rate and Preparatory Interval compared to ADHD and non-ADHD groups

Measure	Speech Rate	Preparatory Interval
ADHD		
1. WIAT WR	-.213**	-.214*
Sig. (2-tailed)	.008	.008
N	153	152
2. WIAT NO	-.192*	-.282**
Sig. (2-tailed)	.017	.000
N	153	152
3. WIAT SP	-.136	-.158
Sig. (2-tailed)	.119	.071
N	132	131
Control		
4. WIAT WR	-.286*	.012
Sig. (2-tailed)	.017	.925
N	70	67
5. WIAT NO	.048	.091
Sig. (2-tailed)	.695	.465
N	70	67
6. WIAT SP	-.184	.117
Sig. (2-tailed)	.227	.449
N	45	44

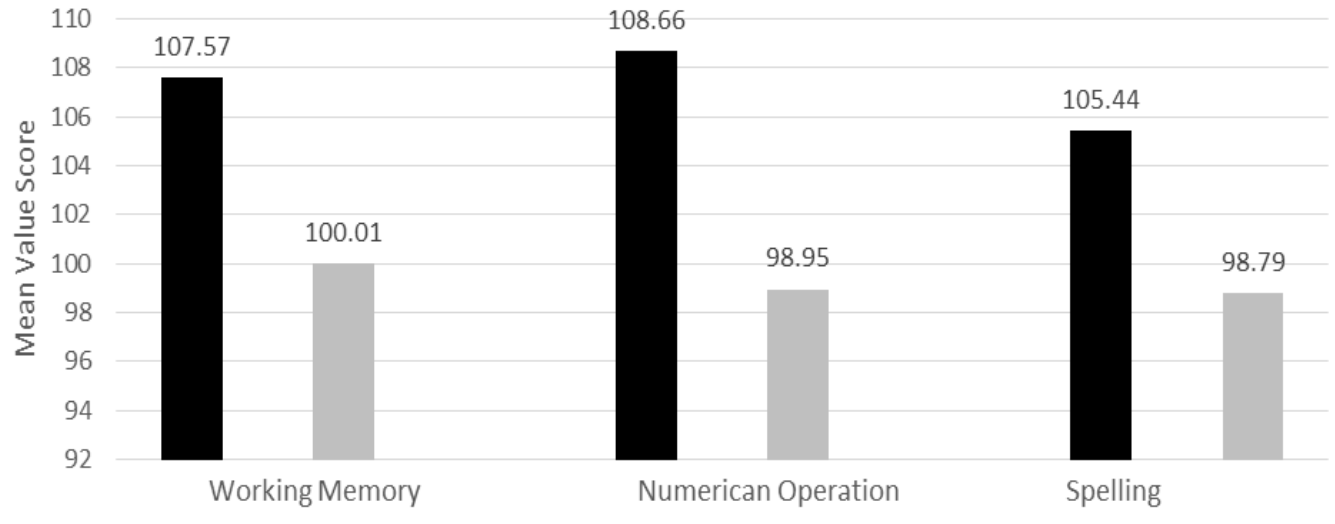
**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Graph 1. *The Mean of seconds for Speech Rate and Preperatory Interval compared to ADHD and controls*



Graph 2. *The Mean values of Academic Acheivement between Control and ADHD Participants*



References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders 5th ed.)*. Arlington, VA: American Psychiatric Publishing.

Andreou, P., et al. (2007). Reaction time performance in ADHD: improvement under fast-incentive condition and familial effects. *Psychological Medicine, 37(12): p. 1703-1715.*

Barry, T. D., Lyman, R. D., & Klinger, L. G. (2002). Academic underachievement and attention-deficit/hyperactivity disorder: the negative impact of symptom severity on school performance. *Journal of School Psychology, 40(3), 259-283*.doi:10.1016/4405(02)00100-0

Biederman, J., & Faraone, S. V. (2005). Attention-deficit hyperactivity disorder. *The Lancet, 366(9481), 237-48*. Retrieved from http://search.proquest.com/docview/199032151?accountid=13158

Bokor, G., & Anderson, P. D. (2014). Attention-deficit/hyperactivity disorder. *Journal of Pharmacy Practice, 27(4), 336-349*. doi:10.1177/0897190014543628

Carte, E. T., Nigg, J. T., & Hinshaw, S. P. (1996). Neuropsychological functioning, motor speed, and language processing in boys with and without ADHD. *Journal of Abnormal Child Psychology, 24(4), 481-498.* doi:10.1007/BF01441570

Conners, C. K., Sitarenios, G., Parker, J. D., & Epstein, J. N. (1998). The revised Conner's parent rating scale (CPRS-R): factor structure, reliability, and criterion validity. *Journal of Abnormal Child Psychology, 26(4), 257-268*. doi:10.1023/A:1022602400621

Daley, D., & Birchwood, J. (2010). ADHD and academic performance: why does ADHD impact on academic performance and what can be done to support ADHD children in the

classroom*? Child: Care, Health & Development, 36(4), 455-464.* doi:10.1111/j.1365-2214.2009.01046.x

DuPaul, G. J., Power, T. J., Anastopoulos, A. D., & Reid, R. (1998). ADHD Rating Scale-IV: checklists, norms, and clinical interpretation. *Journal of Psychoeducational Assessment, 24(2), 172-178.* doi:10.1177/0734282905285792

Epstein, J.N., et al. (2011). Evidence for higher reaction time variability for children with ADHD on a range of cognitive tasks including reward and event rate manipulations. *Neuropsychology, 25(4): p. 427-441.*

Feldman, H. M, M.D., PhD., & Reiff, M. I., M.D. (2014). Attention deficit-hyperactivity disorder in children and adolescents. *The New England Journal of Medicine, 370(9), 838-46.* Retrieved from http://search.proquest.com/docview/1503560335?accountid=13158

Felt, B. T., Biernmann, B., Christner, J. G., Kochhar, P., & Harrison, R. V. (2014). Diagnosis and management of ADHD in children. *American Family Physician, 90(7), 456-464.* Retrieved from http://www.aafp.org/afp/2014/1001/p456.html

Johnson, K.A., et al. (2007). Response variability in attention deficit hyperactivity disorder: evidence for neuropsychological heterogeneity. *Neuropsychologia, 45(4): p. 630-638.*

Karalunas, S.L., et al. (2014). Annual Research Review: Reaction time variability in ADHD and autism spectrum disorders: measurement and mechanisms of a proposed trans-diagnostic phenotype. *Journal of Child Psychology and Psychiatry, 55(6): p. 685-710.*

Klein, C., et al. (2006). Intra-subject variability in attention-deficit hyperactivity disorder. *Biological Psychiatry, 60(10): p. 1088-1097.*

Kofler, M.J., et al. (2013). Reaction time variability in ADHD: A meta-analytic review of 319 studies. *Clinical Psychology Review, 33(6): p. 795-811.*

Loe, I. M., & Fieldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Ambulatory Pediatric Association, 7(1), 82-90.* Retrieved from http://www.sciencedirect.com/science/article/pii/S153015670600267X

Passolunghi, C. M., & Siegel, L. S. (2004). Working memory and access to numerical information in children with disability in mathematics. *Journal of Experimental Child Psychology, 88(4), 348-367.* Retrieved from http://dx.doi.org/10.1016/j.jecp.2004.04.002

Rabiner, D. L., Murrary, D. W., Schmid, L., & Malone, P. S. (2004). An exploration of the relationship between ethnicity, attention problems, and academic achievement. *School Psychology Review, 33(4), 498-509.* Retrieved from http://search.proquest.com.ezaccess.libraries.psu.edu/docview/219654478?pqorigsite=summon

Reynolds, C. R., & Kamphaus, R. W. (2004). *Behavior assessment system for children. (2nd ed.).* Bloomington: Pearson Assessments.

Rosch, K.S., B. Dirlikov, and S.H. Mostofsky (2013). Increased intrasubject variability in boys with ADHD across tests of motor and cognitive control. *Journal of Abnormal Child Psychology, 41(3): p. 485-495.*

Rucklidge, J. J. (2010). Gender differences in attention-deficit/hyperactivity disorder. *Psychiatric Clinics of North America, 33(2), 357-373. doi:10.1016/j.pcs.2010.01.006*

Academic Vita

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EDUCATION

Penn State University | Schreyer Honors College *May 2015*
University Park, PA
B.S. in Psychology, Biological and Evolutionary Science Option
Minor in Spanish

CLINICAL EXPERIENCE

Child Attention and Learning Lab, State College, PA *January 2014-Present*
Undergraduate Research Assistant

- Administer batter of neuropsychological tests to children
- Call families to recruit participants to join the study
- Conduct data entry and double check files

Child Development Lab, State College, PA *Fall 2013*
Undergraduate Research Assistant

- Brain-stormed research designs of interactions with nature and children
- Transcribed video tapes of child's interactions in natural environment
- Researched studies concerning effects of nature on children

Valley Youth House, Allentown, PA *May 2013-August 2013*
Intern/Mentor

- Mentored two children and participated in the respite-based program
- Intervened at pivotal transition points throughout sessions
- Assisted with emotional support when necessary

WORK EXPERIENCE

Penn State Lehigh Valley, Center Valley, PA *Summer 2013 & 2014*
New Student Orientation Leader

- Aided freshman with scheduling and provided advice
- Provided information and answered questions from parents

Rita's Italian Ice, Whitehall, PA *August 2010-June 2014*
Team Member

- Exhibited multitasking while making ice and processing orders for customers
- Delegated tasks to workers while managed closing and opening procedures

VOLUNTEER

Camp Cranium, Camp Victory of Millville, PA *June 2014*
Camp counselor

- Assisted 3 junior girl campers with daily activities
- Provided support for other counselors and campers throughout the week

HONORS/AWARDS

Schreyer Honors College	*Spring 2013-Present*
The Paterno Fellows Program	*Spring 2013-Present*
The President Sparks Award	*May 2013*
The President's Freshman Award	*May 2012*