CAN THE CATTELL-HORN-CARROLL (CHC) THEORY DIFFERENTIATE STUDENT PERFORMANCE ON A COMPUTATION INTERVENTION FOR STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)?

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Abstract: Students with attention-deficit/hyperactivity disorder (ADHD) often have difficulties in school related to behavior and academics. Math achievement continues to be a major concern, with approximately five to eight percent of school-aged children having diagnosed deficits in math achievement. This does not account for school-aged students who are struggling in mathematics. Though there is a high comorbidity rate between ADHD and Specific Learning Disabilities (SLD), little research has been done on examining fluency-based interventions with students who have ADHD. In addition, diagnoses are just labels and do not currently provide treatment options regarding interventions that take into account specific deficits or impairments. If assessments are going to continue to be used, researchers need to work towards identifying ways these tools can be more effective in not only facilitating problem identification, but also intervention development. The current study compared students with ADHD to typically developing students regarding their performance on a Taped Problems intervention to determine whether differing time-delay procedures influenced learning rates. The CHC factors from the WJ III COG were used to match cognitive profiles for students with a diagnosis of ADHD. Results confirmed that the Taped Problems (TP) intervention was effective in increasing math fact fluency for both groups. Specifically, both treatment conditions were equally effective for students without ADHD when compared to the control group; however, for students with ADHD, the 2-s time delay condition was found to be most effective. These results provide evidence for utilizing assessment data to inform evidence-based treatment options.

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CHAPTER I

INTRODUCTION

Academic achievement is a topic of concern for many teachers, parents, and students. Unfortunately, not all students perform well in their academics. For some students their lack of academic achievement could be due to of an instructional mismatch (e.g., the work is too easy or difficult for them). For other students, their difficulties in academic achievement could be related to problems regulating their own behavior; however, for some students, their level of academic achievement is directly related to their diagnosed disability.

Attention Deficit/Hyperactivity Disorder (ADHD) and Specific Learning Disabilities (SLDs) are two disorders that are becoming more prevalent in our society with five percent of children meeting the criteria for ADHD and about 5-15% of school-aged children meeting the criteria for SLD (American Psychiatric Association, 2013). Unfortunately, in many cases, these disorders negatively impact a student's ability to perform well in his or her academics (DuPaul, Gormley, & Laracy, 2013). For this reason, students who are identified as having a disability are often placed on an Individualized Education Plan (IEP) and provided access to special education services in order to facilitate learning and academic success. ADHD is considered to be a neurobiological developmental disorder (McArdle, 2013). In other words, ADHD is not contagious, nor is it something that can be developed over time. Individuals with ADHD are born with the disorder and associated symptoms continue throughout life. The environment, however, can play a role in the severity or presentation of ADHD symptoms. In addition, individuals with

ADHD experience deficits in cognitive functioning.

Researchers have found specific deficits in cognitive functioning that appear to be related to ADHD. These deficits include Working Memory, Long-Term Storage and Retrieval (Glr), Processing Speed (Gs), and Fluid Reasoning (Gf; Schrank & Wendling, 2012). The Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities has been used to explain cognitive functioning and has the basis for many cognitive assessments, including the Woodcock-Johnson Test of Cognitive Abilities (WJ-COG).

According to Smith, Barkley, and Shapiro (2007), more than 80% of individuals with ADHD have a second, co-occurring disorder and approximately 60% have at least two or more additional disorders. Common comorbid diagnoses include SLD, Oppositional Defiant Disorder (ODD), Conduct Disorder (CD), Anxiety, and Depression (American Psychiatric Association, 2013). In the educational setting, students with a diagnosis of ADHD often struggle academically and may have a diagnosis of SLD. The high comorbidity rate between ADHD and SLD may be related to similarities involving specific deficits in cognitive functioning (Mattison & Mayes, 2012) Although SLD with Impairments in Reading is one of the most researched SLD's, researchers are starting to look more into the comorbidity between ADHD and SLD with Impairments in Mathematics.

Computational fluency is essential to the development of complex math skills (Poncy, Skinner, & McCallum, 2012). By increasing computational fluency, thus allowing those skills to become automatic, students will have more cognitive space (i.e. resources), to solve problems of higher complexity.

This paper will be discussing the Cattell-Horn-Carroll (CHC) Theory of Cognitive Ability, which looks at intelligence in terms of broad and narrow abilities. In addition, this theory will be used to examine the possible relationship between ADHD and SLDs to determine whether there might be specific cognitive abilities and/or deficits that underlie both disorders. This could be very useful when trying to determine whether or not a student qualifies for special education services (Flanagan, Fiorello, & Ortiz, 2010) as well as determine what type of intervention would be best for the individual [e.g., whether one intervention is better for a student who has comorbid ADHD and math disability versus a student who only has a math disability, or whether the interventions are generalizable across both disorders (i.e. mutually effective)].

Two things to consider during this study include delayed gratification and processing speed. Delayed gratification has been examined by using a paradigm where an individual is given a small immediate reinforcer and is told if he or she can delay or resist the item for a certain time interval, then he or she will be given a reinforcer of greater magnitude. This paradigm has shown to differentiate ADHD. Research has shown that individuals with ADHD often have difficulty with delayed gratification, thus requiring more immediate feedback (Barkley, Edwards, Laneiri, Fletcher, & Metevia, 2001; Olson, Schilling, & Bates, 1999). On the other hand, deficits in processing speed suggest the need for extended time on tasks so that information can be better understood, processed, and stored.

The purpose of this study is to determine whether diagnoses (i.e., one's cognitive profile) can be linked to specific treatments. This study will be examining some of the most current research on increasing math fluency of students with ADHD. The research explored will include the comorbidity between ADHD and SLD's, more specifically SLD with Impairments in Mathematics, as well as the possible relationship between the disorders through the use of CHC Theory and the different mathematical interventions that can be used to increase math fluency. Specifically, this study will examine the effectiveness of Taped-Problem interventions with regards to the length of time delay for students who have ADHD.

CHAPTER II

REVIEW OF LITERATURE

DSM V Criteria

ADHD is one of the most commonly diagnosed disorders in the United States (Kaiser & Pfiffner, 2011; Krain & Castellanos, 2006) with approximately 5% of children in the United States having a diagnosis (American Psychiatric Association, 2013). According to the Centers for Disease Control and Prevention (CDC, 2017) the percent of children being diagnosed with ADHD has increased from 7% in 2003 to 11% in 2012.

Although ADHD symptomology first appears in early childhood (Banaschewski, Roessner, Dittmann, Santosh, & Rothenberger, 2004), it is often difficult to reliably diagnose until around the age of seven due to the high level of hyperactive, impulsive, and disruptive behaviors common amongst preschool aged children (Barkley, Fischer, Edelbrock, & Smallish, 1991; Lahey, Pelham, Loney, Lee, & Willcutt, 2005). In addition, ADHD related symptoms are required to be present in more than one environment for a diagnosis to be considered (American Psychiatric Association, 2013). For this reason, most children with ADHD are not diagnosed until they reach elementary school. This is also the time when children are being required to sit still for periods of time, focus on specific tasks, inhibit disruptive behaviors, and sustain their attention (McArdle, 2013).

Once children are diagnosed with ADHD, their parents will often discuss potential treatment options with their family's primary care physician or a psychiatrist. In addition, a multidisciplinary team meeting is set up, which often includes the child's parents, teachers, principal, school psychologist, special education teacher, and school counselor. At least once a year the team gathers to discuss the student's psychoeducational evaluation and to determine the student's eligibility for special education services. If services are deemed necessary, the team develops an Individualized Education Program (IEP) for the student. An IEP is a method of intervention and evaluation used to provide an education plan for students who are receiving services in special education. The main idea behind the development of the IEP was to create an individualized program that is specific to the student with disabilities, that meets his or hers educational needs (Yell, Katsiyannis, Ryan, McDuffie, & Mattocks, 2008).

ADHD is considered to be a neurobiological developmental disorder (McArdle, 2013). The term neurobiological describes deficits in brain or cognitive functioning that is present since birth. These deficits are not related or caused by external environmental stimuli and often have a genetic marker. The term developmental refers to deficits that do not typically go away. This means that individuals who are diagnosed with ADHD as children will most likely continue to have ADHD through adolescence and adulthood whereas in previous years ADHD was regarded as only a childhood disorder (Weiss, 2011). Though ADHD symptoms do continue throughout the lifespan, the severity or presentation of these symptoms may decrease with age or as individuals with ADHD learn compensatory skills (Smith et al., 2007).

Although ADHD is a neurobiological disorder, symptoms related to ADHD may change in presentation as the child develops. For instance, pre-school age children diagnosed with ADHD often exhibit symptoms related to hyperactivity and impulsivity (American Psychiatric Association, 2013). According to Brown, Carpenter, and Simerly (2005), when children with ADHD enter elementary school, their symptoms tend to shift towards distractibility, being fidgety, not being able to stay in their seat, and being easily frustrated. As these children become adults, they will often continue to experience problems with disorganization, forgetfulness, losing items, and difficulties completing work related tasks and assignments. On the surface, it appears that as children become older, their symptoms of ADHD declines; however, it is not known whether their symptoms actually decline or if they are able to develop ways to cope with their ADHD symptoms.

ADHD primarily involves behavioral inhibition (Barkley, 2003). Individuals with ADHD typically have trouble regulating their behavior, such as attention span, impulsivity, and activity level, are not at the level that is considered appropriate or the norm for their age (Fabiano et al., 2013; McArdle, 2013). ADHD has also been found to be predictive of deficits related to academic achievement as well as an increased chance of having a co-occurring learning disability (Barkley, 2005).

The American Psychiatric Association (2013) states that there are three types of ADHD that are currently being recognized: predominantly inattentive (ADHD-PI), ADHD predominantly hyperactive/impulsive (ADHD-PHI), and ADHD combined type (ADHD-C). Symptoms of ADHD-PI include difficulty sustaining attention, completing tasks, following instructions, trouble listening, often failing to give close attention to details, difficulty with organizing tasks and activities, often losing things necessary for tasks and activities, and being forgetful (McArdle, 2013). Individuals with ADHD-PI are often difficult to diagnose compared to those with either the hyperactive-impulsive or combined subtype since they typically do not display outward behaviors (Barkley, 2003). Rather than having problems with regulating their behavior, individuals with ADHD-PI are often characterized as being “day-dreamy.”

Whereas ADHD-PI typically involves symptoms related to inattention, ADHD-PHI involves symptoms relating to hyperactivity and impulsivity. According to Barkley (2003), individuals with ADHD-PHI typically exhibit symptoms of disinhibition. Some of the behavioral symptoms related to ADHD-PHI include restlessness, not being able to stay in one's seat, fidgeting and moving around often, interrupting others, impatience, difficulty waiting their turn, inability to play or engage in leisure activities quietly, and excessively talking (American Psychiatric Association, 2013). Since these behaviors are quite noticeable in the classroom setting, these individuals are more easily identified and subsequently diagnosed at higher rates compared to individuals with ADHD-PI.

Lastly, individuals with the combined type (ADHD-C) often show symptoms of both inattention and hyperactivity/impulsivity (American Psychiatric Association, 2013). The symptoms for all three types of ADHD are often dependent on the environment in which the individual is placed. Situations that require concentration, silence, and little movement, such as working on homework or listening to a lecture in class, often elicit these symptoms in individuals with ADHD (Preston, O'Neal, & Talaga, 2013). That is, the symptoms are more noticeable in these types of environments. Although individuals with ADHD-C tend to be described as being disruptive, argumentative, and disorganized, with age these symptoms typically decrease in severity (Barkley, 2003). So whereas individuals with ADHD-C might show symptoms of hyperactivity and impulsivity, by adolescence, these symptoms often decrease or become more leveled, making the inattentive symptoms more apparent.

There are numerous factors that are taken into consideration when diagnosing a child with ADHD. Some of these factors include symptoms the individual is experiencing, whether there is a family history of ADHD, age of onset, how long the symptoms have been present, and behavioral observations to determine whether symptoms are present in more than one environment or if there are certain stimuli that are triggering these symptoms (Preston et al., 2013). According to the DSM – 5, diagnosis is dependent on the following criteria: The individual must elicit at least six of the listed symptoms (at least five symptoms for adults), these symptoms must be present for at least six months, must be present before the age of seven, and must be inconsistent with the individual's developmental level (American Psychiatric Association, 2013). In addition to these criteria, symptoms must also be present in more than one environment (e.g. home and school; Brown et al., 2005; McArdle, 2013) and they must cause impairments in different aspects of the individual's life (e.g. academic achievement and social relationships; American Psychiatric Association, 2013).

ADHD is found across cultures and present in about four to six percent of the population (American Psychiatric Association, 2013; Barkley, 2003; Preston et al., 2013). There are also differences in prevalence rates across gender as well. According to the American Psychiatric Association (2013), ADHD is more often diagnosed in males than females with a ratio of two to one. Some studies have found prevalence rates to be as great as three to seven times higher in males than females (Barkley, 2005). This may be due to the fact that males tend to show more outward or externalizing behaviors (e.g. hyperactivity) than females who tend to be predominantly inattentive.

While the true cause of ADHD is unknown, researchers are trying to determine the underlying factors that contribute to the disorder. So far, research has provided strong evidence for genetic, physiological, and environmental factors (American Psychiatric Association, 2013).

Neurological and Genetics Factors

ADHD is considered to be a neurobiological developmental disorder (McArdle, 2013), meaning that there is believed to be a neurological cause regarding brain functioning that is present from birth and continues throughout an individual's life. Although brain trauma patients do sometimes show symptoms of inattention, ADHD is, for the most part, genetic (Barkley, 2003; Mayes & Calhoun, 2007). In fact, genetics appear to play a significant role in the prevalence of ADHD. Research has shown that ADHD is hereditary (American Psychiatric Association, 2013) with family rates of occurrence being quite significant (75%; Smoot, Boothby, & Gillett, 2007). In other words, the likelihood that a child, whose mother or father has ADHD, will also have ADHD is quite high.

Since ADHD is considered a neurobiological disorder, researchers are trying to determine whether the functioning of specific areas of the brain are linked to deficits associated with ADHD. Currently, studies are looking at impairments in the functioning of the frontal lobe (Preston et al., 2013), more specifically the prefrontal cortex, as a potential cause of the disorder.

There is also significant evidence supporting the concept that individuals with ADHD have impairments related to executive functioning, which is located in the frontal lobe (Krain & Castellanos, 2006). Cognitive processes within the frontal lobe include attention, working memory, decision-making, behavioral inhibition, and planning (Barkley, 2003; Pliszka, Liotti, & Woldorff, 2000; Weiss, 2011). Since the prefrontal cortex is the area of the brain that is responsible for many of our executive functions (Barkley, 2003), this connection between ADHD and impairments regarding the prefrontal cortex appears justified.

In addition to abnormalities in brain development and functioning, researchers have found that individuals with ADHD have abnormalities or impairments related to neurotransmitters, such as dopamine (Preston et al., 2013). Impairments in the prefrontal cortex regarding attention and behavioral inhibition have been found to be significantly lessened by the use of stimulant medication (Pliszka et al., 2000). Stimulant medications work through increasing levels of dopamine in our system. Specific neurotransmitters found to be associated with ADHD include the dopamine transporter gene allele (DAT1), the dopamine D4 receptor (DRD4), and the dopamine beta-hydroxylase gene (DBH; Barkley, 2003; Loo et al., 2003).

In addition to genetic and physiological factors, there is one more factor to consider: genetic-environment interactions. Both genetics and the environment play a role in the development and severity of a child's ADHD. Although ADHD is hereditary (i.e. genetically determined), the environment in which the child is in can influence the severity of the symptoms (McArdle, 2013). In fact, 9-20% of variance in the presentation of ADHD symptoms can be attributed to non-genetic, environmental stimuli (Nigg, 2006). Depending on the child's environment, his or her symptoms related to ADHD may appear to be lessened or more pronounced. Some environmental factors that can increase the risk for developing ADHD include low birth weight and maternal prenatal smoking and/or alcohol consumption (American Psychiatric Association, 2013).

Comorbidity

It is not uncommon for individuals with one disorder, to have a second or comorbid disorder (Weiss, 2011). In fact, at least 50% of individuals with ADHD meet criteria for Oppositional Defiant Disorder (ODD), and about half of those individuals go on to develop Conduct Disorder (CD; Brown et al., 2005), a more serious behavioral disorder. In addition, about 20% of individuals diagnosed with ADHD have anxiety and/or depression (McArdle, 2013; Preston et al., 2013). Comorbidity rates for Specific Learning Disabilities are higher among individuals with ADHD (Brown et al., 2005; McArdle, 2013) with rates ranging from 25-50% (DuPaul et al., 2013). Other disorders that are often comorbid with ADHD include Obsessive-Compulsive Disorder (OCD), Bipolar Disorder, Antisocial Personality Disorder (APD), Intermittent Explosive Disorder, Tic Disorders, and Autism Spectrum Disorder (ASD; American

Psychiatric Association, 2013; Weiss, 2011). For many educators and researchers, the comorbidity of ADHD and SLD is often of particular interest (DuPaul et al., 2013; Fiorello, Thurman, Zavertnik, Sher, & Coleman, 2009; Mattison & Mayes, 2012).

Comorbidity of ADHD and SLD

Individuals with ADHD often have difficulty with academic performance. Most often, lower levels of school performance are related to unproductivity; however, individuals with ADHD sometimes perform lower on standardized achievement tests (Barkley, 2003). According to Barkley (2005), approximately 25% of individuals with ADHD also have an SLD. Like ADHD, SLD is also considered to be a neurodevelopmental disorder (Scanlon, 2013) and involves difficulties in learning and academics.

According the American Psychiatric Association (2013), in order for an individual to be diagnosed with an SLD, he or she must have at least one symptom and that symptom must last at least six months. Some of the symptoms associated with SLD include slow or inaccurate reading, difficulty understanding the meaning of what is read (i.e., comprehension), difficulties with spelling, difficulties in written expression, and difficulties with math computations and math reasoning (Scanlon, 2013). In addition, the academic skills being examined must be quantifiably and substantially lower than the level expected for the individual's age and be apparent in the individual's academic performance. Learning difficulties must begin during school-age years and should not be better accounted for by an intellectual disability, vision or hearing difficulties, lack of language proficiency, other psychological disorders, or inadequate educational instruction.

There are three subtypes regarding SLD: with impairment in reading, with impairment in written expression, and with impairment in mathematics (American Psychiatric Association, 2013; Scanlon, 2013). Individuals who have a diagnosis of SLD with impairments in reading are sometimes referred to as having dyslexia (Barkley, 2003). These individuals typically have deficits in reading fluency or rate, word reading accuracy, and reading comprehension (American Psychiatric Association, 2013; Fiorello et al., 2009; Scanlon, 2013; Zentall & Ferkis, 1993).

Individuals who have a diagnosis of SLD with impairments in written expression often have deficits regarding their accuracy in punctuation, grammar, and spelling, as well as deficits in the organization and clarity of their written expressions (American Psychiatric Association, 2013; Barkley, 2003). The skills required for successful writing typically includes perseverance to task, attention to detail, and organization, all of which are often difficult for individuals with this impairment (DuPaul et al., 2013).

Finally, individuals who have a diagnosis of SLD with impairments in mathematics, also referred to as having dyscalculia, typically have deficits in areas regarding the memorization of mathematical or arithmetic facts, number sense, accuracy in their mathematical reasoning, and accuracy or fluency in their mathematic calculations (American Psychiatric Association, 2013; Barkley, 2003).

Relationship Between ADHD and Math Disabilities

Individuals with ADHD are at an increased risk of having or developing an additional, comorbid disorder. One disorder that has a high comorbidity rate with ADHD is SLD (McArdle, 2013). When looking at SLD’s, although reading is the most diagnosed type of SLD, math disabilities appear to be more highly correlated with ADHD (Zentall & Ferkis, 1993). In other words, individuals with ADHD and SLD more often show symptoms of impairments in mathematics than impairments in reading.

In general, approximately five to eight percent of children have deficits in achievement related to mathematics (Geary, 2004). According to Proctor, Floyd, and Shaver (2005), there are two main areas of math that are looked at when examining whether or not a child has a math disability or if he or she is low achieving. The first area is math calculation skills, which involves being able to apply basic math operations and concepts when solving problems. The second area is math reasoning, which involves being able to solve problems using the knowledge one has with regards to math operations and concepts. So, whereas calculation skills involve the application of mathematical operations when given math problems, math reasoning involves being able to use the knowledge one has with regards to mathematical operations to solve a given problem.

The high comorbidity rate between ADHD and SLD may be related to similarities involving deficits or impairments in executive functions (Mattison & Mayes, 2012) and working memory (DuPaul & Volpe, 2009; Mayes & Calhoun, 2007). In fact, a study conducted by Johnson, Humphrey, Mellard, Woods, and Swanson (2010) demonstrated that students with SLDs had greater impairments in the cognitive functioning compared to other students. The main areas of cognitive functioning that appeared to be impaired included processing speed, working memory, expressive language, and executive functioning. DuPaul and Volpe (2009) found similar impairments in their study involving students with ADHD.

According to Barkley's (2003) Theory of Executive Functioning, executive functions control our ability to plan and organize information and behaviors, emotional and behavioral responses, behaviors involving goal setting and problem solving, self-regulation, and working memory. For individuals with ADHD or SLD, these functions are often impaired meaning that they have deficits or trouble conducting these tasks (McArdle, 2013). For instance, an individual who has deficits in his or her executive functioning may have difficulties making decisions or remember simple facts or pieces of information.

In Barkley's (2003) model, behavioral inhibition is viewed as being the central component to executive functioning. Behavioral inhibition influences and interacts with four specific areas of executive functioning: internalization of speech, working memory, self-regulation of affect/motivation/arousal, and reconstitution. Internalization of speech involves our verbal working memory, or verbal thoughts. Working memory involves the ability to maintain or remember information while participating in some behavior, such as talking. Self-regulation of affect/motivation/arousal refers to emotional self-control while responding to a situation. Lastly, reconstitution involves the reflection of past experiences or information and rearranging or using them to formulate new perspectives, thoughts, or actions. All of these executive functions serve to permit one's self-control.

Math Fact Fluency

Computational fluency is essential to the development of complex math skill (Poncy, et al., 2012) and overall future math achievement (Axtell, McCallum, Bell, & Poncy, 2009; McCallum, Skinner, Turner, & Saecker, 2006). According to Axtell et al. (2009), the term "fluency" involves the ability to not only accurately respond to a stimulus, but to also do so quickly. The idea is that by increasing one's fluency regarding math facts, those basic skills will eventually become automatic, thus freeing up cognitive space (i.e. resources), to solve more complex problems.

Intervention Options and Effectiveness

Over the years, researchers have developed interventions targeting math fact fluency. Though many of these interventions have shown to be effective, there does not appear to be one universally approved method to increase math fact fluency. In addition, it is important to be familiar with and understand these interventions so that practitioners know which intervention method to use when helping a student who is struggling with mathematics.

One intervention that has been used to increase math fact accuracy and fluency is Taped Problems (TP; Poncy, Jaspers, Hansmann, Bui, & Matthew, 2015). Before the intervention begins, the student is provided a worksheet that includes a variety of different math problems (Poncy et al., 2012). According to Poncy, Skinner, and Jaspers (2007), TP involves listening to a series of math problems on an audio recording and then being asked to write the answer. The key is to not only answer the problem correctly, but to do so before the recording provides the answer. There is a two-second delay once the problem has been given in which the student must provide an answer (Poncy et al., 2012). If the student runs out of time before writing down his or her answer, the student is asked to write down the correct answer after the recording provides it; however, if the answer is incorrect, the student crosses out the incorrect answer and then writes what the answer actually was. The purpose of having a brief time delay between the problem and the answer is to promote both accuracy and quickness in response (i.e. fluency) while preventing the student from using different counting strategies that may take a long time (e.g. counting on his or her fingers; Poncy et al., 2015; Poncy & Skinner, 2011; Poncy et al., 2012). With the TP intervention, the goal is to increase the student's automaticity of math facts. When a student is presented a simple math problem, he or she will be able to look at the problem and automatically be able to retrieve and provide the correct answer. By becoming more automatic in the ability to solve basic computational problems, it will allow for more cognitive resources to be available when solving more complex math problems.

Another intervention that has been shown to increase math fact accuracy and fluency is cover, copy, compare (CCC). With CCC, as discussed by Poncy et al. (2007) and Poncy et al. (2012), the student is asked to follow a set of procedures after being provided a worksheet that included a variety of math problems. The student is first asked to cover a math problem so that he or she is unable to see it. After the problem is covered, the student is asked to provide the answer (e.g. write or say aloud) and then uncover the math problem so that he or she can evaluate his or her response. If the correct response is provided, the student will begin the procedures again, but with a new math problem; however, if the response that is provided is incorrect, the same problem and procedures are repeated until the student provides the correct response (Poncy & Skinner, 2011). CCC is shown to be most effective when immediate feedback as well as appropriate and accurate responding are required (Axtell et al., 2009).

When comparing TP with CCC, Poncy et al. (2012) found that TP may be a more effective and efficient intervention, specifically when implementing class-wide. Although CCC was designed to be effective for individual interventions, Poncy and Skinner (2011) found that if CCC is implemented in addition to post-CCC math-fact sprints as well as a weekly reward, CCC might be an effective class-wide intervention. While other studies have found CCC to be a more effective intervention at increasing a student's digits correct per minute, TP was also found to be effective and was less time consuming (Poncy et al., 2007).

Explicit Timing (ET) has also been shown to be effective at increasing rates of math fact fluency. As described by Duhon, House, and Stinnett (2012), with ET, the student is provided a worksheet and is instructed to complete as many problems as possible within a given time frame (e.g., 1 minute). After the time has ended, the number of digits correct is calculated and divided by the number of minutes given. This calculation provides the number of digits the student answered correctly per minute. Researchers have found that providing timed trials increases opportunities to accurately respond, thus enhancing fluency (Rhymer et al., 2002); however, according to Codding et al. (2007), this is only true for individuals who are accurate, but not necessarily fluent. ET alone may not be as effective for students who have difficulty with both accuracy and fluency since ET is designed to promote high rates of responding without any immediate feedback regarding accuracy. Error corrections may occur after ET has been completed, but should not change the DCPM.

History of CHC Theory

The Cattell-Horn-Carroll (CHC) Theory of Cognitive Abilities was developed through the combination of the models created by Raymond Cattell, John Horn, and John Carroll (Evans, Floyd, McGrew, & Leforgee, 2001). Based on information regarding cognitive functioning (Fiorello et al., 2009), these models included broad and narrow band abilities (Flanagan et al., 2010).

According to Kan, Kievit, Dolan, and van der Maas (2011) and Miller (2008), Cattell's model described how individuals have two main abilities or types of intelligence: crystallized and fluid intelligence. Crystallized intelligence (Gc), also known as comprehension-knowledge refers to the ability to use learned knowledge, skills, and experiences to solve problems. Gc is not static and changes over time as new knowledge is learned and experiences are had. Gc is also more susceptible to being increased through intervention. These abilities may include vocabulary, understanding of word meanings and relationships, and overall general knowledge. Fluid intelligence (Gf), on the other hand, refers to the ability to solve novel, unlearned problems (e.g. strategies for problem solving). These abilities typically involve being able to use deductive and inductive methods of reasoning to develop and apply concepts and ideas.

Horn's model was based off of and expanded on Cattell's model involving fluid and crystallized intelligence (Newton & McGrew, 2010). Horn's model emphasized eight broad abilities, two of which, crystalized intelligence (Gc) and fluid reasoning (Gf), were the same concepts that were originally described by Cattell in his model of cognitive abilities. The other six broad abilities include auditory processing (Ga), visual-spatial processing (Gv), processing speed

(Gs), short-term memory (Gsm), long-term storage and retrieval (Glr), and quantitative reasoning (Gq; Evans et al., 2001; Fiorello et al., 2009). Currently, there are a total of 16 broad abilities that are recognized, which can be grouped based concept and function.

The first group, as described by Schneider and McGrew (2012) involves acquired knowledge and includes four broad abilities (1) Reading/writing ability (Grw) involves the acquisition of knowledge (e.g. writing skills and reading fluency) that is necessary for the comprehension and understanding of written language and expression (Miller, 2008). (2) Quantitative reasoning (Gq) refers to the storage of acquired knowledge regarding declarative, procedural, and quantitative information (Miller, 2008; Newton & McGrew, 2010). (3) Comprehension-knowledge (Gc), also referred to as crystallized intelligence, involves the use of general knowledge and language comprehension to solve problems. (4) Domain-specific knowledge (Gkn) involves procedural and declarative knowledge on subjects related to specific interests.

The second group involves sensory-motor domain-specific abilities and, according to Schneider and McGrew (2012), can be divided further into two groups: sensory and motor. The sensory group includes four broad abilities. (1) Auditory processing (Ga) typically involves the ability to take auditory information that has been presented and then analyzes and synthesizes that information. (2) Visual-spatial processing (Gv) typically involves the perception, analysis, spatial orientation, and visual patterned thinking (Miller, 2008). These two processing abilities are quite similar in their functions, however, auditory processing involves sounds and hearing and visual-spatial processing involves images and vision (Newton & McGrew, 2010). (3) Olfactory processing (Go) refers to the ability to understand, control, and manipulate smells. (4) Tactile (haptic) processing (Gh) refers to the ability to understand, control, and manipulate touch stimuli. The motor group includes two broad abilities. (1) Kinesthetic processing (Gk) refers to the ability to understand, control, and manipulate sensations involving body movement. (2) Psychomotor abilities (Gp) refer to the ability to perform motor tasks.

According to Schneider and McGrew (2012), the third group involves domain-independent general capacities and includes the broad ability fluid reasoning (Gf). This group subsumes the fourth group involving parameters of cognitive efficiency, which can be divided into memory and general speed.

The memory group includes two broad abilities (Schneider & McGrew, 2012). (1) Short-term memory (Gsm) refers to the ability to retrieve and hold information in memory for a brief period of time, usually for a few seconds (Miller, 2008). This may include remembering information that you are about to tell someone or write down, or even information that is as simple as trying to remember to do an activity, such as go to the store. (2) Long-term storage and retrieval (Glr) is similar to short-term memory, however, rather than trying to keep information in memory for a brief period of time, the information is encoded and remains in memory for an unlimited amount of time (Newton & McGrew, 2010). In order to retrieve information that is stored in long-term memory, one has to use associations (Miller, 2008), such as listening to a conversation, which reminds you about a related topic.

The general speed group, as described by Schneider and McGrew (2012) includes three broad abilities. (1) Psychomotor Abilities (Gps), which involves the speed of basic motor functions. (2) Processing Speed (Gs), which refers to the ability to perform basic cognitive tasks without much thinking (Newton & McGrew, 2010). This ability should be fairly automatic, especially when focused attention is required (Miller, 2008). Measurements of cognitive ability related to processing speed include reading speed and fluency, writing speed, and how fast an individual can take a test (Newton & McGrew, 2010). (3) Reaction and Decision Speed (Gt), which refers to the amount of time in which an individual reacts to a specific task or stimuli (Evans et al., 2001; Miller 2008).

Carroll's model, similar to Horn's model, involved a set of abilities; however, unlike Horn, Carroll's was not based off of another theorist's model; but rather, he developed his own list of abilities through the use of factor analysis and arranged them in a hierarchical fashion (Schneider & McGrew, 2012). In addition, Carroll also provided a three-stratum theory of cognitive development, which Carroll and Horn later decided to combine with Horn's model of broad abilities to form the CHC Theory of Cognitive Abilities (McGrew, 2009; Newton & McGrew, 2010). In this model, the third stratum, which is located at the top of the model, refers to overall general intelligence (g; Evans et al., 2001; Fiorello et al., 2009). The second stratum, located in the middle of the hierarchical model, refers to the broad abilities of cognition described by Horn (Evans et al., 2001). The first, and lowest level stratum refers to the narrow abilities that are subsumed under the broad abilities (Newton & McGrew, 2010).

Woodcock-Johnson (WJ-III) Relation and CHC Theory

Since the CHC Theory involves measurements of broad and narrow cognitive abilities, it has been used in the development of cognitive assessments that can be used to determine whether or not a student qualifies for special education services (Flanagan et al., 2010). The Woodcock-Johnson III (WJ III) is a good example of an assessment, based on CHC Theory, which has been used to measure students' cognitive abilities along with their academic performance.

In 1989, the Woodcock-Johnson Psychoeducational Battery – Revised (WJ-R) was designed utilizing the Gf-Gc theory, being the first to bridge the gap between contemporary intellectual theory and applied practice (Schrank & Wendling, 2012). Since then, the WJ has been revised as normative samples change and as additional research on the CHC theory continues to develop.

The WJ III is one of the first assessments of cognitive abilities that was based on the CHC theory and includes all nine of the broad abilities (i.e. Gc, Gf, Ga, Gv, Gs, Gsm, Glr, Gq, and Grw; Keith & Reynolds, 2010). Over the years, the WJ III has been used to assess students with ADHD as well as SLD's, while ruling out an Intellectual Disability (ID).

Evans et al. (2001) conducted a study involving the relationship between reading achievement and cognitive abilities as measured by the WJ III and defined by the CHC theory of cognitive abilities. They found that the WJ III was a strong predictor of reading achievement. In fact, crystalized intelligence (Gc) or knowledge involving comprehension, and short-term memory (Gsm) were strongly related to reading achievement. Long-term storage and retrieval (Glr), auditory processing (Ga), and processing speed (Gs) were also found to strongly relate to measures of academic achievement; however, measures regarding visual-spatial processing (Gv) and fluid reasoning (Gf), contrary to previous research did not appear to be significantly related to academic achievement.

Measures of cognitive abilities on the WJ III have also been related to deficits in mathematics. According to Proctor (2012), processing speed (Gs), crystalized intelligence (Gc), and fluid reasoning (Gf) are all related to basic mathematical skills. Mathematical reasoning skills may be related to processing speed (Gs), crystalized intelligence (Gc), and fluid reasoning (Gf) as well as short-term memory (Gsm).

The CHC theory has consistently been shown to reliably measure students' cognitive abilities. Furthermore, there has been an abundance of evidence supporting the WJ III as an assessment of cognitive abilities. Since students with ADHD and SLD have demonstrated impairments regarding their cognitive processes and executive functions, the WJ III could be used to determine whether or not a student has a disability and if that student qualifies for special education services.

ADHD and CHC Theory

Penny, Waschbusch, Carrey, and Drabman (2005) were interested in whether cognitive abilities, as measured by the CHC theory, can be related back to ADHD. Their participants included 52 children age's six to 12, 33 of who had previously been diagnosed with ADHD. Using the WJ-III, Penny and colleagues examined whether the children who were diagnosed with ADHD had any deficits related to broadband abilities specified in the CHC Theory. The results showed that children who have the inattentive subtype (i.e. ADHD-PI) also appeared to have a deficit in their processing speed (Gs); however, this did not appear to be associated with the hyperactivity/impulsivity subtype (i.e. ADHD-PHI). This deficit in processing speed (Gs) does not imply that these children are inaccurate in their responses; rather, they just process information at a slower rate. Their accuracy is still similar to those without a deficit in processing speed (Gs).

In addition to a possible deficit in processing speed (Gs), Penny et al. (2005) also found that children with the inattentive subtype (i.e. ADHD-PI) may also have a deficit in fluid reasoning (Gf); however, this correlation is only moderate in strength. This potential deficit essentially means that they have trouble applying different methods of reasoning when trying to solve a problem. At the same time, both the inattentive (i.e. ADHD-PI) and hyperactive/impulsive (i.e. ADHD-PHI) subtypes had a significant correlation to deficits related to visual-spatial processing abilities (Gv); however, only the inattentive subtype (ADHD-PI) appeared to be associated with auditory processing abilities (Ga).

Math Disabilities

Proctor et al. (2005) also conducted a study regarding cognitive abilities; however, rather than trying to relate the CHC Theory back to ADHD, Proctor and colleagues were interested in math achievement. Using the WJ-III, they compared children who were considered to be low achieving and children who were considered to have average achievement with regards to mathematics. When compared to average achieving children, the results showed that children who were low achieving appeared to have lower abilities related to fluid reasoning (Gf) and comprehension-knowledge (Gc). In addition, these children also showed deficits related to visual-spatial processing (Gv) and short-term memory (Gsm).

Floyd, Evans, and McGrew (2003) also examined the relationship between math achievement and cognitive abilities using the WJ-III. Their results demonstrated that skills related to comprehension-knowledge (Gc) were moderately correlated with calculation skills, but significantly correlated with skills related to math reasoning. Processing Speed (Gs), on the other hand, appeared to be moderately correlated with math reasoning skills, yet significantly correlated with calculation skills. Auditory processing abilities (Ga) also appeared to be moderately correlated with skills related to math calculation.

Relationship between ADHD and Math Disabilities

The results from these studies (i.e. Floyd, et al. 2003; Penny et al., 2005; Proctor et al., 2005), in addition to previous research regarding the relationship between the CHC theory and the WJ III (e.g. Evans et al., 2001), may provide evidence supporting the administration of the WJ III when determining whether or not a student qualifies for special education services. Also, when examining the results from these studies, we can see a clear overlap in cognitive deficits between children who have ADHD and children with a math disability. These abilities include fluid reasoning (Gf), auditory processing (Ga), and visual-spatial processing (Gv). Deficits regarding processing speed (Gs) have been associated with both ADHD and math disabilities (e.g. Floyd et al., 2003); however, the relationship between processing speed (Gs) and math disabilities is still being examined due to inconsistencies in the replication of results (e.g. Proctor et al., 2005).

Conclusion

Overall, student success regarding academic achievement is definitely a subject that is of high priority; however, individuals diagnosed with a disorder (e.g. ADHD or SLD) may have difficulties related to academic achievement. Research has shown that the academic achievement of individuals with ADHD or SLD may be related to deficits in cognitive and executive functioning.

The CHC Theory of Cognitive Ability defines specific areas of cognitive ability that have been shown to relate to academic achievement. Since both ADHD and SLD have shown to involve deficits in cognitive abilities and have been related back to CHC theory, many theorists have used this model (CHC theory) as a basis for cognitive assessments (e.g. Woodcock-Johnson III). The WJ III, along with other measures of assessment, has been and is still continuing to be used to screen students for cognitive deficits and determine whether or not they qualify for special education services.

Fluency is important to the development of complex math skills (Poncy et al., 2012). By increasing one's math fact fluency, the individual will have more cognitive space to solve more complex mathematical problems thus freeing up cognitive space (i.e. resources), to solve more complex problems, this being able to solve more problems not only accurately, but also more efficiently (Axtell et al., 2009).

Both TP and CCC appear to be effective interventions when building math fact accuracy and fluency in students with a SLD in math as well as students who do not have a learning disability (Axtell et al., 2009; Poncy & Skinner, 2011; Poncy et al., 2010; Poncy et al., 2007; Poncy et al., 2012). Since SLD's are highly comorbid with ADHD (Floyd, et al. 2003; Penny et al., 2005; Proctor et al., 2005), it is plausible to assume these interventions would also be effective for individuals who have ADHD, who are struggling in math.

Things to consider during this study include delayed gratification and processing speed. Delayed gratification has been tested by using a paradigm where an individual is given a small immediate reinforcer and is told if he or she can delay or resist the item for a certain time interval, then he or she will be given a reinforcer of greater magnitude. This has shown to be an effective method for differentiating ADHD. Research has demonstrated that individuals with ADHD often have difficulty with delayed gratification, thus requiring more immediate feedback (Anderson, Hinshaw, & Simmel, 1994; Barkley et al., 2001; Olson et al., 1999). On the other hand, deficits in processing speed suggest the need for extended time on tasks so that information can be better understood, processed, and stored.

In this study, a TP intervention is being administered with the focus being on the time delay between the stimulus and the feedback. Individuals with ADHD tend to do better when provided cues to focus. When considering difficulties related to delayed gratification (i.e., deficits in behavioral inhibition), having a 2-s time delay may lead to higher rates of distractibility due to the need for immediate feedback; therefore the no time delay condition may be more effective. On the other hand, when considering deficits related to processing speed, the no time delay condition may lead to increased difficulty in attention. Moving at faster speeds may cause difficulty in tracking or processing. The 2-s time delay condition may be more effective since it will provide additional time to identify the cue prior to the feedback being given.

This study will examine the effectiveness of two TP procedures with students who have ADHD as compared to students who do not have ADHD. The first TP procedure uses no time delay between the administration of each problem and the answer to each problem. The second TP procedure uses a 2-s time delay between the problem and the answer. The study seeks to answer the following questions: (1) Does the length of the time delay between the problem and the answer affect student-learning rate when examining math fact fluency? and (2) Will increasing the length of the time delay increase math fact fluency for students who have ADHD? Specifically, it is hypothesized that the 2-s time delay procedure and the no time delay procedure will both be effective. Since individuals with ADHD typically have delays in processing speed, it is also hypothesized that the 2-s delay procedure will be more effective with regards to increasing math fact fluency for students with ADHD since it will provide them with additional time to respond to each problem whereas the no time delay procedure will be more effective for students without ADHD.

CHAPTER III

METHODOLOGY

Participants

This study examined two groups of students, ages 8 to 14 years (mean = 12 years) from a rural school district in the South-Central region of the United States. The first group included three students who had a diagnosis of ADHD from a licensed psychologist. The second group included three students without ADHD or any addition diagnoses. Participants included in this study all came from low socioeconomic backgrounds and were identified through an archival database collected from a university mental health clinic. This clinic provides mental health services to individuals who are referred for comprehensive diagnostic or psychological evaluations. Referral concerns for these participants included problems regarding behavior, learning and academic achievement, inattention, and hyperactivity.

The assessments measures administered to each participant evaluated intellectual ability, academic achievement, and behavior. School psychology graduate students, under the supervision of a licensed psychologist, conducted these evaluations. Each comprehensive evaluation included a semi-structured interview with one or both parents or caregivers, teachers, and students, as well as parent and teacher rating forms, a structured developmental history, an academic performance review, clinical observations, an intelligence assessment, a continuous performance test, and a Curriculum-Based Assessment (CBA). Diagnoses were determined through the convergence of data and based on whether the data fits the theoretical template for ADHD. To be included in this study, participants in both groups must have received a comprehensive psychological evaluation with results indicating a GIA of above 80 and difficulties in mathematics. An independent reviewer, who was a licensed psychologist, verified the diagnosis as well as the rules for inclusion in the study.

Permission to conduct the study at the school was obtained through the University's Institutional Review Board (IRB) committee and through the school district (see Appendices A and C). Permission to include these participants was obtained through parental consent as well as student assent prior to beginning the study (see Appendices B and D).

CHC Factors

The Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III COG) was administered to all participants during their comprehensive psychological evaluation and will be referenced throughout this study. The WJ-III COG is a norm-referenced, individually administered battery of subtests that measures a range of intellectual abilities. This test is designed to assess individuals ranging from 2 to 90 years of age and consists of standard scores that are based on age that have a mean of 100 and a standard deviation of 15 (Woodcock, McGrew, & Mather, 2001). The WJ-III COG measures general intellectual ability (GIA), clinical clusters, CHC factors, and cognitive categories (McGrew, 2005). The use of this assessment tool will allow psychologists and researchers to examine the students' cognitive functioning with regards to CHC clusters. In addition, this study hopes to find a link between a student's cognitive profile and intervention effectiveness. CHC factors that will be examined include processing speed (Gs), short-term memory (Gsm), long-term storage and retrieval (Glr), and visual processing (Gv). Each of these factors is linked to deficits in executive functioning and is thus common in individuals with ADHD.

Materials

Pre-Screener Probes

Pre-screener data were collected utilizing experimenter-constructed probes (i.e., worksheets) to identify skill placement for each student. Three probes were created for each skill set (i.e., addition, subtraction, multiplication, and division) in order to determine which skill needed to be targeted. Each worksheet contained 48 problems and was randomized to reduce practice effects. The goal for this study is to identify a skill that each participant struggles with. Decision rules on target skill placement are based on the number of DCPM. Math fact fluency scores ranging from 0-19 DCPM indicate that the student significantly struggles on the skill. Scores ranging from 20-39 DCPM indicate that the student is within the instructional range for the skill. In other words, the student is performing at levels similar to other students in the classroom. Fluency scores that range from 40 DCPM and above indicate mastery of the skill. For this study, the goal is to identify a computational skill that is below 20 DCPM.

Assessment and Intervention Probes

Assessment and intervention data were collected utilizing experimenter-constructed probes (i.e., worksheets). Specific skill sets (i.e., addition, subtraction, and division) were determined based on screening measures given prior to the start of the study. Three separate problem sets (Set A, Set B, and Set C) of similar difficulty were used to examine and compare the different treatment conditions. Each set contained a total of 48 mathematical computation problems (8 rows and 6 columns) – 12 items each presented four times. The problems presented in each set were of similar difficulty, but differed with regards to the problems presented so that each set was independent. A total of 12 alternate forms were constructed for each problem set. Of these probes, half were used to collect assessment data and half were used to during intervention sessions. There was a two day minimum before a student could be administered the same assessment or intervention probe.

Audio Equipment

A computer recording containing the audio for the TP intervention was developed for each of the probes (six recordings for each set). On each recording, the experimenter read each problem and corresponding answer for the set in which the recording was made. The recordings were not created based on set, but rather on individual baseline data. In other words, one student might have Set A as the 2-s time delay condition whereas another student it might be Set B. Therefore, various versions of each set were recorded. Audio files were created based on the skill set being addressed (i.e., addition, subtraction, and division). Each audio file contained 12 recordings, six for each set (e.g., A, B, C). A total of 48 audio recordings were created for the TP interventions. Twenty-four audio recordings (i.e., six sets) were created for the 2-s time delay condition (6 for Set A, 18 for Set B, and 12 for Set C) and twenty-four were made for the no time delay condition (18 for Set A, 12 for Set B, and 6 for Set C). Skill sets that were being addressed include Addition, Subtraction, and Division. Each recording was assigned a number that corresponded with the matching probe. In order to control for time, a stopwatch was used. This allowed the experimenter to record the amount of time it took to administer the assessment conditions as well as the amount of transition time between interventions.

Experimental Design, Dependent Measure, and Scoring

An alternating treatments design with a control condition was used to examine and compare the effects of time delay on math fact fluency. Specifically, this study examined whether one of the three conditions (i.e., independent variables) regarding time delay (TP with no delay, TP with 2-s delay, and control condition) is most effective in increasing math computational fluency in students with ADHD (Poncy et al., 2007; Poncy, McCallum, & Schmitt, 2010). The TP interventions were implemented daily and all participants were given both treatment conditions. Throughout this study, the two treatments were counterbalanced. In addition to being administered the two treatment conditions, participants were assessed using the control set. This set included problems that were not intervened upon during the daily interventions (i.e., problems that were not included in either treatment condition).

The dependent variable in this study was Digits Correct per Minute (DCPM). A digit was scored as being correct when the written digit was in the appropriate column. For example, if the student was given the problem 2x3 and provided the answer 6, the student would receive 1 digit correct. A digit will also be scored as being correct if the correct number is written in the correct column (Shinn, 1989). For example, if the student was given the problem 9x3 and provided the answer 27, the student would receive 2 digits correct. If, however, the student provided the answer 7, the student would receive 1 digit correct since the number 7 is in the correct column. If the answer provided does not include numbers that are correct based on column placement (e.g., if the student was given the problem 3x4 and the student answered 21), the student would receive 0 digits correct. The data were collected every day before the treatments and examined all of the math computation problems under evaluation.

Procedures

General Procedures

The TP intervention was conducted at the school twice per day, with one treatment being done at the beginning of the day and one towards the end of the day. A minimum of one hour was provided between treatment conditions during which time the student was asked to go back to class. Having this time between conditions served as a distractor task so that the first treatment condition did not affect the second treatment condition. In addition, treatment conditions were counterbalanced every day. Sessions for the assessment procedure took approximately 4 minutes. Sessions for the 2-s time delay condition lasted approximately 4.5 minutes and the sessions for the no time delay condition lasted approximately 3 minutes. Session times for the 2-s and no time delay conditions doubled during the second intervention phase (i.e., 9 minutes, 6 minutes).

Graduate students in the school psychology program implemented and collected the pre-screener and assessment data. Baseline data were collected prior to the implementation of the intervention. Once baseline data were stable (after four to five days), a training session was completed utilizing probes of a different skill set (e.g., if the student was being intervened on multiplication, addition would be given during the training). At the beginning of the training session, the experimenter distributed the TP intervention-training probe, face down. After the participant received the intervention probe, the experimenter read aloud the following directions, "Today we are going to do something new. We are going to do math problems using something called Taped Problems. (Pause) Look at your worksheet. On the worksheet you will see rows of math problems. I am going to start the computer and it is going to read each problem going across the page. Specifically, the computer will read the problem (2+2), pause, and give the answer (4). It is your job to try and beat the computer by writing down the answer before the computer says the answer. If you write down a different answer, cross out what you wrote and write down the correct answer. Make sure to follow along with the computer, do not speed past it or fall behind it. Are there any questions? Ok, let's practice." Once the participants were familiar with the TP procedures, the intervention began, continuing for 9-16 days depending on the individual student and his or her progress.

Pre-Screener Procedures

Prior to the beginning of the study, each participant was assessed using a curriculum-based assessment to determine which skill needed to be targeted. Each student began on addition and moved up in skill based on performance. To begin, participants were given a packet of three worksheets, all addressing the same skill. After the participants received their packet, the experimenter read the following directions, "The packets on your desk include three sheets of paper. On each sheet are [addition, subtraction, multiplication, division] problems. When I say 'begin' start answering the problems on the first sheet. Begin with the first problem and work each problem across the page. Once you finish a row, go on to the next one. If you come across a problem that you do not know, mark and 'X' through the problem and go on to the next one. If you finish the page before I say stop, set your pencil down on the table. Do not work ahead on any of the additional pages. Any questions? Get ready, get set, begin." After 1-minute had passed, the experimenter instructed the students to stop and turn to the next page in their packet. Once the students were on the next page, the timer was set for 1-min and the participants were instructed to begin. The same instructions and procedures were applied to all three of the sheets. Once all three assessment sheets were completed, the experimenter collected the packets from the participants. These procedures were repeated for those who already mastered or were on grade-level for the skill set being assessed (i.e., scores of 20 DCPM or higher). The median of the three worksheet scores was used to determine the target skill and whether additional skills should be assessed.

Assessment Procedures

Each day, pre-treatment assessment data were collected using a packet of three probes, one from each set (Set A, Set B, and Set C) prior to the administration of the intervention (i.e., prior to the implementation of the first treatment condition). Probe set and treatment condition assignments were based on each individual's baseline data. Stable and non-variable trends in data were randomly assigned one of the treatment conditions. The data trend that showed to most variability or growth was assigned the control condition. In other words, one student might have Set A as the 2-s time delay condition whereas another student it might be Set B.

During each session, the experimenter passed out the assessment packets to the participants and read the following directions, "The packets on your desk include three sheets of paper. On each sheet are [addition, subtraction, division] problems. When I say 'begin' start answering the problems on the first sheet. Begin with the first problem and work each problem across the page. Once you finish a row, go on to the next one. If you come across a problem that you do not know, mark and 'X' through the problem and go on to the next one. If you finish the page before I say stop, set your pencil down on the table. Do not work ahead on any of the additional pages. Any questions? Get ready, get set, begin." After 1-minute had passed, the experimenter instructed the students to stop and turn to the next page in their packet. Once the students were on the next page, the timer was set for 1-minute and the participants were instructed to begin. The same instructions and procedures were applied to all three of the assessment sheets. Once all three assessment sheets were completed, the experimenter collected the packets from the participants.

Intervention Procedures

This study compared two TP intervention procedures (i.e., 2-s time delay and no time delay). The intervention design and procedures were identical in all aspects except for the time delay between when a computation problem was given and when the answer to the problem was provided. Both treatment conditions included six probes (see Appendix E) with corresponding audio recordings. Each day, two intervention sessions took place (one for each treatment condition). The first TP intervention began immediately after the assessment procedure was completed. The second TP intervention was administered later in the day, after all of the participants had been administered the first intervention. The TP treatment conditions were counterbalanced, alternating after each intervention session. In other words, if day one the participants were first given the TP intervention with the 2-s time delay condition followed by the no time delay condition later in the day, then day two they would first be administered the no time delay condition followed by the 2-s time delay condition later in the day.

At the beginning of each session, the experimenter distributed the TP intervention probe, face down, from the treatment condition being assessed. After the participant received the intervention probe, the experimenter read aloud the following directions, "The worksheet on your desk has rows of math problems. I am going to start the computer and it is going to read each problem going across the page. Specifically, the computer will read the problem (2+2), pause, and give the answer (4). It is your job to try and beat the computer by writing down the answer before the computer says the answer. If you write down a different answer, cross out what you wrote and write down the correct answer. Make sure to follow along with the computer, do not speed past it or fall behind it. Are there any questions?" After the directions were read, the audio recording was played. Each TP intervention probe contained a total of 48 problems that were to be completed. The 2-s time delay condition took approximately 4.5 minutes to complete and the no time delay condition took approximately 3 minutes to complete.

After approximately 10 intervention sessions, the TP intervention procedures were intensified in order to promote better growth for some of the participants. The procedures for the second intervention phase were identical to the procedures for the first intervention phase. The difference was that instead of receiving the TP intervention one, participants received the TP intervention twice. In other words, during each treatment condition, instead of being given one TP worksheet, participants were given two. In addition, the probes that were provided were not the same exact worksheet, but were taken from the same intervention probe set. For instance, if Set C were being intervened on, probes one and three may have been given. Like previously, probes were randomized and there was a two-day minimum before a student could be administered the same intervention probe.

Procedural Integrity and Interscorer Agreement

An independent observer was present during each session to collect procedural integrity data during both the assessment and intervention phases (see Appendix F). During these sessions, the observer was given two integrity checklists (one for the assessment phase and one for the intervention phase). During each phase of each session, the observer recorded the student's name, date, the time during which the assessments and interventions begun and ended, whether or not the procedures were followed, and whether the assessments and interventions were implemented correctly. In addition to having an independent observer checking the integrity of the assessment and intervention sessions, an independent rater was also used to rescore the DCPM on around 30% of the total number of assessment sheets that were given throughout the study. The examiner then divided the number of interscorer agreements for DCPM by the total number of interscorer agreements and disagreements for DCPM and multiplied that number by 100 in order to find the overall percentage of interscorer agreement.

Data Analysis

The aim of this study was to examine whether time-delay modifications to math fact interventions (i.e., TP) are more effective at increasing learning rates for students with ADHD, thus linking diagnoses (i.e., one's cognitive profile) to specific treatments. Visual analysis of session graphs was used to evaluate intervention effectiveness by examining DCPM across baseline and intervention phases. A visual analysis of data level and trend was used to compare treatment conditions in order to determine whether one condition was more effective than another. Treatment outcomes were then compared across participants to determine whether there were any group differences between students with ADHD and students without regarding intervention effectiveness.

CHAPTER IV

RESULTS

This study sought to answer the following questions: (1) Does the length of the time delay between the problem and the answer affect student-learning rate when examining math fact fluency? and (2) Will increasing the length of the time delay increase math fact fluency for students who have ADHD?

Participants in this study included two groups of students, ages 8 to 14 years (mean = 12 years). The first group included three students who had a diagnosis of ADHD from a licensed psychologist, who will be referred to as William, Sarah, and Alexander. The second group included three students without ADHD or any addition diagnoses, who will be referred to as David, Andrew, and Tyler. The demographic data for these participants are summarized in Table 1. Interrater reliability by a licensed psychologist for diagnosis verification and participant inclusion in the study was 100%. In addition, participants were not actively taking any medications during the study.

A mean phase difference method was used to calculate the effect sizes for this study (Poncy et al., 2015; Manolov & Solanas, 2013). By using this method, the difference between two phases or conditions with regards to their slope can be accounted for and the scale that is developed and used is based on the dependent variable (i.e., DCPM). The effect size data compares the baseline data with the intervention phase's data in order to determine performance growth. In other words, this calculation allows investigators to examine the effectiveness of the interventions as well as cross compare the different treatment groups. Effect sizes also provide additional support when utilizing visual analyses.

William

Figure 1 displays the DCPM data for William in conjunction to all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session. William was assessed at 7 DCPM on subtraction; therefore, subtraction was selected as the target skill. Baseline data were collected daily over four days. After the fourth day, when baseline data became stable, the treatment conditions were introduced. On the first day of the intervention phase, the 2-s time delay condition was completed in the morning. The no time delay condition was completed in the afternoon once all participants completed the first intervention condition. The order in which the interventions were presented was alternated for the remainder of the study. Beginning on day two of the intervention phase, assessment data were collected prior to the implementation of the first treatment condition. This continued for the remainder of the study.

Visual analysis of the DCPM data indicated that the data were stable and that there were no immediate changes in level, though the 2-s delay condition did demonstrate a slight increase. After the 10th session implementing the TP intervention with little growth, a phase change line was drawn and the intensity of the intervention was increased. In the second phase, two doses of each treatment condition were presented. In other words, rather than receiving one page of problems per treatment condition, he now received two pages. Just like before, the intervention probes were randomized so that no two probes were administered two consecutive days. After the 20th session, the intervention was discontinued. Discontinuation was based on visual analysis and implemented once a clear pattern in results was found.

Visual analysis of the DCPM data indicated significant results. After phase two was implemented, noticeable differences between the two treatment conditions were found. The 2-s delay condition showed a significant increase in trend regarding William's math fluency when compared with the control condition. The no time delay condition remained stable, even with the increase in intensity and remained comparable to the control condition. A direct visual comparison of the treatment conditions showed that the 2-s delay TP condition was more effective in increasing William's math fact fluency (i.e., DCPM).

To provide additional support to the visual analysis results, Table 2 provides the effect size or individual phase means data for Sets A, B, and C. Calculating the average of all points during the baseline phase derived the phase mean for the baseline data, while calculating the average of the final three sessions derived the phase mean for the intervention phase data. The average of the final three sessions was used rather than the average of the entire phase in order to more accurately represent how William performed at the end of the phase. This allows for a better account of overall DCPM growth. The phase means data for the second phase of the intervention were calculated the same was as they were for phase one.

When examining the phase-averages, the DCPM scores for William increased from baseline to phase one of the intervention by 8.75, 2.75, and 2.92 DCPM for Sets A, B, and C, respectively. After the second phase of the intervention was implemented, the phase-averages increased from phase one to phase two by 8.67, 3.67, and 3 DCPM for Sets A, B, and C, respectively. Overall, from baseline to the end of phase two of the intervention, William's math fact fluency for subtraction problems increased a total of 17.42, 6.42, and 5.92 DCPM for Sets A, B, and C, respectively.

When analyzing Figure 1 and Table 2 together, the effect size calculations and the results from the visual analysis data converges demonstrating an increase in growth trends for the different conditions. More specifically, the 2-s time delay condition (Set A) was shown to be most effective in increasing the growth rate of math facts when examined with the no time delay condition and compared to the control condition.

Sarah

Figure 2 displays the DCPM data for Sarah in conjunction to all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session. Sarah was assessed at 10 DCPM on division; therefore, division was selected as the target skill. Baseline data were collected daily over four days. After the fourth day, when baseline data became stable, the treatment conditions were introduced. On the first day of the intervention phase, the 2-s time delay condition was completed in the morning. The no time delay condition was completed in the afternoon once all participants completed the first intervention condition. The order in which the interventions were presented was alternated for the remainder of the study. Beginning on day two of the intervention phase, assessment data were collected prior to the implementation of the first treatment condition. This continued for the remainder of the study.

Visual analysis of the DCPM data indicated that although the data did increase in both trend and level, there was no clear distinction between the treatment conditions. After the ninth session implementing the TP intervention, a phase change line was drawn and the intensity of the intervention was increased. In the second phase, two doses of each treatment condition were presented. In other words, rather than receiving one page of problems per treatment condition, he now received two pages. Just like before, the intervention probes were randomized so that no two probes were administered two consecutive days. After the 19th session, the intervention was discontinued. Discontinuation was based on visual analysis and implemented once a clear pattern in results was found.

Visual analysis of the DCPM data indicated significant results. After phase two was implemented, noticeable differences between the two treatment conditions were found. Although all three treatment conditions continued to increase, the 2-s delay condition showed a significant increase in trend regarding Sarah's math fluency. The no time delay condition, though effective, did not produce as significant results and matched the trend and level of the control group. Problems presented in the control group are not included in the intervention, therefore, any increases made in the control group can be attributed to natural increases in skills due to work being done in the math classroom. A direct visual comparison of the treatment conditions showed that the 2-s delay TP condition was more effective in increasing Sarah's math fact fluency (i.e., DCPM).

To provide additional support to the visual analysis results, Table 3 provides the effect size or individual phase means data for Sets A, B, and C. Calculating the average of all points during the baseline phase derived the phase mean for the baseline data, while calculating the average of the final three sessions derived the phase mean for the intervention phase data. The average of the final three sessions was used rather than the average of the entire phase in order to more accurately represent how Sarah performed at the end of the phase. This allows for a better account of overall DCPM growth. The phase means data for the second phase of the intervention were calculated the same was as they were for phase one.

When examining the phase-averages, the DCPM scores for Sarah increased from baseline to phase one of the intervention by 9.42, 12.25, and 6.25 DCPM for Sets A, B, and C, respectively. After the second phase of the intervention was implemented, the phase-averages increased from phase one to phase two by 5.33, 9.67, and 3.33 DCPM for Sets A, B, and C, respectively. Overall, from baseline to the end of phase two of the intervention, Sarah's math fact fluency for division problems increased a total of 14.75, 21.92, and 9.58 DCPM for Sets A, B, and C, respectively.

When analyzing Figure 2 and Table 3 together, the effect size calculations and the results from the visual analysis data converges demonstrating an increase in growth trends for the different conditions. More specifically, the 2-s time delay condition (Set B) was shown to be most effective in increasing the growth rate of math facts when examined with the no time delay condition and compared to the control condition.

Alexander

Figure 3 displays the DCPM data for Alexander in conjunction to all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session. Alexander was assessed at 8 DCPM on division; therefore, division was selected as the target skill. Baseline data were collected daily over five days. After the fifth day, when baseline data became stable, the treatment conditions were introduced. On the first day of the intervention phase, the 2-s time delay condition was completed in the morning. The no time delay condition was completed in the afternoon once all participants completed the first intervention condition. The order in which the interventions were presented was alternated for the remainder of the study. Beginning on day two of the intervention phase, assessment data were collected prior to the implementation of the first treatment condition. This continued for the remainder of the study. After the 14th session, the intervention was discontinued. Discontinuation was based on visual analysis and implemented once a clear pattern in results was found.

Visual analysis of the DCPM data indicated that both treatment conditions were effective when compared to the control condition; however, a direct visual comparison of the treatment conditions showed that the 2-s delay TP condition was more effective in increasing Alexander's math fact fluency (i.e., DCPM).

To provide additional support to the visual analysis results, Table 4 provides the effect size or individual phase means data for Sets A, B, and C. Calculating the average of all points during the baseline phase derived the phase mean for the baseline data, while calculating the average of the final three sessions derived the phase mean for the intervention phase data. The average of the final three sessions was used rather than the average of the entire phase in order to more accurately represent how Alexander performed at the end of the phase. This allows for a better account of overall DCPM growth.

When examining the phase-averages, the DCPM scores for Alexander increased from baseline to intervention by 12, 15.53, and 1.87 DCPM for Sets A, B, and C, respectively.

When analyzing Figure 3 and Table 4 together, the effect size calculations and the results from the visual analysis data converges demonstrating an increase in growth trends for the different conditions. More specifically, the 2-s time delay condition (Set B) was shown to be most effective in increasing the growth rate of math facts when examined with the no time delay condition and compared to the control condition.

David

Figure 4 displays the DCPM data for David in conjunction to all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session. David was assessed at 12 DCPM on addition; therefore, addition was selected as the target skill. Baseline data were collected daily over four days. After the fourth day, when baseline data became stable, the treatment conditions were introduced. On the first day of the intervention phase, the 2-s time delay condition was completed in the morning. The no time delay condition was completed in the afternoon once all participants completed the first intervention condition. The order in which the interventions were presented was alternated for the remainder of the study. Beginning on day two of the intervention phase, assessment data were collected prior to the implementation of the first treatment condition. This continued for the remainder of the study.

Visual analysis of the DCPM data indicated that the data were increasing in trend and level for all three conditions, however, no clear distinction between the conditions could be made. Problems presented in the control group are not included in the intervention, therefore, any increases made in the control group can be attributed to natural increases in skills due to work being done in the math classroom. Since the data were so closely grouped, it is difficult to determine whether the increases in DCPM were related to the TP intervention or work being done in the classroom. After the 10th session implementing the TP intervention with little distinction, a phase change line was drawn and the intensity of the intervention was increased. In the second phase, two doses of each treatment condition were presented. In other words, rather than receiving one page of problems per treatment condition, he now received two pages. Just like before, the intervention probes were randomized so that no two probes were administered two consecutive days. After the 20th session, the intervention was discontinued. Discontinuation was based on visual analysis and implemented once a clear pattern in results was found.

Visual analysis of the DCPM data indicated significant results. After phase two was implemented, noticeable differences between the three treatment conditions were found. The 2-s delay and the no delay conditions showed significant increases in trend regarding David’s math fluency when compared with the control condition. The control group, however, did not show any changes in level or trend, suggesting the initial increase in DCPM observed during phase one was due to practice. In other words, the data suggests that David had not practiced this skill in a while and just the basic exposure provided a natural increase in fluency as he became familiar with the problems again. A direct visual comparison of the treatment conditions showed that both the 2-s delay TP condition and the no time delay conditions were equally effective in increasing David’s math fact fluency (i.e., DCPM).

To provide additional support to the visual analysis results, Table 5 provides the effect size or individual phase means data for Sets A, B, and C. Calculating the average of all points during the baseline phase derived the phase mean for the baseline data, while calculating the average of the final three sessions derived the phase mean for the intervention phase data. The average of the final three sessions was used rather than the average of the entire phase in order to more accurately represent how David performed at the end of the phase. This allows for a better account of overall DCPM growth. The phase means data for the second phase of the intervention were calculated the same was as they were for phase one.

When examining the phase-averages, the DCPM scores for David increased from baseline to phase one of the intervention by 6.42, 8.83, and 5.67 DCPM for Sets A, B, and C, respectively. After the second phase of the intervention was implemented, the phase-averages increased from phase one to phase two by 0.33, 9.67, and 12 DCPM for Sets A, B, and C, respectively. Overall, from baseline to the end of phase two of the intervention, David's math fact fluency for addition problems increased a total of 6.75, 19.5, and 17.67 DCPM for Sets A, B, and C, respectively.

When analyzing Figure 4 and Table 5 together, the effect size calculations and the results from the visual analysis data converges demonstrating an increase in growth trends for the different conditions. More specifically, the 2-s time delay condition (Set B) and the no time delay condition (Set C) were shown to be equally effective in increasing the growth rate of math facts when compared to the control condition.

Andrew

Figure 5 displays the DCPM data for Andrew in conjunction to all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session. Andrew was assessed at 12

DCPM on division; therefore, division was selected as the target skill. Baseline data were collected daily over four days. After the fourth day, when baseline data became stable, the treatment conditions were introduced. On the first day of the intervention phase, the 2-s time delay condition was completed in the morning. The no time delay condition was completed in the afternoon once all participants completed the first intervention condition. The order in which the interventions were presented was alternated for the remainder of the study. Beginning on day two of the intervention phase, assessment data were collected prior to the implementation of the first treatment condition. This continued for the remainder of the study.

Visual analysis of the DCPM data indicated that the data were increasing in trend and level for all three conditions, however, no clear distinction between the conditions could be made. Problems presented in the control group are not included in the intervention, therefore, any increases made in the control group can be attributed to natural increases in skills due to work being done in the math classroom. Since the data were so closely grouped, it is difficult to determine whether the increases in DCPM were related to the TP intervention or work being done in the classroom. After the ninth session implementing the TP intervention with little distinction, a phase change line was drawn and the intensity of the intervention was increased. In the second phase, two doses of each treatment condition were presented. In other words, rather than receiving one page of problems per treatment condition, he now received two pages. Just like before, the intervention probes were randomized so that no two probes were administered two consecutive days. After the 20th session, the intervention was discontinued. Discontinuation was based on visual analysis and implemented once a clear pattern in results was found.

Visual analysis of the DCPM data indicated significant results. After phase two was implemented, noticeable differences between the three treatment conditions were found. The 2-s delay and the no delay conditions showed significant increases in trend regarding Andrew's math fluency when compared with the control condition. The control group, however, only showed a slight increase in trend, suggesting the initial increase in DCPM observed during phase one was due to practice. In other words, the data suggests that Andrew had not practiced this skill in a while and just the basic exposure provided a natural increase in fluency as he became familiar with the problems again. A direct visual comparison of the treatment conditions showed that both the 2-s delay TP condition and the no time delay conditions were equally effective in increasing Andrew's math fact fluency (i.e., DCPM).

To provide additional support to the visual analysis results, Table 6 provides the effect size or individual phase means data for Sets A, B, and C. Calculating the average of all points during the baseline phase derived the phase mean for the baseline data, while calculating the average of the final three sessions derived the phase mean for the intervention phase data. The average of the final three sessions was used rather than the average of the entire phase in order to more accurately represent how Andrew performed at the end of the phase. This allows for a better account of overall DCPM growth. The phase means data for the second phase of the intervention were calculated the same was as they were for phase one.

When examining the phase-averages, the DCPM scores for Andrew increased from baseline to phase one of the intervention by 12.5, 7.83, and 12.17 DCPM for Sets A, B, and C, respectively. After the second phase of the intervention was implemented, the phase-averages increased from phase one to phase two by 12, 5, and 11.3 DCPM for Sets A, B, and C, respectively. Overall, from baseline to the end of phase two of the intervention, Andrew's math fact fluency for division problems increased a total of 24.5, 12.83, and 23.5 DCPM for Sets A, B, and C, respectively.

When analyzing Figure 5 and Table 6 together, the effect size calculations and the results from the visual analysis data converges demonstrating an increase in growth trends for the different conditions. More specifically, the 2-s time delay condition (Set C) and the no time delay condition (Set A) were shown to be equally effective in increasing the growth rate of math facts when compared to the control condition.

Tyler

Figure 6 displays the DCPM data for Tyler in conjunction to all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session. Tyler was assessed at 16 DCPM on division; therefore, division was selected as the target skill. Baseline data were collected daily over five days. After the fifth day, when baseline data became stable, the treatment conditions were introduced. On the first day of the intervention phase, the 2-s time delay condition was completed in the morning. The no time delay condition was completed in the afternoon once all participants completed the first intervention condition. The order in which the interventions were presented was alternated for the remainder of the study. Beginning on day two of the intervention phase, assessment data were collected prior to the implementation of the first treatment condition. This continued for the remainder of the study. After the 14th session, the intervention was discontinued. Discontinuation was based on visual analysis and implemented once a clear pattern in results was found.

Visual analysis of the DCPM data indicated that both treatment conditions (i.e., 2-s time delay and no time delay) were equally effective in increasing Tyler's math fact fluency (i.e., DCPM) when compared to the control condition.

To provide additional support to the visual analysis results, Table 7 provides the effect size or individual phase means data for Sets A, B, and C. Calculating the average of all points during the baseline phase derived the phase mean for the baseline data, while calculating the average of the final three sessions derived the phase mean for the intervention phase data. The average of the final three sessions was used rather than the average of the entire phase in order to more accurately represent how Tyler performed at the end of the phase. This allows for a better account of overall DCPM growth.

When examining the phase-averages, the DCPM scores for Tyler increased from baseline to phase one of the intervention by 1, 11.07, and 12.73 DCPM for Sets A, B, and C, respectively.

When analyzing Figure 6 and Table 7 together, the effect size calculations and the results from the visual analysis data converges demonstrating an increase in growth trends for the different conditions. More specifically, the 2-s time delay condition (Set C) and the no time delay condition (Set B) were shown to be equally effective in increasing the growth rate of math facts when compared to the control condition.

Summary

A visual analysis and comparison of the results from this study indicate that both treatment groups (i.e., 2-s delay, no delay) resulted in an increase growth rate in DCPM when compared to baseline data and the control condition for typically developing students. In addition, no significant differences in DCPM scores for the two treatment conditions were found, thus both treatment conditions were found to be equally effective in increasing fluency rates for this group. On the other hand, DCPM scores for students with a diagnosis of ADHD showed significant differences between the treatment conditions. More specifically, the 2-s time delay condition was found to be significantly effective in increasing growth rates in DCPM when compared to baseline and control conditions. The no time delay condition, however, was found to be not as effective at increasing DCPM growth rates. In fact, DCPM for the no time delay treatment condition was comparable to the control group for students with a diagnosis of ADHD.

For participants with a diagnosis of ADHD, the average growth of DCPM at the end of the intervention for the 2-s time delay condition was 18.29 DCPM. For the no time delay condition, the average growth rate was 11.06 DCPM. For the control condition, the average growth rate was 5.79 DCPM. For participants with no diagnosis, the average growth of DCPM at the end of the intervention for the 2-s time delay condition was 18.58 DCPM. For the no time delay condition, the average growth rate was 17.75 DCPM. For the control condition, the average growth rate was 6.86 DCPM. The 2-s time delay condition and the control condition are comparable across participants, regardless of diagnosis; however, the no time delay averages of the groups showed significant differences. For participants with a diagnosis of ADHD, the no time delay condition did show to be effective when compared to the control condition; however, this condition was not comparable to the performance of typically developing participants. In addition, the 2-s time delay condition appeared to be most effective for this group. Typically developing participants showed little difference in DCPM when comparing the 2-s time delay and no time delay conditions.

CHAPTER V

DISCUSSION

The focus of this study was to examine the effectiveness of two TP procedures with students who have ADHD. The study sought to answer the following questions: (1) Does the length of the time delay between the problem and answer affect student-learning rate when examining math fact fluency? (2) Will increasing the length of the time delay increase math fact fluency for students who have ADHD?

It was hypothesized that the 2-second time delay procedure and the no time delay procedure would both be effective. It was also hypothesized that the 2-s delay procedure would be more effective with regards to increasing math fact fluency for students with ADHD since it allows them additional time to respond to each problem. In addition, the no time delay procedure was hypothesized to be more effective for students without ADHD.

Historically, the assessment of ADHD has been used for the purpose of either medicating or placing children on an IEP. With this study, the hope is to examine the relationship between ADHD and concerns regarding academic achievement through the use of a cognitive-based assessment with the goal being to facilitate the development and/or selection of effective interventions.

The results of the ADHD pre-screener (i.e., WJ-III assessment) converges with previous research suggesting that individuals with ADHD typically have impairments in Long-Term Storage and Retrieval (Glr), Short-Term Memory (Gsm), and Processing Speed (Gs). According to Simsek and Balaban (2010), Long-Term Storage and Retrieval (Glr), interventions involving rehearsal will likely be more effective. These interventions often involve the use of flashcards and/or verbal or written rehearsal. In addition to these interventions, accommodations often involve the use of visual cues for directions and procedures and having the student spend time rehearsing newly learned information (Wendling & Mather, 2009). With regards to Processing Speed (Gs), interventions including components, such as timed drill and practice (i.e., interventions requiring quick decision making), have been found to be effective (Mahncke, Bronstone, & Merzenich, 2006). In addition to these interventions, accommodations often involve access to immediate feedback and increasing the time between when a question is given and when the student provides a response (Schrank & Wendling, 2012).

An alternating treatments design with a control condition was used to examine and compare the effects of time delay on math fact fluency. The dependent variable in this study used to measure math fact fluency was Digits Correct per Minute (DCPM). Three treatment conditions (no delay, 2-s delay, and control) were compared to determine whether differences in time delay influences the effectiveness of a math intervention on fluency development. These results were compared across two populations: individuals with a diagnosis of ADHD and individuals with no diagnosis. The intervention that was used in this study is the Taped Problems (TP) intervention. TP utilizes methods beneficial for individuals who have deficits in Long-Term Storage and Retrieval (Glr) as well as deficits in Processing Speed (Gs). TP involves rehearsing new information in a drill and practice format. In addition, by providing the correct answer after a certain amount of time has passed (i.e., a delay) allows students access to immediate feedback. Also, since one of the accommodations for deficits in Processing Speed (Gs) is increased time between the question being asked and the response being provided by the student, this study examined the length of time delay between the math problem being administered and correct response being provided to the student.

Things that were considered during this study include delayed gratification and processing speed. Research has shown that individuals with ADHD often have difficulty with delayed gratification, thus requiring more immediate feedback (Anderson et al., 1994; Barkley et al., 2001; Olson et al., 1999). When considering difficulties related to delayed gratification (i.e., deficits in behavioral inhibition), having a 2-s time delay on a TP intervention may lead to higher rates of distractibility due to the need for immediate feedback; therefore the no time delay condition may be more effective. On the other hand, deficits in processing speed suggest the need for extended time on tasks so that information can be better understood, processed, and stored. When considering deficits related to processing speed, having no time delay on a TP intervention may lead to increased difficulty in attention. Moving at faster speeds may cause difficulty in tracking or processing. The 2-s time delay condition may be more effective since it will provide additional time to identify the cue prior to the feedback being given.

Visual analysis was used to evaluate intervention effectiveness by examining DCPM across baseline and intervention phases. Visual analysis of the DCPM data across participants indicated that both treatment groups (i.e., 2-s delay, no delay) were effective in increasing DCPM growth rate for typically developing students. In addition, neither treatment condition appeared to be more effective than the other at increasing fluency rates for this group. On the other hand, the 2-s delay treatment condition was found to be significantly effective in increasing growth rates in DCPM for students with ADHD. The no time delay condition, however, was found to be not as effective at increasing DCPM growth rates as was comparable to the control group. These results support previous research findings, which suggest TP interventions are an effective tool for increasing math fact fluency. In addition, these results provide new evidence for differentiating interventions based on cognitive abilities (i.e., diagnoses). In other words, these results suggest adding in a time delay for students with ADHD or who have deficits processing speed will provide the additional support necessary for the intervention to be more effective. Though adding in a time delay will increase intervention session time, the growth shown in this study suggests that the number of sessions being intervened on will decrease.

These results also provide support for differentiating intervention intensity based on student need. Although these interventions are research and evidence-based, not all students show the same change in learning rate and performance. Some students, with short intervention sessions, demonstrate a significant increase in fluency rates whereas other students do not always show as much growth. For these students it might take additional sessions for the intervention to demonstrate effectiveness, causing some interventionists to lose hope and try a different method. These results provide support for increasing the intensity of the intervention, through increasing opportunities to respond and opportunities for feedback. By increasing the intensity of the intervention, faster rates of growth in performance is likely to occur. These results suggest that adjusting the intensity and/or frequency of the intervention would result in higher rates of growth and would be preferable to selecting a different intervention.

Research has provided empirical evidence supporting numerous math fact interventions targeting accuracy and fluency. These interventions include CCC, TP, and ET (Axtell et al., 2009; Poncy & Skinner, 2011; Poncy et al., 2010; Poncy et al., 2007; Poncy et al., 2012). Since there has been a significant amount of evidence supporting the effectiveness of these interventions for typically developing students, the question arises whether these interventions are as effective for students with disabilities. The goal of this study is to determine whether modifications to specific math interventions (i.e., TP) are necessary for them to be more effective for students with ADHD.

Research has shown that for students without ADHD who struggle in math computation accuracy and fluency, TP interventions are effective (Poncy & Skinner, 2011; Poncy et al., 2007; Poncy et al., 2012). More specifically, TP interventions with no time delay appear to be more effective for these individuals than TP interventions with a time delay (e.g., 2-s, 4-s; Poncy et al., 2015). This study supports prior research that TP interventions are effective in the increase of math fact accuracy and fluency, however, for students with ADHD, this study shows that the TP intervention is more effective with a 2-s time delay versus no time delay. This may be linked to deficits in Processing Speed and Working Memory.

A major strength of this study involves participant selection for inclusion. The participants were matched based on multiple levels, including diagnosis, assessments used during the psychological evaluation, initial computational fluency level, socioeconomic status, and location. In addition, this study utilized a small-n research designed approach, which allowed for less random error in sampling. With the degree of similarity between the participants, researchers can conclude that the results from the study are related to differences in cognitive functioning (i.e., whether or not participants had a diagnosis of ADHD resulting in deficits related to processing speed).

Additionally, this study limited the age range of the participants from eight to fourteen years of age, which is considered to be another strength. This is considered a strength when taken into consideration the changes in cognitive development from childhood to adolescence (Barkley, Grodzinsky, & DuPaul, 1992). These changes in cognitive development could have potentially impacted the results of the study and were therefore controlled for.

Another strength is the use of CHC factors to include and exclude participants. Each participant not only had a diagnosis of ADHD, but also showed deficits in Processing Speed (Gs), Short-Term/Working Memory (Gsm), and Long-Term Storage and Retrieval (Glr). This provides a more homogenous group or sample.

A final strength of this study is that it excludes students who have diagnosed comorbid disorders (e.g., SLD, ODD). The reasoning behind the decision for the exclusion of co-occurring diagnoses was to eliminate possible confounding variables and ensure that the results could be interpreted with confidence. Research has found that comorbid disorders may have an impact on the cognitive profile of students with ADHD (Crawford, Kaplan, & Dewey, 2006). If students with a co-existing diagnosis, such as SLD for example, had been included, it would be unclear of whether the results were related to specific deficits regarding the student's ADHD, if the results are related to the SLD, or if the results stem from the relationship between the two diagnoses.

A limitation of this study is that the sample size was small, inhibiting the ability for generalization to the population as a whole. In addition, the location in which the interventions took place was a small room, away from other students and distractions. This is viewed as a limitation as it would require students to be pulled out of class for a few minutes. With school districts pushing towards inclusion and with the limited resources (e.g., paraprofessionals) available, this environment may not be available. Future studies examining TP interventions in small groups (e.g., learning centers) or class-wide might be beneficial. Studies on class-wide implementation will allow researchers to determine whether similar results are found in the general education classroom. Successful class-wide implementation would provide support for students being able to independently implement the intervention, resulting in decreased resource requirements, and increase instructional time in the general education setting.

Regarding location, future studies might also investigate possible differences between rural and urban based settings as well as possible differences between participants from differing socioeconomic backgrounds. Depending on the location of the school, there may be additional access to resources, which could impact student growth and performance. Replication of this study in urban-based settings or at schools with additional funding might be necessary.

Another limitation involved the presentation (i.e., subtypes) of the participants ADHD diagnosis not being controlled for. Students with a diagnosis of ADHD were included in the study regardless of their subtype. Researchers have started examining differences between the different subtypes (i.e., ADHD-PHI, ADHD-PI, ADHD-C) and there is accumulating evidence separating ADHD-PHI and ADHD-PI suggesting that they may be two separate disorders (Barkley, 2003). In addition, differences between these subtypes may suggest a difference in an individual's cognitive profile (i.e., abilities), which could influence the results of this study. Future studies should compare different subtypes of ADHD to determine whether there are differing cognitive deficits and whether performance on a TP intervention may differ further regarding both the length of the time delay and the intensity in which the intervention is provided (i.e., need for increased opportunities to respond to see growth). The severity of the participants' ADHD symptoms was also not accounted for, which could have had an impact on the results. Future studies should control for both ADHD type and symptom severity.

While an aptitude by treatment effect was found in this study, replication is needed to provide support for this finding. Future studies regarding replication should also examine whether similar results are found across larger sample sizes and differing demographics. The results from this study could significantly impact the field of education and school psychology regarding decision-making for the diagnosis and treatment of ADHD; however, current limitations of generalizability must be further examined.

In addition, future studies might further investigate the CHC factors with regards to individuals with ADHD. More specifically, comparing the differences between younger individuals and older individuals with ADHD in the population with regards to these CHC factors. Future studies might also include the severity of the participants' symptoms related to ADHD and whether the severity influences their cognitive profiles in terms of CHC factors.

Lastly, future studies involving the replication of this study might further investigate the effects of the intervention once fluency once participants DCPM are at the instructional and mastery range (i.e., above 20 DCPM). At these higher levels of fluency, would the 2-s delay condition continue to be more effective at increasing DCPM for students with ADHD or would the two conditions level out and become equally effective? In addition, would differences be seen between these conditions when comparing students who are accurate, but not fluent on math computation problems and students who are neither accurate nor fluent? These are some areas that future studies may address.

CHAPTER VI

CONCLUSION

The purpose of this study was to examine the effectiveness of two TP procedures with students who have ADHD. The study sought to answer the following questions: (1) Does the length of the time delay between the problem and the answer affect student-learning rate when examining math fact fluency? And (2) Will increasing the length of the time delay increase math fact fluency for students who have ADHD? Specifically, it was hypothesized that the 2-second time delay procedure and the no time delay procedure will both be effective. Since individuals with ADHD typically have delays in processing speed, it was also hypothesized that the 2-s delay procedure will be more effective with regards to increasing math fact fluency since it allows more time to respond to each problem.

The findings from this study showed that students with ADHD typically have significant deficits in areas related to Long-Term Storage and Retrieval (Glr) and Processing Speed (Gs). This study also provides support for the use of TP interventions to increase accuracy and fluency with regards to basic math facts. Furthermore, this study suggests that increasing the time between the problem that's presented and the answer may enhance rates of learning for students with ADHD. Based on the degree of similarity between the participants that were controlled for during the selection process, these results are most likely due to differences in cognitive functioning, specifically their speed of processing. Further research is needed to determine whether these results generalize to the national population and whether these results can be replicated with other math fact skills.

REFERENCES

Anderson, C. A., Hinshaw, S. P., & Simmel, C. (1994). Mother-child interactions in ADHD and comparison boys: Relationships with overt and covert externalizing behavior. *Journal of Abnormal Child Psychology, 40*, 57-88. doi: 10.1007/BF02167903

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

Axtell, P. K., McCallum, R. S., Bell, S. M., & Poncy, B. (2009). Developing math automaticity using a classwide fluency building procedure for middle school students: A preliminary study. *Psychology in the Schools, 46*, 526-538. doi: 10.1002/pits.20395

Banaschewski, T., Roessner, V., Dittmann, R. W., Santosh, P. J., & Rothenberger, A. (2004). Non-stimulant medications in the treatment of ADHD. *European Child & Adolescent Psychiatry, 13*, i102-i116. doi: 10.1007/s00787-004-1010-x

Barkley, R. A. (2003). Attention-deficit/hyperactivity disorder. In E. J. Mash & R. A. Barkley (Eds.), *Child psychopathology.* (2nd ed., pp. 75-143). New York, NY: The Guilford Press.

Barkley, R. A. (2005). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (3rd ed.). New York, NY: Guilford Press.

Barkley, R. A., Edwards, G., Laneri, M., Fletcher, K., & Metevia, L. (2001). Executive functioning, temporal discounting, and sense of time in adolescents with attention deficit hyperactivity disorder and oppositional defiant disorder. *Journal of Abnormal Child Psychology, 29*, 541-556. doi: 10.1023/A:1012233310098

Barkley, R. A., Fischer, M., Edelbrock, C. S., & Smallish, L. (1991). The adolescent outcome of hyperactive children diagnosed by research criteria-III. Mother-child interactions, family conflicts and maternal psychopathology. *Journal of Child Psychology and Psychiatry, 32*, 233-255. doi: 10.1111/j.1469-7610.1991.tb00304.x

Barkley, R. A., Grodzinsky, G., & DuPaul, G. (1992). Frontal lobe functions in attention deficit disorder with and without hyperactivity: A review and research report. *Journal of Abnormal Child Psychology*, *20*, 163-188. doi: 10.1007/BF00916547

Brown, R. T., Carpenter, L. A., & Simerly, E. (2005). *Mental health medications for children: A primer.* New York, NY: The Guilford Press.

Centers for Disease Control and Prevention (2017). *Attention-deficit/hyperactivity disorder (ADHD).* Retrieved from https://www.cdc.gov/ncbddd/adhd/index.html

Codding, R. S., Shiyko, M., Russo, M., Birch, S., Fanning, E., & Jaspen, D. (2007). Comparing mathematics interventions: Does initial level of fluency predict intervention effectiveness? *Journal of School Psychology, 45*, 603-617. doi: 10.1016/j.jsp.2007.06.005

Crawford, S. G., Kaplan, B. J., & Dewey, D. (2006). Effects of coexisting disorders on cognition and behavior in children with ADHD. *Journal of Attention Disorders, 10*, 192-199. doi: 10.1177/1087054706289924

Duhon, G. J., House, S. H., & Stinnett, T. A. (2012). Evaluating the generalization of math fact fluency gains across paper and computer performance modalities. *Journal of School Psychology, 50*, 335-345. doi: 10.1016/j.jsp.2012.01.003

DuPaul, G. J., Gormley, M. J., & Laracy, S. D. (2013). Comorbidity of LD and ADHD: Implications of DSM-5 for assessment and treatment. *Journal of Learning Disabilities, 46*, 43-51. doi:10.1177/0022219412464351

DuPaul, G. J., & Volpe, R. J. (2009). ADHD and learning disabilities: Research findings and clinical implications. *Current Attention Disorders Reports, 1*, 152-155. doi: 10.1007/s12618-009-0021-4

Evans, J., J., Floyd, R. G., McGrew, K. S., & Leforgee, M. H. (2001). The relations between measures of cattell-horn-carroll (CHC) cognitive abilities and reading achievement during childhood and adolescence. *School Psychology Review, 31*, 246-262. Retrieved from http://web.a.ebscohost.com.argo.library.okstate.edu/ehost/pdfviewer/pdfviewer?sid=46e7e251-eba8-4ea5-80f1-9594768920d2%40sessionmgr4002&vid=1&hid=4209

Fabiano, G. A., Pelham Jr., W. E., Majumdar, A., Evans, S. W., Manos, M. J., Caserta, D., … Carter, R. L. (2013). Elementary and middle school teacher perceptions of attention-deficit/hyperactivity disorder prevalence. *Child Youth Care Forum, 42*, 87-99. doi: 10.1007/s10566-013-9194-1

Fiorello, C. A., Thurman, K., Zavertnik, J., Sher, R., & Coleman, S. (2009). Comparison of teachers' and school psychologists' perceptions of the importance of CHC abilities in the classroom. *Psychology in the Schools, 46*, 489-500. doi:10.1002/pits.20392

Flanagan, D. P., Fiorello, C. A., & Ortiz (2010). Enhancing practice through application of cattell-horn-carroll theory and research: A “third method” approach to specific learning disability identification. *Psychology in the Schools, 47*, 739-760. doi:10.1002/pits.20501

Floyd, R. G., Evans, J. J., & McGrew, K. S. (2003). Relations between measures of cattell-horn-carroll (CHC) cognitive abilities and mathematics achievement across the school-age years. *Psychology in the Schools, 40*, 155-171. doi: 10.1002/pits.10083

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities, 37*, 4-15. doi: 10.1177/00222194040370010201

Johnson, E. S., Humphrey, M., Mellard, D. F., Woods, K., & Swanson, H. L. (2010). Cognitive processing deficits and students with specific learning disabilities: A selective meta-analysis of the literature. *Learning Disability Quarterly, 33*, 3-18. doi: 10.1177/073194871003300101

Kaiser, N. M., & Pfiffner, L. J. (2011). Evidence-based psychosocial treatments for childhood ADHD. *Psychiatric Annals, 41*, 9-15. doi: 10.3928/00485713-20101221-03

Kan, K. J., Kievit, R. A., Dolan, C., & van der Maas, H. (2011). On the interpretation of the CHC factor Gc. *Intelligence, 39*, 292-302. doi:10.1016/j.intell.2011.05.003

Keith, T. Z. & Reynolds, M. R. (2010). Cattell-horn-carroll abilities and cognitive tests: What we’ve learned from 20 years of research. *Psychology in the Schools, 47*, 635-650. doi:10.1002/pits.20496

Krain, A. L., & Castellanos, F. X. (2006). Brain development and ADHD. *Clinical Psychology Review, 26*, 433-444. doi: 10.1016/j.cpr.2006.01.005

Lahey, B. B., Pelham, W. E., Loney, J., Lee, S. S., & Willcutt, E. (2005). Instability of the DSM-IV subtypes of ADHD from preschool through elementary school. *Archives of General Psychiatry, 62,* 896-902. doi: 10.1001/archpsyc.62.8.896

Loo, S. K., Specter, E., Smolen, A., Hopfer, C., Teale, P. D., & Reite, M. L. (2003). Functional effects of the DAT1 polymorphism on EEG measures in ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry, 42*, 986-993. doi: 10.1097/01.CHI.0000046890.27264.88

Mahcke, H. W., Bronstone, A., & Merzenich, M. M. (2006). Brain plasticity and functional loses in the aged: Scientific bases for a novel intervention. *Progressive in Brain Research, 157,* 81-109. doi: 10.1016/S0079-6123(06)57006-2

Mattison, R. E. & Mayes, S. D. (2012). Relationships between learning disability, executive function, and psychopathology in children with ADHD. *Journal of Attention Disorders, 16*, 138-146. doi: 10.1177/1087054710380188

Mayes, S. D., & Calhoun, S. L. (2007). Learning, attention, writing, and processing speed in typical children and children with ADHD, autism, anxiety, depression, and oppositional-defiant disorder. *Child Neuropsychology, 13*, 469-493. doi: 10.1080/09297040601112773

McArdle, P. (2013). Attention deficit hyperactivity disorder. *Pediatrics and Child Health, 23*, 40-41. doi: 10.1016/j.paed.2012.11.003

McCallum, E., Skinner, C. H., Turner, H., & Saecker, L. (2006). The taped-problems intervention: Increasing multiplication fact fluency using a low-tech, classwide, time-delay intervention. *School Psychology Review*, *35*, 419-434.

McGrew, K. S. (2005). The Cattell-Horn-Carroll theory of cognitive abilities. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment* (2nd ed., pp. 136-181). New York, NY: Guildford Press.

McGrew, K. S. (2009). CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research. *Intelligence, 37*, 1-10. doi:10.1016/j.intell.2008.08.004

Miller, B. D. (2008). Cattell-horn-carroll (CHC) theory-based assessment with deaf and hard of hearing children in the school setting. *American Annals of the Deaf, 152*, 459-466. Retrieved from http://search.proquest.com.argo.library.okstate.edu/docview/214475865?OpenUrlRefId=info:xri/sid:primo&accountid=4117

Newton, J. H., & McGrew, K. S. (2010). Introduction to the special issue: Current research in cattell-horn-carroll-based assessment. *Psychology in the Schools, 47*, 621-634. doi:10.1002/pits.20495

Nigg, J. T. (2006). *What causes ADHD? Understanding what goes wrong and why*. New York, NY: Guilford Press.

Olson, S. L., Schilling, E. M., & Bates, J. E. (1999). Measurement of impulsivity: Construct coherence, longitudinal stability, and relationship with externalizing problems in middle childhood and adolescence. *Journal of Abnormal Child Psychology, 27*, 151-165. doi: 10.1023/A:1021915615677

Penny, A. M., Waschbusch, D. A., Carrey, N., & Drabman, R. S. (2005). Applying a psychoeducational perspective to ADHD. *Journal of Attention Disorders, 8*, 208-220. doi: 10.1177/1087054705278746

Pliszka, S. R., Liotti, M., & Woldorff, M. G. (2000). Inhibitory control in children with attention-deficit/hyperactivity disorder: Event-related potentials identify the processing component and timing of an impaired right-frontal response-inhibition mechanism. *Biological Psychiatry, 48*, 238-246. doi: 10.1016/S0006-3223(00)00890-8

Poncy, B. C., Jaspers, K. E., Hansmann, P. R., Bui, L., & Matthew, W. B. (2015). A comparison of taped-problem interventions to increase math fact fluency: Does the length of time delay affect student learning rates? *Journal of Applied School Psychology, 31*, 63-82. doi: 10.1080/15377903.2014.963273

Poncy, B. C., McCallum, E., & Schmitt, A. (2010). Cover, copy, and compare versus facts that last: Evaluating and comparing a behavioral and a constructivist intervention targeting computational fluency. *Psychology in the Schools, 47*, 917–930.

Poncy, B. C., & Skinner, C. H. (2011). Enhancing first-grade students' addition-fact fluency using classwide cover, copy, and compare, a sprint, and group rewards. *Journal of Applied School Psychology, 27*, 1-20. doi: 10.1080/15377903.2011.540499

Poncy, B. C., Skinner, C.H., & Jaspers, K. E. (2007). Evaluating and comparing interventions designed to enhance math fact accuracy and fluency: Cover, copy, and compare versus taped problems. *Journal of Behavioral Education, 16*, 27-37. doi: 10.1007/s10864-006-9025-7

Poncy, B. C., Skinner, C. H., & McCallum, E. (2012). A comparison of class-wide taped problems and cover, copy, and compare for enhancing mathematics fluency. *Psychology in the Schools, 49*, 744-755. doi: 10.1002/pits.21631

Preston, J. D., O'Neal, J. H., & Talaga, M. C. (2013). *Handbook of clinical psychopharmacology for therapists* (7th ed.). Oakland, CA: New Harbinger Publications, Inc.

Proctor, B. (2012). Relationships between cattell−horn−carroll (CHC) cognitive abilities and math achievement within a sample of college students with learning disabilities. *Journal of Learning Disabilities, 45*, 278-287. doi:10.1177/0022219410392049

Proctor, B. E., Floyd, R. G., & Shaver, R. B. (2005). Cattell-horn-carroll broad cognitive ability profiles of low math achievers. *Psychology in the Schools, 42*, 1-12. doi: 10.1002/pits.20030

Rhymer, K. N., Skinner, C. H., Jackson, S., McNeill, S., Smith, T., & Jackson, B. (2002). The 1-minute explicit timing intervention: The influence of mathematics problem difficulty. *Journal of Instructional Psychology, 29*, 305-311. Retrieved from http://web.a.ebscohost.com.argo.library.okstate.edu/ehost/pdfviewer/pdfviewer?vid=4&sid=2fe36ccb-d358-4afe-8d64-c5393a938086%40sessionmgr4008

Scanlon, D. (2013). Specific learning disability and its newest definition: Which is comprehensive? And which is insufficient? *Journal of Learning Disabilities, 46*, 26-33. doi:10.1177/0022219412464342

Schneider, W. J., & McGrew, K. S. (2012). The cattell-horn-carroll model of intelligence. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (3rd ed., pp. 99-144). New York, NY: Guilford Press.

Schrank, F. A., & Wendling, B. J. (2012). The woodcock-johnson III normative update: Tests of cognitive abilities and tests of achievement. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (3rd ed., pp. 297-335). New York, NY: Guilford Press.

Shinn, M. R. (Ed.). (1989). *Curriculum-based measurement: Assessing special children.* New York, NY: Guilford Press.

Simsek, A., & Balaban, J. (2010). Learning strategies of successful and unsuccessful university students. *Contemporary Educational Technology, 1*, 36-45. Retrieved from http://www.eric.ed.gov.argo.library.okstate.edu/contentdelivery/servlet/ERICServlet?accno=ED542214

Smith, B. H., Barkley, R. A., & Shapiro, C. J. (2007). Attention-deficit/hyperactivity disorder. In E. J. Mash & R. A. Barkley (Eds.), *Assessment of childhood disorders* (4th ed., pp. 53-123). New York, NY: Guilford Press.

Smoot, L. C., Boothby, L. A., & Gillett, R. C. (2007). Clinical assessment and treatment of ADHD in children. *International Journal of Clinical Practice, 61*, 1730-1738. doi: 10.1111/j.1742-1241.2007.01519.x

Weiss, N. (2011). Assessment and treatment of ADHD in adults. *Psychiatric Annals, 41*, 23-31. doi: 10.3928/00485713-20101

Wendling, B. J., & Mather, N. (2009). *Essentials of evidence-based academic interventions.* New York, NY: John Wiley & Sons.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III.* Itasca, IL: Riverside Publishing.

Yell, M. L., Katsiyannis, A., Ryan, J. B., McDuffie, K. A., & Mattocks, L. (2008). Ensure compliance with the individuals with disabilities education improvement act of 2004. *Intervention in School and Clinic, 44*, 45-51. doi: 10.1177/1053451208318875

Zentall, S. S., & Ferkis, M. A. (1993). Mathematical problem solving for youth with ADHD, with and without learning disabilities. *Learning Disability Quarterly, 16,* 6-18. doi: 10.2307/1511156

APPENDICES

Table 1. Individual Demographic Information

Name	Gender	Age	Grade	Diagnosis	Skill	DCPM
William	Male	12	5th	ADHD-PI	Subtraction	7
Sarah	Female	13	7th	ADHD-PHI	Division	10
Alexander	Male	12	7th	ADHD-PI	Division	8
David	Male	8	2nd	None	Addition	12
Andrew	Male	12	7th	None	Division	12
Tyler	Male	14	8th	None	Division	16

Table 2. Individual Within-Phase Means (i.e., Effect Sizes) Across Problem Sets and Growth Between Baseline and Intervention, Baseline and Intervention x2, and Intervention and Intervention x2 Phases

Problem Set	Baseline	Intervention	Intervention x2	Baseline-Intervention Growth	Baseline-Intervention x2 Growth	Intervention-Intervention x2 Growth
Set A (2-s delay)	5.25	14	22.67	8.75	17.42	8.67
Set B (no delay)	5.25	8	11.67	2.75	6.42	3.67
Set C (control)	5.75	8.67	11.67	2.92	5.92	3

Table 3. Individual Within-Phase Means (i.e., Effect Sizes) Across Problem Sets and Growth Between Baseline and Intervention, Baseline and Intervention x2, and Intervention and Intervention x2 Phases

Problem Set	Baseline	Intervention	Intervention x2	Baseline-Intervention Growth	Baseline-Intervention x2 Growth	Intervention-Intervention x2 Growth
Set A (no delay)	3.25	12.67	18	9.42	14.75	5.33
Set B (2-s delay)	5.75	18	27.67	12.25	21.92	9.67
Set C (control)	6.75	13	16.33	6.25	9.58	3.33

Table 4. Individual Within-Phase Means (i.e., Effect Sizes) Across Problem Sets and Growth Between Baseline and Intervention

Problem Set	Baseline	Intervention	Intervention x2	Baseline-Intervention Growth	Baseline-Intervention x2 Growth	Intervention-Intervention x2 Growth
Set A (no delay)	12	24	---	12	---	---
Set B (2-s delay)	14.8	30.33	---	15.53	---	---
Set C (control)	15.8	17.67	---	1.87	---	---

Table 5. Individual Within-Phase Means (i.e., Effect Sizes) Across Problem Sets and Growth Between Baseline and Intervention, Baseline and Intervention x2, and Intervention and Intervention x2 Phases

Problem Set	Baseline	Intervention	Intervention x2	Baseline-Intervention Growth	Baseline-Intervention x2 Growth	Intervention-Intervention x2 Growth
Set A (control)	9.25	15.67	16	6.42	6.75	0.33
Set B (2-s delay)	11.5	20.33	31	8.83	19.5	9.67
Set C (no delay)	14	19.67	31.67	5.67	17.67	12

Table 6. Individual Within-Phase Means (i.e., Effect Sizes) Across Problem Sets and Growth Between Baseline and Intervention, Baseline and Intervention x2, and Intervention and Intervention x2 Phases

Problem Set	Baseline	Intervention	Intervention x2	Baseline-Intervention Growth	Baseline-Intervention x2 Growth	Intervention-Intervention x2 Growth
Set A (no delay)	4.5	17	29	12.5	24.5	12
Set B (control)	6.5	14.33	19.33	7.83	12.83	5
Set C (2-s delay)	6.5	18.67	30	12.17	23.5	11.3

Table 7. Individual Within-Phase Means (i.e., Effect Sizes) Across Problem Sets and Growth Between Baseline and Intervention

Problem Set	Baseline	Intervention	Intervention x2	Baseline-Intervention Growth	Baseline-Intervention x2 Growth	Intervention-Intervention x2 Growth
Set A (control)	12	13	---	1	---	---
Set B (no delay)	14.6	25.67	---	11.07	---	---
Set C (2-s delay)	18.6	31.33	---	12.73	---	---

Figure 1. William's DCPM data for all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session

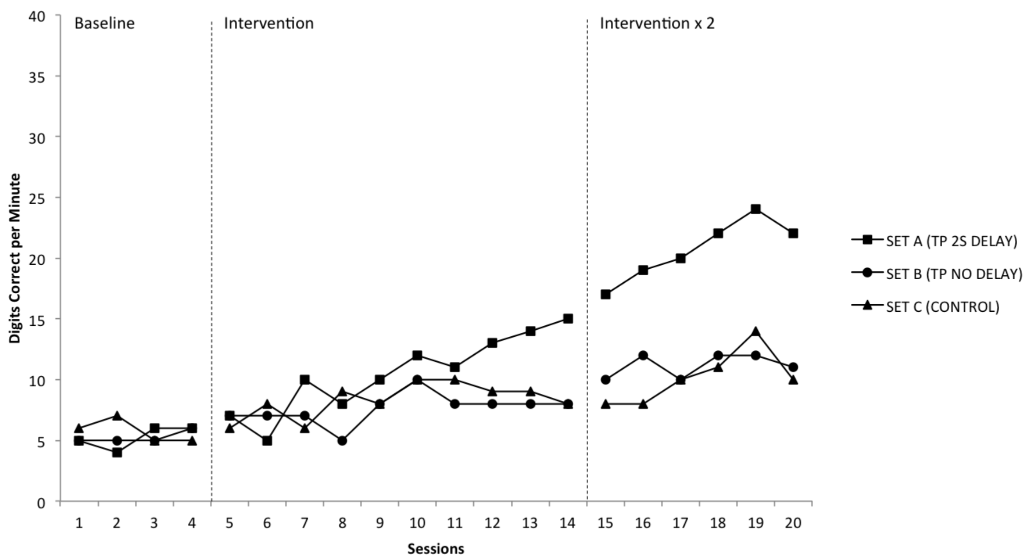


Figure 2. Sarah's DCPM data for all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session

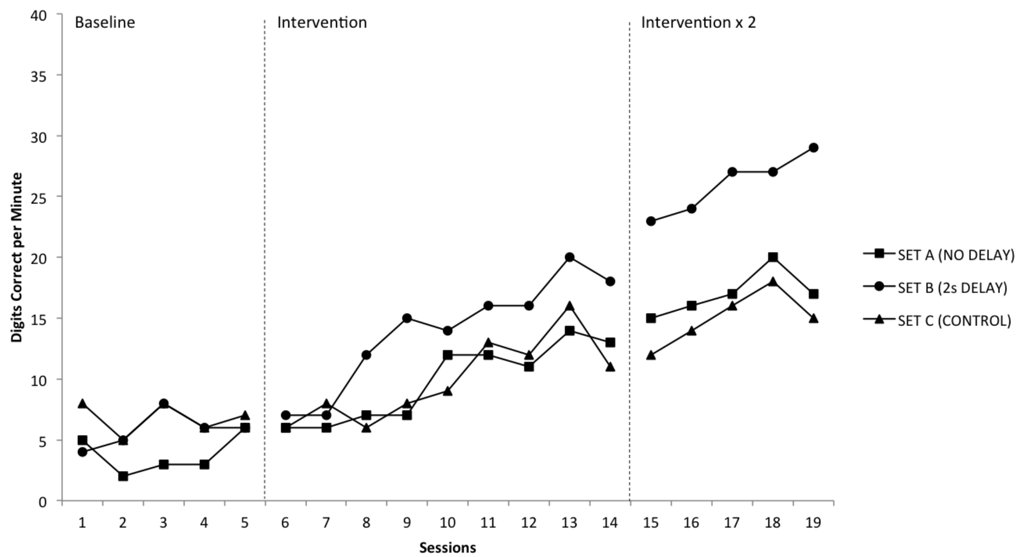


Figure 3. Alexander's DCPM data for all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session

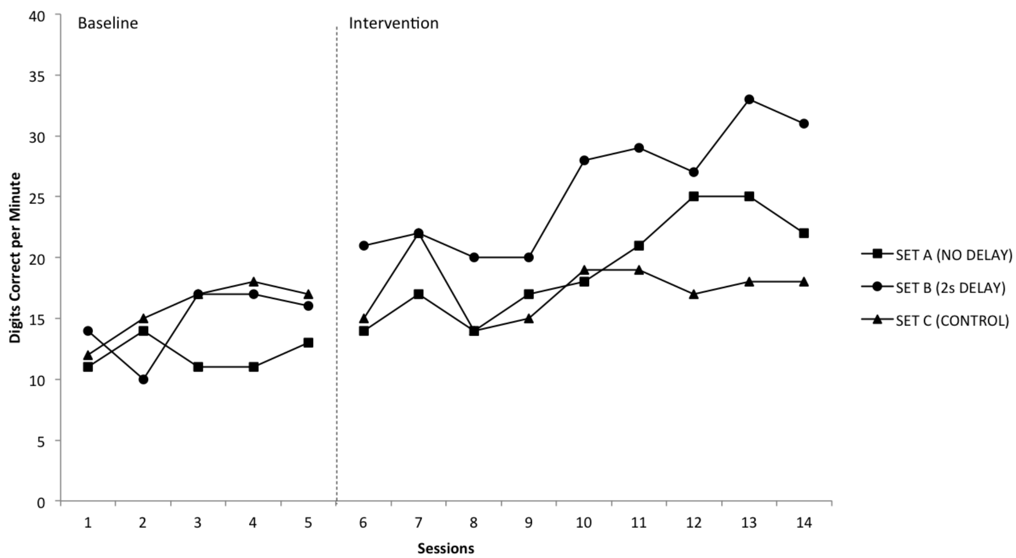


Figure 4. David's DCPM data for all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session

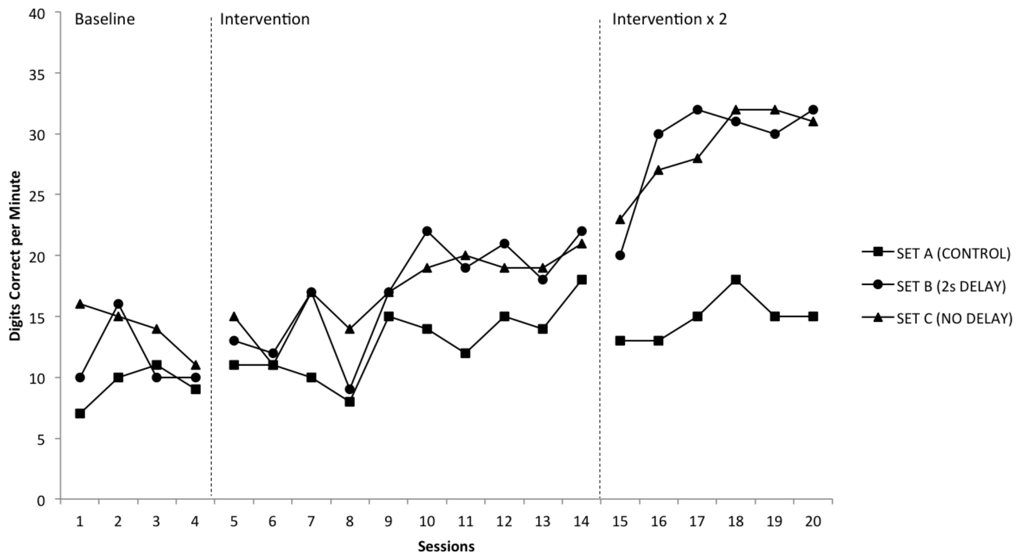


Figure 5. Andrew's DCPM data for all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session

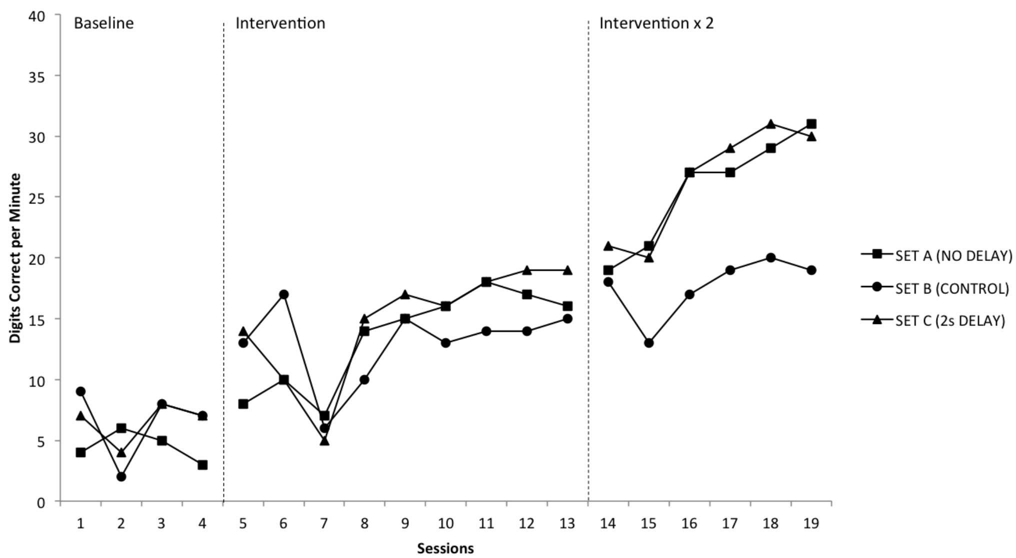
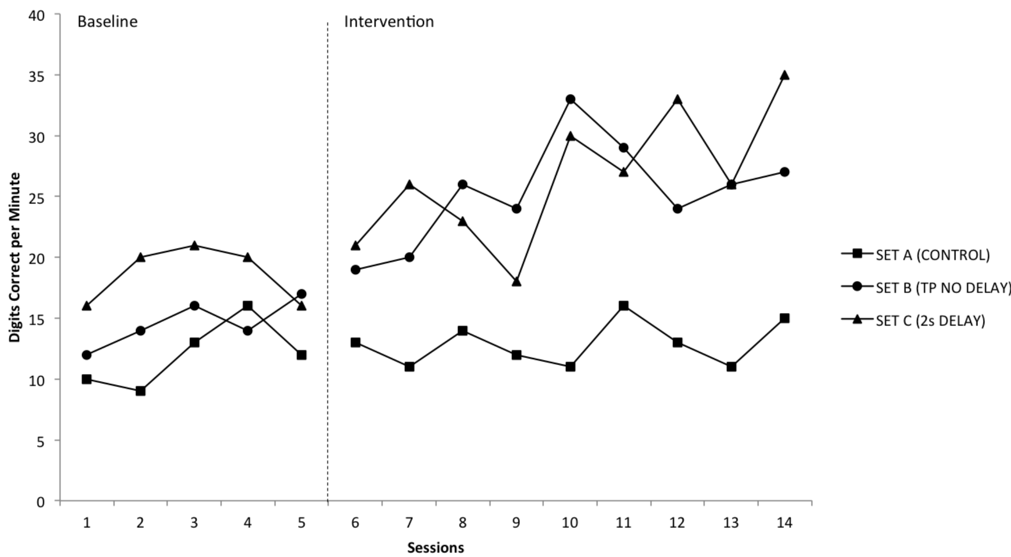


Figure 6. Tyler's DCPM data for all three treatment conditions (i.e., 2-s time delay, no time delay, control) by session



Appendix A
Recruitment Letter/Informed Consent

Principal __________,

I would like to request your permission to collect data for my dissertation at your school. I appreciate you spending this time with me and would like to briefly discuss the purpose and methods of the proposed evaluation with you.

Study's Title: Can the Cattell-Horn-Carroll (CHC) Theory Differentiate Student Performance on a Computation Intervention for Students with Attention Deficit Hyperactivity Disorder (ADHD)?

Investigator: Lauren A. Coffey, M.S., Graduate Student at Oklahoma State University

Purpose: The investigator of this research study is requesting to work with you in answering a question about what modifications to intervention procedures elicits the most efficient learning rates when teaching basic math facts. In the process of answering this question, students' participation in the intervention should increase their ability to accurately and quickly complete basic math facts. Curriculum-based assessments will be administered and evaluated to appropriately place the identified group of students in materials at their instructional level and to monitor student progress. The goal of these assessments will be to identify instructional materials that are matched to students' current level of skill development and to demonstrate how the students are responding to the intervention procedures. The assessment and intervention will in no way affect the activities of the general curriculum.

The purpose of the current research study is to evaluate the effectiveness of mathematics interventions implemented in the school setting, which have been developed by school psychology consultants. The primary purpose of this study is to determine what are the most effective and efficient mathematics intervention for students who have ADHD that allow them to make gains quickly with a minimal amount of resources.

Procedures:
The primary investigator will administer all parts of the research project, which will take place at the school of which each participant attends.

Phase one: The first part of the project will be to test students identified for participation in order to identify what basic math skill to target with each student (e.g., addition, subtraction, multiplication, or division). Students will be given three 1-minute math fact assessments in each skill under investigation to gather these data. The group will be placed in the most basic, fact skill that they score an average of less than 15 digits correct per minute with. Once the appropriate skill is identified, the materials needed will be selected.

Phase two: The second part of the project will consist of the administration of three one-minute basic fact probes for three to five days to establish baseline levels of student responding. Students will be given three 1-minute math fact assessments in each skill under investigation each day to gather these data.

Phase three: The third part of the project will consist of the implementation math fact interventions. The purpose of this phase is to gauge how students increase the speed with which they complete basic math fact problems in response to the math fact intervention procedure(s). Students' progress will be monitored each day before the first intervention is administered by giving three one-minute basic fact assessments. The amount of time these interventions will take each day is estimated to be around 15 minutes and will take place during specials or during their "WIN" (What I Need) time (i.e., WIN is a scheduled time when students break into groups based on their skills and academic needs for additional practice). The study is anticipated to last approximately 4-8 weeks.

Risks of Participation: The assessment and practice will in no way affect the activities of the general curriculum. Since these activities (curriculum-based measurement, math worksheets, increased practice) are part of the typical classroom activity there are no known risks associated with this project which are greater than those ordinarily encountered in the classroom setting.

Benefits: This study may also be beneficial for your students since it will provide increased practice in a subject area they may be having difficulty with. The results of this study can also be used to give the principal and teachers feedback about the effectiveness and efficiency of the math intervention.

Confidentiality: Every effort will be made to maintain the confidentiality of the data obtained from this study. The data will be housed at Oklahoma State University and only the Primary Investigators working on the project will have access to it. Electronic data will be stored on a password-protected data file located on an encrypted flash drive. The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you or your students. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Compensation: No monetary compensation is offered for participation in the study. The benefits provided by the study are explained above.

Contacts: If you have any questions with regard to you or your students' involvement in this study please contact us at your earliest convenience:

Lauren A. Coffey, M.S., Graduate Student at Oklahoma State University, 405-627-6434

Brian Poncy, Ph.D., Professor at Oklahoma State University, 405-744-4808

If you have questions about your rights as a research volunteer, you may contact Dr. Hugh Crethar, IRB Chair, 223 Scott Hall, Stillwater, OK 74078, (405) 744-3377 or irb@okstate.edu.

Participant Rights: Participation in this study is voluntary and you may choose to withdraw from the assessment and/or intervention at any time. No risks from withdrawal or termination are anticipated.

Signature: I give my permission for faculty and/or students from Oklahoma State University to work with me in assessing, developing and implementing an intervention in my classroom for the purposes of this research.

Signature of Principal	School Site	Date

I certify that I have personally explained this document before requesting that the participant sign it.

Signature of Researcher	Date

Appendix B
Parent Consent/Permission Form

Dear Parent,

You're son/daughter has been identified as a child who may benefit from an individualized intervention designed to increase school success in the area of mathematics. The intervention is designed to target academic skills related to basic mathematics and will be developed for your child based on a curriculum-based assessment of his/her needs. The assessment will include individualized academic activities that will identify specific math skills that your son/daughter struggle. This assessment as well as the intervention will take place in a quiet, distraction-free setting, outside of the classroom (e.g., conference room, library) reserved by one of the school's administrators. The goal of the assessment would be to identify a school based program that would increase your child's educational success in math.

The assessment and intervention materials will be developed by faculty and graduate students from the School Psychology program at Oklahoma State University. In addition, graduate students from this program will be administering both the assessment and intervention. I am writing to request your permission include your son/daughter in this intervention as well as request your permission to use your son's/daughter's intervention results within this research project. If you choose to allow us to include your child's results, they may also be included in research reports on ways to increase valued academic performances in schools. If your child's results are included in any research reports, his/her name will not be included in the report. If you do not choose to allow us to include your child's results in the research project, it will not impact the services that your child will already be receiving. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. You may choose to withdraw your child from the assessment and/or intervention at any time. Specific details regarding to research project as well as our contact information is attached.

If you have any questions with regard to your child's involvement in this study please contact us at your earliest convenience.

Sincerely,

____________________________ ________________
Signature of Researcher Date

Lauren A. Coffey, M.S.
Doctoral Student
Oklahoma State University
(405) 627-6434

Brian Poncy, Ph.D.
Associate Professor
Oklahoma State University
(405) 744-4808

Appendix C
Permission Form Attachment
Research Project

Study's Title: Can the Cattell-Horn-Carroll (CHC) Theory Differentiate Student Performance on a Computation Intervention for Students with Attention Deficit Hyperactivity Disorder (ADHD)?

Investigator: Lauren A. Coffey, M.S., Graduate Student at Oklahoma State University

Purpose: The investigator of this research study is looking to answer questions about what modifications to intervention procedures elicits the most efficient learning rates when teaching basic math facts in students with ADHD. Your child has been identified for participation in this study through a records review at the OSU School Psychology Center. Your student will be participating as a student with ADHD or in the control group of students without a diagnosis of ADHD. Both groups will receive the same instruction. Your students' participation in the intervention should increase their ability to accurately and quickly complete basic math facts. Curriculum-based assessments will be administered and evaluated to appropriately place the students with materials at their instructional level and to monitor student progress. The goal of these assessments will be to identify instructional materials that are matched to students' current level of skill development and to demonstrate how your students are responding to the intervention procedures. The assessment and intervention will in no way affect the activities of the general curriculum.

Procedures:

The primary investigator will administer all parts of the research project, which will take place at the school of which each participant attends.

Phase one: The first part of the project will be to test students identified for participation in order to identify what basic math skill to target with each student (e.g., addition, subtraction, multiplication, or division). Students will be given three 1-minute math fact assessments in each skill under investigation to gather these data. The group will be placed in the most basic, fact skill that they score an average of less than 15 digits correct per minute with. Once the appropriate skill is identified, the materials needed will be selected.

Phase two: The second part of the project will consist of the administration of three one-minute basic fact probes for three to five days to establish baseline levels of student responding. Students will be given three 1-minute math fact assessments in each skill under investigation each day to gather these data.

Phase three: The third part of the project will consist of the implementation math fact interventions. The purpose of this phase is to gauge how students increase the speed with which they complete basic math fact problems in response to the math fact intervention procedure(s). Students' progress will be monitored each day before the first intervention is administered by giving three one-minute basic fact assessments. The amount of time these interventions will take each day is estimated to be around 15 minutes and will take place during specials or during their "WIN" (What I Need) time (i.e., WIN is a scheduled time when students break into groups based on their skills and academic needs for additional practice). The study is anticipated to last approximately 4-8 weeks.

Risks of Participation: The assessment and practice will in no way affect the activities of the general curriculum. Since these activities (curriculum-based measurement, math worksheets, increased practice) are part of the typical classroom activity there are no known risks associated with this project which are greater than those ordinarily encountered in the classroom setting.

Benefits: This study may also be beneficial for students since it will provide increased practice in a subject area they may be having difficulty with. The results of this study can also be used to give the principal and teachers feedback about the effectiveness and efficiency of the math intervention.

Confidentiality: Every effort will be made to maintain the confidentiality of the data obtained from this study. The data will be housed at Oklahoma State University and only the Principal Investigators working on the project will have access to it. Electronic data will be stored on a password-protected data file located on an encrypted flash drive. The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you or your students. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

Contacts: If you have any questions with regard to you or your students' involvement in this study please contact us at your earliest convenience:

Lauren A. Coffey, M.S., Graduate Student at Oklahoma State University, 405-627-6434

Brian Poncy, Ph.D., Professor at Oklahoma State University, 405-744-4808

If you have questions about your rights as a research volunteer, you may contact Dr. Hugh Crethar, IRB Chair, 223 Scott Hall, Stillwater, OK 74078, (405) 744-3377 or irb@okstate.edu.

Participant Rights: Participation in this study is voluntary and you may choose to withdraw your student from the assessment and/or intervention at any time. No risks from withdrawal or termination are anticipated.

Student's Name: ________________________________

____ I give my permission for my child to be included in the research project.

____ No, I prefer that my child not be included in the research project.

Parent/Guardian Signature: ____________________________ Date: ___________

Appendix D
Student Assent Form

Dear Student,

We are interested in learning about ways to help students have better success in math. During this project, you will be asked to complete math activities. These activities will help us determine what skills we should work on so that we can help you do better in math. We will meet every day for about 15 minutes to work on different activities. This project will last for about 4-8 weeks depending on everyone's progress. Your parent/guardian already knows about this project.

Please know that you do not have to participate and that you may stop at any time.

If you have any questions about the form or what we are doing, please ask us. Thank you for your help.

Sincerely,

Lauren A. Coffey, M.S.
Doctoral Student
Oklahoma State University

Brian Poncy, Ph.D.
Associate Professor
Oklahoma State University

I have read this form and agree to help with your project.

____ ________________
(your signature) Date

I certify that I have personally explained this document before requesting that the participant sign it.

____ ________________
Signature of Researcher Date

Appendix E
Math Computation Probe Samples

Form 1A Name: ____________________________

8 + 9	3 + 3	2 + 5	7 + 7	6 + 9	8 + 2
3 + 5	7 + 6	5 + 6	8 + 3	4 + 4	9 + 4
7 + 7	3 + 5	7 + 6	3 + 3	8 + 3	8 + 9
2 + 5	9 + 4	5 + 6	4 + 4	6 + 9	8 + 2
8 + 9	3 + 5	7 + 6	3 + 3	5 + 5	7 + 7
6 + 9	8 + 2	2 + 5	8 + 3	4 + 4	9 + 4
3 + 3	6 + 9	3 + 5	7 + 7	8 + 3	2 + 5
5 + 6	8 + 9	7 + 6	4 + 4	8 + 2	9 + 4

Form 1A Name: ____________________________

17 - 9	6 - 3	7 - 5	14 - 7	15 - 9	10 - 2
8 - 5	13 - 6	11 - 6	11 - 3	8 - 4	13 - 4
14 - 7	8 - 5	13 - 6	6 - 3	11 - 3	17 - 9
7 - 5	13 - 4	11 - 6	8 - 4	15 - 9	10 - 2
17 - 9	8 - 5	13 - 6	6 - 3	10 - 5	14 - 7
15 - 9	10 - 2	7 - 5	11 - 3	8 - 4	13 - 4
6 - 3	15 - 9	8 - 5	14 - 7	11 - 3	7 - 5
11 - 6	17 - 9	13 - 6	8 - 4	10 - 2	13 - 4

Form 1A Name: ______________________________

72 ÷ 9 =	9 ÷ 3 =	10 ÷ 2 =	49 ÷ 7 =	54 ÷ 6 =	16 ÷ 8 =
15 ÷ 3 =	42 ÷ 7 =	30 ÷ 5 =	24 ÷ 8 =	16 ÷ 4 =	36 ÷ 9 =
49 ÷ 7 =	15 ÷ 5 =	42 ÷ 6 =	9 ÷ 3 =	24 ÷ 3 =	72 ÷ 8 =
10 ÷ 5 =	36 ÷ 4 =	30 ÷ 6 =	16 ÷ 4 =	54 ÷ 9 =	16 ÷ 2 =
72 ÷ 9 =	15 ÷ 3 =	42 ÷ 7 =	9 ÷ 3 =	30 ÷ 5 =	49 ÷ 7 =
54 ÷ 6 =	16 ÷ 8 =	10 ÷ 2 =	24 ÷ 8 =	16 ÷ 4 =	36 ÷ 9 =
9 ÷ 3 =	54 ÷ 9 =	15 ÷ 5 =	49 ÷ 7 =	24 ÷ 3 =	10 ÷ 5 =
30 ÷ 6 =	72 ÷ 8 =	42 ÷ 6 =	16 ÷ 4 =	16 ÷ 2 =	36 ÷ 4 =

Appendix F

Screener – Treatment Integrity

Student: ___________________ Date: ___________ Start/End Time: ___________

Materials

Required: □ Probe(s) □ Implementation Checklist □ Pencil □ Stopwatch

Intervention Procedures

1. Document student's name, date, start time, and end time. □

2. Provide student with pencil and worksheet. □

3. Tell student to put their name and date on the worksheet. □

4. Read directions. □

   "The sheet on your desk has (addition, subtraction, multiplication, division) problems. When I say "BEGIN," start answering the problems. Start at the first problem, work across the page, then go to the next row. You should work as fast as you can without skipping problems. If you come to a problem that you do not know, mark an 'X' through it and go on to the next problem. Continue working until I tell you to stop. Are there any questions? Ready. Begin."

5. Start timer. □

6. Monitor student procedural adherence. Prompt student if directions are violated. □

7. After 1 minute has passed, tell the student "stop, put your pencil down." □

8. Collect worksheet. □

Assessment – Treatment Integrity

Student: ___________________ Date: ___________ Start/End Time: ___________

Materials

Required: □ Probe(s) □ Implementation Checklist □ Pencil □ Stopwatch

Intervention Procedures

1. Document student's name, date, start time, and end time. □

2. Provide student with pencil and worksheet. □

3. Tell student to put their name and date on the worksheet. □

4. Read directions. □

   "The sheet on your desk has (addition, subtraction, multiplication, division) problems. When I say "BEGIN," start answering the problems. Start at the first problem, work across the page, then go to the next row. You should work as fast as you can without skipping problems. If you come to a problem that you do not know, mark an 'X' through it and go on to the next problem. Continue working until I tell you to stop. Are there any questions? Ready. Begin."

5. Start timer. □

6. Monitor student procedural adherence. Prompt student if directions are violated. □

7. After 1 minute has passed, tell the student "stop, put your pencil down." □

8. Repeat 2 times. □

9. When finished collect the worksheets. □

Baseline – Treatment Integrity

Student: ___________________ Date: ___________ Start/End Time: ___________

Materials

Required: □ Probe(s) □ Implementation Checklist □ Pencil □ Stopwatch

Intervention Procedures

1. Document student's name, date, start time, and end time. □
2. Provide student with pencil and worksheet (Set A, B, or C). □
3. Tell student to put their name and date on the worksheet. □
4. Read directions. □

   > "The sheet on your desk has (addition, subtraction, multiplication, division) problems. When I say "BEGIN," start answering the problems. Start at the first problem, work across the page, then go to the next row. You should work as fast as you can without skipping problems. If you come to a problem that you do not know, mark an 'X' through it and go on to the next problem. Continue working until I tell you to stop. Are there any questions? Ready. Begin."

5. Start timer. □
6. Monitor student procedural adherence. Prompt student if directions are violated. □
7. After 1 minute has passed, tell the student "stop, put your pencil down." □
8. Repeat with the other two probe sets (Set A, B, or C). □
9. When finished collect the worksheets. □

Taped Problems – Student Training Protocol

Use this to train students how to use TP procedures.

1. Document student's name, date, start time, and end time. □

2. Provide student with pencil and worksheet. □

3. Tell student to put their name on the worksheet. □

4. Read the following directions: □

   "Today we are going to do something new. We are going to do math problems using something called Taped Problems. (Pause) Look at your worksheet. On the worksheet you will see rows of math problems. I am going to start the computer and it is going to read each problem going across the page. Specifically, the computer will read the problem (2+2), pause, and give the answer (4). It is your job to try and beat the computer by writing down the answer before the computer says the answer. If you write down a different answer, cross out what you wrote and write down the correct answer. Make sure to follow along with the computer, do not speed past it or fall behind it. Are there any questions? Ok, let's practice."

5. Continue reading: □

   "I am going to start the computer and we are going to do the first row and then stop. Ready, begin". (Start audio file).

6. After the first row, stop the file. Read: □

   "Do you have any questions? I am going to restart the computer and we will finish the page. Ready, begin."

7. Repeat as necessary until students can independently follow the tape. The student should also be able to describe the procedures. □

Taped Problems – Treatment Integrity Protocol

Student: ___________________ Date: ___________ Start/End Time: ___________

Materials

Required: □ TP Worksheets □ Implementation Checklist □ Pencil □ Audio File

Intervention Procedures

1. Document student's name, date, start time, and end time. □

2. Provide student with pencil and worksheet. □

3. Tell student to put their name on the worksheet. □

4. Start the audio file. It will read a brief set of directions and then begin to read the problems and answers. The audio file will instruct students when to stop. □

5. Monitor student procedural adherence, ensuring that students are following along with the tape, trying to beat the tape (not just writing answers along with the tape). □

6. When finished collect the worksheets. □

Taped Problems – Assessment Treatment Integrity

Student: ___________________ Date: ___________ Start/End Time: ___________

Materials

Required: □ Probe(s) □ Implementation Checklist □ Pencil □ Stopwatch

Intervention Procedures

1. Document student's name, date, start time, and end time. □
2. Provide student with pencil and worksheet (Set A, B, or C). □
3. Tell student to put their name and date on the worksheet. □
4. Read directions. □

    "The sheet on your desk has (addition, subtraction, multiplication, division) problems. When I say "BEGIN," start answering the problems. Start at the first problem, work across the page, then go to the next row. You should work as fast as you can without skipping problems. If you come to a problem that you do not know, mark an 'X' through it and go on to the next problem. Continue working until I tell you to stop. Are there any questions? Ready. Begin."

5. Start timer. □
6. Monitor student procedural adherence. Prompt student if directions are violated. □
7. After 1 minute has passed, tell the student "stop, put your pencil down." □
8. Repeat with the other two probe sets (Set A, B, or C). □
9. When finished collect the worksheets. □

Taped Problems – Treatment Integrity Protocol – Part 1

Student: ___________________ Date: ____________ Start/End Time: __________

Materials: □ TP Worksheets □ Implementation Checklist □ Pencil □ Audio File

Intervention Procedures

1. Document student's name, date, start time, and end time. □
2. Provide student with pencil and worksheet. □
3. Tell student to put their name on the worksheet. □
4. Start the audio file. It will read a brief set of directions and then begin to read the problems and answers. The audio file will instruct students when to stop. □
5. Monitor student procedural adherence, ensuring that students are following along with the tape, trying to beat the tape (not just writing answers along with the tape). □
6. When finished collect the worksheets. □

Taped Problems – Treatment Integrity Protocol – Part 1

Student: ___________________ Date: ____________ Start/End Time: __________

Materials: □ TP Worksheets □ Implementation Checklist □ Pencil □ Audio File

Intervention Procedures

1. Document student's name, date, start time, and end time. □
2. Provide student with pencil and worksheet. □
3. Tell student to put their name on the worksheet. □
4. Start the audio file. It will read a brief set of directions and then begin to read the problems and answers. The audio file will instruct students when to stop. □
5. Monitor student procedural adherence, ensuring that students are following along with the tape, trying to beat the tape (not just writing answers along with the tape). □
6. When finished collect the worksheets. □

VITA

LAUREN ASHLEY COFFEY

Candidate for the Degree of

Doctor of Philosophy

Dissertation: CAN THE CATTELL-HORN-CARROLL (CHC) THEORY DIFFERENTIATE STUDENT PERFORMANCE ON A COMPUTATION INTERVENTION FOR STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)?

Major Field: EDUCATIONAL PSYCHOLOGY, OPTION IN SCHOOL PSYCHOLOGY

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Completed the requirements for the Doctor of Philosophy Educational Psychology, Option in School Psychology at Oklahoma State University, Stillwater, Oklahoma in May, 2018.

Completed the requirements for the Master of Science in School Psychometrics at Oklahoma State University, Stillwater, Oklahoma in December, 2014.

Completed the requirements for the Bachelor of Arts in in Psychology at Oklahoma State University, Stillwater, Oklahoma in May, 2013.

Experience:

Oklahoma Tiered Intervention System of Support (OTISS) Specialist Consultant (Summer 2016 – Spring 2017)

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