AN INVESTIGATION INTO THE RELATIONSHIPS BETWEEN READING RATE, PROCESSING SPEED, AND EXTENDED TIME

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Abstract

Through ESSA (2015) and IDEIA (2004), all students must participate in statewide assessments and students with disabilities are entitled to receive reasonable adaptations and accommodations in order to ensure that the assessments accurately measure their achievement within the designated academic areas. Research indicates that the provision of an accommodation should be based upon a student's individual needs; however, studies within this area frequently compare the effects of an accommodation on the performance of students with a disability and students without a disability. Currently, extended time is the most frequently requested and provided accommodation for state assessments across disabilities. This study sought to determine whether there is a relationship between reading rate and the boost from extended time on reading, a relationship between cognitive processing speed and the boost from extended time on reading, and a relationship between reading rate and cognitive processing speed. The Nelson-Denny Reading Test (NDRT) Forms I and J and the Woodcock-Johnson Tests of Cognitive Abilities, 4th Edition (WJ-IV COG) were used to assess 21 students attending a suburban high school in New Jersey. Results indicated there is a relationship between cognitive processing speed and boost from extended time on the Vocabulary subtest ($r = -.38$) and a relationship between reading rate and performance on the Letter-Pattern Matching test ($r = .37$). Results indicated there is not a relationship between reading rate or overall cognitive processing speed and boost from extended time on comprehension or general reading ability and there is not a relationship between reading rate and overall cognitive processing speed. Further investigation is needed to determine whether extended time provides a differential boost for students based upon reading fluency or cognitive processing speed.

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Chapter I

Introduction

The Every Student Succeeds Act (ESSA) of 2015 requires all states to adopt rigorous academic content standards, challenging achievement standards, and high-quality academic assessments. States are required to administer language arts and mathematics assessments to students every year from grades three through eight and at least once in grades nine through twelve. They are also required to administer science assessments to all students at least once in grades three through five, grades six through nine, and grades ten through twelve. This act further specifies that students with disabilities must be included in such assessments in a way that accurately measures their achievement within the designated academic areas. If needed, students with disabilities must be provided with reasonable adaptations and accommodations, in accordance with the Individuals with Disabilities Education Improvement Act (IDEIA) of 2004. Accommodations are provided to students to limit the impact of characteristics associated with their disability that will negatively affect test performance but are irrelevant to the construct being measured (Lewandowki, 2007).

Characteristics that may negatively affect scores unrelated to the construct being measured could include poor reading fluency during a mathematics assessment, orthopedic impairment during a writing assessment, blindness during a reading assessment, and slow processing speed during a comprehension assessment. The most frequently allowed accommodations in state policies include: individual administration; dictating responses to proctor or scribe; small group administration; large print; braille; extended time; interpreter for instructions; read, reread, simplify, and/or clarify directions; computer or machine response; read aloud; mark answers in test booklet; and testing with breaks (Thurlow & Bolt, 2001).

Research indicates that extended time is one of the most commonly used test accommodations across all grade levels. (Elliott & Marquart, 2004; Lewandowski et al., 2007; Tindal & Ketterlin-Geller 2004). According to Thurlow & Bolt (2001), 32 out of the 48 states with statewide assessment programs have extended time as an accommodation in their state policies Out of the 16 remaining states, two states prohibit the use of extended time and five states allow extended time under certain circumstances.

Educational Disabilities

IDEIA (2004) identified ten disability categories which may qualify school age children for special education and related services. The disability categories include: mental retardation, hearing impairments (including deafness), speech or language impairments, visual impairments (including blindness), emotional disturbance, orthopedic impairments, autism, traumatic brain injury, other health impairments, and specific learning disabilities. An additional disability category exists for children ages 3 through 9, or any subset of this age group, presenting with a developmental delay in one or more of the following areas: physical development, cognitive development, communication impairment, social or emotional development, or adaptive development with mental retardation. Specific learning disabilities (SLDs), speech or language impairments (SLIs), and other health impairments (OHIs) are the most frequently identified educational disabilities for students. According to the U.S. Department of Education (2017), 68% of students receiving Special Education and Related Services in the Fall of 2015 were eligible due to SLDs, SLIs, or OHIs.

Specific Learning Disability. SLD refers to a disorder in one or more psychological processes that adversely affects the ability to listen, think, speak, read, write, spell, or perform mathematical computations (IDEIA, 2004). SLD is the most frequently identified disability category for students (U.S. Department of Education, 2017). Students SLDs accounted for 34% of students eligible for special education and related services during the 2015-2016 school year (National Center on Education Statistics, 2018). Reading disorders are the most common SLDs and many children diagnosed with reading disorders continue to struggle with reading through adulthood (Ready, Chaudry, Schatz, & Strazzullo, 2013).

Shanahan et al. (2006) conducted a study to investigate whether processing speed is a shared risk factor for reading disability (RD) and attention-deficit/hyperactivity disorder (ADHD) and whether processing speed deficits are similar among these disorders. Participants in this study were 395 children aged 8 to 18 divided into four groups: RD, ADHD, comorbid, and control. Processing speed was measured using a battery of linguistic and non-linguistic measures. There was a significant difference between children with and without RD (d = .75) and children with and without ADHD (d = 1.37) on processing speed tasks with verbal output. Additionally, there was a significant difference between children with and without RD (d = .94) and children with and without ADHD (d = 1.55) on processing speed tasks with motor output. The relationship between RD and performance on processing speed tasks with verbal output (r = .54) was stronger than the relationship between ADHD and performance on processing speed tasks with verbal output (r = .26). Similarly, the relationship between RD and performance on processing speed tasks with motor output (r = .53) was stronger than the relationship between ADHD and performance on processing speed tasks with verbal output (r = .32).

Speech or Language Impairments. SLI refers to a communication disorder that adversely affects educational performance (IDEIA, 2004). SLI is the second most identified disability category for students (U.S. Department of Education, 2017). Students with an SLI accounted for 20% of students eligible for special education and related services during the

2015-2016 school year (National Center on Education Statistic, 2018). Students with language impairments present with more reading difficulties and reading disorders than students without language impairments (Tomblin, Zhang, Buckwalter, & Catts, 2000).

Other Health Impairment. OHI refers to a chronic or acute health problem that limits alertness within the educational environment and adversely affects educational performance (IDEIA, 2004). OHI is the third most identified disability category for students (U.S. Department of Education, 2017). Students with OHI accounted for 14% of students eligible for special education and related services during the 2015-2016 school year (National Center on Education Statistics, 2018).

ADHD is a frequently identified OHI for students. Students with ADHD present with more reading difficulties and reading disorders than students without ADHD (Tomblin et al., 2000). Additionally, ADHD is associated with executive functioning deficits. Research has demonstrated that working memory and processing speed scores for participants with ADHD are significantly lower than their verbal comprehension scores on cognitive assessments (Brown et al., 2011; Mayes, Calhoun, Chase, Mink, & Stagg, 2009). Individuals with ADHD may present with weaker reading skills than neurotypical individuals in the absence of comorbid reading or language disabilities because of their impaired executive functioning, particularly in the areas of working memory and processing speed (Brown et al., 2011; Jacobsen et al, 2011; Runyon, 1991).

Jacobson et al. (2011) conducted a study to investigate whether children with ADHD without comorbid reading disorders would show deficits in processing speed and whether a decrease in executive control would be associated with a reduction in reading fluency. Supplemental analyses were conducted to investigate additional executive control aspects that may be related to reading fluency. Participants included 41 children with ADHD and 21 students without ADHD aged 9 to 14 that obtained scores of 80 or higher on the General Ability Index of the Wechsler Intelligence Scale for Children, 4th Edition, Integrated (WISC-IV-I) (Wechsler, Kaplan, Fein, Kramer, Morris, & Delis, 2004).

The Processing Speed Index of the WISC-IV-I is comprised of the Coding and Symbol Search subtests. Jacobson et al. (2001) used the Symbol Search subtest to measure graphomotor speed. For this subtest, participants were given two minutes to visually scan arrays of symbols and mark yes or no to indicate whether the target symbols were in the arrays. The Coding subtest was used to measure graphomotor speed and response selection. For this subtest, participants were given two minutes to correctly select and copy symbols that were paired with specific numbers. Participants without ADHD performed better than the students with ADHD on the Processing Speed Index ($\eta^2 = .188$) and the Coding subtest ($\eta^2 = .217$); however, both groups performed similarly on the Symbol Search subtest. These results indicate the difference in processing speed between the two groups may be due to differences in the executive functions that are required for response selection, as opposed to differences in graphomotor speed.

Jacobson et al. (2011) examined reading fluency with three measures: Gary Oral Reading Test, 4th Edition (GORT-IV; Weiderholt & Bryant, 2000) reading fluency; Woodcock Johnson Tests of Achievement, 3rd Edition (WJ-III ACH; Woodcock, McGrew, & Mather, 2001) reading fluency subtest; and Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, and Rashotte, 1999) phonetic decoding efficiency. The GORT-IV was used to measure contextual oral reading fluency. For this task, the participants read increasingly difficult text passages aloud and were instructed to read for comprehension. The TOWRE was used to measure non-contextual oral reading fluency. For this task, the participants were given 45 seconds to read sight and nonsense words that increased in complexity. Participants without ADHD performed better than participants with ADHD on the GORT-IV ($\eta^2 = .171$) and TOWRE ($\eta^2 = .129$). Performance on the Coding subtest accounted for a significant proportion of the variance predicting scores on the GORT-IV ($R^2 = .092$) and TOWRE ($R^2 = .121$).

Verbal working memory was measured by the Letter-Number Sequencing and Digit Span Backward subtests on the WISC-IV-I. The Letter-Number Sequencing subtest required participants to read sequences of numbers and letters and then orally present the numbers in ascending order and the letters in alphabetical order. The Digit Span Backward subtest required participants to listen to orally presented strings of numbers and then orally present the numbers in backward order. Verbal working memory predicted a significant proportion of variance in performance on the GORT-IV ($R^2 = .137$) and TOWRE ($R^2 = .221$). These results provide further evidence that aspects of executive control are related to reading fluency.

What are Test Accommodations?

There is not one standard definition for test accommodations and some researchers have defined them more stringently than others. In an article that reviewed 59 studies focusing on the effects of test accommodations, the term accommodation was used "to signify any change in the content or administration of a standardized test" (Sireci, Scarpati, & Li, 2005, p. 460). Another article that examined the use of accommodations in large-scale mathematics assessment programs defined accommodations as "changes that are allowable by state policies and which do not change the construct being measured" (Tindal & Ketterlin-Geller, 2004, p. 1). Others have provided more robust definitions by discussing the need for test alterations in relation to disabilities or functional impairments, while maintaining that the construct must remain unaltered (American Educational Research Association et al., 2014; Kettler, 2012; Weston, 2002). Additional research has further elaborated that test accommodations should meet the following criteria: (a) unchanged constructs; (b) based upon individual need; (c) generate similar inferences between accommodated and standard scores; and (d) differential effects (Hollenbeck, 2002).

Across literature on the topic of test accommodations, one recurring requirement is the need for the construct being measured to remain unchanged. Accommodations are meant to provide students with disabilities the opportunity to demonstrate their knowledge about designated constructs while allowing valid conclusions to be drawn from the obtained test scores (Hollenbeck, 2002; Kettler, 2012). Once a construct is changed, a test no longer measures the construct that was intended. This interferes with any conclusions that can be drawn from the obtained test scores. Alterations to a test that also change the construct being measured are considered modifications (Tindal & Ketterlin-Gellar, 2004). For example, if a test was designed to assess automaticity of basic mathematics facts and a calculator is provided as modification, then the test is measuring students' proficiency with using a calculator.

Test accommodations should be based on the individual needs of students, as opposed to disability status or simply improved test scores. It is crucial to recognize the needs of a student to access the test in the selection of appropriate test accommodations. This can be done by identifying the functional impairments that are related to the student's disability. A functional impairment is an access skill deficit that impacts a student's ability to demonstrate knowledge about the construct being measured. For example, attention, working memory, and reading fluency are access skills needed to demonstrate reading comprehension, whereas reading comprehension, number recognition, and calculation are access skills needed to demonstrate algebraic knowledge (Kettler, 2012). Therefore, extended time may be an appropriate accommodation on a reading comprehension test for students that lack reading fluency, whereas frequent redirection during a reading comprehension test may be an appropriate accommodation for inattentive students or those with difficulties sustaining attention. Similarly, a human reader may be an appropriate accommodation on an algebra test for students that are not fluent readers and a calculator may be an appropriate accommodation during an algebra test for students that are not fluent with their basic math facts.

The purpose of test accommodations is to reduce measurement error by removing construct-irrelevant variables that impact performance (Hollenbeck 2002; Sireci et al., 2005; Weston, 2002). Through providing appropriate accommodations to students based upon individual need, the measurement of the construct being assessed is improved. The goal of providing appropriate accommodations to students with disabilities is to ensure the assessment measures the same construct for them as the construct being measured by the unaccommodated assessment administered to students without disabilities (Thompson, Blount, & Thurlow, 2002). This ensures scores obtained by students with disabilities are comparable to the scores of students without disabilities so similar inferences can be drawn regarding their performance. The ability to draw similar inferences from the results for students with and without disabilities is particularly important for high-stakes tests that are used for considering student promotion/graduation, college acceptance, teacher effectiveness/raises, and school funding/sanctions (Bolt, Krentz, & Thurlow, 2002).

Differential effects for students with and without disabilities provide evidence for the use of accommodations. In other words, accommodations should improve the performance of students with disabilities more than the performance of students without disabilities. The scores of students provided with test alterations based upon their functional impairments should be differentially boosted compared to the scores of students without functional impairments

(Hollenbeck, 2002). The presence of a differential boost in the scores of students with disabilities, compared to the scores of students without disabilities, provides evidence that the accommodation addressed an aspect of the students' functional impairment (Lindstrom, 2010). If there is not a differential boost in the scores of students with disabilities, a test alteration should not be considered an accommodation. A test alteration that results in a similar boost in scores for students with and without disabilities is considered a modification.

Reading Comprehension

Successful reading is a complex cognitive task that requires phonemic awareness, oral reading fluency, vocabulary knowledge, and comprehension (National Institute of Child Health and Human Development, 2000). Ehri and McCormack (1998) posited that reading at the individual word level requires progression through five phases: pre-alphabetic, partial-alphabetic, full-alphabetic, consolidated alphabetic, and automatic alphabetic. The final phase, automatic alphabetic, is the fluent reading of words. The ability to read fluently reduces cognitive load and allows the reader to focus on the meaning of the text, as opposed to the process of reading (Rabinski, Padak, McKeon, Wilfong, Friedauer, & Heim, 2005). As such, reading fluency and reading comprehension are closely related. Further, fluent reading may serve as pre-requisite skill for reading comprehension (Pikulski & Chard, 2005).

Fischco (2019) released an updated version of the Nelson-Denny Reading Test (NDRT). Reading comprehension tests, such as the NDRT, require individuals to read passages and then answer multiple choice questions (Brown, Bennett, & Hanna, 1981; Fishco, 2019). The NDRT examines two types of reading comprehension: literal and interpretive. Literal comprehension refers to an individual's understanding of explicitly stated information within the passage. Interpretive comprehension refers to an individual's ability to reason with the information presented in the passage. The NDRT provides norms for standard time and extended time conditions. This is beneficial because it permits comparisons between the two conditions and allows conclusions to be made for determining whether there is a differential boost from extended time.

Extended Time as a Testing Accommodation

Students with ADHD and learning disabilities report difficulty with completing tests and assignments within allotted time frames because they must reread the information several times before they are able to successfully comprehend and encode the information (Brown, Reichal, & Quinlin, 2011; Runyon, 1991). One possible explanation is ADHD and learning disabilities, specifically RDs, are correlated with processing speed deficits (Shanahan et al., 2006; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2010). For this reason, extended time may serve as an appropriate testing accommodation for such students by reducing the influence of processing speed for tests that are not measuring this construct (Huesman & Frisbie, 2000); however, research has yielded mixed results.

Meta-Analyses. Thompson et al. (2002) conducted a meta-analysis to examine testing accommodations to determine whether they gave the scores of students with disabilities a differential boost. Seven of the studies that were examined used extended time as a test accommodation. Four out of the seven studies determined there was a differential boost in favor of students with disabilities; three out of the seven studies did not find differential effects between students with and without disabilities.

Sireci et al. (2005) conducted a meta-analysis in search of evidence for differential effects using the interaction hypothesis. According to the interaction hypothesis, students with functional impairments will perform better under test conditions with appropriate accommodations than under test conditions without appropriate accommodations. The interaction hypothesis also asserts that students without functional impairments will perform the same under test conditions with accommodations and without appropriate accommodations. The meta-analysis examined eight studies that used extended time as a test accommodation. Five out of the eight studies either supported or partially supported the interaction hypothesis.

Fuchs, Fuchs, & Capizzi (2005) conducted a literature review on appropriate test accommodations for students with learning disabilities. In the review, they compared students with learning disabilities primarily in the area of reading that did not have mathematics goals in their Individualized Education Programs (IEPs) and students with documented difficulties in the area of mathematics. The former group of students demonstrated larger boosts in performance on mathematics tests with extended time than the latter group. Overall, extended time resulted in higher test scores for students with and without disabilities; however, extended time did not provide a differential boost for students with disabilities. Furthermore, typically achieving students benefitted more from extended time than students with learning disabilities.

Every two years, the National Center on Education Outcome (NCEO) releases a summary of research published on the effects of test accommodations. There were twenty-four studies that investigated the effects of extended time as a testing accommodation between 2005 and 2014. Overall, the results were mixed. The studies discussed in the 2005-2006, 2007-2008, and 2009-2010 reports did not take into consideration the students' specific disabilities. One study discussed in the 2010- 2011 report indicated extended time improved reading comprehension scores for students with ADHD. All four studies discussed in the 2013-2014 report concluded extended time did not produce differential effects for students with either ADHD or Learning Disabilities and students without disabilities. The participants in the four studies included in the 2013-2014 were post-secondary students, which limits the generalizability of their results.

Table 1

Effects of Extended Time as a Testing Accommodation

Research Years	# of studies	Results
2005-2006 (Zenisky & Sireci, 2007)	6	Three reported a positive effect on scores for students with disabilities. One reported a positive effect on scores for students with and without disabilities. One reported it did not explain differential item functioning. One reported differential item functioning for read aloud and extended time was consistent with differential item functioning for read-aloud only.
2007-2008 (Cormier et al., 2010)	6	Two reported there was not a differential boost for students with disabilities. One reported item completion takes more time for students that use magnification tools. One reported students with disabilities require more time to write expository essays. One reported students with disabilities performed similarly on extended and standard time tests. One reported test anxiety negatively affected scores on timed tests.

Table 1 - Continued

Research Years	# of studies	Results
2009-2010 (Rogers et al., 2012)	5	Three reported students with disabilities did not score differently with extended time. Two reported a differential boost for students with disabilities.
2011-2012 (Rogers et al., 2014)	3	One reported improved reading comprehension scores for students with ADHD. One reported there was not a differential effect for students with and without disabilities. A meta-analysis supported the differential boost hypothesis.
2013-2014 (Rogers et al., 2016)	4	All reported extended time did not produce differential effects for students with either ADHD or Learning Disabilities and students without disabilities.

Extended Time and ADHD. Brown et al. (2011) conducted a study to determine whether students with ADHD have significantly weaker scores on the Working Memory Index (WMI) and Processing Speed Index (PSI) than on the Verbal Comprehension Index (VCI) of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003) or Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997). Additionally, the study examined whether students with ADHD, without specific learning disabilities in reading, have reading comprehension scores on the NDRT Forms G and H (Brown, Fishco, & Hanna, 1993) closer to their VCI scores if given extended time. Extended time was provided to participants that were not able to complete the NDRT under the standard time condition. The scores obtained from the standard and extended time conditions were calculated using the NDRT norms in the standard time condition.

Participants included 145 children aged 13 to 18 with average basic reading skills and were diagnosed with ADHD. Average basic reading skills were defined as scores of 80 or higher on the word attack and word reading subtests of the WJ-III ACH (Woodcock, McGrew, & Mather, 2001) or the Wechsler Individual Achievement Test, 2nd Edition (WIAT-II; Wechsler, 2002). The mean word attack (106.8) and word recognition (106.5) scores on the WJ-III or WIAT-II were in the average range. Brown et al. (2011) concluded the participants' reading comprehension was not impacted by impairments in phonics, decoding, word recognition, or word pronunciation.

The mean VCI (118.6) score on the WISC-IV or WAIS-III was in the high average range and the mean WMI (102.8) and PSI (99.9) scores were in the average range. The mean VCI score was significantly higher (p = < .0001) than the mean WMI and PSI scores. The mean Perceptual Organization Index (POI) (112.6) score was also in the high average range (Brown et al., 2011).

The mean reading comprehension score on the NDRT Forms G and H was significantly higher (p = < .0001) in the extended time (112.6) condition than the standard time condition (100.95). On the reading comprehension section, 42.8% of participants obtained a score within one standard deviation of their VCI score in the standard time condition, compared to 77.9% of participants in the extended time condition. The mean vocabulary score on the NDRT was significantly higher (p = < .0001) in the extended time (111.5) condition than the standard time condition (107.6). On the vocabulary section, 63.4% of participants obtained a score within one standard deviation of their VCI score in the standard time condition, compared to 72.9% of participants in the extended time condition. According to normative data provided by the WIAT-III, 88% to 89% of individuals score within one standard deviation of their VCI score on a standardized measure of reading comprehension. Therefore, the participants' scores on the

NDRT in the extended time condition were closer to that which would be expected based upon the normative data provided by the WIAT-III (Brown et al., 2011).

The results of this study indicated participants' relative weaknesses in working memory and processing speed impacted their performance on the NDRT Forms G and H in the standard time condition. These findings provide evidence for the use of extended time as a test accommodation for some students with ADHD, due to the executive functioning impairments associated with this disorder. The generalizability of these results may be limited due to the participants' high average VCI scores and average basic reading skills. Additionally, the generalizability of these results may be limited due to the way reading comprehension and vocabulary were measured. Brown et al. (2011) noted, "The Nelson-Denny Reading Test has been criticized for having a low ceiling" (p. 85-86). Therefore, the NDRT may not provide a suitable challenge for students with higher ability or for those required to read and comprehend more complex text for tests.

Miller, Lawrence, Lewandowski, & Antshe (2015) conducted a study using a modified version of the NDRT. Specifically, only reading comprehension was administered, Forms G and H were combined, and administration time was reduced from twenty minutes to fifteen minutes. The purposes of this study were to determine whether students with ADHD perform more poorly on reading comprehension items correct in standard time condition than typical peers, to determine whether there was an interaction between the ADHD versus typical groups and standard time versus time and a half, and to determine whether there was an interaction between the ADHD versus typical groups and standard versus double time. Participants included 38 college students with ADHD and 38 college students that did not indicate a history of learning or psychiatric disorders, did not report use of medication, did not receive any test accommodations, and did not meet criteria ADHD. The modified version of the NDRT was administered to the students in the standard time, time and a half, and double time conditions.

There was no interaction between group and time condition for items answered correctly, number of items attempted, or percent of items correct. That is, the performance of students with ADHD and typical students improved equally during the extended time condition. Large effect sizes were reported for number of items the ADHD group answered correctly in the time and a half (g = 1.44) and double time (g = 2.49) conditions compared to the number of items the typical group answered correctly in the standard time condition. Further, large effect sizes were reported for the number of items the ADHD group attempted in the time and a half (g = 1.58) and double time (g = 2.79) conditions compared to the number of items the typical group attempted in the standard time condition. Miller et al. (2015) noted, “In this study, extended time did not level the playing field, but rather reversed the playing field, conferring an advantage to the ADHD group” (p. 6). Extended time provided two advantages for the ADHD group. Firstly, the ADHD group was able to access 63% more of the test in the time and a half and 103% more of the test in the double time conditions than typical students in the standard time condition. Secondly, the ADHD group increased the number of items answered correctly by 108% in the double time condition.

Extended Time and Learning Disabilities. Runyan (1991) conducted a study to evaluate the effects of extended time for individuals with and without learning disabilities on a test of reading comprehension. The NDRT Forms G and H was administered to 16 college students with learning disabilities and 15 typically achieving college students in the standard and extended time conditions. All students with learning disabilities reported a significant history of reading difficulties and had achievement scores at least 1.5 standard deviations below their intelligence. Reading rate and reading comprehension were significantly higher for typically achieving students than students with ADHD in the standard time condition. Students with learning disabilities achieved a significantly higher mean percentile rank comprehension score during the extended time condition, whereas there was not a significant effect for typically achieving students. There was not a significant difference between reading comprehension scores for both groups in the extended time condition. Additionally, there was not a significant difference between reading comprehension scores for students with ADHD in the extended time condition and typically achieving students in the standard time condition.

The results from this study indicate typically achieving students are able to perform at their ability level under standard time conditions and students with learning disabilities typically do not perform at their ability level unless they are provided with extended time. Runyan (1991) proposed two explanations for these findings. The first explanation was the students with ADHD required extended time due to difficulties with maintaining attention and concentration. The second explanation was students with ADHD lack automaticity with processing visual and phonological information, thus their attention is diverted to decoding and processing words instead of focusing on the text’s content.

Lewandowski, Lovett, and Rogers (2008) conducted a study to examine the effect of extended time on reading comprehension. Participants included 32 students with learning disabilities in reading and 32 students without learning disabilities aged 15 to 18. Reading comprehension was examined using the NDRT Forms G and H, which was administered to participants in modified-standard and extended time conditions. The standard time condition was decreased from twenty minutes to thirteen minutes and the extended time condition was decreased from thirty minutes to nineteen and a half minutes. Additionally, general cognitive ability was measured using the Raven Standard Progressive Matrices test (RSPM, Court & Raven, 1995). Reading fluency was measured using the Reading Fluency subtest of the WJ-III. There was not a significant difference in RSPM scores between the two groups (d = .09). Students without learning disabilities performed significantly better on the Reading Fluency subtest than students with learning disabilities (d = 1.82).

A significant interaction between group and time was found for the number of items answered correctly on the NDRT (η^2 = .024). Students without disabilities performed significantly better than students with learning disabilities in the standard time (*d* = 2.68) and extended time (*d* = 3.39) conditions. Students without learning disabilities also performed significantly better in the standard time condition than students with learning disabilities in the extended time condition (*d* = 1.17). Extended time resulted in a differential boost in favor of students without learning disabilities. Lewandowski et al. (2008) noted students with learning disabilities answered more reading comprehension questions correctly in the extended time condition than in the standard time condition.

Similarly, a significant interaction between group and time was found for the number of items attempted on the NDRT (η^2 = .135), yet students without disabilities attempted significantly more items than students with learning disabilities in the standard time (*d* = 2.39) and extended time (*d* = 3.13) conditions. No difference in the number of items attempted was found between students without learning disabilities in the standard time condition and students with learning disabilities in the extended time condition (*d* = .06). Even though there was not a differential boost in favor of students without learning disabilities, Lewandowski et al. (2008) argued extended time allowed students with disabilities to access the same number of reading comprehension questions as students without learning disabilities during the standard time condition.

Lewandowski et al. (2008) calculated the percent of items answered correctly by dividing the number of items answered correctly by the number of items attempted. No significant interaction between group and time was found for the percent of items answered correctly ($\eta^2 = .00$). Additionally, there was no main effect of time. Students without learning disabilities demonstrated significantly higher percentages of items answered correctly, collapsed over time, than students with learning disabilities ($\eta^2 = .32$). The percent of items answered correctly by students with learning disabilities was not increased during the extended time condition.

Access Skills Addressed by Extended Time Accommodations

In the aforementioned studies, determinations regarding the appropriateness of extended time as a testing accommodation were made by comparing the scores of students with and without disabilities. One flaw in this approach is that it does not take into consideration whether the students with disabilities lacked access skills that would require extended time. Another approach to identifying the need for testing accommodations is to directly measure access skills and then select appropriate accommodations based upon functional impairment. Accommodations selected to address functional impairments should be correlated with a differential boost in scores for such individuals. Best practices indicate extended time is an appropriate accommodation to address functional impairments in the areas of reading fluency and processing speed (Kettler, 2012).

Reading Fluency

The Woodcock-Johnson Psycho-Educational Battery (WJPEB) was designed as a wide range measure of cognitive abilities, scholastic aptitudes, achievement, and interest (Woodcock, 1978, p. 1). The Achievement Battery included a series of subtests that measured achievement across five clusters: math, reading, written language, skill, and knowledge (Ysseldyke & Algozzine, 1980). A later revision, the WJ-III ACH, added two reading clusters: Basic Reading Skills and Reading Comprehension. The Basic Reading Skills cluster is a measure of sight vocabulary, phonics, and structural analysis skills and the Reading Comprehension cluster is a measure of comprehension, reasoning, and vocabulary (Villareal, 2014).

The most recent edition, the Woodcock-Johnson Tests of Achievement – Fourth Edition (WJ-IV ACH; Shrank, Mather, & McGrew, 2014), introduced the Reading Fluency cluster, a measure of prosody, automaticity, and accuracy (Villareal, 2014). According to the National Reading Panel (NRP) (2000), reading fluency, or the ability to quickly and accurately read text with proper expression, is a critical component of skilled reading. The NRP (2000) further asserted that reading fluency is dependent upon basic reading skills and may facilitate reading comprehension. Research also indicates the relationship between decoding skills and reading comprehension is mediated by reading fluency for students in grades two through five (Decker, Strait, Roberts, & Wright, 2018).

The WJ-IV Technical Manual (2014) reported large correlations between the Reading Fluency and Basic Reading Skills (r = .69-.76) clusters of the WJ-IV for children aged 6 to 19. Benson (2008) examined the effects of the Basic Reading Skills cluster on the Reading Fluency cluster of the WJ-III ACH. Basic reading skills had a large to very large direct effect on reading fluency for the validation sample ranging across grades kindergarten to twelve (r = .59 to .84). This study provides support for the NRP's (2000) assertion that well-developed word recognition skills are an essential component of reading fluency.

Reading fluency may serve as pre-requisite skill for reading comprehension by reducing cognitive load and allowing the reader to focus on the meaning of the text, as opposed to the process of reading (Jacobson et al., 2011; National Reading Panel, 2017; Pikulski & Chard, 2005; Rabinski, et al., 2005). Large to very large correlations between the Reading Fluency and Reading Comprehension (*r* =.68-.74) clusters of the WJ-IV ACH for children aged 6 to19 were reported in the WJ-IV Technical Manual (2014). Benson (2008) examined the effects of the Reading Fluency cluster on the Reading Comprehension cluster of the WJ-III ACH. Reading fluency had a very large direct effect on reading comprehension for the validation sample in grades kindergarten to three (*r* =.75), medium direct effect for the validation sample in grades four to six (*r* =.38), and small direct effect for the validation sample in grades seven to twelve (*r* =.17). Jenkins, Fuchs, Van den Broek, Espin, & Deno (2003) found a large correlation (*r* =.83) between reading speed and reading comprehension on the Iowa Test of Best Skills (ITBS; Hieronymus, Hoover, Oberley, Cantor, Frisbie, Dunbar, Lewis, & Lindquist. 1990) for fourth grade students. Per Jenkins et al. (2003), this result supports findings from previous studies indicating contextual reading fluency and inefficient decoding interfere with reading comprehension.

Additionally, research indicates there is a relationship between reading comprehension and basic reading skills. The WJ-IV Technical Manual (2014) also reported very large correlations between the Reading Comprehension and Basic Reading Skills (*r* =.72-.80) clusters of the WJ-IV for children aged 6 to 19. Reading decoding skills demonstrated a very large direct effect on reading comprehension for children aged 5 to 6 (R^2 = .75), a nearly perfect direct effect for children aged 7 to 8 (R^2 = .90), a large direct effect for children aged 9 to 13 (R^2 = .62), and a medium direct effect for children aged 14 to 19 (R^2 = .43) on the WJ-III ACH (Floyd, Meisinger, Gregg, & Keith, 2012). Shankweiler (1999) found very large correlations between word reading and passage comprehension ($r = .89$, $p < .0001$) and non-word reading and passage comprehension ($r = .79$, $p < .0001$) on various measures for children aged 7.5 to 9.5 years. Basic reading skills may facilitate reading comprehension; however, reading comprehension also requires adequate executive functioning, including processing speed (Brown et al., 2011).

Table 2

Correlations with Reading Fluency

Constructs	Study	Sample	Magnitude of Correlation
Reading Fluency & Basic Reading Skills	WJ-IV Technical Manual (2014)	Ages 6-19	Large (*r* = .69-.76)
	Benson (2008)	Grades k-12	Large to Very Large (*r* = .59 to .84)
Reading Fluency & Reading Comprehension	WJ-IV Technical Manual (2014)	Ages 6-19	Large to Very Large (*r* =.68-.74)
	Benson (2008)	Grades k-3 Grades 4-6 Grades 7-12	Very Large (*r* =.75) Medium (*r* =.38) Small (*r* =.17)
Reading Comprehension & Reading Speed	Hieronymus et al. (1990)	Grade 4	Very Large (*r* = .83)
Reading Comprehension & Basic Reading Skills	WJ-IV Technical Manual (2014)	Ages 6-19	Very Large (*r* = .72-.80)

Table 2 - Continued

Constructs	Study	Sample	Magnitude of Correlation
Reading Comprehension & Reading Decoding Skills	Floyd et al. (2012)	Ages 5-6	Very Large (R^2 = .75)
		Ages 7-8	Nearly Perfect (R^2 = .90)
		Ages 9-13	Large (R^2 = .62)
		Ages 14-19	Medium (R^2 = .43)
Passage Comprehension & Word Reading	Shankweiler (1999)	Ages 7.5-9.5	Very Large (r = .89)
Passage Comprehension & Non-Word Reading	Shankweiler (1999)	Ages 7.5-9.5	Very Large (r = .79)

Processing Speed

The Cognitive Battery of the WJPEB included a series of subtests that measured four cognitive processes: verbal ability, reasoning, perceptual speed, and memory (Ysseldyke & Algozzine, 1980). In 1989 the WJPEB was replaced by the Woodcock-Johnson Psycho-Educational Battery – Revised (WJ-R; Woodcock & Johnson, 1989). The WJ-R was designed to measure seven of the broad cognitive abilities described by Horn's Gf-Gc theory of intelligence: comprehension-knowledge, long-term retrieval, visual processing, auditory processing, fluid reasoning, processing speed, and short-term memory (Shrank, 2005). The Cattell-Horn-Carroll (CHC) Model of Intelligence built upon the Gf-Gc theory of intelligence and provided the framework for the Woodcock-Johnson Test of Cognitive Abilities, 3rd Edition (WJ-III COG) and WJ-IV COG.

The CHC Model of Intelligence identified eight broad areas of intelligence. G*s*, or cognitive processing speed, is defined as the "ability to perform simple, repetitive tasks quickly and fluently" (Schneider & McGrew, 2012, p. 119). G*s*-P, or perceptual speed is a core component of G*s* and is defined by four narrow sub abilities: (a) P*pr,* or pattern recognition, is the ability to quickly recognize simple visual patterns; (b) P*s*, or scanning, is the ability to scan, compare, and locate visual stimuli; (c) P*m*, or memory, is the ability to perform visual perceptual speed tasks that place significant demands on immediate working memory; and (d) P*c*, or complex processing, is the ability to perform visual pattern recognition tasks that impose additional cognitive demands, such as spatial visualization, estimating and interpolating, and heightened memory span loads (WJ-IV Technical Manual, 2014). G*s* and G*s*-P are related to reading because the quick and accurate identification of letters, syllables, orthographic patterns, and words allows cognitive resources to be allocated to more complex tasks, such as reading comprehension (Floyd, Keith, Taub, & McGrew, 2007; Konold et al., 2003).

McGrew & Wendling (2010) conducted a meta-analysis of nineteen studies completed between 1988 and 2009 which used various measures of cognitive ability and achievement. To facilitate the interpretation of their findings, results were classified based on the percent of studies that found significance. Significant results in ≥80% of studies were classified as high, significant results in 50% - 79% were classified as medium, and significant results in 30 – 49% of studies were considered low.

The study concluded G*s* was consistently significant (medium) in the prediction of basic reading skills for children aged 6 to 13. Additionally, the influence of G*s*-P on basic reading skills was consistently significant for children aged 6 to 8 and 14 to 19 (low) and children aged 9 to 13 (medium). McGrew & Wendling (2010) noted, "The importance of G*s*-P is not surprising given the confirmed relationship between perceptual speed, speed of processing, and the need for automaticity in integrating phonological and orthographic codes in word reading" (p. 661-662).

Research indicates there is a relationship between *Gs* and basic reading skills. The WJ-IV Technical Manual (2014) reported a medium size correlation between G*s* and the Basic Reading Skills (*r* =.32-.38) clusters for children aged 6 to 19. G*s* also demonstrated a small effect on the Basic Reading Skills cluster (*r* =.17) of the WJ-IV for students aged 9 to 13 (Woods, 2017). Floyd (2007) examined the effects of CHC abilities on reading decoding skills, as measured by the Letter-Word Identification and Word Attack tests of the WJ-III. G*s* had a medium direct effect for ages 5 and 6 (*r* =.38) and a small direct effect for ages 7 and 8 (*r* =.20) on reading decoding skills using the two-stratum model of CHC abilities. G*s* had a medium direct effect on reading decoding skills for ages 5 and 6 (*r* =.46) and ages 7 and 8 (*r* =.32) using the three-stratum model of CHC abilities.

Urso (2008) conducted a study that examined relationships among the G*s* cluster and related tests, Visual Matching, Decision Speed, Rapid Picture Naming, Pair Cancellation, and Cross-Out with reading achievement on the WJ-III. There was a medium correlation between G*s* and the Basic Reading Skills cluster (*r* = .40) and a large correlation between G*s* and the Letter-Word Identification test (*r* = .51). Medium correlations were also reported for the Basic Reading Skills cluster and Visual Matching (*r* = .46), Pair Cancellation (*r* = .49), Rapid Picture Naming (*r* = .34) and Cross-Out (*r* = .40) tests. From 11% to 24% of the variance in performance on the Visual Matching, Rapid Picture Naming, Pair Cancellation, and Cross-Out tests could be predicted by performance on the Basic Reading Skill Cluster. Additionally, medium correlations were reported for the Letter-Word Identification test and Visual Matching (*r* = .550) and Pair Cancellation (*r* = 520) tests.

The magnitude of the relationship between G*s* and reading fluency varies across studies, samples, and age levels. The WJ-IV Technical Manual (2014) reported large correlations between G*s* and the Reading Fluency (*r* =.52-.56) cluster for children aged 6 to 19. Urso (2008) reported a medium correlation between the G*s* cluster and the reading fluency test (r = .377, p < .05, two-tailed) on the WJ-III. Similarly, Benson (2008) examined the effect of G*s* on the Reading Fluency cluster of the WJ-III. There was a large direct effect for the validation sample in grades four to six (*r* =.59) and a very large direct effect for the validation sample in grades seven to twelve (*r* =.89). Even though the association between G*s* and reading fluency is strong (Cormier, McGrew, Bulut, & Funamoto, 2017), Benson (2008) found a small direct effect of G*s* on reading fluency for the validation sample in grades kindergarten to three (*r* =.22).

G*s* and G*s*-P are directly related to reading comprehension, in addition to being related to it through basic reading skills and reading fluency. The WJ-IV Technical Manual (2014) reported a medium correlation between G*s* and the Reading Comprehension (*r* =.32-.37) cluster for children aged 6 to 19. G*s* demonstrated a small effect on the Reading Comprehension cluster (*r* =.12, p < .05) of the WJ-IV for students aged 9 to 13 (Woods, 2017). Additionally, performance on the Reading Fluency cluster could be predicted by performance on the Letter-Pattern Matching (AUC = .925) and Pair Cancellation (AUC = .906) tests on the WJ-IV for children aged 2 to 18 (Norfolk, 2017). A small relationship between G*s* and the Passage Comprehension test (*r* =.21) on the WJ-R was found for students in grades five and six (Vanderwood, McGrew, Flanagan, and Keith, 2002). Further, the relationship between G*s*-P and reading comprehension was consistently significant for children aged 6 to 13 (medium) and for children aged 14 to 19 (low) across various measures of cognitive functioning and achievement (McGrew & Wendling, 2010).

Research Questions and Predictions

This study answered three primary research questions:

1. Is there a relationship between reading rate on the NDRT Forms I and J and boost from extended time?
2. Is there a relationship between processing speed and boost from extended time?
3. Is there a relationship between reading rate on the NDRT Forms I and J and processing speed?

It was predicted that reading rate on the NDRT would be correlated with a boost in scores from extended time. Specifically, students with a slower reading rate would have a larger increase in comprehension scores during the extended time condition than students with a typical reading rate. Similarly, it was predicted that processing speed would be correlated with a boost in scores from extended time. That is, students with a slower processing speed would have a larger increase in comprehension scores during the extended time condition than students with an average processing speed. Finally, it was predicted that reading rate on the NDRT would be correlated with processing speed. Students with a slower reading rate on the NDRT were expected to have a slower processing speed whereas students with a faster reading rate on the NDRT were expected to have a faster processing speed.

Chapter II

Method

Participants

Students enrolled in North Arlington High School in North Arlington, NJ were the participants in this study. North Arlington High School is part of a public-school district and serves general education and special education students from ninth through twelfth grade. The school offers a variety of program options for students, including general education, general education with a teacher's aide, in-class resource, and pull-out resource. Informed consent letters were distributed to the families of students via mail regarding participation in the study.

Table 3

Demographic Characteristics of Total Sample

Characteristic	*n* = 21	*%*
	Gender	
Male	6	*29%*
Female	15	*71%*
Transgender	0	
Not Identified	0	

Table 3 - Continued

Characteristic	*n* = 21	%
	Race/Ethnicity	
European American	12	*57%*
African American	0	*0%*
Latino American	5	*23%*
Native American/Alaskan Native/Pacific Islander	0	*0%*
Asian American	2	*10%*
Other	2	*10%*
	Grade	
9	5	*24%*
10	2	*9%*
11	5	*24%*
12	9	*43%*

Table 3 - Continued

Characteristic	*n* = 21	%
	Disability Status	
Classified with an IEP	5	*24%*
Identified with a 504 Plan	2	*9%*
No disability	14	*67%*
	Socioeconomic Status	
Eligible for free/reduced lunch	10	*48%*
Not eligible for free/reduced lunch	10	*48%*
No response	1	*4%*

The participants in this study consisted of 15 female and 6 male students. A majority of participants were European American (57%), and a representative subsample were Latino American (23%). The 12th grade was the most represented grade (43%) and the 10th grade was the least represented grade (9%). A disproportionate number of students classified with an IEP (24%) or a 504 plan (9%) participated in this study. According to the NJ School Performance Report for the 2018-2019 school year (2020), 13% of students attending North Arlington High School were identified as having a disability. Socioeconomic status was determined by eligibility for free/reduced lunch. According to the NJ School Performance Report for the 2018-2019 school year (2020), 19% of students attending North Arlington High School were eligible for free/reduced lunch. Therefore, a disproportionate number of students that were eligible for free/reduced lunch (48%) participated in this study.

Measures

Nelson-Denny Reading Test. NDRT Forms I and J was used to examine students' reading performance under standard time and extended time conditions. This measure is a two-part reading survey test for high school students, college students, and adults. It measures achievement in vocabulary development, comprehension, and reading rate. This test was designed to avoid racial and gender bias. Norms are available for standard and extended time administrations. Forms I and J are parallel forms that can be used interchangeably. Raw scores can be converted into index scores, grade-based percentile ranks, age-based percentile ranks, grade equivalents, and age equivalents which aid in the interpretation and comparison of scores. Index scores were used for the current study.

The NDRT is comprised of the Vocabulary and Comprehension subtests. Forms I and J are administered to students in a group format during the standard (35 minutes total) and extended (56 minutes total) time conditions. The Vocabulary subtest is a 15 minute (standard time condition) or 24 minute (extended time condition) test of language development. It consists of eighty multiple choice items, each with five response options. The Comprehension subtest is a 20 minute (standard time condition) or 32 minute (extended time condition) test of reading rate and comprehension. It consists of seven reading passages and thirty-eight multiple choice questions about the contents of the passages. Students are instructed to mark the word they are currently reading at the end of the first minute. This information is used to calculate the reading rate raw score. Reading rate raw scores are converted to index scores and percentile ranks. Raw scores for the Vocabulary and Comprehension subtests are calculated by counting the number of correct responses. Subtest raw scores are converted to age-based index scores and percentile ranks. Total scores are generated by adding the index scores for the Vocabulary and Comprehension subtests and converting the sums to the corresponding percentile ranks, General Reading Ability index scores, and confidence intervals.

Fishco (2019) computed several types of reliability coefficients to examine different sources of error variance for the NDRT Forms I and J. The average Cronbach's coefficient alphas for the Vocabulary and Comprehension subtests were very large ($\alpha \geq .85$) for the age-based and grade-based samples. The average Cronbach's coefficient alphas for the General Reading Ability index were nearly perfect for the age-based ($\alpha \geq .94$) and grade-based ($\alpha \geq .93$) samples. Test-retest reliability for the Vocabulary and Comprehension subtests and the General Reading Ability index were nearly perfect for the grade-based sample (r = .92 to .97). Test-retest reliability for Reading Rate was very large for the age-based (r = .79) and grade-based (r = .88) samples. Alternate forms immediate administration reliability corrected and uncorrected coefficients were very large to nearly perfect for the Vocabulary (r = .84 to .96) and Comprehension (r = .82 to .93) subtests, Reading Rate (r = .70 to .92), and General Reading Ability index (r = .90 to .97) for age-based and grade-based samples. Alternate forms delayed administration reliability corrected coefficients were large to nearly perfect for the Vocabulary (r = .82 to .99) and Comprehension (r = .69 to .95) subtests, Reading Rate (r = .76 to .97), and General Reading Ability index (r = .79 to .98) for age-based and grade-based samples.

Fishco (2019) used qualitative and quantitative methods to provide evidence for the validity of the NDRT Forms I and J. The Vocabulary and Comprehension subtests demonstrated acceptable item discrimination coefficients for age-based and grade-based samples. Moderate to very large correlation coefficients between the NDRT Forms I and J the Test of Silent

Contextual Reading Fluency-Second Edition (TOSCRF-2) (r = .52), the Test of Silent Word Reading Fluency-Second Edition (TOSWRF-2) (r = .49), the Gray Oral Reading Tests-Fifth Edition (GORT-5) (r = .83), the Wechsler Individual Achievement Test-Third Edition (WIAT-III) (r = .65), and the NDRT Forms G and H (r = .66 to .68) provide evidence of criterion-prediction validity. Efforts to reduce test bias based upon gender and race were made by conducting logistic regression procedures to detect differential item functioning (DIF). In the grade-based sample, 28 item comparisons were found to be statistically significant and, in the age-based sample, 25 item comparisons were found to be statistically significant. Effect sizes were calculated for the item comparisons identified as statistically significant. Fishco (2019) determined that item comparisons with effect sizes that were moderate to large (R^2 = .35 or higher) would be examined for possible removal. One item fit this criterion; however, it was not removed from the test because it possessed good discrimination and difficulty characteristics.

Smith (1998) and Murray-Ward (1998) conducted reviews of the previous version of the NDRT. The NDRT Forms G and H provided norms for students attending high school, two-year colleges, and four-year colleges, as well as individuals attending law enforcement academies. Attempts were made to match the high school norming sample with the demographic information obtained from the 1980 U.S. Census; however, students with a low socio-economic status were underrepresented and students with an average socio-economic status were overrepresented (Smith, 1998).

Alternate form reliability is in the very large range for the Comprehension subtest (.81) of the NDRT Forms G and H (Coleman, Lindstrom, Nelson, Lindstrom, & Gregg, 2010). Although the test developers consider alternate forms to be the most appropriate estimate of reliability, KR-20 reliability estimates are reported within the NDRT Technical Report (Murray-Ward, 1998; Smith, 1998). Internal consistency estimates for all areas assessed by the NDRT are acceptable (Vocabulary = .89; Comprehension = .81; Reading Rate = .68; and Total Test = .90). Test-retest reliability estimates were not reported (Smith, 1998).

According to studies conducted by educational institutions using earlier versions of the NDRT Forms G and H, scores on the NDRT are correlated with students' grades and may be used to predict academic success (Smith, 1998). Evidence for content validity is lacking because the test developers provided limited information on the sources and criteria for word and passage selection and they only cited studies that examined the validity of previous forms of the NDRT (Murray-Ward, 1998; Smith, 1998). Although the test developers purported the NDRT could be used to diagnosis reading problems, the validity evidence to substantiate this claim is lacking (Murray-Ward, 1998; Smith; 1998).

Woodcock-Johnson IV, Tests of Cognitive Abilities (Cognitive Processing Speed Cluster). The Woodcock-Johnson IV, Tests of Cognitive Abilities (WJ-IV COG) is an individually administered norm-referenced measure of cognitive ability for individuals aged three to ninety years and over. It contains eighteen tests that measure different aspects of cognitive ability. Seven of the tests are used to generate a General Intellectual Ability (GIA) score, which provides an estimate of global intelligence. It is derived through an individual's performance on the following tests: Oral Vocabulary, Number Series, Verbal Attention, Letter-Pattern Matching, Phonological Processing, Story Recall, and Visualization.

Tests of the Cognitive Processing Speed cluster of the WJ-IV COG were administered in order to determine students' ability to quickly and accurately perform simple tasks within specified time frames. These tests require students to sustain controlled attention and concentration. The tests that compose this cluster, Letter-Pattern Matching and Pair Cancellation were administered to students individually.

Letter-Pattern Matching is a perceptual speed test that measures an aspect of cognitive efficiency. Specifically, it measures the speed at which an individual can make visual symbol discriminations and identify common spelling patterns. For this test, individuals are asked to repeatedly locate and circle the two identical letter patterns in a row of six patterns for three minutes. The test increases in difficulty from single-letter to four-letter patterns.

Pair Cancellation is a test that measures executive processing, attention/concentration, and processing speed abilities. It provides information about interference, inhibition control, and ability to sustain attention and be vigilant. For this test, individuals are asked to accurately locate and mark a repeated pattern for three minutes.

The WJ-IV COG underwent extensive statistical analyses in order to produce a psychometrically sound testing measure. There is evidence this measure is sufficiently reliable and precise for measuring an individual's cognitive ability. The reliability of the Cognitive Processing Speed cluster score was computed using Moiser's unweighted composite. The Cognitive Processing Speed cluster demonstrates good reliability for individuals aged 14 through 19 (.93 to .94). Independent support for the inclusion of the Letter-Pattern Matching and Pair Cancellation tests on the Cognitive Processing Speed cluster was provided by multiple iterations of cross-battery Cattell-Horn-Carroll (CHC) expert consensus. Within the Cognitive Processing Speed cluster, internal structure validity was evidenced through examining the patterns of intercorrelations among test and cluster scores. There is a large correlation between Letter-Pattern Matching and Pair Cancellation (.58) for individuals aged 14 through 19.

Numerous correlational analyses were conducted to demonstrate the following clusters and subtests measure related, yet distinct constructs for individuals aged 14 through 19. The Cognitive Processing Speed cluster and the Short-Term Working Memory cluster share a medium correlation (.45). There is a large correlation (.56) between the Cognitive Processing Speed cluster and the Reading Fluency cluster of the Woodcock-Johnson IV Tests of Achievement. Medium to large correlations (.37-.64) were also found between the Cognitive Processing Speed cluster and the Reading, Broad Reading, Basic Reading Skills, Reading Comprehension, Reading Comprehension- Extended, and Reading Rate clusters of the Woodcock-Johnson IV Tests of Achievement. Ward's hierarchical minimum variance cluster analysis method was used to link the most highly correlated tests into clusters. Confirmatory Factor analyses were conducted using Model Development (MD) and cross-validation samples (MCV). Factor loadings of the Letter-Pattern Matching (MD = .75; MCV = .76) and Pair Cancellation (MD = .57; MCV = .60) tests on the Cognitive Processing Speed cluster were moderate to large using the Broad 9-Factor Model. Similarly, factor loadings of the Letter-Pattern Matching (MD = .76; MCV = .76) and Pair Cancellation (MD = .58; MCV = .59) tests on the Cognitive Processing Speed cluster were moderate to large using the Broad + Narrow 13-Factor Model. Moderate to large concurrent validity is evidenced between the Cognitive Processing Speed cluster and the Processing Speed Index on WAIS-IV (.44) and the WISC-IV (.55) for individuals aged 16 through 82 and individuals aged 6 through 16, respectively.

Procedure

The principal investigator recruited North Arlington High School by proposing the study to the Superintendent, Director of Special Services, and High School Principal. Final approval was granted by the North Arlington Board of Education. Students were recruited by sending letters to their parents/guardians via mail. The letters contained information about the study, contact information for the principal investigator, and requests for consent from parents/guardians and assent from students.

The Comprehension subtest of the NDRT was administered to students after school over the course of four days. Forms I and J were administered to all participants under both time conditions. Proctors monitored the students to confirm that they marked the word they were reading at the end of the first minute of the Comprehension subtest. The researcher distributed the test materials and read the directions aloud. The test materials were collected by the researcher at the end of each test administration.

The tests that compose the Cognitive Processing Speed cluster of the WJ-IV COG were administered to students in one session that lasted ten minutes. Two graduate level student assistants administered the Letter-Pattern Matching and Pair Cancellation subtests to students individually over the course of four days. Standardized test administration procedures were utilized for both of the tests.

Evaluation materials were purchased by the researcher. All research information was deidentified. Students were given identification numbers that were used on all evaluation materials.

Data Analysis

This study was designed to determine whether there is a relationship between reading rate on the NDRT and boost from extended time, whether there is a relationship between processing speed and boost from extended time, and whether there is a relationship between reading rate on the NDRT and processing speed. In other words, the purpose of this study was to determine whether lower reading rates were associated with greater boosts, whether slower processing speeds were associated with greater boosts, and whether lower reading rates were associated with slower processing speeds.

Quantitative techniques were used to analyze the data. Raw scores obtained from the NDRT during the standard time administration and the extended time administration were converted into standard scores based upon the norms for each respective condition. Boost was calculated by subtracting the standard scores obtained on the NDRT during the standard time condition from the standard scores obtained on the NDRT during the extended time condition.

Correlational Analysis. Bivariate Pearson correlations were calculated to determine whether there is a positive relationship between reading rate on the Nelson-Denny Reading Test and boost from the extended time administration versus the standard time administration. A second correlational analysis was conducted to determine whether there is a positive relationship between processing speed and boost. A third correlational analysis was conducted to determine whether there is a positive relationship between reading rate and processing speed.

A Pearson correlation is used to measure the strength and direction of the linear relationship between two variables. Correlation coefficients range from -1.00 to 1.00. A negative value indicates the variables move in opposite directions and a positive value indicates the variables move in the same direction. Correlation coefficients of .1-.29 indicate small relationships, correlation coefficients of .3-.49 indicate moderate relationships, correlation coefficients of .5-.69 indicate large relationships, correlation coefficients of .7-.89 indicate very large relationships, and correlation coefficients of .9-.1.0 indicate nearly perfect relationships (Cohen, 1992; Hopkins, 2014).

Table 4

Predicted Positive Correlation Ranges

	Reading Rate	Processing Speed	Boost
Reading Rate	—		
Processing Speed	Medium (+)	—	
Boost	Medium (+)	Medium (+)	—

.1-.29 = Small .3-.49 = Medium .5-.69 = Large
.7-.89 = Very Large .9-1.0=Nearly Perfect

Chapter III

Results

The following tests have a normative mean of 100 and standard deviation of 15. Processing speed was measured using the Cognitive Processing Speed cluster of the WJ-IV (M = 96.2, SD = 13.2). Participants in this study scored about .25 standard deviations below the mean of the normative sample. The Cognitive Processing Speed cluster is composed of the Letter-Pattern Matching and Pair Cancellation tests. Participants in this study scored about .25 standard deviations above the mean of the normative sample on the Letter-Pattern Matching test (M = 102.4, SD = 10.9). Participants in this study scored about .50 standard deviations below the mean of the normative sample on the Pair Cancellation test (M = 92.9, SD = 13.1).

Reading ability was measured using the General Reading Ability index of the NDRT during the standard time (M = 106.6, SD = 15.6) and extended time (M = 112.0, SD = 15.3) conditions. Participants in this study scored about .50 standard deviations above the mean of the normative sample during the standard time condition and about .75 standard deviations above the mean of the normative sample during the extended time condition.

The General Reading Ability index is composed of the Vocabulary and Comprehension subtests. Participants in this study scored about .25 standard deviations above the mean of the normative sample during the standard time condition ($M_{\text{standard time}}$ = 103.8, SD = 15) and about .50 standard deviations above the mean of the normative sample during the extended time condition ($M_{\text{extended time}}$ = 107.0, SD = 13.9) on the Vocabulary subtest. Participants in this study scored about .50 standard deviations above the mean of the normative sample during the standard time condition ($M_{\text{standard time}}$ = 108.7, SD = 17.7) and about one standard deviation above the mean of the normative sample during the extended time condition ($M_{\text{extended time}}$ = 115.0, SD =

17.7) of the Comprehension subtest. Reading rate was calculated during the first minute of the Comprehension subtest. Participants in this study had a reading rate score of about .67 standard deviations below the mean of the normative sample (M = 90.5, SD = 12.5).

Relationship Between Reading Rate and the Boost from Extended Time

To answer the first research question, a Pearson correlation was calculated to determine whether there is a relationship between reading rate on the NDRT Forms I and J and the boost from extended time. The correlation between reading rate and the boost from extended time on the Vocabulary subtest was not significant ($r(19) = -.32$, $p = .079$). The correlation between reading rate and the boost from extended time on the Comprehension subtest was not significant ($r(19) = -.12$, $p = .302$). The correlation between reading rate and the boost from extended time on the General Reading Ability score was not significant ($r(19) = -.24$, $p = .147$).

Relationship Between Processing Speed and the Boost from Extended Time

To answer the second research question, a Pearson correlation was calculated to determine whether there is a relationship between cognitive processing speed and the boost from extended time. The correlation between processing speed and the boost from extended time on the Vocabulary test was significant ($r(19) = -.38$, $p = .045$). The correlation between processing speed and the boost from extended time on the Comprehension test was not significant ($r(19) = -.18$, $p = .218$). The correlation between processing speed and the boost from extended time on the General Reading Ability score was not significant ($r(19) = -.30$, $p = .093$).

Relationship Between Reading Rate and Processing Speed

To answer the third research question, a Pearson correlation was calculated to determine whether there is a relationship between reading rate on the NDRT Forms I and J and processing speed. The correlation between reading rate and the cognitive processing speed was not significant ($r(19) = .33$, $p = .072$). The correlation between reading rate and performance on the Letter-Pattern Matching test was significant ($r(19) = .37$, $p = .049$). The correlation between reading rate and performance on the Pair Cancellation test was not significant ($r(19) = .26$, $p = .128$).

Table 5

Correlations

	Reading Rate	Processing Speed
Reading Rate	—	—
Processing Speed	.33	—
Boost: Vocabulary	-.32	-.38*
Boost: Comprehension	-.12	-.18
Boost: GRA	-.24	-.30
Letter-Pattern Matching	.37*	—
Pair Cancellation	.26	—

Correlational Ranges
.1-.29 = Small .3-.49 = Medium .5-.69 = Large .7-.89 = Very Large
.9-1.0=Nearly Perfect

*Correlation is significant at the .05 level (1-tailed)

Chapter IV

Discussion

This study investigated three research questions. The first research question examined whether there is a relationship between reading rate and a boost in scores from extended time on reading comprehension. The second research question examined whether there is a relationship between cognitive processing speed and a boost in scores from extended time on reading comprehension. The third research question examined whether there is a relationship between reading rate and cognitive processing speed. Pearson's correlations were conducted for the research questions. With the exception of the relationship between cognitive processing speed and the boost from extended time on the Vocabulary subtest and the relationship between reading rate and scores on the Letter-Pattern Matching test ($r = .37$), the correlations were not significant. Limitations and suggestions for future research are discussed later in this chapter.

Reading Rate and Extended Time

First, this study investigated the relationship between reading rate and the boost from extended time on the NDRT. A Pearson correlation was calculated for reading rate and the difference between the standard time and extended time scores on the General Reading Ability index of the NDRT. There was a small negative correlation between reading rate and the effect of extended time on the General Reading Ability index. The p-value was calculated and the correlation was not significant. A Pearson correlation was calculated for reading rate and the difference between the standard time and extended time scores on the Comprehension subtest of the NDRT, which yielded results inconsistent with the initial prediction. There was a small negative correlation between reading rate and the boost from extended time on the Comprehension subtest. The p-value was calculated and the correlation was not significant. A

Pearson correlation was also calculated for reading rate and the difference between the standard time and extended time scores on the Vocabulary subtest of the NDRT. There was a medium negative correlation between reading rate and the boost from extended time on the Vocabulary subtest. The p-value was calculated and the correlation was not significant. These results indicate there is not a relationship between reading rate, as measured by the NDRT, and the boost from extended time on the General Reading Ability index, Comprehension subtest, or the Vocabulary subtest.

Processing Speed and Extended Time

Next, this study investigated the relationship between cognitive processing speed, as measured by the Cognitive Processing Speed cluster of the WJ-IV, and the boost from extended time on the NDRT. A Pearson correlation was calculated for cognitive processing speed and the difference between the standard time and extended time scores on the General Reading Ability index of the NDRT. There was a medium negative correlation between cognitive processing speed and the boost from extended time on the General Reading Ability index. The p-value was calculated and the correlation was not significant. A Pearson correlation was calculated for cognitive processing speed and the difference between the standard time and extended time scores Comprehension subtest, which yielded results inconsistent with the initial prediction. There was a small negative correlation between cognitive processing speed and the boost from extended time on the Comprehension subtest. The p-value was calculated and the correlation was not significant. A Pearson correlation was also calculated for cognitive processing speed and the difference between the standard time and extended time scores on the Vocabulary subtest of the NDRT. There was a small negative correlation between cognitive processing speed and the boost from extended time on the Vocabulary subtest. The p-value was calculated and the correlation was significant. These results indicate there is not a relationship between cognitive processing speed and the boost from extended time on the General Reading Ability index or Comprehension subtest of the NDRT; however, there is a relationship between cognitive processing speed and boost from extended time on the Vocabulary subtest. Specifically, as cognitive processing speed decreased, the boost from extended time on the Vocabulary test increased.

Reading Rate and Processing Speed

Finally, this study investigated the relationship between reading rate, as measured by the NDRT, and cognitive processing speed, as measured by the Cognitive Processing Speed cluster of the WJ-IV. A Pearson correlation was calculated for reading rate and cognitive processing speed, which yielded results inconsistent with the initial prediction. Although there was a medium positive correlation between reading rate and cognitive processing speed, as predicted, the correlation was not significant. A Pearson correlation was calculated for reading rate and the Letter-Pattern Matching test of the WJ-IV. There was a medium positive correlation between reading rate and the Letter-Pattern Matching test. The p-value was calculated and the correlation was significant. A Pearson correlation was calculated for reading rate and the Pair Cancellation test of the WJ-IV. There was a medium positive correlation between reading rate and the Pair Cancellation test. The p-value was calculated and the correlation was not significant. These results indicate there is not a relationship between reading rate and cognitive processing speed or the Pair Cancellation subtest of the WJ-IV; however, the results indicate there is a relationship between reading rate and the Letter-Pattern Matching subtest of the WJ-IV. Specifically, as reading rate increased, the speed of making visual symbol discriminations and identifying common spelling patterns on the timed test increased.

Research Implications

According to the WJ-IV Technical Manual (2014), there is a large to very large correlation between reading fluency and reading comprehension for children aged 6 through 19. Current research indicates the ability to read fluently reduces cognitive load and facilitates reading comprehension (Decker et al., 2018; National Reading Panel, 2000; Pikulsi & Chard, 2005; Rabinski et al., 2005). One study investigating the WJ-IV ACH, demonstrated that reading fluency had a small direct effect on reading comprehension scores for students in grades 7 through 12 (Benson, 2008). Another study found a very large correlation between the reading speed and reading comprehension scores of 4th grade students on the Iowa Test of Best Skills (Jenkins et al, 2003). Further, students with disabilities report difficulty with completing tests within allotted time frames (Brown et al., 2011; Runyon, 1991).

Based upon the aforementioned research, this study hypothesized there would be a medium positive correlation between reading rate, as measured by the NDRT, and the difference between standard time and extended time scores on the Comprehension subtest of the NDRT. The results from this study indicate there is not a relationship between reading rate and the boost from extended time on comprehension. This finding is consistent with the results from a previous study that found reading rate, as measured by the NDRT Forms G and H, did not correlate with the need for extended time on the Comprehension subtest of the NDRT (Ofiesh et al., 2005).

Reading rate for this study and the study conducted by Ofiesh et al. (2005) was obtained by having participants read a passage for one minute and then record the number in the margin that corresponded to the last sentence they read. The previously discussed research examined reading fluency, which involves speed and accuracy. This indicates that reading accuracy, in conjunction with speed, facilitates reading comprehension, which may help to explain the non-significant correlation between reading rate and comprehension in this study.

According to the WJ-IV Technical Manual (2014) there are medium correlations between cognitive processing speed and basic reading skills and between cognitive processing speed and reading comprehension. Processing speed may support reading comprehension because speed and accuracy with identifying letters, syllables, orthographic patterns, and words reduces cognitive load (Floyd et al., 2007; Konald et al., 2003). Similarly, difficulties with reading are correlated with processing speed deficits (Shanahan et al., 2006; Wilcutt et al., 2010).

Based upon the aforementioned research, this study hypothesized there would be a medium positive correlation between cognitive processing speed, as measured by the WJ-IV, and the difference between standard time and extended time scores on the NDRT. The results from this study indicate there is a medium negative correlation between cognitive processing speed and the boost from extended time on vocabulary, which is consistent with the results from a previous study that found processing speed tests from the WAIS-R and WJ-R predicted the probability that college students would benefit from extended time on the NDRT Forms G and H (Ofiesh, 2000).

The results from this study indicate there is not a relationship between cognitive processing speed and the boost from extended time on comprehension. This result may have differed from the results found by Ofiesh (2000) for several reasons. The participants in the latter study were college students, whereas the participants in this study were high school students. Additionally, Ofiesh (2000) used the Visual Matching test of the WAIS-R, which required participants to view a key consisting of the numbers that were paired with a symbol and then copy the correct numbers into boxes located below the paired symbols, and the Cross-Out test of the WJ-R, which required participants to scan arrays and mark the target symbols within the arrays. These tests differed from the cognitive processing speed tests used in this study. Additionally, this study used the Cognitive Processing Speed cluster of the WJ-IV for conducting the correlation with the boost from extended time on reading comprehension, rather than using scores on the individual cognitive processing speed tests. Finally, Ofeish (2000) administered the NDRT Forms G and H, whereas this study administered the NDRT Forms I and J, which has updated norms.

According to the WJ-IV Technical Manual (2014) there is a large correlation between cognitive processing speed and reading fluency. One study found there was a medium correlation between cognitive processing speed and reading fluency, as measured by the WJ-III, for participants aged 6 through 9 (Urso, 2008). Another study found a very large direct effect of cognitive processing speed on reading fluency, as measured by the WJ-III, for participants in grades 7 through 12 (Benson, 2008).

Based upon the aforementioned research, this study hypothesized there would be a medium positive correlation between reading rate, as measured by the NDRT, and cognitive processing speed, as measured by the WJ-IV. The results from this study indicate there is not a relationship between reading rate and overall cognitive processing speed. Currently, research regarding the correlation between reading rate, as measured by the NDRT, and cognitive processing speed is lacking. As previously discussed, reading fluency is more comprehensive than reading rate, which may explain the difference between the results from this study and previous research. A medium positive correlation between reading rate and the Letter-Pattern Matching subtest of the WJ-IV was found by this study, which is similar to results from a previous study. Norfolk (2017) found that reading fluency could be predicted by performance on the Letter-Pattern Matching subtest of the WJ-IV.

Practical Implications

School psychologists, IEP teams, and other educators are tasked with determining appropriate accommodations for students. An appropriate test accommodation should address an access skill deficit that impedes the ability to demonstrate knowledge about the construct the test was designed to measure. Currently, extended time is the most commonly requested and frequently used test accommodation. This study investigated the relationship between two access skills, reading rate and cognitive processing speed, and the boost from extended time on a reading comprehension test. All of the participants in this study were provided with extended time on the NDRT. With the exception of the relationship between cognitive processing speed and boost in vocabulary, the differences in scores between the standard time and extended time conditions were not related to reading rate nor to cognitive processing speed. Although research regarding the relationship between reading rate and reading comprehension is lacking, there is research demonstrating a relationship between cognitive processing speed and reading comprehension.

The presence of a differential boost in scores provides evidence that an accommodation addressed a functional impairment. Previous research has yielded mixed results regarding whether extended time provides a differential boost in the scores of students with disabilities compared to students without disabilities; however, research regarding whether extended time provides a differential boost in the scores of students with a specific functional impairment, such as slower reading rate or cognitive processing speed, compared to students without a specific functional impairment is lacking. Therefore, further research is required to ascertain whether reading rate and cognitive processing speed should be factors used in the determination of using extended time as a test accommodation.

Limitations

The generalizability of this study is limited by multiple factors. First, the sample size was small (n = 21) and there was an overrepresentation of female students (n = 15). Further, there was an underrepresentation of minority students. None of the students participating in this study identified as African American nor Native American/Alaskan Native/Pacific Islander. Secondly, the average cognitive processing speed, as measured by the WJ-IV, of the participants in this study was about .25 standard deviations below the mean score of the normative sample. Additionally, the average reading rate, as measured by the NDRT, of the participants in this study was about .67 standard deviations below the mean of the normative sample. Finally, the reading rate of the participants in this study was self-scored, which may have impacted the reliability of the reading rate scores.

A heightened level of social sensitivity is a hallmark of adolescence, which can lead to self-consciousness and feelings of stress in situations they believe peers are evaluating them (Somerville, 2013). This sensitivity may have impacted the performance of participants if they believed that their peers were judging them during the group administration of the NDRT. Further, the social comparison theory posits that individuals compare their abilities with the abilities of those around them (Festinger, 1954). Participants may have been comparing their progress on the NDRT with the progress of their peers, which may have impacted their performance. For example, some participants may have observed that other participants already completed the test, thus feeling pressured to work faster or questioning their own ability to complete the test. Therefore, the group administration of the NDRT may have posed another limitation of this study.

Future Research

Frequently, studies compare the results of students with disabilities and without disabilities, without taking functional impairments into consideration. In order to ensure extended time as a testing accommodation meets the following criteria: (a) unchanged constructs; (b) based upon individual need; (c) generate similar inferences between accommodated and standard scores; and (d) differential effects (Hollenbeck, 2002), future research should look to identify specific characteristics that require extended time to remediate functional impairments.

In the future, it would be beneficial to conduct a similar study that addresses the limitations of this study. A larger sample size with a better representation of minorities is needed. Additionally, a larger sample size may yield cognitive processing speed scores that are more consistent with the normative sample of the WJ-IV. Furthermore, reading fluency should be measured by the WJ-IV. This would allow the study to examine the relationship between reading fluency and reading rate, as measured by the NDRT. Finally, using reading fluency, as opposed to reading rate, may produce significant results for a study examining the effects of extended time on reading comprehension.

Conclusions

The federal government requires all states to administer assessments to students every year from grades three through eight and at least once in grades nine through twelve (ESSA, 2015). Students with disabilities are entitled to receive reasonable accommodations on these tests (IDEIA, 2014). Accommodations are changes to a standardized test that do not alter the construct the test was designed to measure, thus allowing valid conclusions to be drawn from the obtained test scores (Hollenbeck, 2002; Kettler, 2012; Sireci, Scarpati, & Li, 2005; Tindal & Ketterlin-Geller, 2004). Others have added that the necessity for test accommodations should be determined by the individual needs of the students in relation to functional impairments (American Educational Research Association et al., 2014; Kettler, 2012; Weston, 2002). The presence of a differential boost in scores provides evidence that the accommodation addressed a functional impairment (Hollenbeck, 2002; Lindstrom, 2010).

Research indicates that extended time is one of the most commonly used test accommodations across all grade levels (Elliott & Marquart, 2004; Lewandowski et al., 2007; Tindal & Ketterlin-Geller 2004). This study sought to determine whether there is a relationship between reading rate and the boost in scores from extended time on reading comprehension, whether there is a relationship between processing speed and the boost in scores from extended time on reading comprehension, and whether there is a relationship between reading rate and cognitive processing speed. In most analyses, the differences in scores between the standard time and extended time conditions were not related to reading rate nor to cognitive processing speed, with the exception of the relationship between cognitive processing speed and the boost from extended time on the Vocabulary subtest. Based upon these results, there was no evidence of a relationship between the boost from extended time and overall cognitive processing speed, nor between boost from extended time and reading rate. Results from this study indicate there is no evidence of a relationship between reading rate and overall cognitive processing speed; however, evidence of a relationship between reading rate and performance on the Letter-Pattern matching was found.

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