Walden University

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Corrie Wilson

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Walden University
2017

Abstract

Working Memory Difficulties and Eligibility for K–12 Special Education

by

Corrie L. Wilson

MEd, Northern Arizona University, 2004

BS, Northern Arizona University, 1997

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

School Psychology

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Abstract

Working memory (WM) has long been associated with deficiencies in reading. Approximately 35% of students in the United States who receive special education services do so under the category of specific learning disability (SLD). The study's theoretical underpinning was Baddeley's model of WM; previous research revealed a significant literature gap regarding how WM difficulties affect eligibility for special education under the category of SLD in reading. In this quasi-experimental study, a purposive sample was taken from archival data of two groups of K–12 students who had been referred for special education eligibility evaluation: The two groups were students evaluated for SLD in reading eligibility who (a) did not meet criteria and (b) did meet criteria. A one-way analysis of variance was conducted to determine whether a significant difference existed between the two group's score differences between a measure of global intelligence and WM. Archival Wechsler Intelligence Scale for Children, 4th Edition, Kaufman Assessment Battery for Children, 2nd Edition, or Woodcock-Johnson Tests of Cognitive Abilities, 3rd Edition scores were used. Although no significant difference was evidenced between global intelligence and WM, the group that did not meet SLD criteria had significantly better WM scores than the group that was found eligible for SLD. By better understanding the relationship between WM and special education eligibility, practitioners may be able to implement more meaningful, better targeted research based interventions for enhancing learning outcomes for students with reading SLD, a group at high risk for high school drop out.

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

For more than 30 years, working memory (WM) has been associated with deficiencies in reading. In the 1970s, Morrison, Giordani, and Nagy (1977) and Torgesen (1978) found that students with reading disabilities performed significantly worse than students without reading disabilities on serial memory tasks. In 1983, Jorm discussed that students with reading disabilities have deficits in long-term storage of phonological information that, in turn, affects the short-term store. In the 1990s, multiple researchers investigated the effect of WM deficits on children with reading disabilities (Baddeley, Gathercole, & Papagno, 1998; de Jong, 1998; Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996).

In the 2011–2012 school year, approximately 2,303,000 students in the United States were determined to be eligible for special education services under the category of specific learning disability (SLD) (National Dissemination Center for Children with Disabilities [NICHY], 2012). Despite these facts, insufficient research investigates the overlap of WM and SLD eligibility. It is important that school psychologists, special education teachers, and other professionals who work with students with SLD understand the effect that WM has to properly design and implement interventions. In this chapter, I will explain the background and purpose of this study, explain the theoretical foundations associated with the study, and define the important terms that will appear throughout this dissertation.

Background of the Study

Psychologists understand WM as the ability to hold information while engaged in other cognitively challenging activities (Baddeley, 2012). In addition, WM is responsible for temporarily activating long-term memory (LTM), learning, reasoning, and comprehension (Alloway, 2007b). WM has a limited capacity, with significant loss of information possible if that capacity is overloaded. One can understand WM in a practical sense by attempting to hold an address in one's mind while listening to directions on how to arrive to the destination (Swanson, Zheng, & Jerman, 2009).

WM has a strong relationship with the ability to understand (Smith-Spark & Fisk, 2007) and decode text (Dehn, 2011). Below average (below a standard score of 85 on a standardized assessment with a mean of 100 and a standard deviation of 15) WM is associated with behavioral difficulties, below average overall academic achievement, and unemployment later in life (Roberts et al., 2011). Some researchers have found that WM is a more powerful predictor for learning success than verbal or performance cognitive ability test scores (Alloway, 2009; Alloway & Alloway, 2010).

In 1975, the U.S. Congress passed Public Law 94-142 (PL 94-142), the Education for All Handicapped Children Act. The purpose of this act was to ensure that all children, including those with disabilities, had access to a free and appropriate public education (FAPE). Although this was groundbreaking legislation for special education, it lacked details regarding criteria to be used when identifying a student with SLD (Lichtenstein, 2008). Because of this lack of clarity, the identification of learning disabilities (LDs) has been a topic of intense debate since special education's inception (Gresham, 2002).

Problem Statement

The Individuals With Disabilities Act (IDEA) definition of SLD includes "a disorder in one or more of the basic psychological processes" (IDEA, 2004), and yet the relationship between WM, a basic psychological process, and whether a child is qualified as a student with SLD in reading is largely unexamined. The specific problem may be that practitioners are developing interventions for students with SLD that do not address the root of their learning problems. One-third of students with SLD have been retained in a grade at least once, and the high school dropout rate for students with SLD is 19% (Cortiella & Horowitz, 2014) as opposed to the 7% dropout rate overall (U.S. Department of Education Institute of Education Sciences National Center for Education Statistics, 2015). This indicates that interventions being provided are not as effective as they could be. Although many factors could be contributing to this problem, unaddressed WM deficits could play a large part.

Research regarding reading-based SLD abounds, yielding 153,000 results between 2007 and 2015 in a Google Scholar search (search term: *reading disability*) and literature regarding WM assessment and intervention is beginning to blossom, yielding 22,400 results since 2007 (search term: *WM assessment and intervention*). There were only 91 peer-reviewed journal articles that directly referenced all three search terms: *WM*, *specific learning disability*, and *eligibility*.

Purpose of the Study

The purpose of this study was to quantitatively examine the relationship between WM and special education eligibility for SLD in reading for students evaluated because they were suspected to have a SLD. An independently contracted company carried out evaluations to complete psychoeducational evaluations for charter and district schools during the 2013–2014 and 2014–2015 school years. *WM* was defined as subtest scores of digit span from the Wechsler Intelligence Scale for Children, fourth edition (WISC-IV; Wechsler, 2003), number recall from the Kaufman Assessment Battery for Children, second edition (KABC-II; (Kaufman & Kaufman, 2004), or numbers reversed from the Woodcock-Johnson Tests of Cognitive Abilities, third edition (WJIII; Woodcock, McGrew, & Mather, 2005), depending on which evaluation tool was used. *Global intelligence* was defined as full-scale IQ (FSIQ from the WISC-IV), general intellectual ability (GIA from the WJIII), or either the fluid crystallized index (FCI), nonverbal index (NVI), or mental processing index (MPI) from the KABC-II. Students were qualified for SLD in reading if they have met Arizona eligibility requirements for SLD in basic reading skills, reading fluency, reading comprehension, or any combination of the three.

The quasi-independent variables consisted of two groups: (a) students who were evaluated for an SLD but did not meet criteria and (b) students who met the eligibility criteria to be qualified for special education as a student with an SLD. The dependent variable was the difference between the global intelligence scores and the WM scores.

Research Question and Hypotheses

Research question (RQ): Is there a statistically significant difference on the difference between a measure of global intelligence (as measured by the WJIII, KABC-II, or WISC-IV) and WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-

IV) by following groups: students who have been evaluated and do not qualify for SLD and students who have been evaluated and do qualify for SLD?

H_0: The difference between WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) and global intelligence will not be significantly different.

H_1: The difference between WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) and global intelligence will be significantly greater in the population of SLD-qualified students than evaluated students.

Theoretical Foundation

Psychologists understand WM as the ability to hold information while engaged in other cognitively challenging activities (Baddeley, 2012). In this study, I will primarily focus on Baddeley's WM model. In 1974, Baddeley and Hitch were concerned with the relationship between short-term memory (STM) and LTM (Baddeley, 2004), proposing a model of WM that was composed of three components: (a) the central executive, (b) the visuospatial sketchpad, and (c) the phonological loop (Baddeley & Hitch, 1974). Chapter 2 will contain a more detailed explanation.

Federal special education legislation will be discussed in Chapter 2. Because this study took place in Arizona, the focus was on the criteria for eligibility from the Arizona Department of Education (ADE). Although ADE's criteria for SLD allows for the use of all three of the models, the addition of "a response to other alternative research-based procedures" (2015b, p. 18) was not added until 2014, and many districts have yet to implement this portion. ADE's current criterion is as follows:

> A response to scientific, research-based intervention (with documentation of a statement of assurance); or a significant discrepancy that documents a pattern of strengths and weaknesses between achievement and ability in one or more areas: oral or written expression, reading or listening comprehension, basic reading skills, fluency, mathematics calculation, or reasoning; or a response to other alternative research-based procedures. The disorder may result in an imperfect ability to listen, think, speak, read, write, spell, or do math. Based on the standards above, each LEA should establish its own criteria for the determination of SLD. (p. 18)

Nature of the Study

I used a quasi-experimental design due to the small sample size available and because the participants cannot be randomly assigned to these two groups. The target population for this study was K–12 students who have been referred for a special education evaluation for a SLD in a public or charter school in Arizona. I obtained the sample through purposive sampling. I chose students from evaluations conducted by a company independently contracted to complete psychoeducational evaluations for charter and district schools during the 2013–2014 and 2014–2015 school years.

The quasi-independent variables consist of two groups, chosen from students who were referred for a special education evaluation: (a) students who were evaluated for an SLD but did not meet criteria and (b) students who met the eligibility criteria to be qualified for special education as a student with an SLD. The dependent variable was the difference between the global intelligence scores and the WM scores.

To examine the effect of the two conditions on the dependent variables, I conducted an analysis of variance (one-way ANOVA) determine whether a significant difference exists between the dependent variable (difference between global IQ and WM) and independent variables (evaluated students, qualified students).

Definitions

Cattell-Horn-Carroll (*CHC*) *theory of intelligence*: One of the most comprehensive and research-supported theories of cognitive functioning that is made up of nine broad abilities and more than 70 narrow abilities.

Central executive: One of the components of Baddeley and Hitch's (1974) components of WM that is responsible for the attentional control.

Discrepancy approach to SLD identification: A traditional model of determining a SLD by comparing IQ to academic achievement to measure whether a substantial difference exists between them.

Dyslexia: "Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities" (International Dyslexia Association, 2016).

Episodic buffer: A component of Baddeley's (2000) model of WM that forms a temporary storage system that binds information together from different sources into chunks.

Global Intelligence (*KABC-II*): Expressed in one of three ways:

- Fluid Crystallized Index (FCI): Used most often, this is a score that represents general cognitive ability based on the Cattell-Horn-Carroll (CHC) theoretical model. It is composed of 10 subtests that yield four broad ability scale indices (Kaufman & Kaufman, 2004).
- Mental Processing Index (MPI): A score that represents general intellectual functioning based on Luria's model. It is composed of eight subtests and deemphasizes language ability and acquired knowledge (Kaufman & Kaufman, 2004).
- Nonverbal Index (NVI): A score that provides a well-normed, reliable, and valid measure of cognitive abilities of children with language-related handicaps and of children who are not fluent in English (Kaufman & Kaufman, 2004).

Global Intelligence (*WISC-IV*): Expressed as FSIQ (full-scale IQ). This score is derived from the sum of the scaled scores on seven subtests (Wechsler, 2003).

Global Intelligence (*WJIII*): Expressed as general intellectual ability (GIA). This score represents a weighted combination of seven to fourteen subtests and best represents an individual's overall intellectual functioning (Schrank, McGrew, & Woodcock, 2001).

Individuals With Disabilities Education Act: Also known as Individuals with Disabilities Education Improvement Act (IDEA). A law that ensures that children with disabilities in the United States receive early intervention, special education, and related services (IDEA, 2004).

Participant groups: (quasi-independent variable):

- Evaluated students: The population of students who were assessed to determine whether a SLD was present.
- Qualified students*:* The population of students who were evaluated for a SLD and met eligibility requirements to be qualified for special education services as a result.
- Referred students*:* The population of students who were referred for a special education evaluation by either the school team or the parent. In this study, this may be an initial referral or a referral for a re-evaluation.

Phonological loop: A component of Baddeley's (1992) WM model that stores and rehearses speech-based information.

Reading comprehension: The ability to read, understand, and process information from text.

Reading decoding: The ability to apply letter–sound relationships to correctly pronounce written words.

Reading disability: A specific learning disability in any area of reading (decoding, fluency, or comprehension).

Reading fluency: The ability to read with speed, accuracy, and correct expression.

Specific learning disability: The educational classification for a learning disability under IDEA. Defined by IDEA as follows:

> *Specific learning disability* means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken

or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations, including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. (2004)

Visuospatial sketchpad: A component of Baddeley's (1992) model of WM that manipulates visual images.

Working memory: The verbal and visual temporary storage and manipulation of information.

Assumptions

I made the following assumptions in this study:

- Evaluating personnel followed standard administration procedures when administering assessments.
- Students' score profiles used for this study are representative of the population of children who are referred for special education eligibility with an SLD.
- Global scores and scores from WM subtests from the WISC-IV (Wechsler, 2003), WJIII (Woodcock et al., 2005), and KABC-II (Kaufman & Kaufman, 2004) can be compared to each other.

Scope and Delimitations

Previous research on WM and disabilities has focused on the relationship between WM and ADHD. I investigated the relationship between WM and LDs. The participants in this study were limited to students from 5 to 17 years who were referred for a special education evaluation for an SLD by a company independently contracted to complete psychoeducational evaluations for charter and district schools during the 2013–2014 and 2014–2015 school years. The delimitations of this study excluded students who were not evaluated using the WISC-IV, WJIII, or KABC-II and/or were evaluated for a category other than SLD. Results from this study should be able to be generalized to school-aged students referred for an SLD evaluation in Arizona. Other states are excluded, because eligibility criteria vary from state to state.

Limitations

Sample size may have been a limitation of the study, because the population from which I drew it is limited. Because I used archival data, I could not add to the sample to increase its size. The sample size was even smaller, owing to the fact that some students were administered intelligence tests other than the three chosen for this study, which excluded them from the population. In addition, because this study was conducted in the southwestern region of the United States, results may not be able to be generalized to other areas of the country.

According to Harris et al. (2006), using a quasi-experimental model may result in alternative explanations for apparent causal effects due to the difficulty in controlling for confounding variables. In this case, confounding variables could be different examiners or the difference between the assessment tools.

Significance of the Study

My intent in this study was to gather information from throughout Arizona on students who have been evaluated for special education eligibility in the under the category of SLD in the area of reading. I analyzed data to determine the strength and direction of relationships between eligibility requirements for special education services under the SLD category in the area of reading and scores on WM tasks within cognitive and executive functioning measures administered in the evaluation process.

Many researchers believe that WM deficiencies could be a root cause of reading disabilities (Gathercole, Alloway, Willis, & Adams, 2006). If this is true, even research based reading interventions might be more effective if WM deficits were treated before treating reading deficits. It is clear from the research from the past several decades that WM significantly affects all areas of academic achievement. In addition, the research that has been carried out comparing students with SLD to peers without SLD demonstrates that WM capacity is significantly different. A PSW approach (which Arizona has just begun to implement) makes the most empirical sense for SLD eligibility. In this dissertation, I examined the relationship between WM and SLD eligibility in Arizona. This may increase the research base for the PSW approach and provide practitioners with information to guide interventions.

Summary

In this chapter, I introduced a quasi-experimental study to examine the relationship between WM and special education eligibility. I explained the theoretical basis of the study, Baddeley's model of WM and Arizona's special education eligibility laws were explained; I defined key terms; and I listed the research questions and hypotheses. In addition, I addressed delimitations and limitations, which focus on the small sample size and location for the study, as well as the significance of the study. In

Chapter 2 will, I review the literature related to WM, special education eligibility, and SLDs. In Chapter 3, I will review the methodology for the study.

Chapter 2: Literature Review

The IDEA definition of SLD contains within it “a disorder in one or more of the basic psychological processes” (IDEA, 2004), and yet the relationship between WM, a basic psychological process, and whether a child is qualified as a student with SLD in reading, is largely unexamined. The purpose of this study was to quantitatively examine the relationship between WM and special education eligibility for SLD in reading for students evaluated for an SLD by a company independently contracted to complete psychoeducational evaluations for charter and district schools during the 2013–2014 and 2014–2015 school years.

This chapter provides a review of the current literature pertinent to WM and special education eligibility. The literature search was conducted using the following databases: PsycARTICLES, SAGE Premier, ERIC, Academic Search Complete, Wiley Online Library, National Institutes of Health, and ProQuest. Keywords for searches included *WM*, *special education eligibility,* and *dyslexia.* Search combinations included *WM and dyslexia*, *WM score and special education*, *WM score and reading disability*, *special education referral and WM*, *specific learning disability and eligibility*, *WM and reading*, and *WM and reading disability.*

The chapter begins with the literature search strategy. Next is a discussion of the theoretical foundation for WM, specifically, Baddeley’s theory proposed in 1974 and revised in 2000. In addition, I present the framework for special education eligibility for SLD, first at a national level, and then in Arizona. I then explore the research available about the relationship between WM and academics, and then WM and special education eligibility.

Literature Search Strategy

I carried out the review of the literature for this study by searching the following databases: PsycARTICLES, SAGE Premier, ERIC, Academic Search Complete, Wiley Online Library, National Institutes of Health, and ProQuest. Individual search terms used were *WM*, *special education eligibility*, and *dyslexia*. Search combinations included *WM and dyslexia*, *WM score and special education*, *WM score and reading disability*, *special education referral and WM*, *specific learning disability and eligibility*, *WM and reading*, and *WM and reading disability*. I reviewed seminal literature including textbooks relating to WM and special education in addition to current, peer-reviewed literature, and doctoral dissertations from 2004 to the present.

Research regarding reading-based SLD abounds, yielding 153,000 results between 2007 and 2015 in a Google Scholar search (search term: *reading disability*) and literature regarding WM assessment and intervention is beginning to blossom, yielding 22,400 results since 2007 (search term: *WM assessment and intervention*). According to Berninger and Swanson (2013), WM research is increasingly being applied to address WM problems for students with SLD. In spite of this, a gap in the literature exists regarding the effect WM has on special education eligibility in the area of reading disabilities. A Google Scholar search of *WM* and *specific learning disability* and *eligibility* yielded only 556 results (2007 to present). Of these results, only 16% of the citations are peer-reviewed journal articles. Almost half of the results (49.6%) are mentions of the search terms in books or book sections, 28% of the search results are theses or dissertations, and the rest are reports or conference papers.

An examination of the 91 peer-reviewed journal articles from the search reveals that only one article directly discusses both SLD eligibility and WM (Berninger & May, 2011). Seven more discuss SLD eligibility and cognitive processes, which include WM, however, the focus was not on WM exclusively (Decker, Hale, & Flanagan, 2013; Dombrowski & Gischlar, 2014; Fiorello et al., 2007; Galletly, Knight, & Dekkers, 2010; Hale, Fiorello, Kavanagh, Holdnack, & Aloe, 2007; Johnson, 2014; Naeem, Mahmood, & Saleem, 2014). Three of the articles (Flanagan, Fiorello, & Ortiz, 2010; Ihori & Olvera, 2015; Schultz, Simpson, & Lynch, 2012) focused on SLD eligibility and the pattern of strengths and weaknesses (PSW) model, which includes:

> (a) the identifying an academic need in one of the seven areas found in federal guidelines for SLD, (b) determining if there is an area or areas of cognitive weakness that have a research-based link to problems in the identified academic area, (c) establishing whether there are other cognitive areas which are average or above, and (d) analyzing these findings for a pattern that will rule out or confirm the presence of SLD. (Schultz et al., 2012, p. 88)

One of the cognitive processes involved in SLD determination includes WM (Miciak, Fletcher, Stuebing, Vaughn, & Tolar, 2014). Four of the articles discuss cognitive processes and SLD, but not eligibility criteria (Fuchs, Hale, & Kearns, 2011; Hale et al., 2008; Jiménez & García de la Cadena, 2007; Johnson, Humphrey, Mellard, Woods, & Swanson, 2010). Two articles focus on aspects of the Cattell-Horn-Carroll

(CHC) theory of intelligence, which includes WM, and WM's relation to academic achievement (McGrew, 2012; McGrew & Wendling, 2010). The majority of the rest of the pertinent articles cover various aspects of SLD eligibility without directly discussing WM, whereas the remainder only make mention of the search terms, but do not directly relate to WM. In addition, although there is much new research on the relationship between WM and executive functioning skills in general and reading, "there are no practitioner-oriented texts on the market that focus exclusively on the role of executive skills in reading comprehension" (Cartwright, 2015, p. 23).

Background

According to 2011–2012 U.S. Department of Education (U.S. DOE, 2013) data, 12.9% of students (*N* = 6,401,000) ages 6 through 21 years were served under IDEA Part B (IDEA, 2004). Of that group, 36% (*n* = 2,303,000) were eligible under the category SLD, which has the highest prevalence of the 13 categories of eligibility under IDEA (NICHY, 2012).

In a screening of more than 3,000 school aged children in U.S. public schools, approximately one in 10 students were identified as having WM difficulties (Alloway, Gathercole, Kirkwood, & Elliott, 2009). WM has a strong relationship with the ability to understand (Cain, Oakhill, & Bryant, 2004) and decode text (Dehn, 2011). Below average (below a standard score of 85 on a standardized assessment with a mean of 100 and a standard deviation of 15) WM is associated with behavioral difficulties, below average overall academic achievement, and unemployment later in life (Roberts et al., 2011). Some researchers have found that WM is a more powerful predictor for learning success than verbal or performance cognitive ability test scores (Alloway, 2009; Alloway & Alloway, 2010).

Theoretical Foundations

Theoretical Foundation of Working Memory

Psychologists understand WM as the ability to hold information while engaged in other cognitively challenging activities (Gathercole et al., 2006). Additionally, WM is responsible for temporarily activating LTM, learning, reasoning, and comprehension (Alloway, 2007b). It has been noted that WM has a limited capacity, with disastrous loss of information possible if that capacity is overloaded. One can understand WM in a practical sense by attempting to hold an address in one's mind while listening to directions on how to get to the destination (Swanson et al., 2009).

This study will primarily focus on Baddeley's WM model. In 1974, Baddeley and Hitch were concerned with the relationship between STM and LTM (Baddeley, 2004), proposing a model of WM that was comprised of three components: (a) the central executive, (b) the visuospatial sketchpad, and (c) the phonological loop (Baddeley & Hitch, 1974). The central executive is assumed to be an attention controlling system, and is assisted by two subsidiary systems: the visuospatial sketch pad and the phonological loop (Baddeley, 1992). The phonological loop holds speech based memory for a couple of seconds using rehearsal processes. It is also thought to be able to convert visually presented stimuli into a phonological code (Baddeley, 2004). The phonological loop is typically assessed using a digit span measure (Schuchardt, Maehler, & Hasselhorn, 2008). For example, the Digit Span subtest of the Wechsler Intelligence Test for Children

– Fifth Edition (WISC-V) requires the test subject to repeat a series of digits both forward and backward (Weschler, 2014).

The visuospatial sketch pad is responsible for the manipulation and temporary storage of visual and spatial information (Baddeley, 2004). The visual-spatial subsystem can be examined with a Corsi-Block tapping test (Piccardi et al., 2008). In this assessment, nine randomly positioned dice are presented. The examiner taps a certain number of dice and the respondent must tap the dice in the same order. The number of dice being tapped is increased as the subject answers correctly. Schuchardt et al. (2008) used these same tests to assess central executive function. However, the digit span had to be repeated backwards, and a double span task was used to assess whether the children could coordinate the functioning of the phonological loop and the visual-spatial sketchpad.

In 2000, Baddeley outlined some of the limitations of his model, and added a fourth component, the episodic buffer, which is "assumed to be a limited-capacity temporary storage system that is capable of integrating information from a variety of sources" (Baddeley, 2000, p. 421). One function of the episodic buffer is to chunk information in the STM and integrate it with information in the LTM (Baddeley, 2004).

Baddeley's model will be used for this study because it is the most widely used model within educational and school-based research, having been used in studies with children from as preschool through adolescent stage of development.

Theoretical Foundation of Special Education Eligibility

In 1975, the U.S. Congress passed Public Law 94-142 (PL 94-142), the Education for All Handicapped Children Act. The purpose of this act was to ensure that all children, including those with disabilities, had access to a FAPE. While this was groundbreaking legislation for special education, it lacked details regarding criteria to be used when identifying a student with SLD (Lichtenstein, 2008). Because of this lack of clarity, the identification of LD has been a topic of intense debate since special education's inception (Gresham, 2007).

Before the passage of PL 94-142, the concept of “unexpected underachievement” for LD was used as a definition for LD (Lichtenstein, 2008). The initial definition of LD came from Kirk and Bateman (1962). They proposed that LD was a collection of neuro-developmental disabilities that affected academic learning. They added an exclusion clause that stated that LD did not include children who were intellectually disabled (mentally retarded at that time) or impaired by emotional disabilities, sensory issues, or socioeconomic factors.

In 1975, Rutter and Yule studied children using the Performance IQ scale of the Wechsler Intelligence Scale for Children (WISC) and measures of reading. They defined two groups of children: (a) specific reading retardation, which included children with reading scores two standard errors below their IQ, and (b) general reading backwardness, which were children with reading scores that were below average, but within two standard errors of their IQ (Fletcher et al., 2001).

In 1977, the US DOE published "Additional Procedures for Evaluating Children with Specific Learning Disabilities" to clarify the unspecific language of PL 94-142. The exclusionary criteria from Kirk and Bateman's (1962) definition was included. Also included were two criteria for classifying students with LD. The first was "failure to benefit from adequate instruction," and the second was "a severe discrepancy between achievement and intellectual ability" (Speece, Case, & Molloy, 2003, p. 147). IDEA currently defines SLD as:

> …a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations, including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia (US DOE, 2006).

Current identification practices for SLD vary by state, and can be classified into three models (Schultz & Stephens, 2009). The first is the discrepancy approach, and 67% of states allow for its use, while 20% of states explicitly prohibit its use (Maki, Floyd, & Roberson, 2015). The second model is Response to Intervention (RTI), which 16% of states use exclusively. Finally, there are processing deficit approaches/pattern of strengths and weaknesses. About half of the states do not allow for the use of these approaches.

Because this study takes place in Arizona, the focus is on the criteria for eligibility from the ADE. Although ADE's criteria for SLD allows for the use of all 3 of the models, the addition of "a response to other alternative research-based procedures"

(ADE, 2015a, p. 18) was not added until 2014, and many districts have yet to implement this portion. ADE's current criteria is as follows:

> a response to scientific, research-based intervention (with documentation of a statement of assurance); or a significant discrepancy that documents a pattern of strengths and weaknesses between achievement and ability in one or more areas: oral or written expression, reading or listening comprehension, basic reading skills, fluency, mathematics calculation, or reasoning; or a response to other alternative research-based procedures. The disorder may result in an imperfect ability to listen, think, speak, read, write, spell, or do math. Based on the standards above, each LEA should establish its own criteria for the determination of SLD.

Literature Review

Specific Learning Disability Eligibility in the Literature

As discussed earlier, SLD eligibility is a "hot topic" in the field. Following the Rutter and Yule study (1975), Ysseldyke, Algozzine, and Epps (1983) found 17 operationalized definitions of criteria for qualifying students with LD across the United States. Over the course of the evolution of the discrepancy formula, Bender (2007) identified four different ways the formula has been adapted. The first method was to subtract the student's performing grade level from his or her actual grade level and look for a severe discrepancy. This method did not account for the student's intelligence level or any other factors that may inhibit academic achievement. The second formula was an adaptation of the first. Expected grade level was calculated using actual grade placement and intelligence, and this was then compared to performance grade level. There was no ability to use standard deviations, however. The third evolution was closer to what is used currently. The same procedure was followed as in the previous formula, but this time, standard scores were used. In this way, the IQ and the academic achievement scores were able to be mathematically compared using standard deviations. Finally, the formula was completed with the use of a regression table. This is done to account for the statistical regression of standard scores. It allows for more accuracy when a student's IQ is either extremely high or extremely low.

One of the reasons that the discrepancy model has endured for over 40 years is that the method has some advantages. One advantage is that it is an objective criterion that is easy to understand and apply. Once one has a grasp on the formula, there is no other training needed to apply it to each set of scores encountered. It absolutely validates the presence or absence of a specific construct (like underachievement) (Kavale, Kauffman, Bachmeier, & LeFever, 2008). In addition, the discrepancy model uses statistical properties to establish an LD population that is predictable. Regardless of debates surrounding methods for identifying students with LD, the fact will always remain that student with LD have average to above average intelligence and are not performing to their potential. This provides an additional advantage for the discrepancy model (Council for Exceptional Children, 2011).

One of the reasons for the continuing debate surrounding the discrepancy model is that the model itself is "flawed" and unsubstantiated by research (Vaughn & Fuchs, 2006). There were methodological problems with the Rutter and Yule (1975) study, which was instrumental in the evolution of the discrepancy formula. The main difficulty with the study was that there were no exclusionary criteria applied to the children studied (Fletcher et al., 2001). Approximately 36% of the children who were grouped with the "backwards readers" (those with deficient reading scores within 2 standard deviations of their IQ) had either a known or suspected neurological disorder. In addition, a large number of children also had IQ scores that would be considered "deficient", which would not meet the exclusion criteria set forth by research (Kirk & Bateman, 1962) as well as the 1977 Department of Education regulations. An additional dilemma with the IQ-achievement discrepancy formula is that it does not differentiate between poor readers who are easily remediated and those who are not. Vellutino, Scanlon, and Reid Lyon (2000) demonstrated that IQ is not a predictor of whether students would make significant growth on measures of reading following interventions.

One of the most significant objections to the discrepancy model is the idea that children must "wait to fail" (Compton, Fuchs, Fuchs, Lambert, & Hamlett, 2012). In many cases, a significant IQ-achievement discrepancy does not appear until a student is in the third or fourth grade. In the meantime, the child does not receive services, and continues to fall further and further behind (Speece & Case, 2001). Because of this, young students, kindergarten through about third grade, often do not benefit from the use of the discrepancy model. Additionally, IQ and achievement testing is merely a snapshot in time of the student's ability and academic achievement (Lichtenstein, 2008). A student sitting in a psychologist's office without the distractions or motivations of a classroom setting also may describe the student's skills out of context. A final dissatisfaction of the model is that neither IQ testing nor achievement testing provide details for those who will be choosing interventions for remediation (Berkeley, Bender, Gregg Peaster, & Saunders, 2009). A standard score on a reading test does not inform the school team what types of reading interventions are likely to assist in the student's academic growth.

With all of the objections to the discrepancy model, RTI arose out of the lack of scientific support (Francis et al., 1996; Siegel, 1989; Vellutino et al., 2000). Additionally, researchers were frustrated with the seeming over-identification of students with LD and the variation of discrepancy formulas from state to state (Berkeley et al., 2009). There was a great deal of concern about identifying students who had not received adequate instruction as LD (Bender, 2007). In 1997, the National Joint Committee on Learning Disabilities (NJCLD) wrote a letter to the Office of Special Education Programs (OSEP) discussing their concerns with the discrepancy model (Preston, Wood, & Stecker, 2015). Following this letter, OSEP formed the LD initiative to identify possible solutions to this problem, and RTI emerged as an initial suggestion.

Simply put, RTI is defined as "the change in behavior or performance as a function of an intervention" (ADE, 2009, p. 2). The process involves implementing interventions that would be expected to increase academic proficiency (there is also behavioral RTI, but for the purposes of this paper, only academics will be discussed). When growth is not observed even with interventions, a disability is assumed to be present (Berkeley et al., 2009). There are five core components to the RTI framework (Bradley, Danielson, & Doolittle, 2005). The first two are high quality whole-classroom instruction and school-wide screening using valid and reliable instruments. Continuous progress monitoring of each student must be in place, and research based interventions need to be provided for those students needing remediation. Finally, a vital piece is the fidelity of the interventions both in quality and quantity.

RTI involves a three (or occasionally four) tiered system (Bender, 2007; National Association of School Psychologists, 2003). The first tier, also referred to as the Universal Tier, includes all students in general education. High quality instruction must be present in every classroom, using research based methods. Teachers should also be differentiating for various levels of learning within the class (ADE, 2009; Bender, 2007). Tier 2 is for the students who have been targeted for remediation or prevention by the universal screening received in tier 1. This tier includes the instruction in tier 1, as well as more intensive, small group instruction using research based interventions. Tier 3 would include the instruction in tier 1 as well as intervention of longer duration, smaller group or individualized and may lead to special education referrals. At that point, a comprehensive evaluation by a multi-disciplinary team would be completed to determine eligibility for special education and related services.

There are many advantages to utilizing the RTI method. The first is that, unlike the discrepancy model, RTI works for all ages and grade levels. Research based interventions and progress monitoring tools are available for every level. The second advantage is that schools are required to be proactive in providing interventions to students who demonstrate a need for them. For this reason, students receive research based interventions earlier than they would if the school waited for the discrepancy to become large enough (ADE, 2009). In addition, due to the progress monitoring component of RTI, specific skills deficits are identified as well as types of interventions that are likely to have positive results for the purposes of planning further intervention techniques. As the research base grows, RTI can evolve and the process can be refined and perfected (Gresham, 2007). Finally, the RTI process may decrease the number of students who are referred to special education, as those who can be remediated prior to referral are addressed in the general education setting. This also means that more of the referrals that are made for evaluation may have a higher rate of validity (Council for Exceptional Children, 2008).

As with the discrepancy method, RTI has disadvantages as well. Some critics believe that only very low-achieving students will be placed in special education, while other students with disabilities will go unidentified (VanDerHeyden, 2006). Whether this is the case or not, RTI does not differentiate between students who have SLD and those who are "pervasive underachievers." The RTI process is also not able to make distinctions between those students who have LD and those with other disabilities such as mental retardation, emotional or behavioral disorders, and attention-deficit/ hyperactivity disorder (Berkeley et al., 2009).

Other pitfalls of RTI include the rather subjective nature of parts of the process, which can be inappropriately influenced by parents, teachers, or others who simply want a student to be identified. Additionally, the process is ineffective if it is not implemented by trained staff using research based interventions that are implemented with integrity (Burns, Jacob, & Wagner, 2008). Finally, some interventions have only modest evidence.

When data is collected using those interventions, students may be inappropriately identified (Berkeley et al., 2009).

Currently, the National Association of School Psychologists' (NASP) position on SLD eligibility includes the following: "When a specific learning disability is suspected, and appropriate instruction and intervention within general education fail to meet a child's educational needs, a comprehensive evaluation by qualified professionals is an essential step in determining SLD eligibility and individualized educational needs," (NASP, 2011, p. 2). In addition to this, NASP warns against relying upon an ability-achievement discrepancy model as a sole means of identifying SLD, and note that it is critical for school psychologists to use only research based methods for SLD identification.

In 2004, the Individuals with Disabilities Education Improvement Act (IDEIA) was passed. This included the following clause: "May permit the use of other alternative research-based procedures for determining whether a child has a specific learning disability, as defined in 34 CFR 300.8(c)(10)." Since then, many have attempted to operationalize definitions of a PSW. There are three prominent models for PSW. The first is called the Ability-Achievement Consistency model proposed by Flanagan, Ortiz, and Aflonso (2007). This model documents an area of low academic achievement and identifies a deficit in a cognitive ability that is linked by research to the academic area (Hanson, Sharman, & Esparza-Brown, 2008). It is based on the CHC theory of intelligence. The second model is the Consistency-Discrepancy model from Naglieri (1999). This model is based on the Planning, Attention, Sequential Processing, and

Simultaneous Processing (PASS) theory of intelligence, which is based on the Luria model of intelligence (Hanson et al., 2008). This model uses the Cognitive Assessment System (CAS) (Naglieri, Das, & Goldstein, 1997) and looks for relationships between processing scores and academic scores. Finally, the Concordance-Discordance model was proposed by Hale and Fiorello (2004). This model is part of the Cognitive Hypothesis Testing (CHT) in which assessors must demonstrate the validity of cognitive testing results by observing signs of cognitive weakness in the classroom (Hanson et al., 2008).

In a white paper regarding SLD identification and intervention, an expert consensus came to five specific conclusions (Hale et al., 2010):

1. The SLD definition should be maintained but statutory requirements in identification should be strengthened.
2. Neither ability-achievement discrepancy nor RTI alone are sufficient for SLD identification.
3. To meet SLD requirements, a PSW approach makes the "most empirical and clinical sense" (p. 228).
4. An empirically validated RTI model could be used as a preventative measure for learning problems, but SLD identification requires a comprehensive evaluation.
5. "Assessment of cognitive and neuropsychological processes should be used not only for identification, but for intervention purposes as well…" (p. 230).

Working Memory and Academics in the Literature

Several studies have investigated the role WM plays in all areas of academics and the literature has clearly demonstrated the link. Recent research demonstrates that WM is one of the best predictors of academic skills attainment regardless of the type of knowledge being acquired, and even when a student's general ability is statistically accounted for (Alloway, Banner, & Smith, 2010; Alloway et al., 2009). Children in special education who have been identified as having both math and reading difficulties tend to perform poorly in WM tasks, while students in special education for problems of a behavioral or emotional nature tend to perform in the average range (Alloway, 2006). Additionally, students who were identified as having poor WM (standard scores <85) in their first year of formal schooling struggled with tasks that involved simultaneous storage and processing one year later (Alloway, 2006). These students had difficulty remembering multi-step instructions, keeping their place while reading, and appear to not pay attention to the teacher, in spite of not displaying attention deficits on the Conners' Teacher Rating Scale (Conners, 1997). Research demonstrates that children with below average WM can appear to mentally wander from a cognitively challenging task due to an overloaded WM (Cockcroft, 2015). As a result, some of these children are identified as having attention difficulties rather than memory impairments. In the classroom, children with low WM may have difficulty keeping track of multilevel tasks such as listening to a teacher and taking notes at the same time. They may also experience difficulty updating information in their memory if they have trouble retrieving it. Alloway (2006) suggests that if children fail in learning situations because they cannot store and manipulate information in their WM, academic skill acquisition will be difficult.

One study examined whether memory and inhibition in preschoolers predicted numeracy and literacy in 1st grade. The investigators measured STM with the Kauffman Assessment Battery for Children-II (KABC-II) Digit Span Forward subtest for preschoolers and the Wechsler Intelligence Scale for Children-III (WISC-III) Digit Span Backwards subtest for the 1st graders. Early delays in WM did not predict later delays in academics, however, 1st grade WM did predict 1st grade academic success (Davidse, de Jong, & Bus, 2015). Stevenson, Bergwerff, Heiser, and Resing (2014) used two measures from the Automated WM Assessment (Alloway, 2007a), AnimaLogica (Stevenson, 2012), a test of analogical reasoning, and biannual standardized academic achievement tests regularly administered in the Netherlands. They found that children with more efficient WM or better performance on the analogical reasoning test obtained higher scores on a reading and math achievement assessment. They were further able to determine that verbal WM, but not visuospatial WM, was a good predictor of both reading and math achievement within the course of a school year.

Other investigators have examined the effects of WM intervention on academic skill acquisition. Alloway (2012) used the Vocabulary subtest from the Wechsler Abbreviated Scales of Intelligence (Wechsler, 1999), the Numerical Operations subtest from the Wechsler Objective Numerical Dimensions (Wechsler, 1996), the Spelling subtest from the Wechsler Objective Reading Dimensions (Wechsler, 1993), and the Automated WM Assessment (Alloway, 2007a) to assess academic and memory skills.

Participants then were given 8 weeks of intervention; the training group participated in a program designed to increase WM called Jungle Memory (Memosyne Ltd., 2011) in addition to targeted learning support, while the control group only received the targeted learning support (Alloway, 2012). The training group made significant progress in WM, vocabulary, and math following the interventions, while the control group did not show any substantial improvement in any area. One of the suggestions made from this research was that WM functions as a “bottleneck” for learning in episodes that require increased knowledge. The reasonable conclusion to be reached would be that it would be quite difficult for students with learning difficulties to “catch up” without WM training.

Gathercole and Pickering (2000) examined academic achievement’s relationship to each of the components of WM separately. They used UK national curriculum assessments along with 13 tests from WM batteries. As occurred in other studies, children who performed below their current grade level in one or more areas of the curriculum also performed poorly on measures of WM. The biggest deficits occurred in the assessments measuring the central executive function, which required children to process and store information simultaneously. The authors expected this correlation, however, what surprised them was the correlation between the poor achievement on the curriculum measures and scores on the visuo-spatial assessments. The link between these was significantly more than expected, as there had been little research that the visuo-spatial sketchpad plays a key role in scholastic learning outside of mathematics. Finally, while the phonological loop plays a large role in language acquisition, it did not have a high correlation with the achievement tests.

Working memory and math. If the literature regarding reading disabilities and WM is sparse, research regarding WM and math is even more so, however, studies demonstrate the important part that WM plays in supporting math procedures. The central executive is important for sequencing, decision making, and coordinating the flow of information, especially when there are more complex problems (Menon, 2010), while visuo-spatial memory is thought to function as a "mental blackboard" for holding things such as place value and column alignment (Alloway, 2006). Poor WM leads children to rely on immature problem solving strategies (Geary & Damon, 2006), and low WM scores have been found to be closely related to poor computational skills (Alloway, 2006). Isolated impairment in mathematics is closely associated with deficits in perceptual reasoning, WM, and processing speed (Poletti, 2014).

Peng and Fuchs (2016) completed a meta-analysis and found that children with math disabilities showed more severe numerical WM deficits than children with reading disabilities. Swanson, Lussier, and Orosco (2015) investigated the role of WM capacity on math word problem solving accuracy in 2^{nd} and 3^{rd} graders with and without math difficulties. In this study, WM was not measured by standardized IQ tests but three varying WM tasks. Treatment effects were significantly moderated by WM capacity. Attout and Majerus (2014) discovered that even though students with developmental dyscalculia have impaired verbal WM, the deficit seems to be restricted to "the retention of serial order information while the retention of item information appears to be preserved," (p. 443). During a dual task study, when hearing addition problems with two or three addends, children ages 6-7 were not affected by phonological interference, but severely impacted by visual-spatial interference (Raghubar, Barnes, & Hecht, 2010). Children ages 8-9 were also affected by visual spatial interference, but not as much as the younger children.

Studies have also demonstrated that differences in WM contribute to performance on tasks involving fractions even after controlling for other cognitive variables and math achievement levels (Compton et al., 2012). Fractions may task the WM systems even more so because children must simultaneously consider the numerator and the denominator while completing numerical operations. The researchers in this study delivered the typical 4th grade curriculum chapters on fractions to a control group, and an added fluency component to the intervention group. Results indicated that the fluency practice only appeared to be helpful with students who had low average, but not below average, WM (Fuchs et al., 2014). When dealing with word problems, Swanson (2014) found that WM capacity played an important role in determining the effectiveness of strategy instruction. For children who had math difficulties and low WM capacity, none of the strategies were effective in increasing post-test scores, which may explain why some children do not benefit from strategy instruction.

The relationship between WM and math skills appears to change from childhood to adolescence. In a group of 7 year olds, there was a strong association between math skills and WM, however, this association was no longer significant by the time the children were adolescents (Alloway, 2006). In adults, a central executive load can make solving single digit problems of all operations difficult (Raghubar et al., 2010), while the role of the phonological loop seems to depend on the strategy used to complete the computation, not on the operation being performed. In multi-digit arithmetic, the central executive is found to be the most important for the "carry" operation in addition and complex multiplication problems.

Working memory and reading. In 1983, Jorm reviewed the scant research available at the time regarding "specific reading retardation" and WM. He bemoaned the problem that there was no agreed upon criterion for defining reading disabilities, but cites Rutter and Yule (1975) who differentiate between "general reading backwardness" (children with overall poor ability) and "specific reading retardation" (children with a deficit in reading only). Jorm then outlined the research based on reading and each of the three (at the time) factors of Baddeley's WM model. He concluded that "retarded readers" tended not to utilize the articulatory (now phonological) loop adequately, did not differ from typical readers in the use of the visuo-spatial scratch pad, and did not utilize strategies well from the central executive. Current research demonstrates similar results, showing that dyslexic children may present impairment in tasks using the phonological loop, but have average performance in skills that require use of the visuo-spatial sketchpad (Cruz-Rodrigues et al., 2014).

Gathercole et al. (2006) found that students with reading disabilities performed worse on measures of WM capacity than their non-disabled peers. They administered measures from the WM Test Battery for Children (Pickering & Gathercole, 2001) and the Phonological Assessment Battery (Frederickson, Frith, & Reason, 1997). They discovered that WM abilities were significantly related to the severity of the LD. Swanson, Howard, and Saez (2006) also found that even when readers were statistically matched on fluid intelligence, strong readers outperformed children with reading difficulties on WM measures.

Studies have also demonstrated that WM skills in students with reading disabilities do not improve over time (Alloway, 2006). Others have examined whether WM training could improve reading comprehension. Dahlin (2011) provided WM training to one group and pre- and post-tested the trained group and a control group. WM training did not enhance performance on word decoding or orthographic tests, however, the effect size for the improved reading comprehension performance from the trained group was substantial. This is theorized to be the case due to the improved ability to store verbal information as well as the increased control of attention, which seems to be linked to WM.

More than one study (Georgiou & Das, 2015; Peng & Fuchs, 2016; Pimperton & Nation, 2012) found that students who were poor in reading comprehension performed significantly worse on verbal WM tasks than their peers who had higher reading comprehension scores, however, there was no significant difference between the groups on nonverbal WM tasks. In the Pimperton and Nation study, the poor comprehenders were also rated on the Working Memory Rating Scale (WMRS) (Alloway et al., 2008) as having more WM related problem behaviors, but no significant deficits relative to the control group with regards to hyperactivity, oppositional defiance, or ADHD. Nevo and Breznitz (2013) investigated the growth of WM and reading in kindergarten and first graders. Both grade levels improved significantly over time on all areas of WM. As expected, poor decoders scored lower on both reading and WM tests. In kindergarten, phonological and visuospatial memory measures were highly correlated with three reading skills: decoding, reading comprehension, and reading time. However, by the end of 1st grade, all three of the reading skills were only highly correlated with phonological WM measures. This is hypothesized to have occurred because as children developmentally progress with basic reading skills, they require and use fewer executive resources in order to read with success.

When the neuropsychological characteristics of children with dyslexia are examined in comparison to typically developing children, differences are indicated in full scale, verbal, and perceptual IQs, impairment in executive functions, phonological WM, semantic memory, and right-left discrimination (Cruz-Rodrigues et al., 2014). In spite of this, academic impairment in children with dyslexia does not appear to be explained by the child's intelligence level, since academic difficulties remain, even when intelligence level has been statistically accounted for. Brandenburg et al. (2015) suggest that elementary school children recode visually presented material phonetically, and even children with poor phonological skills are unlikely to use a visual strategy, however, if they do, it will likely be incorrect.

The influence of WM on reading seems to persist into late adolescence and adulthood, at least in those who have a previously identified learning difficulty. University students between the ages of 17 and 58 who had diagnosed learning difficulties were tested using the Wechsler Adult Intelligence Scale – III (Wechsler, 1997) and the Word Reading, Spelling, and Reading Comprehension subtests from the Wide Range Achievement Test –IV (Wilkinson & Robertson, 2006). Across all three subtests, the Verbal Comprehension and WM indices were the largest contributors to performance (Alloway & Gregory, 2013). In spite of this, WM only played a modest role in word reading and reading comprehension, but was a larger predictor of spelling performance. This suggests that many reading processes are more automatic in adulthood, lessening the burden on the WM. In an additional study, Smith-Spark and Fisk (2007) found that WM deficits in dyslexic university students extended beyond the phonological domain into the visuospatial domain, while in a group of 77 adolescents with dyslexia and performance IQs of at least 80, Rose and Rouhani (2012) found that verbal WM was a significant predictor of reading fluency.

WM studies have been replicated all over the world. In Australia, Callinan, Theiler, and Cunningham (2015) demonstrated that 77% to 82% of third graders assessed could be correctly sorted in the groups “students with LD,” “low achieving students,” and “regularly achieving students,” using only measures of phonological processing, rapid naming, and verbal (working) memory. In Taiwan, Wang and Yang (Wang & Yang, 2014) found that WM significantly contributed to word recognition in both dyslexic and typically developing 3rd and 4th graders. All students in this study had a standard score IQ of at least 90 (*M*=100, *SD* = 15) and significantly poor word recognition skills as measured by the Diagnostic Battery for Chinese Reading Disabilities (Ker, 2007). Brandenburg et al. (2015) suggest that in German, the phonological loop is not as critical in severe reading problems as the central executive. However, central executive functioning was associated with both poor spelling and poor reading. This finding has been replicated in English studies (Swanson & Jerman, 2007). Lastly, in Israel, Nevo and

Bar-Kochva (2015) found that the visual-spatial component of WM as early as kindergarten predict reading performance in Hebrew.

Finally, Beneventi, Finn Egil, Ersland, and Hugdahl (2010) provide physical evidence for the differences in WM in children with dyslexia. Both the dyslexic group and the control group had the same pattern of activation that included the prefrontal cortex, cingulate gyrus, parietal lobe, and the cerebellum, demonstrating that those with dyslexia use the same cortical network and information processing strategies as those without. In contrast, the group without dyslexia had significantly more activation than the dyslexic group in the posterior middle frontal gyrus, the superior parietal lobule, and the left cerebellum. These regions of the brain are associated with continuous memory updating and temporal order memory (Wager & Smith, 2003).

Working Memory and Special Education Eligibility

Very little has been written about the interaction between WM and special education eligibility. In general, children with special education needs are six times more likely to have WM impairments that their typically developing peers (Cockcroft, 2015). Poletti (2014) examined the profiles of WISC-IV (2003) scores of children who were eligible for special education with SLD and a control group. He found that the SLD group had significantly lower scores in the Digit-Span, Letter-Number Sequencing, and Coding subtests than the control group. Digit-Span and Letter-Number Sequencing make up the WM index, and Coding contributes to the Processing Speed Index. Johnson et al. (2010) also discovered that the biggest differences in cognitive processing between children who were eligible for SLD and their typical peers appear in the areas of phonological processing, verbal WM, and processing speed.

When examining specific areas of WM, Maehler and Schudchardt (2009) found that children eligible for SLD showed deficits in all aspects of WM, and the deficits are present regardless of overall intelligence levels. Similarly, Giofre and Cornoldi (2015) found that children with SLD had average verbal and non-verbal intelligence scores but significantly lower scores in WM and processing speed. Finally, in a doctoral dissertation, Porter (2011) examined whether children eligible for special education as children with SLD in a specific school district were significantly impacted by WM. She found that the students who were tested and determined eligible according to the Missouri criteria for SLD had significantly lower WM Index and Processing Speed Index scores than their Verbal Comprehension and Perceptual Reasoning scores on the WISC-IV (Wechsler, 2003). Additionally, the students who were tested and did not qualify had no significant difference amongst the indices.

Summary and Conclusions

It is clear from the research across the past several decades that WM has a significant impact on all areas of academic achievement. Additionally, the research that has been carried out comparing students with SLD to peers without SLD demonstrates that WM capacity is significantly different in these 2 groups, however, the relationship between WM capacity and eligibility for special education has been only minimally examined. An examined history of special education eligibility for SLD reveals a lack of research base for a discrepancy model and a growing need for research in the area of “other alternative research-based procedures” (IDEIA, 2004), specifically, the PSW approach. This dissertation will examine the relationship between WM and SLD eligibility in Arizona. This may increase the research base for the PSW approach and provide practitioners with information to guide interventions. The next chapter will outline the methods used to compare WM scores among groups of students.

Chapter 3: Research Method

The IDEA definition of SLD contains within it "a disorder in one or more of the basic psychological processes" (IDEIA, 2004) and yet the relationship between WM, a basic psychological process, and whether a child is qualified as a student with SLD in reading appears to remain unexamined. This dissertation is intended to fill a gap in understanding the relationship between WM and special education eligibility in reading for students evaluated because they were suspected to have a SLD. In this chapter. I will discuss the quasi-experimental research design and rationale, explain the population and sample group, review the measurement tools that I used, and describe the data analysis procedures.

Research Design and Rationale

In this study, the quasi-independent variables consisted of two groups: (a) students who were evaluated for an SLD but did not meet criteria and (b) students who met the eligibility criteria to be qualified for special education as a student with an SLD. Students were qualified for SLD in reading if they have met Arizona eligibility requirements for SLD in basic reading skills, reading fluency, reading comprehension, or any combination of the three.

The dependent variable is the global intelligence scores yielded by one of three assessments and the WM scores yielded by the same assessments. *Global intelligence* will be defined as FSIQ from the WISC-IV, GIA from the WJIII, or either the FCI, NVI, or MPI from the KABC-II, depending on which evaluation tool was used. *WM* is defined as subtest scores of digit span (from the WISC-IV) (Wechsler, 2003), number recall (from the KABC-II; Kaufman & Kaufman, 2004), or numbers reversed (from the WJIII; Woodcock et al., 2005).

I used a quasi-experimental design. A quasi-experimental design is often used when it is not feasible to conduct a randomized control trial (Harris et al., 2006). This is also often the design of choice when there is only a small sample size available. Because the participants cannot be randomly assigned to the two groups, a quasi-experimental design was the most effective choice. One possible constraint on the study was that there may not have been enough students that fit the inclusion criteria to have an acceptable sample size. Because I used archival data, there was no way to add to the sample.

Methodology

Population and Sampling Procedure

The target population for this study was K—12 who have been referred for a special education evaluation because they were suspected to have a SLD in reading at a public or charter school in Arizona. The sample was obtained through purposive sampling, which is the most effective strategy when one or more specific, predefined groups are needed for a sample (Lund Research, 2012a). I chose students from evaluations conducted by a company independently contracted to complete psychoeducational evaluations for charter and district schools during the 2013–2014 (N = 482) and 2014–2015 (N = 529) school years. G*Power is a computer program that computes statistical power analyses for various statistical tests (Faul, Erdfelder, Buchner, & Lang, 2009). Using G*Power 3.1.9.2, to achieve an effect size of .25 (medium) when running a one-way ANOVA with three groups, a total sample size of 210 students was needed.

The contracting company is an organization that offers educational training, clinic-based therapies, and school based staffing to public and charter schools in Arizona. The data from the contracting company regarding special education referrals already exists in the form of a spreadsheet with each student evaluated, his or her demographic info, testing instrument used, and special education diagnosis as a result of the evaluation if applicable. A letter was written to the contracting company requesting the de-identified data (see Appendix A).

To achieve the needed sample, students who were referred for an evaluation but not evaluated for SLD were removed. In addition, students who were evaluated using a cognitive assessment other than the WISC-IV (Wechsler, 2003), the WJIII (Woodcock et al., 2005), or the KABC-II (Kaufman & Kaufman, 2004) were excluded because those three assessments have WM subtests that can be compared. Although both Wechsler and Woodcock Johnson test batteries have been recently updated, the previous versions were used for this study since it is based on school years prior to the new versions' releases.

Instrumentation and Operationalization of Constructs

Students in the population being studied have been tested using a variety of assessment tools. In order to have a large enough sample, students were chosen who had been assessed using one of three tools: The WISC-IV (Wechsler, 2003), The Woodcock – Johnson Tests of Cognitive Ability – Third Edition (WJIII) (Woodcock et al., 2005), and the KABC-II (Kaufman & Kaufman, 2004). These three measures can be compared because they have numeral based WM subtests. Other assessment tools used in the population either do not have a WM subtest or index, or the subtest is different enough that it cannot provide a reasonable comparison.

WISC-IV. David Wechsler began his testing career as a World War I examiner and was influenced by the Stanford-Binet/Army Alpha system (Kaufman, Flanagan, Alfonso, & Mascolo, 2006). The first in the Wechsler series of assessment tools was the Wechsler-Bellevue Intelligence Scale (Wechsler, 1939). The first Wechsler for children was developed 10 years later (Kaufman et al., 2006).

The WISC IV contains 15 subtests, 10 of which form the core battery, and yields four index scores: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. The indexes combine to yield a FSIQ (Pearson Education Inc., 2016). Subtest results are reported in scaled scores with a mean of 10 and a standard deviation of 3 (Wechsler, 2003). Indexes and the FSIQ are reported in standard scores with a mean of 100 and a standard deviation of 15.

The WISC-IV was standardized on a sample of 2,200 children between the ages of 6 and 16:11 years old. The sample was stratified on age, sex, parent education level, region, and race/ethnicity (Pearson Education Inc., 2016). Test-retest reliability coefficients across age groups ranged from .79 to .90 for core subtests and .79 to .88 for supplemental subtests. FSIQ reliability coefficient is .96 for every age group (Maller & Thompson, 2005). Validity has been established by examining the relationship between the WISC-IV FSIQ and other tests. The WISC-IV FSIQ correlates substantially with the WISC-III, Wechsler Preschool and Primary Scale of Intelligence - Fourth Edition

(WPPSI - IV) and the Wechsler Adult Intelligence Scale - Third Edition (WAIS-III) at .89 (Kaufman et al., 2006).

Global intelligence and WM on the WISC-IV. Global intelligence on the WISC-IV is represented by the FSIQ, which is meant to "represent the child's overall cognitive ability" (Wechsler, 2003, p. 2). The FSIQ is derived from the four indices, which is a changed from the previous version of the WISC, which only utilized verbal and performance composites. This update was included so that greater contributions to the FSIQ were made from WM and processing speed "in keeping with contemporary intelligence research" (Williams, Weiss, & Rolfhus, 2003, p. 2)

This study utilized the Digit Span subtest from the WISC-IV to represent WM. Digit Span is a core WM index test and is comprised of Digits Forward and Digits Backward (Williams et al., 2003). While the Letter Number Sequencing subtest is an additional measure of WM, Digit Span only consists of numerals, so it can be more easily compared with the other measures being utilized in the study. Both the Digit Span subtest scores and the FSIQ scores were analyzed from students who have qualified for special education as a student with SLD and students who have been evaluated but did not meet Arizona's criteria for eligibility as a student with SLD.

WJ-III. The first version of the WJ test was the Woodcock-Johnson Psycho-Educational Battery published in 1977 (WJPEB) (Schrank, 2011). The battery began as a series of controlled experiments to measure differential learning capacities. In 1989, Woodcock revised his battery and published the Woodcock-Johnson Psycho-Educational Battery – Revised (WJ-R) based on John Horn's newly presented *Gf-Gc* theory. The test measured seven broad cognitive abilities: comprehension-knowledge (Gc), long-term retrieval (Glr), visual processing (Gv), auditory processing (Ga), fluid reasoning (Gf), processing speed (Gs), and short-term memory (Gsm). In 2000, McGrew and Flanagan presented an integrated model of the Cattel-Horn and Carroll models that became known as the Cattell-Horn-Carroll (CHC) theory (Flanagan, 2008). It is upon this theory that the WJIII is built (Schrank, 2011).

The WJIII includes 31 cognitive tests in two components. The Standard Battery has tests 1-10 and the Extended Battery has tests 11-21. Eleven additional tests are published in the Diagnostic Supplement as a separate battery (Schrank, 2011). The test measures the original seven cognitive abilities from the WJ-R and yields a GIA score. All scores are reported in standard scores with a mean of 100 and a standard deviation of 15. The WJIII was normed using a sample of 8,818 participants: 1,143 preschool children, 4,783 students in kindergarten through 12th grade, and 1,843 adults (Cizek & Sandoval, 2003). Internal consistency reliability is in the .80s and .90s for individual tests and in the .90s for the clusters. Validity for the Global was correlated in the .70s with other intellectual abilities tests.

Global intelligence and WM on the WJIII. On the WJIII, global intelligence is represented by the GIA score. The GIA is derived from a weighted combination of 7 subtests (Schrank, 2011). WM was represented by the Numbers Reversed subtest. This is a core WM index test and requires test subjects to temporarily store and recode orally presented information (Schrank, 2011). Both the Numbers Reversed subtest scores and the GIA scores were analyzed from students who have qualified for special education as a student with SLD and students who have been evaluated but did not meet Arizona's criteria for eligibility as a student with SLD.

KABC-II. The original Kauffman Assessment Battery for Children (K-ABC) was published in 1983 (Kaufman, Lichtenberger, Fletcher-Janzen, & Kaufman, 2005). The KABC-II was published in 2004 and is based on a dual theoretical model, allowing clinicians to choose which model is the best suited to each child being assessed. The KABC-II is composed of 18 core and supplementary subtests (Braden & Thorndike, 2005). There are 4 indexes that are reported in standard scores with a mean of 100 and a standard deviation of 15. Subtests are scored in scaled scores with a mean of 10 and a standard deviation of 3 (Kaufman & Kaufman, 2004). The KABC-II was standardized on a national sample of 3,025 children. Subtests reliability coefficients are mostly in the .80s and .90s, although some of them are in the .70s for younger children (Braden & Thorndike, 2005). Test-retest reliability for global scores were .87 to .92.

Global intelligence and WM on the KABC-II. The KABC-II offers one of three indices to represent global intelligence. The MPI is based on Luria's Neuropsychological Theory of intelligence. Luria's model conceptualized intelligence as 3 separate but related units: the Attention-Arousal system, the Simultaneous Processing system, and the Planning system (Naglieri & Das, 1990). The MPI excludes measures of acquired knowledge and is based on 5 subtests, while the FCI includes those measures and is based on 7 (Kaufman et al., 2005). The FCI is based on the CHC Theory of Intelligence. Finally, the KABC-II also has a NVI for valid assessment of children who are hearing impaired, have limited English proficiency, or have moderate to severe speech or language impairments.

WM was represented by the Number Recall subtest. This subtest is similar to the Digit Span – Forward test on the WISC-IV. This study utilized the Number Recall subtest and either the MPI, FCI, or NVI scores, depending on which was computed. Both the Number Recall subtest scores and the MPI/FCI/NVI scores were analyzed from students who have qualified for special education as a student with SLD and students who have been evaluated but did not meet Arizona's criteria for eligibility as a student with SLD.

Special Education Eligibility for SLD. Arizona allows public education agencies (PEAs) to choose from 3 different options for identifying children with SLDs (ADE, 2015b). The first is based on a lack of response to "scientific, research-based intervention" (p. 37). In order to use this method, the PEA must file their plan to use RTI with the state at the beginning of each school year. The second option is the use of a significant discrepancy between IQ and achievement, however, the state does not define "significant," and allows the PEA to decide on the method of determining what is significant. The final option is an "other alternative research-based procedure" (p. 37), which is also not defined. All of the charter and public schools that contract with the company used in this study utilize the discrepancy model based on a regression analysis. The formula used for the regression analysis is based on a work group product from the United States Department of Education – Special Education Programs (USDE-SEP) in 1983 (Reynolds et al.). Regression analysis formulas take into account that IQ and achievement tests are not perfectly correlated, and determines the discrepancy depending on the correlation between the 2 specific tests being used (Baer, 2000).

$$Z_{yc} = \left(z_x r_{xy}\right) - \left(\left(1.96\sqrt{1 - r_{xy}^2}\right) - \left(1.65 \left(\left(\sqrt{1 - r_{xy}^2}\right) \left(\sqrt{1 - \frac{r_{yy} + \left(r_{xx} r_{xy}^2\right) - \left(2r_{xy}^2\right)}{1 - r_{xy}^2}} \right) \right) \right) \right)$$

r_{xy} = test to test correlation – IQ to achievement

r_{yy}, r_{xx} = internal consistency reliabilities

Figure 1. Severe discrepancy formula suggested by USDE-SEP work group on measurement issues in the assessment of learning disabilities.

According to Arizona's Keys to Successful Outcomes (ADE, 2015b), for eligibility for SLD, a significant discrepancy can occur in one or more of the following areas: oral or written expression, reading or listening comprehension, basic reading skills, reading fluency, mathematics calculation, or mathematics reasoning. For the purposes of this study, the focus was on students who have a significant discrepancy in reading comprehension, basic reading skills, and/or reading fluency.

Data Analysis Plan

This study analyzed data using the IBM SPSS 23 provided by Walden University. Before data could be analyzed, WM subtest scores from the WISC-IV and KABC-II were converted from a scaled score (*M* =10, *SD* = 3) to a standard score (*M* = 100, *SD* = 15) to ensure the ability to compare. This was accomplished using a score conversion table

(Dumont Willis, 2003). The data distributions were then checked for normality, outliers, and missing data.

To examine the research questions, an Analysis of Variance (one-way ANOVA) was conducted to determine if there a significant difference between the dependent variable (difference between global IQ and WM) and independent variables (evaluated students, qualified students). One way ANOVA is an appropriate statistical analysis when the purpose of research is to assess if mean differences exist on one continuous dependent variable by an independent variable with two or more discrete groups (Statistics Solutions, 2013).

Research Question and Hypotheses

Research Question (RQ): Is there a statistically significant difference on the difference between a measure of global intelligence (as measured by the WJIII, KABC-II, or WISC-IV) and WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) by following groups: students who have been evaluated and do not qualify for SLD and students who have been evaluated and do qualify for SLD?

H_0: The difference between WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) and global intelligence will not be significantly different.

H_1: The difference between WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) and global intelligence will be significantly greater in the population of SLD qualified students than evaluated students.

Threats to Validity

External Validity

Threats to external validity are factors that reduce the ability to generalize results of a study (Lund Research, 2012b). In the case of this study, the quasi-experimental research design makes it difficult to use probability sampling. Because of this, selection bias is possible, as the sample is not randomly assigned. This may limit the generalizability of the results (Lund Research, 2012b). To help with reducing selection bias, the population the sample was drawn from a wide variety of socio-economic statuses, ethnicities, and ages. Additionally, using archival data increased the external validity, as the subjects are unaware of the research (Cuffaro, 2011).

Internal Validity

According to Harris, et al. (2006), using a quasi-experimental model may result in alternative explanations for apparent causal effects due to the difficulty in controlling for confounding variables. In the case of this study, there is not likely to be a maturation or history threat, as growth was not measured over time. The students were not being pre and post tested, so testing and instrumentation threats were not of concern. Because some students may have withdrawn from their schools while the evaluations were taking place, it is possible that this would pose a mortality threat (Trochim, 2006), however, this was a small risk, and the data were excluded if a partial evaluation was completed.

Construct and Statistical Conclusion Validity

According to Cuffaro (2011), using archival data risks construct invalidity by experiencing gaps in data, which make it difficult to determine whether or not the data represents the population. In the case of this study, because the sample was drawn from various schools, both charter and public, across socio-economic statuses, the data adequately represented the Phoenix Metropolitan Area.

Statistical conclusion validity is threatened by Type 1 errors when one rejects the null hypothesis even though it is true (Gravetter & Wallnau, 2013). Measures to protect from this included providing statistical power and sample size to detect a medium to large effect.

Ethical Procedures

A letter was written to the contracting company requesting the data, and a data use agreement was completed (Appendix A). The spreadsheets have already been coded with identifying information removed, making the data anonymous. The data fields required were: Gender, grade level, date of birth, special education label, test instruments used, global IQ score, and WM score. The data was stored on Dropbox.com and encrypted with a password for at least 5 years. The only people who had access to the folder with the spreadsheets were the owner of the contracting company and her administrative assistant.

One potential minimum risk was the unintended disclosure of confidential information (educational records). The only situation that would cause this outcome would be if the company shared their original spreadsheets with the students' names. Since these spreadsheets were stored on a separate folder, it was unlikely that accidental access would occur.

Although I am employed by the contracting company, and it is possible that I may have administered some of the assessments that were in my data set, it is not possible to know which ones. Additionally, I did not choose which cases I assessed, as they were assigned to me by my supervisor based on caseloads, geography, and availability. Because I used secondary data analysis, the population was not asked to do anything for the specific purposes of research, and the parents already provided informed consent for their children to be evaluated. The contracting company completed a letter of cooperation.

Summary

This chapter provided the proposed quasi-experimental methodology for studying the extent to which WM is a factor in special education eligibility. The quasi-independent variables were outlined, and consisted of two groups: (a) students who were evaluated for an SLD but did not meet criteria and (b) students who met the eligibility criteria to be qualified for special education as a student with an SLD. The dependent variable, which was the global intelligence scores yielded by one of three assessments and the WM scores yielded by the same assessments, and the definitions of each of the variables were described. A one-way ANOVA was proposed to determine if there was a significant difference between the dependent variable and independent variables, and threats to validity and ethical procedures were discussed.

Chapter 4: Results

The purpose of this study was to quantitatively examine the relationship between WM and special education eligibility for SLD in reading for students evaluated because they were suspected to have a SLD. The research question examined was: Is there a statistically significant difference evidenced in the difference between a measure of global intelligence (as measured by the WJIII, KABC-II, or WISC-IV) and a measure of WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV)?

I conducted my study by analyzing test scores from two participant groups: (a) students who have been evaluated and do not qualify for SLD and (b) students who have been evaluated and do qualify for SLD. The null hypothesis stated that the difference between WM and global intelligence would not be significantly different. The alternate hypothesis was that the difference between WM and global intelligence would be significantly greater in the population of SLD qualified students than evaluated students who did not qualify for SLD. I tested this using a one-way ANOVA.

In this section, I present the methods that I used to gather and analyze the data and I describe the sample from which I gathered the data. I will describe external validity and the results of the ANOVA carried out to address the research question and hypotheses, and I will present some results from additional statistical analyses following the analysis of the hypothesis. Finally, the chapter will conclude with a summary of findings.

Data Collection

The target population for this study was K–12 who had been referred for a special education evaluation because they were suspected to have a SLD in reading at a public or charter school in Arizona. I obtained the sample through purposive sampling, which is the most effective strategy when one or more specific, predefined groups are needed for a sample (Lund Research, 2012a). I chose students from evaluations conducted by a company independently contracted to complete psychoeducational evaluations for charter and district schools during the 2013-2014 and 2014-2015 school years. The contracting company is an organization that offers educational training, clinic based therapies, and school based staffing to public and charter schools in Arizona. The data from the contracting company regarding special education referrals already existed in the form of a spreadsheet with each student evaluated, his or her demographic info, testing instrument used, and special education diagnosis as a result of the evaluation if applicable. I wrote a letter to the contracting company requesting the deidentified data (see Appendix A).

The original sample contained archival data from a total of 1,021 students who had been referred for a special education evaluation during the school years 2013–2014 and 2014–2015. I removed students who were referred for a special education evaluation but not evaluated for SLD (n = 513). In addition, I excluded students who were evaluated using a cognitive assessment other than the WISC-IV (Wechsler, 2003), the WJIII (Woodcock et al., 2005), or the KABC-II (Kaufman & Kaufman, 2004) (n = 272). Of the original sample pool, a total of 241 students were examined. The characteristics of this sample is further described Table 1.

Table 1

Demographics of Sample

Characteristic	*n*	%
Qualified for special education		
Yes	99	41.08
No	142	58.92
Gender		
Male	143	59.3
Female	98	40.7
Assessment used		
WISC-IV	119	49.4
KABC-II	90	37.3
WJIII	32	13.3
Grade		
Kindergarten (0)	10	4.1
1	25	10.4
2	35	14.5
3	34	14.1
4	22	9.1
5	24	10.0
6	19	7.9
7	23	9.5
8	17	7.1
9	18	7.5
10	8	3.3
11	6	2.5
Age (years)		
5	5	2.1
6	17	7.1
7	24	10.0
8	37	15.4
9	27	11.2
10	27	11.2
11	18	7.5
12	23	9.5
13	23	9.5
14	14	5.8
15	17	7.1
16	8	3.3
17	1	.4

Note. WISC-IV, Wechsler Intelligence Scale for Children, fourth edition; KABC-II, Kaufman Assessment Battery for Children, second edition; WJIII, Woodcock Johnson Tests of Cognitive Abilities, third edition.

The sample is representative of the U.S. population of students identified as being identified with a SLD. For example, in the 2014–2015 school year nationwide, students with SLD were 60.63% male (U.S. Department of Education: Office of Special Education Programs, 2016), whereas 59.3% of the study sample was male. In addition, the schools represented in the sample are representative of schools across Arizona. Table 2 outlines key demographics for the ZIP codes represented (City Data, 2017), as well as for all of Arizona (U.S. Census Bureau, 2016) and the United States (Ryan & Bauman, 2016).

Table 2

Demographics of Schools

ZIP code/region	Median household income	% White	% Black	% American Indian	% Asian	% Native Hawaiian and other Pacific Islander	% Other	% 2 or more races	% Hispanic or Latino
85018	$54,028	71.4	2.9	1.7	1.9	0.1	0.1	1.8	19.9
85022	$46,475	72.8	3.5	1.3	2.9	0.09	0.2	1.7	17.3
85023	$48,935	64.7	3.5	1.3	3.3	0.16	0.13	2.0	24.7
85033	$33,662	14.3	4.6	0.87	0.7	0.09	0.1	1.0	78.3
85034	$21,488	16.1	10.3	2.4	0.8	0.05	0.1	0.7	69.3
85086	$83,135	82.2	1.9	0.7	2.2	0.12	0.14	1.9	9.7
85224	$62,283	64.4	4.5	1.4	6.6	0.1	0.17	2.6	20.2
85234	$79,068	70.4	3.1	0.8	4.8	0.25	0.15	2.5	18.0
85260	$76,194	84.9	1.5	0.34	5.3	0.07	0.1	1.8	5.97
85283	$55,414	53.0	6.3	6.4	4.7	0.34	0.15	2.2	26.7
85301	$27,103	26.0	7.4	1.6	1.5	0.14	0.13	1.8	61.4
85308	$68,079	78.8	2.3	0.59	4.7	0.15	0.19	1.9	11.4
85310	$90,038	84.1	1.3	0.53	2.8	0.11	0.15	1.9	9.1
85364	$38,281	30.1	2.1	1.1	1.5	0.11	0.16	1.3	63.6
85374	$48,681	74.3	3.78	0.36	1.4	0.13	0.11	1.6	18.3
85383	$102,773	80.6	2.2	0.79	4.4	0.08	0.89	3.0	8.0
85395	$76,861	79.4	8.11	1.42	3.7	0.06	3.19	--	28.4
85501	$40,138	61.6	0.67	3.97	0.8	0.05	0.08	1.2	31.7
85719	$29,813	61.9	3.5	1.42	6.1	0.16	0.19	2.6	24.1
86301	$46,164	84.3	0.67	1.4	1.4	0.16	0.10	1.7	10.3
Avg. of all ZIP codes included	$56,431	62.77	3.71	1.52	3.1	0.13	0.33	1.9	27.82
Arizona	$51,492	83.5	4.8	5.3	3.4	0.3	---	2.7	30.7
United States	$51,939	77.1	13.3	1.2	5.6	0.2	--	2.6	17.6

Descriptive Statistics

Descriptive statistics for the sample are reported in Table 3. Global and WM scores are reported as standard scores (*M* = 100, *SD* = 15). The difference between IQ and WM scores was larger for the qualified group (*n* = 99, *M* = 1.61, *SD* = 12.696) than the not qualified group (*n* = 142, *M* = 1.25, *SD* = 11.379).

Table 3

Descriptive Statistics

Statistic	Global IQ[a]	WM[a]	Difference: Not qualified	Difference: qualified
N	241	241	142	99
Mean	91.82	90.42	1.25	1.61
Median	91	90	1.5	3
SD	11.901	13.720	11.379	12.696
Variance	141.642	188.236	129.481	161.180
Range	57	78	60	56
Minimum	64	52	-32	-25
Maximum	121	130	28	31
Skewness	.185	.162	-.056	-.013
Kurtosis	-.188	-.072	.169	-.257

Note. IQ, intelligence quotient; WM, working memory; *SD*, standard deviation.
[a]Standard scores (*M* = 100, *SD* = 15).

Analysis of the Assumptions

Outliers

The first assumption for the one-way ANOVA is that there are no significant outliers. The data analyzed were the difference between each student's global IQ score and WM score, expressed as standard scores (*M* = 100, *SD* = 15). When the data were assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box, there were two outliers in the Qualified group (31, 31) and two outliers in the Not Qualified group (-31, -32). Upon further inspection, I concluded that they were neither the result of data entry error nor measurement errors, but genuinely unusual data points. I included them in the analysis because the result was not materially affected. I ran a one-way ANOVA with and without the outliers to determine the effect of the outliers, and the conclusions were comparable.

Normality and Homogeneity of Variances

The assumption of normality is necessary for using a one-way ANOVA (Laerd Statistics, 2015). Data were normally distributed for each group (Qualified and Not Qualified), as assessed by Shapiro-Wilk test ($p > .05$). Additionally, there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .281$).

Results

Data analysis was conducted using IBM SPSS 23 provided by Walden University. The first analysis examined the difference between global IQ scores and WM scores of students who did and did not qualify for special education. The null and alternative hypotheses for this analysis were as follows:

H_0: The difference between WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) and global intelligence will not be significantly different.

H_1: The difference between WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) and global intelligence will be significantly greater in the population of SLD qualified students than evaluated students.

The second analysis examined whether the assessment tool affected WM. The third and fourth analyses examined the differences in the groups by global IQ score and WM scores.

One-Way Analysis of Variance: Differences

I conducted a one-way ANOVA to determine if the difference between global IQ scores and WM scores was different for groups of students referred for a special education evaluation due to a suspected LD. Students were classified into two groups: Not Qualified (*n* = 142) and Qualified (*n* = 99). Differences increased from the Not Qualified group (*M* = 1.25, *SD* = 11.379) to the Qualified group (*M* = 1.61, *SD* = 12.696), between these groups was not statistically significant, $F(1, 239) = .051$, $p = .822$.

One-Way Analysis of Variance: Assessment tools

In order to determine if the assessment tool used impacted the results, I conducted an additional one-way ANOVA. Global IQ scores were normally distributed for each test, as assessed by Shapiro-Wilk tests ($p > .05$). Additionally, there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .702$). Means for the global IQ scores appeared similar for the WISC-IV (*n* = 119, *M* = 93.50, *SD* = 11.737), KABC-II (*n* = 90, *M* = 90.84, *SD* = 11.623), and WJIII (*n* = 32, *M* = 88.28, *SD* = 12.560). Differences between the tests were not statistically significant, $F(2, 238) = 2.956$, $p = .054$. Tukey post hoc analysis revealed no significant differences between any of the groups.

WM scores were normally distributed for KABC-II and WJIII as assessed by Shapiro-Wilk tests ($p > .05$), but WISC-IV was not ($p = .005$). There was homogeneity of variances, as assessed by Levene's test for equality of variances (p = .810). WM means were smallest for WJIII (M = 84.31, SD = 15.509) larger for KABC-II (M = 89.94, SD = 13.249), and largest for WISC-IV (M = 92.42, SD = 13.151), and this difference was significantly different, $F(2, 238) = 4.625$, p = .011. Tukey post hoc analysis revealed that the mean difference from WISC-IV to WJIII (8.108, 95% CI [1.76, 14.46]) was statistically significant (p = .008), but no other group differences were statistically significant.

One-Way Analysis of Variance: Working Memory

Following the original one-way ANOVA, I analyzed the data from a different perspective. I conducted a one-way ANOVA to determine if there was a difference in WM scores expressed as standard scores (M = 100, SD = 15) between the Qualified and Not Qualified groups. There was only one outlier in the Not Qualified group (130) and there were no outliers in the Qualified group. WM scores were normally distributed for Qualified and Not Qualified, as assessed by visual inspection of Normal Q-Q Plots. There was a homogeneity of variances, as assessed by Levene's test for equality of variances (p = .400). WM decreased from the Not Qualified group (n = 142, M = 91.96, SD = 13.062) to the Qualified group (n = 99, M = 88.21, SD = 14.393), and this difference was significantly different, $F(1, 239) = 4.409$, p = .037.

One-Way Analysis of Variance: Global IQ

I conducted a one-way ANOVA to determine if there was a difference in global IQ scores expressed as standard scores (M = 100, SD = 15) between the Qualified and Not Qualified groups. There were two outliers in the Not Qualified group (65, 64) and two in the Qualified group (121, 121). Data was normally distributed for each group (Qualified and Not Qualified), as assessed by Shapiro-Wilk test ($p > .05$). There was a homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .385$). Global IQ decreased from the Not Qualified group ($n = 142$, $M = 93.21$, $SD = 11.424$) to the Qualified group ($n = 99$, $M = 89.82$, $SD = 12.339$), and this difference was significantly different, $F(1, 239) = 4.817$, $p = .029$.

Summary

Initially, I posed one research question: Is there a statistically significant difference evidenced in the difference between a measure of global intelligence (as measured by the WJIII, KABC-II, or WISC-IV) and WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV) by analyzing archival data from two groups: (a) students who have been evaluated and do not qualify for SLD and (b) students who have been evaluated and do qualify for SLD. The null hypothesis was that the difference between WM and global intelligence would not be significantly different. After calculating the ANOVA, the group means were not statistically significant different ($p > .05$) and, therefore, I could not reject the null hypothesis and I could not accept the alternative hypothesis.

To examine the data further, I computed additional ANOVAs and found that the group that was not qualified had higher WM scores ($M = 91.96$, $SD = 13.062$) than the qualified group ($M = 88.21$, $SD = 14.393$), which was a statistically significant difference ($p = .037$). Additionally, global IQ scores were higher for the not qualified group ($M = 93.21$, $SD = 11.424$) than the qualified group ($M = 89.82$, $SD = 12.339$), which was also a significant difference (p = .029). Global IQ scores were not significantly different (p = .054) between tests. WM scores were significantly different between the WISC-IV and WJIII (p = .008) but not between any other groups. I will discuss the implications of all of these findings and directions for future research in the following chapter.

Chapter 5: Discussion, Conclusions, and Recommendations

For more than 30 years, WM has been associated with deficiencies in reading. Previous research has demonstrated that WM has a significant impact on all areas of academic achievement. In addition, the research comparing students with SLD to peers without SLD demonstrates that WM capacity is significantly different in these two groups; however, the relationship between WM capacity and eligibility for special education has been only minimally examined.

The purpose of this study was to quantitatively examine the relationship between WM and special education eligibility for SLD in reading for students evaluated because they were suspected to have a SLD. The target population for this study was K–12 students who had been referred for a special education evaluation for a SLD in a public or charter school in Arizona using archival data from the 2013–2014 academic year.

Initially, I posed one research question: Is there a statistically significant difference on the difference between a measure of global intelligence (as measured by the WJIII, KABC-II, or WISC-IV) and WM (as measured by a WM subtest on the WJIII, KABC-II, or WISC-IV)? I did this by following groups: (a) students who were evaluated and did not qualify for SLD and (b) students who had been evaluated and did qualify for SLD. The null hypothesis was that the difference between WM and global intelligence would not be significantly different. When I ran the ANOVA, the group means were not statistically significant different ($p > .05$) and, therefore, I could not reject the null hypothesis and I could not accept the alternative hypothesis.

To examine the data further, I computed additional ANOVAs, and I found that the group that was not qualified had significantly higher global IQ scores and WM scores than the qualified group. Global IQ scores were not significantly different between tests. WM scores were significantly different between the WISC-IV and WJIII but not between any other groups.

In Chapter 5, I describe the interpretation of these findings within the context of the current literature, explain the limitations of the study, and provide recommendations for further research. I will conclude with some implications of the study findings and a summary of the study.

Interpretation of Findings

Although a significant difference did not exist in the original ANOVA, a significant difference existed between the groups' WM scores. One possible explanation for this is the amount of impact that the WM indices have on the assessments' global scores. On the WJIII, the numbers reversed subtest averages a 0.135 g weight for ages 5 to 17 years (Schrank et al., 2001), and on the KABC-II, the number recall subtest averages a 0.515 loading for ages 5 to 18 years (Kaufman & Kaufman, 2004).

Working Memory Research and Findings

Gathercole et al. (2006) found that students with reading disabilities performed worse on measures of WM capacity relative to nondisabled peers. In addition, when the neuropsychological characteristics of children with dyslexia were examined in comparison with typically developing children, differences have been indicated in global, verbal, and perceptual IQs, impairment in executive functions, phonological WM, semantic memory, and right-left discrimination (Cruz-Rodrigues et al., 2014). Although this study examined only global IQ and overall WM (versus specific subtypes of WM), both global IQ and WM scores were significantly lower in the qualified group, echoing the results found by both Gathercole et al. (2006) and Cruz-Rodrigues et al. (2014).

Nevo and Breznitz (2011) measured WM skills using tasks assessing all of Baddeley's WM components in children at age six. The WM scores accurately predicted the children's reading abilities (decoding, comprehension, and fluency) one year later. In addition, Berninger et al. (2010) found that WM affects both word reading and reading comprehension. These, along with this study's findings, indicate a need for close monitoring of students' WM skills, especially when diagnosing LDs.

Special Education Eligibility Research and Findings

Decker et al. (2013) note that cognitive assessment is not synonymous with IQ testing, especially since specific cognitive abilities are directly correlated with academic skills. The findings in this study support the use of the Ability-Achievement Consistency model of a PSW approach, proposed by Flanagan et al. (2007). This model, based on the CHC theory of intelligence, documents an area of low academic achievement and identifies a deficit in a cognitive ability that is linked by research to the academic area (Hanson et al., 2008). Hale et al. (2010) explain that a method of identifying LDs that "identifies a pattern of psychological processing strengths and weaknesses, and achievement deficits consistent with this pattern of processing weaknesses, makes the most empirical and clinical sense" (p. 228). This is supported by the findings in this and other studies.

Limitations and Generalizability of the Study

One limitation of this study is that since I used archival data, there was no way to increase the sample size. Because of this, I used evaluations that had been completed using three different assessment tools. If I had used evaluations that had all been completed using the same cognitive assessment tool in this study, it may have yielded more accurate results, and ensured the results were not affected by the psychometric differences amongst assessment tools. While the global IQ scores were not significantly different amongst the three used batteries, there was a significant difference between the WISC-IV WM scores and the WJIII WM scores. This may be due to a difference in norming or the way the test is constructed. The mean WJIII WM score was significantly lower, possibly indicating that has a more difficult subtest than the WISC-IV WM.

The results of this study are generalizable to both Arizona and the US. The ZIP codes that are included in the study cover a wide range of socio-economic statuses as well as racial diversity. The sample is similar to the population of Arizona and the United States. The limitation of the generalizability in this study is that because the data were anonymous, there is no way to know if the specific students in the study were distributed across the same racial and socio-economic demographics as the schools'.

Recommendations for Future Research

The results of this study demonstrated that further research is needed surrounding the impact of WM on the need for special education services, specifically for SLD in reading. As noted earlier, it would be ideal to conduct a similar study with students who have all been assessed using the same instrument. Toffalini, Giofre, and Cornoldi (2017) conducted such a study examining intellectual profiles of children who were assessed using only the WISC-IV. For students with SLDs in reading, spelling, and arithmetic, WM indexes were significantly lower from the normative score (100).

Further investigation could also be completed utilizing newer tools, such as the Wechsler Intelligence Scales for Children – Fifth Edition (WISC-5) (Weschler, 2014), which has a new ancillary Auditory Working Memory Index as well as a new sequencing task in the Digit Span subtest. These tasks require intact auditory processes, phonological loop maintenance, executive functioning, and procedural learning (Pearson Education Inc., 2014), so it would be interesting to observe the correlations between these tasks and special education eligibility.

Implications

Social Change at the Policy Level

Implications for positive social change include the addition of this study to the growing literature base regarding special education eligibility for students with SLD. With 67% of states allowing for use of the discrepancy method and half of states not allowing for pattern of strengths and weaknesses approaches (Maki et al., 2015), more research is needed for each of these approaches to SLD identification. Toffalini et al. (2017) demonstrate that discrepancies within the intellectual profile should be accounted for. In addition, Buttner and Hasselhorn (2011) note that while the ability-achievement discrepancy approach is losing favor and RTI is gaining dominance, “the ongoing political and scientific debate concerning which kind of response to LDs is adequate and how it should be implemented indicates that many issues remain unresolved” (p. 81).

Social Change at the Individual and Societal Levels

Individuals with less than a high school diploma have a 12.4% unemployment rate and earn a median income of $471 per week, as opposed to 8.3% unemployment with a high school diploma and a median income of $652 weekly (National Center for Learning Disabilities, 2013). With 19% of students with SLD dropping out of high school, it is clear that better, more targeted interventions are needed. Linking cognitive processes to interventions that are individualized for each child's needs is a practice highly supported by current research (Decker et al., 2013). Thurlow and Johnson (2011) note the importance of individualizing the instructional process in dropout prevention. By closely examining the relationship between WM and special education eligibility, practitioners may be able to implement more research based interventions, creating positive social change for both individual students as well as society at large.

Conclusions

In this current study, I selected a sample of students who had been evaluated for special education eligibility to examine the relationship between WM and special education eligibility for SLD in reading. I designed the research using a one way ANOVA to determine if there was a statistically significant difference evidenced in the difference between a measure of global intelligence and WM by following two groups of students: (a) those evaluated and who do not qualify for SLD and (b) those evaluated and do qualify for SLD. While there was not a significant difference in the original ANOVA, there was a significant difference between the groups' WM scores.

In the 2011-2012 school year, approximately 2,303,000 students in the United States were determined to be eligible for special education services under the category of SLD (NICHY, 2012). It is important that school psychologists, special education teachers, and other professionals who work with students with SLD understand the impact WM has in order to properly design and implement interventions. By closely examining the relationship between WM and special education eligibility, practitioners may be able to implement more precise and meaningful research based interventions for enhancing learning outcomes for students who may be identified with a SLD.

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Appendix A: Data Use Agreement

This Data Use Agreement ("Agreement"), effective as of 2/1/16 ("Effective Date"), is entered into by and between Corrie Wilson ("Data Recipient") and Eleutheria LLC/PBIS Arizona ("Data Provider"). The purpose of this Agreement is to provide Data Recipient with access to a Limited Data Set ("LDS") for use in scholarship/research **in accord with laws and regulations of the governing bodies associated with the Data Provider, Data Recipient, and Data Recipient's educational program.** In the case of a discrepancy among laws, the agreement shall follow whichever law is stricter.

1. Definitions. Due to the project's affiliation with Laureate, a USA-based company, unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the USA "HIPAA Regulations" and/or "FERPA Regulations" codified in the United States Code of Federal Regulations, as amended from time to time.

2. Preparation of the LDS. Data Provider shall prepare and furnish to Data Recipient a LDS in accord with any applicable laws and regulations of the governing bodies associated with the Data Provider, Data Recipient, and Data Recipient's educational program.

3. Data Fields in the LDS. **No direct identifiers such as names may be included in the Limited Data Set (LDS).** In preparing the LDS, Data Provider shall include the **data fields specified as follows**, which are the minimum necessary to accomplish the project: Gender, grade level, date of birth, special education label, test instruments used, global IQ score, and working memory score

4. Responsibilities of Data Recipient. Data Recipient agrees to:

    a. Use or disclose the LDS only as permitted by this Agreement or as required by law;

    b. Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;

    c. Report to Data Provider any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law;

    d. Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Data Recipient under this Agreement; and

    e. Not use the information in the LDS to identify or contact the individuals who are data subjects.

5. Permitted Uses and Disclosures of the LDS. Data Recipient may use and/or disclose the LDS **for the present project's activities only.**

6. Term and Termination.

   a. Term. The term of this Agreement shall commence as of the Effective Date and shall continue for so long as Data Recipient retains the LDS, unless sooner terminated as set forth in this Agreement.

   b. Termination by Data Recipient. Data Recipient may terminate this agreement at any time by notifying the Data Provider and returning or destroying the LDS.

   c. Termination by Data Provider. Data Provider may terminate this agreement at any time by providing thirty (30) days prior written notice to Data Recipient.

   d. For Breach. Data Provider shall provide written notice to Data Recipient within ten (10) days of any determination that Data Recipient has breached a material term of this Agreement. Data Provider shall afford Data Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Data Provider.

   e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

   a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

   b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

   c. No Third Party Beneficiaries. Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.

d. Counterparts. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

e. Headings. The headings and other captions in this Agreement are for convenience and reference only and shall not be used in interpreting, construing or enforcing any of the provisions of this Agreement.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

DATA PROVIDER	**DATA RECIPIENT**
Signed: ______________________________	Signed: _____________________
Print Name: Katie Sprouls, PhD	Print Name: Corrie Wilson
Print Title: CEO	Print Title: Walden Researcher