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Is the Presence of a Specific Learning Disability Related to Working Memory or Social Skills Deficits?

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Is the Presence of a Specific Learning Disability

Related to Working Memory or Social Skills Deficits?

by

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ABSTRACT

As prolific as research on learning disabilities is, there is still a dearth of research examining relationships between learning disabilities and other factors such as working memory and social skills. These relationships are important to study in order to better understand the wide range of impacts disabilities may have. The present study investigated archival data from a training clinic at the University of Calgary to determine if there is a relationship between a diagnosis of a Specific Learning Disability, working memory deficits, and social skills deficits. There were 57 client files which met criteria and were included in the study. A *t*-test and binary logistic regression test were used to analyze the data. Results indicated that working memory and social skill scores did not appear to have a relationship with specific learning disability diagnosis. Implications for future studies and the null results of this study are further explored.

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TABLE OF CONTENTS

ABSTRACT ii
ACKNOWLEDGEMENTS iii
TABLE OF CONTENTS iv

CHAPTER ONE: INTRODUCTION AND RATIONALE 1
Background 1
Purpose of the Study 4

CHAPTER TWO: LITERATURE REVIEW 6
Specific Learning Disabilities 6
Brief history of specific learning disabilities. 6
Early identification method of SLDs. 8
Current definitions and diagnostic criteria of SLD. 11
Current methods for identifying SLD. 14
Working Memory 22
Definition of working memory. 22
Models of working memory. 22
Impact of working memory on academics. 27
Social Skills 29
What are social skills? 29
Relationship between social skills and academics. 30
Summary 31

CHAPTER THREE: METHOD 33
Research Design 33
Participants and Data 33
Measures 34
Weschler Intelligence Scale for Children, Fourth Edition. 35
Behaviour Assessment System for Children, Second Edition. 35
Data Analysis 37

CHAPTER FOUR: RESULTS 39
Data Preparation 39
Working Memory and Presence of SLD 39
Working Memory, Presence of SLD, and Social Skills 40

CHAPTER FIVE: DISCUSSION 42
Interpretation of Results 42
Implications 45
Limitations of Study 46
Future Directions 48

Conclusion 49
References..50

Chapter One: Introduction and rationale

Background

The academic struggles of students with Specific Learning Disabilities (SLDs) have been at the forefront of school psychology research (Altarac & Saroha, 2007). The prevalence rate of SLDs is estimated to be between 5-15% of school age children (American Psychiatric Association, 2013). Specific Learning Disabilities is a term used for students who have a difficulty learning or applying academic skills and who fall well below expected levels for their age in terms of reading, writing, and/or mathematics skills (American Psychiatric Association, 2013). In addition, research has shown that children with SLDs struggle not just in academics but in other areas of their life as well. Individuals with SLDs have a higher rate of long-term negative outcomes in areas such as social skills, peer acceptance, and internalizing problems (Klassen, Tze, & Hannok, 2013; Meier, DiPerna, & Oster, 2006). It is believed that the cognitive processing deficits that contribute to lower academic performance may also contribute to the other negative outcomes some children with SLD experience (Swanson & Harris, 2013).

Researchers do not agree about the importance of cognitive factors in conceptualizing and diagnosing SLDs and, if they do affect academic learning, to what degree they contribute to those deficits. For the current study, cognitive factors (i.e., cognitive processing abilities) are the common components measured on a cognitive test, such as working memory, processing speed, and visuospatial processing. This disagreement on the importance of cognitive factors has led to two camps. Researchers in the first camp argue that cognitive processing deficits are a causal factor of SLDs (e.g., Ashkenazi et al., 2013). For example, Ashkenazi and colleagues' (2013) review showed that neurobiological and cognitive deficits in working memory and visuospatial processing seemed to be the underlying cause of math and reading disabilities in children age 4 - 12. While Ashkenazi and colleagues did not break down math or reading disabilities into different types, such as fluency versus applied math disabilities, they stated that a working memory deficit seemed to be present in most participants with a learning disability.

A second camp believes that a student can have an SLD without a cognitive deficit; although, a cognitive deficit can exacerbate or worsen the outcomes of the SLD (e.g., Lewandowski & Lovett, 2014). For example, Geary and colleagues (2012) claimed that cognitive deficits, notably working memory and visuospatial processing, seemed to intensify but not be a direct cause of mathematical learning disabilities. Similar research has found that learning disabilities do not always have an accompanying cognitive impairment. Some children with math learning disabilities can have cognitive deficits while others show no cognitive impairment (Bartelet, Ansari, Vaessen, & Blomert, 2014).

Spurred by this debate, there has been a renewed interest in studying the effect of cognitive processes on academic functioning (e.g., Passolunghi & Mammarella, 2012) with working memory being one area of research (Baddeley, 2003; Dehn, 2011; Gathercole & Baddeley, 2014). This research has, in line with the current debate, been focused on examining the impact of working memory on academic learning (Baddeley, 2012).

The current study falls into the first camp and views cognitive deficits as highly correlated with the presence of an SLD. As working memory aids in storing, encoding, and utilizing information, it is seen as a crucial component involved in the processes of math calculations and understanding reading passages (Dehn, 2011). Working memory is also required for binding concepts together for all forms of learning. As Cowan (2014) explained, understanding what a parallelogram is requires an understanding and combination of concepts such as parallel, intersections of lines, and basic numerology, all of which are stored in working memory as they are bound together. Working memory serves as the chalkboard or basepoint upon which concepts for math, reading, writing, and all academics work upon as concepts are learnt, combined, and utilized. As such, a deficit in working memory would lead to an SLD given how important working memory is for academics. Multiple studies have found a higher incidence rate of SLD in students who have a working memory deficit (e.g., De Weerdt, Desoete, & Roeyers, 2013; Swanson, 1993; Swanson & Berninger, 1996). This view is further supported by studies showing cognitive factors neurologically underlying SLDs (e.g., Ashkenazi et al., 2013). Thus, the claim is that a working memory deficit would inevitably cause difficulties in academics and a higher probability of a diagnosable learning disability.

Furthermore, working memory has multiple subdomains, such as visuospatial and phonological working memory, with each having their own impact on various aspects of learning. Currently, researchers are examining how specific components of working memory can lead to, or exacerbate, SLDs. For example, Geary (2012) examined visuospatial working memory in students diagnosed with an SLD in math. The study found that students with a math learning disability in the first to fourth grades had lower working memory scores in all areas compared to typically-achieving students. Surprisingly, these students also had lower visuospatial memory scores than persistently low-achieving students. Studies such as this one support the premise that underlying working memory deficits are linked to certain SLDs (e.g., visuospatial working memory deficit correlated with a math learning disability). Although there is evidence that cognitive domains other than working memory, such as visuospatial processing

(Geary, 1993) and processing speed (Shanahan et al., 2006), are also linked to SLDs, working memory deficits, in various forms, seem to be ubiquitously found in all SLDs (Dehn, 2011). As such, working memory is the primary focus for the current study.

A second focus of the current research on SLDs has examined what other aspects of a child's life are affected by the presence of an SLD. Some literature has suggested various secondary outcomes related to the presence of an SLD, including weak socials skills, internalizing problems, and poor well-being (i.e., unhealthy weight; Phillips et al., 2014; Swanson & Malone, 1992; Swanson & Harris, 2013; Upadyaya & Salmela-Aro, 2013). Although all of these secondary outcomes are important, the current study focused on social skills given the amount of research linking social skills to academics (e.g., Cooper et al., 2014; DeLay et al., 2016; Meier, DiPerna & Oster, 2006; Jaffar & Eladi, 2016). Studies suggest weak social skills can have compounding effects for children with SLDs who likely already stand out in a school setting because of their academic struggles. They may experience social isolation, rejection, and bullying (Jenkins, Demaray, & Tennant, 2017; Ozben, 2013).

Purpose of the Study

The goal of the current study was to determine whether the presence of a working memory deficit signified the presence of an SLD, as well as examine how social skills and working memory predict a concurrent SLD diagnosis. There is a wealth of literature in this area already; however, these studies only looked at working memory and other factors in isolation (e.g., Shanahan et al., 2006; Gathercole & Baddeley, 2014). Research has paired working memory deficits and SLDs (e.g., De Weerdt, Desoete, & Roeyers, 2013; Imbo et al., 2007) or academic success and social skills (e.g., Cooper et al, 2014; Kavale & Forness, 1996; Meier, DiPerna & Oster, 2006), but no single study has examined SLD, working memory, and social skills together.

This study examined the presence of working memory deficits and social skills struggles in children diagnosed with a Specific Learning Disability. This study sought to broaden our understanding of the relationship between working memory, SLDs, and social skills when all factors are analyzed within the same population using archival data from a university clinic. Researching multiple variables in a single study is challenging.

A better understanding of the contribution of working memory and social skills to SLD identification may help to improve or to develop interventions that target specific factors when aiding students with an SLD. This research may also highlight potential areas to monitor for students with SLDs, such as social skills, that may be negatively impacted by concurrent working memory deficits. In this sense, interventions could take a more holistic approach, working on both ameliorating underlying symptoms and deficits of SLDs as well as preventing future negative symptoms associated with SLDs, such as poor social skills.

There are two research questions posed in this study:

1. Are there significant differences in working memory scores between SLD and non-SLD cases? It is hypothesized that those with weaker working memory are significantly more likely to have a diagnosis of an SLD.

2. Do weaker social skills and/or working memory raise the probability of having a diagnosis of SLD? Given the literature, it is hypothesized that those with an SLD should be more likely to have a working memory deficit and a low social skills score.

Chapter Two: Literature Review

Specific Learning Disabilities

Brief history of specific learning disabilities.

Specific Learning Disabilities (SLD) have been traced back to Europe starting in the late 19th century when Adolf Kussmaul first coined the term "word blindness" (Kussmaul, 1877). This term was used to describe those who had no vision or intellectual problems yet were unable to read. This finding spurred further research in the 19th century to understand the etiology of SLDs given that there seemed to be no clear cause, such as vision problems. The research that followed focused on the neurological underpinnings of reading and speech disorders, especially after brain injury. For example, Sir Franz Joseph Gall conducted research on patients with brain injuries, noting that his patients' symptoms differed depending on which area of the head was wounded (Gall & Spurzheim, 1818). Pierre Paul Broca and others expanded upon Gall's research in the mid-19th century determining that there were indeed specific disabilities linked to specific brain areas, such as speech articulation difficulties caused by damage to Broca's area (Broca, 1861) and speech comprehension difficulties caused by damage to Wernicke's area (Danly, Cooper, & Shapiro, 1983). Furthermore, in the early 20th century, Sir Henry Head concluded that certain brain lesions could cause sensory issues that could lead to impairment in learning or other cognitive functions (Head & Holmes, 1911). This research helped to solidify the idea that brain damage, resulting in subsequent cognitive deficits, could lead to academic difficulties. However, it was not until later in the 20th century that research began to truly differentiate cognitive ability and academic skills.

Near the middle of the 20th century, theorists began to make a distinction between cognitive ability and academic skills (Swanson & Harris, 2013). Researchers began to conceptualize them as separate entities instead of as overlapping constructs, a view that is still held today, although it is somewhat contentious (National Reading Panel, 2000). In fact, certain diagnostic criteria, such as that of the Learning Disabilities Association of Canada (LDAC; Learning Disabilities Association of Canada, 2015), require both a cognitive and academic assessment for a diagnosis of an SLD, further supporting the idea that these areas are separate. However, there are still areas where the differentiation between academic and cognitive ability is not clear. As an example, vocabulary is a taught academic skill; however, the Cattell-Horn-Carroll (CHC) theory views vocabulary acquisition as an overlap between an academic skill and personal cognitive aptitude (McGrew & Wendling, 2010) and the Wechsler tests measure it as if it was purely an intellectual skill (Wechsler et al., 2003). In CHC theory, vocabulary would not fit into either the purely academic or cognitive category but instead exist on a continuous spectrum between the two. As such, it is not always clear that any singular measure fits cleanly into a specific category, such as vocabulary being purely an academic skill.

Regardless of the difficulty with separating tasks into cognitive abilities, academic skills, or some other domain, it is clear that individual differences within these domains are important to understanding why certain students have an SLD (e.g., Nijakowska, 2012). Research (e.g., Geary, 2014; Imbo et al., 2007) shows that cognitive profiles, coupled with academic profiles, aid in understanding SLDs. As such, to better understand SLDs, research in areas such as working memory is imperative.

Early identification method of SLDs.

In the first half of the 20th century, a student with low achievement was thought to also have lower intelligence (Kirk, 1963), even though there was evidence from the 19th century contradicting this (e.g., Broca 1861). However, this view shifted as cognitive ability and academic skills were separated, and it was recognized that individuals with SLDs could have intact cognitive abilities. In line with this discrepancy, in the 1960s Barbara Bateman created a definition of SLD, which stated that SLDs should be measured in terms of an achievement-aptitude discrepancy (Bateman, 1965). Simply put, she defined an SLD as lower than predicted academic performance based on IQ. As such, the discrepancy model became the focus for both diagnosis and intervention, which sought to raise academic performance to expected levels.

Since then, Bateman's (1965) original model, and the current discrepancy approach that was built upon Bateman's work, has faced four major criticisms. The first criticism of the discrepancy approach is that it requires waiting for students to "fail" sufficiently in academics before they can receive interventions (Torgesen et al., 2001). Waiting for students to fail results in various problems such as SLDs being more difficult to treat when they are diagnosed later in life (Lewandowski & Lovett, 2014). Additionally, other deficits, such as aggression and poor social behaviours (Swanson & Malone, 1992), may begin to surface due to the SLD that is left undiagnosed and untreated. The second criticism is that students may slip through the cracks and not be identified, especially students with low average to borderline intellectual functioning or students who put in more effort than average to overcome their academic deficits. The third criticism is that interventions built around the achievement-aptitude discrepancy approach were ineffective (Talbott et al., 1994), and this is still a concern for current approaches that were built upon the achievement-aptitude discrepancy. The final criticism is that the discrepancy approach has statistical and practical problems, such as poor reliability within the test scores (Fletcher et al., 2007) and no clear guidelines regarding how much of a discrepancy between scores is needed before a diagnosis is given. Furthermore, as highlighted by Fletcher and colleagues (2002), there is virtually no evidence suggesting that the discrepancy model has the reliability and validity to accurately identify SLDs. This can be due to various reasons, such as relying on singular test scores (such as full-scale IQ) gathered at one time point, making it nearly impossible to account for examinee or examiner characteristics (Fletcher et al., 2002). If the examinee did not have proper sleep or food on the day of the test or an abnormal event occurred during testing, such as a major interruption, the test results may be skewed.

As of now, the original Bateman model has been largely discredited (Miciak, Fletcher, & Stuebing, 2015). However, even though it is discredited, Bateman's work set the groundwork for understanding what an SLD is and how to diagnose SLDs. By having a solid understanding of SLDs and properly conceptualizing SLDs, it becomes easier to conduct research on how other factors, such as working memory, impact SLD. Furthermore, many of the ideas espoused by Bateman and others, such as discrepancy scores and cognitive testing, have influenced the practice of assessment, identification, and treatment of SLDs, and have led to the creation of better SLD identification methods (Gresham, Van DerHeyden, & Witt, 2005). As well, in some schools, the achievement-aptitude discrepancy approach is still used as a method of diagnosing and treating SLDs. Although still used, due to all the criticisms previously discussed, practice in both Canada and the United States is currently trending towards using other methods of SLD identification instead of the discrepancy approach, which is no longer a mandated method in the United States (IDEA, 2004).

As well, research, such as the Isle of Wight studies (Rutter, Tizard, & Whitmore, 1970; a compilation of studies referred to as the Isle of Wight studies) and their replications (Rutter, 1989), has attempted to improve the achievement-aptitude discrepancy approach. However, other studies (e.g., Vellutino et al., 2000) were unable to replicate the findings from the Isle of Wight studies and stated that discrepancy scores do not provide any useful information to inform remediation, with some poor readers being easy to remediate and others more difficult. Vellutino and colleagues assert that how amenable the reading difficulty was to intervention had no relation to the scores provided from the achievement-aptitude assessment approach.

From the failings of the original discrepancy model, researchers have tried to take the pieces that work from this model, such as examining the discrepancy between academic scores and assessment of areas other than academics, and create alternative models. For example, while the original discrepancy model waited for children to fail, current models are now proactively identifying cognitive components that may severely impact academics, such as working memory, to aid students earlier (e.g., Berninger et al., 2016). As previously mentioned, children with SLDs often have normal cognitive ability; however, researchers believe that there could be differences in children's cognitive profiles that may be indicative of future academic problems. Some researchers (Fuchs et al., 2012) have looked at individual components of cognition and noted that they seem to be predictive of learning disabilities. For example, children's phonological processing (Fuchs et al., 2012) and their skill in rapid automatized naming (Araújo et al., 2015) predicts their reading performance (Fuchs et al., 2012). Furthermore, researchers have noted that children with SLDs commonly show poor working memory performance (Swanson et al., 1990; Swanson & Harris, 2013). Currently, relationships between other cognitive domains (e.g., visuo-spatial) and SLDs (Kohli et al., 2005) are being researched, finding that math SLDs seem to be linked to visuo-spatial processes. However, while these connections are important for understanding the epidemiology of SLDs, this study's focus remains primarily on working memory given its strong links to multiple SLDs.

Current definitions and diagnostic criteria of SLD.

Before moving on to current models used to identify SLD, it is prudent to discuss common definitions of SLD in Canada. Currently there are two common definitions and accompanying diagnostic criteria used for diagnosing SLDs in Canada: the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association [APA], 2013) and the Learning Disabilities Association of Canada (LDAC, 2015). Another set of diagnostic criteria for SLDs, which has influenced LDAC, is the tenth revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10; World Health Organization, 2010). As well, the Individuals with Disabilities Education Improvement Act (IDEA, 2004), which ensures that students with disabilities receive aid, special education, and interventions, is also used to classify SLDs for educational purposes. However, for this study, given the prevalence of the DSM and LDAC diagnostic methods within Canada, only those two definitions and diagnostic criteria will be reviewed.

The DSM-5 (APA, 2013) defines SLD as difficulties learning and using academic skills, specifically in the areas of reading, written expression, and/or mathematics (American Psychiatric Association, 2013). Each of these areas of disability can be either in core processes, such as word recognition and fluency or higher level processes, such as comprehension, application, content, and organization (APA, 2013). For a DSM-5 diagnosis, the person must show difficulty in at least one of the following: reading fluency, reading comprehension, spelling, writing, arithmetic facts, number sense, or mathematical reasoning. These difficulties must be below what would be expected for the person's age and cause significant interference with academic and/or occupational performance. Finally, the academic difficulties cannot be better explained by another reason such as poor visual acuity, lack of proficiency in the necessary language, or an intellectual disability. Once these criteria are met, a diagnosis of an SLD is made in reading, written expression, or mathematics, with the potential for comorbid SLD diagnoses. As well, a person receiving a diagnosis is assigned a severity level ranging from mild to severe based upon how many academic domains the person struggles with, the expected amount of support needed, and the likelihood that the person can finish academic tasks accurately and efficiently given supports.

The other frequently used definition is provided by the Learning Disabilities Association of Canada (Learning Disabilities Association of Canada, 2015). Of note, LDAC does not use the word "specific" when talking about SLDs, and instead uses just LD. Even though LDAC does not use SLD, the LDAC's definition aligns with the concept of learning disabilities having specific types and features. To improve continuity, and given that SLD and LD are used interchangeably, the term SLD is used throughout this document. LDAC defines SLD as a disorder that impacts acquisition, organization, retention, understanding or use of verbal/nonverbal information (LDAC, 2015, para. 1). For an LDAC diagnosis, the person must show interference with the acquisition and use of at least one of the following: oral language, reading, written language, or mathematics. The person may also show difficulties with organizational skills, social perception, social interaction or perspective taking. These difficulties must not be explained by factors such as hearing/vision, socio-economic factors, ineffective teaching, or lack of motivation. A diagnosis also requires that the person demonstrates at least average intellectual functioning. The diagnosis given can range in severity and in the number of domains affected.

There are some similarities between the LDAC and DSM-5 definitions of SLDs, including a range of severities, impact on various areas such as math and reading, and lifelong impact; although symptomology can change over time. However, there are also some key differences.

The first major difference is that the LDAC stipulates that an assessment of cognitive processing must be part of the diagnosis of an SLD; whereas, the DSM-5 does not require it. With regards to the DSM-5, the need for assessing cognitive processing was removed in this edition. This was due to the committee's view that there is a lack of evidence suggesting the effectiveness of both utilizing and accurately measuring cognitive processing scores, as processing deficits are usually inferred from cognitive tests and not directly measured (Tannock, 2013). However, LDAC is not the only organization to continue to include cognitive processing in SLD identification. Both the ICD-10 and the IDEA (2004). The second difference is that the DSM-5 no longer excludes SLD identification when intellectual functioning falls in the below average range (e.g., standard score < 70), while the LDAC definition continues to require the student to have an average or above intelligence to qualify for an SLD diagnosis. The third and final difference is the stance on the influence of neurological processes on SLD. The LDAC definition states that SLDs are due to genetic and/or neurobiological factors or injury which, in turn, impact learning processes. On the other hand, the DSM-5 states that there is a lack of evidence linking learning disabilities to cognitive or neurological factors. Furthermore, the DSM-5 asserts that the neurological factors present in neuroimaging studies of SLDs (e.g., Longcamp et al., 2016) are also found in other neurodevelopmental disorders (e.g., ADHD) and do not have the specificity needed for diagnostic purposes. While both definitions have merits, the divide that these opposing views create in the research makes results more difficult to analyze. Without a consistent definition and set of parameters, research comparing factors such as working memory to SLDs is burdened by researchers using different definitions for the same construct.

Current methods for identifying SLD.

In addition to the application of the discrepancy model as a method for identifying SLDs, three additional methods are currently being utilized in the field: Cognitive processing approach, Response to Intervention (RTI), and Low-achievement approach (Lewandowski & Lovett, 2014). Unfortunately, while it would be beneficial to discuss the specificity and sensitivity of each method, this information is not currently available.

Of note, a difficulty for all methods is how to deal with comorbid diagnoses. It would make research and intervention easier if students only had a singular diagnosis, such as either SLD or ADHD. However, in practice students more often have comorbid diagnoses (DuPaul, Gormley, & Laracy, 2013; Koolwijk et al., 2014). Within just SLDs, it is rare for a student to only have one type (Willcutt et al., 2013). Research must therefore account for comorbidities when both diagnosing SLDs and conducting SLD research and choosing whether to incorporate or dismiss comorbid diagnoses.

Cognitive Processing Approach. The cognitive processing approach has evolved over time, with the most popular early version being the IQ-achievement discrepancy model (Lewandowski & Lovett, 2014). As previously noted from the work of Barbara Bateman (1965), the discrepancy model of SLD identification required a discrepancy between performance on an intellectual and academic assessment. Given the issues with this model, researchers began to build models based on cognitive theories in order to overcome the weaknesses apparent in the discrepancy approach. For example, the processing strengths and weaknesses (PSW) model was built upon the Cattell-Horn-Carroll (CHC) theory. The CHC theory assumes that there is an overarching intelligence, called general ability or *g*, which can be measured. However, there are also multiple subcategories of *g*, such as fluid reasoning and quantitative knowledge, which are represented within *g* but also can be individually measured (McGrew, 2005). Each of these subcategories are related to certain aspects of academic performance; for example, students who have poor spatial relations or processing speed, which are subcategories of *g*, are more likely to struggle in math or reading respectively and are more likely to have a diagnosable SLD in their respective area of deficit (Niileksela & Reynolds, 2014).

In terms of diagnosing SLDs, clinicians can use models based off the CHC theory, such as the Processing Strengths and Weaknesses (PSW) model. The PSW model, when testing for and determining cognitive strengths and weaknesses, uses many of the same factors that CHC uses (Flanagan et al., 2013). By using these same factors, the PSW model attempts to find isolated weaknesses in cognitive functioning, through assessment, which then match on to specific areas of academic concern. Furthermore, the PSW model looks at cognitive areas that do not relate to the academic area in concern to determine strengths that the students may have. For example, students who struggle with math and have a strength in quantitative reasoning and a weakness in processing speed will be far different than students who struggle with quantitative reasoning but demonstrate average processing speed. The PSW model has also been used to help create interventions or better understand the epidemiology of a diagnosed SLD (Miciak et al, 2014). From the PSW model, other models are being created. One example is the Concordance-Discordance Model of SLD identification which analyzes discrepancies between a processing strength and weakness, as well as an achievement deficit that is directly related to the processing weakness, in order to identify children who are most likely to have an SLD (Hale & Fiorello, 2004).

Response-to-Intervention. The second model, RTI, is used more commonly in the United States but is beginning to appear in Canada. RTI is not an entirely new concept but is instead an amalgamation of various techniques schools were already implementing, such as applied behavioural analysis and constant monitoring strategies (Brown-Chidsey & Steege, 2011). RTI pulled these systems into a singular construct with various levels built into the program which students move between based on data gathered within each level (Brown-Chidsey & Steege, 2011). As such, RTI is a behavioural model with a focus on evidence-based general instruction, frequent observations, interventions, and data-based decision making. The RTI model has a strong evidence base for not only providing interventions for students struggling with academics but also for identifying and diagnosing SLDs in many students according to proponents (Kovaleski, VanDerHayden, & Shapiro, 2013; Miciak, Fletcher & Stuebing, 2016; Reschly, 2014). However, using RTI to diagnose SLDs is not universally accepted. Researchers from other approaches state that SLDs are linked inextricably to basic cognitive processes, and since RTI does not measure cognitive processes and instead looks at whether students are struggling academically or not, it can not be an effective diagnostic method (Batsche, Kavale, & Kovaleski, 2006; McKenzie, 2009; Willis & Dumont, 2006).

In RTI, all students receive evidence-based instruction and are screened globally while in tier 1 (general education) to identify struggling students. For example, all students in a certain grade are assessed using a screener three times per year (i.e., fall, winter, spring), which often uses state or larger norm base. Students who do not meet a predetermined cut off, which varies between school districts and sometimes between schools, require more specialized supports and are moved to tier 2. In tier 2, students are given small group interventions to aid their specific struggle, such as reading comprehension or math fluency (Reschly, 2014) with consistent progress monitoring for determining tier movement. If insufficient progress is made, they are given individual interventions as part of tier 3. Tier 3 is considered by some to be special education and to be the final step before special education by others, within which students receive specialized, sometimes one-on-one, treatment (Fuchs, Fuchs, & Stecker, 2010). In RTI, typically students are considered for an SLD diagnosis when they fail to respond to the interventions provided throughout the tiers (Lewandowski & Lovett, 2014); however, they may receive a diagnosis before tier 3 as this tier is sometimes considered special education.

As mentioned, RTI is used by some schools to identify SLDs and implement interventions for these students. However, RTI has six major issues. First, there is a difficulty implementing evidence-based instruction in general education. For example, Fuchs and Fuchs

(2006) stated that evidence-based instruction is difficult to implement and ensure it is administered with fidelity but is required within RTI to ensure that students receive sufficient education and are not incorrectly identified as having an academic struggle. As well, it also requires a system-wide implementation within the school which is not easy (Ikeda et al., 2007). Second, Reschly (2014) detailed the high cost of implementing RTI in terms of money, resources, and time. For example, large amounts of resources (e.g., money, teacher time, space) are required to ensure treatment and progress monitoring fidelity throughout the RTI process. As the cost per student rises with each tier level, this can exacerbate the issue of determining which students belong in which tier in order to properly allocate resources. Third, given the fact that students must go through multiple tiers as well as multiple iterations of interventions before they can even reach the point of potential diagnosis, this method of SLD identification is the slowest method of diagnosis. Fourth, cut-off scores are inconsistent between areas. In practice, the cut offs for moving between tiers and potential diagnosis are not well defined, with each jurisdiction implementing them in slightly different ways to suit their own needs leading to problems with fidelity (Fuchs & Fuchs, 2006). As well, how much progress is needed to move between tiers is also unclear. Overall, there is no standardized method of determining when adequate progress is made or even what adequate progress looks like in order to move students between tiers. Fifth, if the RTI model is not conducted with fidelity, such as not using multiple academic measures or the use of ongoing assessments, then RTI loses much of its benefit. Furthermore, other researchers (e.g., Mastropieri & Scruggs, 2005) acknowledge that RTI is not always accurate, and due to a lack of consistency with implementation across states and borders, it is difficult to maintain fidelity with regards to implementation. Sixth, there is no system in place to address the needs of those students who do not respond to intervention at tier 3. As they are already receiving individualized treatment at this tier, RTI does not have guidelines for how to help these students further and may need to look to outside sources.

In sum, some researchers view RTI as having a strong evidence base for use as an approach to SLD identification. However, there are criticisms of RTI such as its diagnostic ability, lack of consistency between schools, and inconsistent cut-off scores. In addition to these criticisms, RTI also has multiple barriers to implementation, such as requiring a large commitment of time and resources to ensure stringent monitoring systems and treatment fidelity.

Low-Achievement Approach. The final way of identifying SLD is commonly referred to as the low-achievement approach. As explained by Lewandowski and Lovett (2014) as well as originally by Siegel (1992), it is a very quick way of identifying an SLD that tries to minimize subjectivity by emphasizing specific cut-off scores. In this approach, if a student has a score on an academic achievement measure, below a certain percentile (e.g., below the 16th percentile) and shows impairment in real-world academic functioning, through poor grades in the classroom, then the student would be diagnosed with an SLD.

Early adopters were convinced of this identification method’s utility because students who performed poorly in reading, regardless of the cause, seemed to benefit from interventions (e.g., Talbott, Lloyd, Tankersley, 1994; Weinstein & Cooke, 1992). However, even Talbott and colleagues (1994) in their review recognized that while the interventions appeared to provide benefits, there were gaps between research effects and their transferability to actual classrooms. They discuss three main reasons for these gaps. First, in the studies they reviewed, the control group had no treatment provided which is not usually the case in schools where all students may receive some extra help from teachers or outside of class. Second, the authors provided the treatment to the experimental groups, which is not standard in schools as treatment is usually provided by teachers who often do not have specialized intervention training. While this is a criticism it is also common in research of other diagnostic methods. Lastly, the effects of intervention were measured on retell assessments and may not translate to better performance on actual school assignments or academic work.

The low-achievement approach shares some similarities with the RTI model. First, they both use cut-off scores to assess the eligibility of a student to be given more specialized services or interventions. However, these cut-off scores, whether comparing the students' scores in a norm-based or criterion-based approach, are used differently. In the RTI model, cut-off scores are used to determine the initial need for intervention of a student, whereas in the low-achievement approach, these cut-off scores are solely used for diagnosing. Second, both RTI and the low-achievement approach do not normally use cognitive assessment. The use of cognitive assessments is currently debated within the field, with proponents of cognitive assessment stating its importance for developing effective interventions and accommodations (Decker, Hale, & Flanagan, 2013) and detractors asserting that cognitive assessment has not yet been supported enough to be used for SLD diagnosis (McGill & Busse, 2017).

For diagnosing, the low-achievement approach looks at what academic area the client is struggling with and then diagnoses based solely on that academic performance. As such, it can discriminate between various types of learning difficulties; however, it lacks the information to determine why a student may be struggling, such as varying cognitive profiles or ecological factors, which are considered important when determining interventions (Cohen, 2014). For example, this approach may identify two children struggling with reading fluency, but it cannot explain why each child struggles in that area. Furthermore, cognitive profiles, which the low-achievement approach lacks, are important and can be used to inform academic interventions and allow for accommodations for the student so that the intervention has a higher chance of success. In conclusion, the low-achievement approach has its strengths, such as its efficiency, but there are concerns regarding the sometimes-arbitrary cut-off scores and lack of cognitive factors, which vary in importance to different researchers and practitioners.

There are a variety of methods for identifying SLDs, and currently, there is no gold standard for diagnosing SLDs, with each method having strengths and weaknesses. The debate regarding which diagnostic method is the best is still ongoing. This difficulty in coming to a consensus on how to diagnose SLD has lead to difficulties when discussing SLDs and conducting research in this area, such as two studies using different methods of diagnosis for SLD leading to different sample populations being studied (Scanlon, 2013). As such, research results have been divided, with the results being highly dependent on which method of diagnosis was used in the study. Even the current study suffers from this, as SLD diagnostic method was unknown for participants.

For this study, SLD types are not split into distinct types such as math or reading SLDs. SLDs are treated as a singular group for this study because research has shown that regardless of type of SLD or diagnostic method, most children diagnosed with any SLD demonstrate a deficit in working memory, especially in terms of the executive processing component (detailed later; Imbo et al., 2007; Swanson et al., 1990).

Working Memory

Definition of working memory.

Working memory is defined as a system that retains a small amount of information in a readily accessible form for immediate processing (Cowan, 2014). Working memory is a system that gathers information from either sensory systems or long-term memory. Afterwards, it temporarily stores this information and manipulates it, adding details or connecting it to other memories, before either forgetting it or storing it in long-term memory (Bayliss, Jarrold, Gunn, & Baddeley, 2003). While the definition of working memory has not changed much, multiple models have been created that explain the processes underlying working memory and how it interacts with various systems, such as long-term memory.

Models of working memory.

In his comprehensive review of working memory, Dehn (2011) identified six major models of working memory: 1) Information Processing, 2) Atkinson-Shiffrin, 3) Levels-of-processing, 4) Baddeley's Model, 5) Kane and Engle's Executive Attention, and 6) Cowan's Embedded Process. However, while the first three models served as significant stepping stones for later models, they have not been supported reliably enough to be considered current models. Currently, Kane and Engle's Executive Attention and Cowan's Embedded Process models are under significant review and research to further establish their credibility. Meanwhile, the Baddeley model has undergone the most extensive research and revision and is considered a strong model of how working memory functions. Due to this, it is the main model focused upon for future discussion, but the Kane and Engle model and Cowan's model are discussed for comparison purposes.

Kane's and Engle's Executive Attention Model. The Executive Attention Model (Kane et al., 2001) focuses on working memory as a separate construct from short-term memory. Kane and colleagues state that working memory is reliant upon inhibition, which is the process of inhibiting external stimuli from interfering with focus on a specific stimulus. As such, how much individuals can store and manipulate in working memory at one time is dependent on how well they can focus on relevant stimuli while simultaneously inhibiting attention to distracting stimuli (Kane et al., 2001). In terms of retrieval, Kane and Engle (2000) showed evidence that working memory is based on cued recall to retrieve information from either long-term memory or recently forgotten information from short-term storage. Furthermore, this model allows for individual differences. For example, some individuals may be better at sifting through and using cues to guide memory retrieval while others become inundated by external stimuli and are poorer at memory retrieval when multiple cues are given. The defining aspect of this model is that inhibition is the key determinant of working memory capacity and efficiency.

Cowan's Embedded Process Model. Cowan (2001) developed a model of working memory linked to long-term memory. His model stated that there are multiple levels of activation within a single memory system, which he refers to as long-term memory. To simplistically explain this model, all information is stored in long-term memory and is "retrieved" when the section of long-term memory that holds specific information rises above a certain level of activation. Thus, working memory and long-term memory are not separate constructs but two interwoven systems that work together. As such, the senses pull information from the surroundings which then activates long-term memories associated with this information. At this point, the new information coming in is manipulated and combined with the information stored in the activated area of long-term memory in an attempt to interpret the new information and potentially form new memories or change old ones.

Since this model relies on activating parts of long-term memory, ability to focus on specific memories will determine efficacy in retrieving and manipulating memories. Furthermore, Cowan (2005) suggested that items outside of the focus of attention but still within long-term memory storage are also activated, which can lead to retrieval of unnecessary or interfering memories. For example, while studying for an exam and reviewing notes, one may also activate unnecessary memories tied to taking those notes, such as humourous conversations or useless anecdotes provided during instruction. These unnecessary memories can interfere with focusing on the pertinent memories, such as those regarding the actual studying material, and "clog up" the working memory space needed for studying. Working memory capacity, as a result, is bound more by the attentional capabilities than actual storage capacity.

To expand on this model, Oberauer (2002) focused on the aspect of divided activation in long-term memory. He posited that multiple areas of long-term memory could be activated at the same time, potentially up to four at once. The focus of attention would move between these simultaneously activated areas and process them in turn. However, these activated areas may interfere with each other and distort or misrepresent memories brought into working memory. As such, people are better off focusing on a single item instead of dividing attention among various items that activate long-term memories inadvertently. While it is difficult to only focus on a single memory, this can be aided by minimizing external stimuli, such as avoiding trying to study while also watching a movie which increases the stimuli that can potentially activate areas of long-term memory. If it is ever necessary to focus on multiple memories, such as remembering multiple math rules at once for a complex problem, the recall of these memories, with enough practice and repetition, can become automatized and require less resources to activate and recall, thus reducing the chance of interference between memories.

Baddeley's Model. Originally proposed in 1974, Baddeley's model has seen multiple iterations and changes over time and is currently considered one of the most comprehensive models of working memory (Dehn, 2011). The current model consists of four main modules: phonological loop, episodic buffer, visuospatial sketchpad, and central executive (Baddeley, 2006). The phonological loop analyzes and interprets aurally presented information and manipulates it. Whereas visually presented information, which can be composed of either visual or spatial components, is analyzed by the visuospatial sketchpad. Both of these mechanisms have their own storage capacity, with the phonological loop having a smaller available capacity than the visuospatial sketchpad for most people. Furthermore, retention of information currently being processed by the visuospatial sketchpad or phonological loop can be improved through repetition, by reciting the information in one's head over and over for the phonological loop or looking at stimuli repeatedly over a short interval for the visuospatial sketchpad.

Both modules, referred to as slave modules by Baddeley (2006), are controlled and regulated by the central executive. This module acts as a magnifying lens, focusing on only the most important pressing bits of information collected by the phonological loop and visuospatial sketchpad. This allows people to work on simultaneous tasks and not be overloaded by the information, as well as to integrate oral and visual information into unified memories. The episodic buffer, the newest addition in this model, further aids the central executive in this task. This module extracts information from long-term memory to integrate it with information currently being processed by the central executive, and it controls directed searches of long-term memory. It is also the major component used in encoding new information into episodic long-term memory. The episodic buffer does this by acting as a direct interface between long-term memory storage and the information currently stored within the visuospatial sketchpad and/or the phonological loop. Through this direct interface, the episodic buffer can modify long-term memories by adding information from the slave modules, or store new information after repeated exposure (Pickering & Gathercole, 2004).

For this study, the Weschler Intelligence Scale for Children – Fourth Edition (WISC-IV, Wechsler et al., 2003) was the measure chosen for assessing working memory. The WISC-IV aligns with the Baddeley working memory model, with the phonological loop being tied closely to the working memory subtests. With the release of the WISC-V in 2014, a visual working memory subtest, that uses the visuospatial sketchpad, has been added which improves its alignment with the Baddeley model. The WISC-IV, using the Baddeley working memory framework, has been used to analyze both verbal and visuospatial working memory (Pham & Hasson, 2014). As well, when trying to show the reliability and validity of other working memory measures, based on the Baddeley model, the WISC-IV has been used as the measure of comparison (St Clair-Thompson, 2014). Furthermore, Colliflower (2013) states that the WISC-IV aligns theoretically with the Baddeley working memory model in that both believe working memory and attention are closely tied together. The working memory index score is comprised of two subtests: Digit Span and Letter-Number Sequencing. Both tasks use the phonological loop and are auditory recall tasks. However, the forward span portion of the digit span task, which involves repeating digits in the same order they are heard, does not require any modules other than the phonological loop and is not considered a strong test of working memory (Rosenthal et al., 2006).

Impact of working memory on academics.

Working memory has been consistently linked to various forms of learning disabilities. Some studies have attempted to link certain deficits in working memory, such as poor functioning of the central executive module of working memory, to specific types of learning disabilities, such as a math disability (Imbo et al., 2007). While each component of WM can impact academic performance, the executive component has consistently been shown to be the most likely to be impaired in students with learning disabilities (Swanson et al., 1990). Furthermore, other studies have found a deficit in working memory was present in all students diagnosed with an SLD, regardless of academic area impacted (De Weerdt, Desoete, & Roeyers, 2013; Swanson, 1993; Swanson & Berninger, 1996). Measuring the executive component is difficult as researchers must parse out its use from that of the slave modules, which is normally done through concurrent memory load tasks such as remembering digits while sorting cards. The executive component is especially important during the WISC-IV digits backward task due to the increased attentional demands (Rosenthal et al., 2006). As discussed next, more recent studies have begun to uncover links between specific working memory deficits and certain SLDs. The components discussed in this section of working memory are pulled directly from Baddeley's model.

In terms of specificity, Dehn (2011) detailed in his summary which academic areas are frequently linked to specific working memory components. For example, mathematics is often linked to both visuospatial and executive aspects of working memory; whereas, decoding during reading is more closely related to the phonological loop. However, the connection between academics and working memory components is not always clear cut. Overlap exists between components of working memory and academic areas. For example, verbal working memory has been linked to both written language in deaf students and reading comprehension (Arfé, Rossi, & Sicoli, 2015; Argyropoulos et al., 2017). Before any correlation can be made between a working memory deficit and any SLD, a sensitive assessment measure is needed to determine if there is an underlying working memory deficit and also determine what type of working memory deficit it is.

While Dehn (2011) reviewed mounting evidence for the link between working memory and SLDs, it is still unclear what mechanism causes this link. There are two potential relationships. First, there could be a problem with manipulation of information within working memory (Ericsson & Kintsch, 1995). For example, two related math facts being manipulated in working memory might be meshed together improperly, such as manipulating decimal digits and basic addition facts at the same time, leading to an incorrect solution. Second, perhaps there is a lack of working memory capacity, leading to a student being unable to process enough information at once to solve complex math or comprehension questions (Henry, 2001). However, there is still no single relationship with enough evidence to be considered proof of a causal relationship. As Dehn (2011) stated, the direction of the potential relationship is still under investigation. It is unknown whether working memory deficits cause learning disabilities or if a lack of adequate learning leads to a working memory deficit.

Social Skills

What are social skills?

Social skills are defined as verbal and non-verbal behaviors used with the goal of a optimizing social reinforcement through the use of effective and appropriate initiations and responses (Merrell & Gimpel, 2014). Appropriate social skills change depending on context and can be learnt or improved by intervention. Thorndike (1927) originally proposed that social skills, alongside adaptive behaviors, which are the tools that children use to function within the world such as language development and academic competencies, fell under the umbrella of social competence. Thorndike (1927) stated that social competence was one of three types of intelligence, alongside cognitive and academic intelligence, and is the sum total of people's performance in responding and adapting to fluctuating social situations in various areas of their life. A working model of social competence was created by Graham and Reschly (1987) and is still considered relevant and used today (Merrell & Gimpel, 2014). However, the model is still being modified and contested, especially when discussing the importance of adaptive behaviours with some proponents believing that social skills should be under adaptive behaviours instead of viewed as a separate construct (Merrell & Gimpel, 2014).

Social competence, using the subdomains of social skills and adaptive behaviours, is measured in terms of the success of socially acceptable behaviours. Being accepted by peer groups is one example of social success. Researchers (e.g., Gresham & Elliott, 1987) have found that students can have deficits in either acquiring or appropriately performing social skills and adaptive behaviours during social interactions. This finding has been incorporated into commonly used assessment measures such as the Behavior Assessment System for Children –

Second Edition (Reynolds & Kamphaus, 2004, BASC-2; Papazoglou, Jacobson, & Zabel, 2013). With this definition, researchers have begun to explore how social skills are impacted by, and impact other, areas such as academics.

Relationship between social skills and academics.

The importance of social skills cannot be overstated. Strong social skills benefit people of all ages and lead to positive outcomes in multiple domains, such as school and work. For example, Meier, DiPerna, and Oster (2006) found that students in Grades 1 to 6 who were more cooperative with their peers in class during social interactions were rated more favorably and more likely to academically succeed by their teachers. Strong social skills in childhood later benefit adults in creating stronger work teams and maximizing work output in many job settings (Morgeson et al., 2005). As such, anything that impedes or diminishes social skill development can lead to a more challenging time making friends and performing well in a social environment. Further, difficulty forming social connections and having under-developed social skills has been linked to multiple negative outcomes such as depression (Nilsen et al., 2013), poorer life satisfaction (Ozben, 2013), and higher anxiety symptoms (Motoca, Williams, & Silverman, 2012).

In a meta-analysis, children with learning disabilities were often less liked, more likely to be rejected, and demonstrated more aggressive and anti-social behaviours (Swanson & Malone, 1992) than their peers, as measured mostly through teacher and self-assessments. This has been seen at various ages and appears to be more harmful during the transition to high school than during elementary and middle school (McIntosh et al., 2008). Another meta-analysis (Kavale & Forness, 1996) found that those with an SLD usually have a concurrent social skills deficit.

However, they state that the relationship between SLDs and social skills, though some current research has found similar results suggesting those with an SLD struggle to use adequate social skills (Filippello, Marino, Spadaro, & Sorrenti, 2013). As such, much of this work on SLDs and social skills is correlational and both causality and directionality are unknown. There are currently three main hypotheses that could account for the relationship between social skills and academic performance. First, academic skills predict social skills. For example, students who were higher achievers in school seemed more inclined to have social interactions and build social skills (Jaffar & Eladi, 2016). Second, poor social skills may lead to poor academic performance. Students who struggle with proper social interactions may lack peers to work on assignments together or may be more disruptive in the classroom due to poor social interactions and thus suffer academically (DeLay et al., 2016). Finally, a third variable may mediate the relationship between social skills and academic success. For example, some reviews have hypothesized that a third variable, such as inattention (Spira & Fischel, 2005) or anxiety (Strahan, 2003) are linked to both social skills and academic deficits.

Summary

Current research has been focused on determining links between working memory, social skills, and SLDs. This research is complicated by multiple definitions and methods of diagnosing SLDs and varying models of working memory. Mounting research, as reviewed by Dehn (2011), supports a correlational link between working memory and SLDs, with certain types of working memory being more strongly correlated to certain SLDs. The link between social skills and SLDs is much less tenable, with no studies currently finding a causal link, though many finding a correlation. Researchers are still trying to determine what relationship, if any, exists between social skills and SLDs and other intermediary variables that may impact this relationship. For working memory and social skills, research is still mostly theoretical with no relationship found yet but multiple ideas as to how they may interact. Finally, no study has looked at the relationship between all three variables together, and this study seeks to fill this hole.

Chapter Three: Method

The purpose of the current study was to analyze the relationship between working memory scores and the presence of an SLD in a clinical population. As well, the impact of social skills scores and working memory scores on the probability of an SLD being present was also analyzed. This chapter describes the method used in this study. As this study used archival clinic data, the focus of this chapter is primarily on research design, participants, measures utilized, and the analyses chosen to answer the research questions.

Research Design

The current study used archival data from assessment files from a university-based clinic at a large university in western Canada. Clients consented for their assessment data to be used for research when they consented to services. Based on the previous literature review, these clients were considered an acceptable population that already has the necessary data collected over the course of four years. The variables included in the analyses are working memory scores, social skills ratings, and the presence of a diagnosed SLD.

Participants and Data

This was a convenience sample of 57 children (Mean age = 10 years, 2 months, SD = 2 years, 3 months) who met the inclusion criteria (outlined in the next paragraph). There were 20 females and 37 males. Nineteen had a confirmed diagnosis of an SLD. Of those diagnosed with an SLD, there were 10 males and 9 females. Current gender ratios in public schools suggest that approximately one third of students with an SLD are female (Cortiella & Horowitz, 2014). As such, there was higher number of females with an SLD in this sample which may be due to the small sample size or the differences between clinical and non-clinical samples (Thurston, 2008).

Given the difficulty with retrieving the actual files, as well as how the data was catalogued and retrieved, other variables of interest such as socioeconomic status or educational level of parents were unavailable for analysis and is a limitation of this study.

Participants' files were included in the analysis if the participants were a) between the ages of 8 to 16 years old; b) had been administered the Weschler Intelligence Scale for Children – Fourth Edition (WISC-IV, Wechsler et al., 2003); c) given the Behavior Assessment System for Children – Second Edition (BASC-2, Reynolds & Kamphaus, 2004); and d) had not been diagnosed, either previously or during assessment, with an Intellectual Disability. As this was archival data, not every participant had the same parts of the BASC-2. For instance, some included only the parent reports, whereas some included self-reports and teacher reports as well. For the present study, only parent reports were utilized for analysis purposes because of the small number of teacher and self-reports. Of the 57 files reviewed from 2011 to 2016, 26 had accessible BASC-2 social skills scores. As such, only these participants were used during analyses involving social skills, which required a BASC-2 social skills score, while the remaining 31 clients were excluded for social skills analyses but still included in analyses not involving social skills.

Measures

The cognitive and social skills measures included in this study are commonly used in the field of school psychology and were used with the majority of the clinics' clients. Given this, and their strong reliability and validity, the Weschler Intelligence Scale for Children, Fourth Edition (WISC-IV) working memory index was chosen as a measure of working memory while the

Behaviour Assessment System for Children, Second Edition (BASC-2) was chosen as the social skills measure.

Weschler Intelligence Scale for Children, Fourth Edition.

The WISC-IV is an intelligence measure that assesses verbal comprehension, perceptual reasoning, working memory and processing speed. The scores of two subtests make up the Working Memory Index: Letter-Number Sequencing and Digit Span. Both of these tasks measure verbal working memory. The index demonstrates strong internal-consistency reliability (<0.90), a test-retest reliability between 0.84 to 0.93, and a strong inter-scorer agreement (<0.90; Drozdick et al., 2012). The WISC-IV has shown strong predictive validity both in terms of multiple standardization samples as well as its replication across major ethnic groups and various countries around the world (Drozdick et al., 2012). Furthermore, it has convincing evidence supporting it as a clinical tool for detecting disorders such as ADHD, SLDs, and Autism Spectrum Disorder (ASD), among others. Finally, Drozdick and colleagues (2012) outlined strong correlations between the WISC-IV and other cognitive measures (e.g., DAS-II and KABC-II) with correlations between 0.76 and 0.87. For this study, only the working memory index data was used; although, the full WISC-IV battery was administered to each client. While the fifth edition of the WISC was released in 2014, not enough clients were given that version to provide an adequate sample size.

Behaviour Assessment System for Children, Second Edition.

The BASC-2 is used to assess behaviour through various reports (e.g., teacher, parent, and child reports) and is designed to be used with individuals aged 2 to 25 years. The BASC-2 measures Externalizing Problems, Internalizing Problems, and Adaptive Skills. For this study, only the social skills ratings from the adaptive skills domain on parent reports were analyzed from each administration. The social skills T-score is derived from 8 questions. As mentioned, the BASC-2 measures social skills in terms of raters' perceptions of both acquiring and appropriately performing social skills during social interactions. While not ascribing to any particular model, it attempts to measure common social interactions that occur in a student's life, such as interactions with both peers and family. Although it is ideal to obtain a BASC rating from the teacher, parent, and child or adolescent, only the rating from the parent was analyzed as the self-report and teacher forms were inconsistently used in this university clinic and did not provide a suitable sample for statistical purposes. The parent rating scales have a preschool (ages 2 to 5), child (ages 6 to 11), and adolescent (ages 12-21) version. The more current, third edition, of the BASC was released near the end of 2015 and was not used with this clinic population.

The BASC PRS scale used in this study has shown strong reliability. The internal consistency and test-retest reliability for the PRS scale exceeded 0.90 and has a median interrater reliability coefficient of .74, 0.69, and 0.77 for preschool, child, and adolescent age children respectively (Tan, 2007). The BASC-2 has shown good criterion-related validity when the BASC-2 was compared to other standardized behaviour measures such as the Achenbach System of Empirically Based Assessment (Tan, 2007). A factor analysis was conducted to determine construct validity which showed moderate to high loadings among the individual criteria and their respective domains (Tan, 2007). As such, the BASC-2 is considered an appropriate measure of social skills for the purpose of this study.

Data Analysis

All data was analyzed with the IBM SPSS Statistics version 23. The data was first examined to discover any missing values or potential outliers. As parametric tests were used, assumptions for normality were also analyzed. There were no missing data for analysis purposes. Any participants who were missing social skills values were not used in any analysis involving social skills.

Regarding outliers, only univariate outliers were analyzed. Given the simplicity of the variables being analyzed and the fact that no multivariate statistics were used, there was no need to analyze multivariate outliers. Univariate outliers were identified as scores that were greater than three standard deviations from the sample mean (Tabachnick & Fidell, 2013), with no outliers being found. Furthermore, normality was within acceptable parameters when examined using histograms, Shapiro-Wilks test, and probability-probability plots. Skewness and kurtosis were also analyzed using histograms, with neither falling outside of acceptable parameters.

To answer the two questions posed at the beginning, a *t*-test and a binary logistic regression were conducted. First, a power analysis was done to determine what population size would be necessary, even knowing that a clinical sample typically struggles to reach large sample sizes. Next, to answer whether the presence of a working memory deficit was found in participants with a diagnosed SLD, participants' data was split into two groups, those with and those without an SLD diagnosis. Their working memory scores, gathered using the WISC-IV, were then compared using a *t*-test to assess if there was a difference between the two groups. A second *t*-test was run comparing the two groups but with cases containing a comorbid diagnosis removed. Next, a binary logistic regression was conducted to determine if a low score in working memory and/or social skills predicted membership in the SLD group. For this analysis, social skills scores from the BASC-2 were included along with working memory scores. Like the *t*-test analysis, cases containing co-morbid diagnoses were then excluded and the binary logistic regression and was run a second time.

Chapter Four: Results

Data Preparation

During data preparation, no outliers were identified in the data set using box plots, scatter plots, histograms, or exploratory data analyses. The skewness and kurtosis of the histograms revealed that there were no concerns and all values fell within the acceptable range between -1.5 and 1.5 as identified by Tabachnick and Fidell (2013). The results suggested that none of the variables deviated from normality and were all able to be used in the parametric tests of this study. The power analysis for the proposed *t*-test, to obtain statistical power at the typical .80 level (Cohen, 1988), showed that 51 participants per group were needed. Likewise, for the binary regression, the power analysis determined that 68 participants were needed.

Working Memory and Presence of SLD

A *t*-test was conducted to determine the relationship between working memory scores on the WISC-IV and the presence of a subsequent SLD. Given the non-significant Levene's Test (F = .147), equal variances were assumed for the *t*-test. The sample size was 57 (19 with SLD, 38 without; see table 1). This test revealed that the working memory scores of clients with a diagnosed SLD (M = 92.61, SD = 12.4) did not differ from clients without a diagnosed SLD (M = 93.64, SD = 14.3, t[55] = -.263, p = 0.794).

Because of the potential effect of comorbidities on SLD research, as noted previously (e.g., DuPaul, Gormley, & Laracy, 2013; Koolwijk et al., 2014), a second *t*-test was run with comorbid diagnoses removed (n = 30; see Table 1). This left a sample size of 30 with each client either having no diagnoses (n = 23, M = 94.70, SD = 14.6) or only a diagnosis of SLD (n = 7, M

= 91.14, *SD* = 12.9). The *t*-test revealed that there was no significant difference in terms of working memory scores between the two groups, *t*[28] = -5.78, $p = 0.568$.

Working Memory, Presence of SLD, and Social Skills

The binary logistic regression test only included participants, from the original sample, who had social skills data; the sample size was 26 (7 SLD, 19 no SLD; see Table 2). The results of this test showed that neither working memory ($p = 0.703$) nor social skills ($p = 0.361$) were good predictors of the presence of an SLD, χ^2 (2) = 1.056, $p = .590$. This is further supported by the model only explaining 6% of the variance (Nagelkerke's R^2), suggesting a weak relationship.

When comorbid diagnoses were removed and the regression was run again (5 SLD, 14 no SLD; see Table 2) neither working memory p = 0.720) nor social skills (p = 0.627) predicted the presence of an SLD, $\chi^2(2) = 11.304$, $p = .185$. The second model was only able to explain 2.9% (Nagelkerke's R^2) of the variance, again suggesting a weak relationship.

Table 1

Number of Participants Used in t-*test (Total = 57)*

	Comorbid Diagnoses Included		No Comorbid Diagnoses Included	
	With SLD	Without SLD	With SLD	Without SLD
t-Test	19	38	7	23

Table 2

Number of Participants Used in Binary Regression (Total = 26)

	Comorbid Diagnoses Included		No Comorbid Diagnoses Included	
	With SLD	Without SLD	With SLD	Without SLD
Binary Regression	7	19	5	14

Chapter Five: Discussion

Interpretation of Results

Working memory deficits have long been touted as a contributing factor to SLDs (e.g., Dehn, 2011). When the current study compared the working memory scores of a SLD and non-SLD group, the difference between means was non-significant. Nor was there evidence that social skills and working memory predicted SLD membership after applying a regression analysis. Lastly, removing cases with a comorbid diagnosis did not result in significant findings

The finding that students with working memory deficits were not more likely to be identified with an SLD was unexpected given that there is a body of research linking the two (De Weerdt, Desoete, & Roeyers, 2013; Imbo et al., 2007; Swanson, 1993; Swanson & Berninger, 1996). One possible explanation for the null findings of this study, is the inconsistent use of working memory measures across studies. For example, Pickering and Gathercole (2004) evaluated working memory using the Working Memory Test Battery for Children (Pickering & Gathercole, 2001), which measures visual, auditory, and central executive working memory. Other studies, such as this one, have used the WISC-IV, which only measures verbal working memory. It is possible that using the WISC-IV did not provide as complete a measure of working memory and that components of working memory other than verbal memory are more likely to predict an SLD. Furthermore, it has been argued that, in the WISC-IV, only the digits backward subtest is a true measurement of working memory because the digits forward subtest relies on short-term verbal memory (Rosenthal et al., 2006). By combining multiple types of memory tasks, such as digits forward, which is a simple memory task, and both digits backwards and letter-number sequencing, which are working memory tasks, the composite score is measuring multiple components of memory. Even with these weaknesses, the WISC-IV was used in this study as it is considered a standard practice assessment measure and was the most frequently used measure in the clinic that was available for data analysis. However, the limitations of measurement should be considered when comparing the results of this study to other research that has found a link between working memory and SLD.

A second factor that could have contributed to differences between this study and others was the use of a clinical population. In a clinical population, the participants either already have a diagnosis or are usually coming to a clinic due to some distress or abnormality in behavior. Thus, all participants in this study, including the controls, are more likely to show behavioural or academic difficulties than those in a school sample. Thus, the results can be different when comparing groups since the control group is different than a control group from a school sample. Furthermore, a clinical sample provides easier access to certain data such as comorbid diagnoses, which is often lacking in non-clinical samples (Thurston et al., 2008). Though this information can be missing even in clinical samples if it was undisclosed or not part of the questions asked during intake. This data allows for more nuanced analyses to try and parse out the impact of comorbid diagnoses which is not accounted for in school samples.

However, controlling for comorbid diagnoses is not always a positive. Studies using other populations, such as school samples, may have more ecological validity. Although isolating comorbid diagnoses with a clinical sample can be beneficial for statistical analyses, it is rare in actual practice to find students that only have one diagnosis (DuPaul, Gormley, & Laracy, 2013; Koolwijk et al., 2014). Even many students with a learning disability have more than one type of learning disability (Willcutt et al., 2013).

A final factor that makes comparing studies challenging is how researchers conceptualize SLD. First, with no universally accepted method of identifying SLD (e.g., discrepancy model, LDAC definition, DSM-V), the sample population can change depending on the jurisdiction in which research is performed. These different classification methods can lead to some students receiving a diagnosis under one method and no diagnosis under a different method (Proctor & Prevatt, 2003). As such, some studies may have their SLD group composed of those diagnosed through the LDAC method, who would not have had an SLD diagnosis under the DSM-V method. These differences can lead to sample variation and different results.
Furthermore, there are differences in how researchers group and separate those with an SLD. Some studies (e.g., Pickering & Gathercole, 2004) split learning disabilities into broad groups (e.g., reading disabilities, writing disabilities, and general learning difficulties). Meanwhile, other researchers subdivided them into specific types of SLDs (e.g., reading comprehension, math calculation, written expression; Geary 2014). The current study based SLD membership on the identification of the clinician and did not distinguish between models or the degree to which the clinician distinguished even between broad categories (e.g., mathematics, reading, written expression). These three factors can help account for the discrepancy in results between the current study and the existing literature.

Social skills

For the second question, neither social skills deficits nor working memory deficits were associated with a higher likelihood of a client having an SLD diagnosis. While previous researchers (e.g., Cooper et al., 2014; Filippello et al., 2013; Kavale & Forness, 1996; Meier, DiPerna & Oster, 2006) have found tentative links between social skills and SLDs, they are all correlational, and most caution that there are many unanswered questions regarding the link between SLDs and social skills. The major difference between the current study and other studies that could account for this difference in results is the method of assessing social skills. The current study used a single social skills subtest that is part of a larger behavioural assessment measure as it is a commonly used tool in the clinic and so was readily available. Other studies used measures such as observations, multiple rating forms, social stories, and mock scenarios, which was not possible with archival data. Given the uncertainty in the literature of how social skills and SLDs are related, it is possible that the current social skills measure did not capture a certain aspect of social skills that is more closely tied to SLDs.

Implications

For students, these null results imply that their academic struggles do not necessarily have an underlying working memory deficit. While working memory deficits can make learning more difficult, it is not a requirement for an SLD diagnosis using the DSM-5. Consequently, assessing working memory can be beneficial in understanding a student's academic profile, but a low score would not immediately imply there is a risk for an SLD diagnosis.

With regards to social skills, these results imply that practitioners do not need to relate poor social skills displayed by students as a warning sign of a possible learning disability or that a student with a learning disability will necessarily struggle socially. This is said with caution, as research (e.g. Filippello et al., 2013, Kavale & Forness, 1996) does suggest that those with a learning disability are more likely to struggle with social interactions; however, the reason for this is not understood yet. Interventions can be built around academic struggles without necessarily requiring that the intervention also tackle areas such as working memory or social skills. However, the current results are not conclusive. As researchers have shown (e.g., Filippello et al., 2013; Jaffar & Eladi, 2016; Kavale & Forness, 1996; Swanson & Malone, 1992), some relationship seems to exist between social skills, working memory and academics as those with a learning disability are more likely to struggle with social interactions although the cause or directionality is unclear. Thus, these implications will require more research to substantiate them.

Limitations of Study

This study has five major limitations. The first major limitation of this study is related to the sample population. The sample size was quite low which makes generalizing results more difficult and increases the possibility of a type II error. The sample size for analyses including social skills were even lower due to missing social skills data for many of the participants and the removal of comorbid diagnoses for the second analyses. While trying to isolate students who only have an SLD may be better for research, it makes generalizing results to the general population more difficult given that many students with an SLD have a comorbid diagnosis (DuPaul, Gormley, & Laracy, 2013; Lewandowski & Lovett, 2014).

The second limitation involves bias within the sample. Many of the participants were referred to the clinic due to academic struggles. This means they likely demonstrated more visible struggles, such as poor test scores or socioemotional difficulties. These existing conditions could skew ratings. If this is true, then there are potential biases in the social skills data. For instance, since we do not know the referral reason for participants, it is possible that participants in the control group were referred to the clinic for poor social skills or behavioural issues and, in such a small sample size, skewed the social skills data for the control group. Thus, the lack of difference between the SLD and non-SLD groups in terms of social skills scores may be due to some students having lower social skills regardless of SLD identification.

The third limitation, related to the sample population, is a lack of important demographic parameters such as socioeconomic status, school background information, and data regarding guardian's level of education or occupation. This information would have provided more opportunities to further analyze the data and provide a more robust understanding of the clinical population. Factors such as low socioeconomic status have been linked to poor academics (Alloway, Alloway, & Wootan, 2014; Demir, Prado, & Booth, 2015) and poorer working memory (Hackman et al., 2014) and thus could serve as a potential intermediary variable to further discuss the null results of this study.

The fourth limitation is that the method of diagnosis for each participant was unknown. This is a major limitation for this study as it is impossible to know what criteria the participants met originally to be given a diagnosis. As found by Proctor and Prevatt (2003), different students will be given a diagnosis of SLD depending on the method of diagnosis. To illustrate, the LDAC definition requires a processing skills deficit (e.g., working memory) to be present for SLD identification while the DSM-5 does not. It is possible that participants who are given a diagnosis under a specific method, such as through the LDAC method, were more likely to have working memory deficit; whereas, those diagnosed with the DSM-5 method do not. However, it is impossible to analyze this information given that the participants in this study could have been diagnosed through any number of different methods using all sorts of varying criteria.

Fifth, while the WISC-IV and BASC-2 are measures of working memory and social skills, respectively, they are still only one measure of each. When analyzing a construct as complex as working memory, multiple or more robust measures would aid in providing a more accurate score for the use of correlation. More specific measures, such as the Working Memory Test Battery for Children (Pickering & Gathercole, 2001), could provide more reliable scores of working memory. The Social Skills Improvement System (SSIS) would be a more specific tool to assess social skills (Gresham & Elliott, 2008). Furthermore, certain measures are more comprehensive. The WISC-IV only measures auditory working memory, which is a limitation of this study. Measures such as the WISC-V add visual working memory, leading to more accurate results and the ability to parse out the impact of visual from auditory working memory when analyzing their individual relationships to SLDs.

Future Directions

Future studies should attempt to address two areas of importance. First, the results of this study will require further substantiation to overcome the large amount of evidence suggesting that working memory and SLD are correlated. Any future studies should be consistent regarding participant and assessment measure selection. As there are multiple ways of diagnosing SLDs or measuring cognitive and academic scores, studies should attempt to use a consistent methodology to allow for comparison between studies more accurately. As of now, this is not an easy task with vocal proponents on both sides arguing for their definitions and methodologies to be the defining one to be used for future studies. More research will be needed before any one definition and diagnostic method becomes, if ever, the accepted one. For now, it is important to be aware of the multiple different methods when trying to compare and interpret the results of various studies.

Second, given the pervasive nature of SLDs and the number of students who struggle with academics, future studies must continue to focus on all other variables that impact and are impacted by SLDs such as social skills. While the current study did not find any support for a direct link between social skills and SLDs, research has shown the importance of teaching children social skills alongside academics, especially for those with an SLD, to ensure success both in and out of school (DeLay et al., 2016; Swanson & Malone, 1992). As such, it is vitally important that future studies do not dismiss the importance of intermediary variables, such as social skills, that could impact the academic success of those with and without SLDs.

Conclusion

The cognitive processing deficits underlying SLDs have received considerable attention within the literature. Despite the null findings of this study, there is a body of evidence (De Weerdt, Desoete, & Roeyers, 2013; Swanson, 1993; Swanson & Berninger, 1996) to suggest that working memory plays a role in academic functioning. Less is understood about the relationship between social skills and SLDs. The null finding of this study is not unexpected given that other research has not found a causal link. The clinical sample used in the current study is different from the school-based samples typically used in SLD research. Given limitations such as small sample size and missing parameter data, the results of this study are to be taken tentatively with more research needed to substantiate the claims made. Regardless of the limitations of this study, it can be argued that working memory and social skills are worthy areas of investigation and should be explored in future research.

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