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Measuring SRL Differences During Mathematics with SRL Microanalysis

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MEASURING SRL DIFFERENCES DURING MATHEMATICS WITH SRL

MICROANALYSIS

by

Aliya Halterman

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ABSTRACT

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Utah State University, 2022

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Self-regulated learning (SRL) is an essential skill for achievement and progress in several settings including academics. It is known that students with attention-deficit/hyperactivity disorder (ADHD) struggle with SRL skills. However, this knowledge has been acquired primarily from self-report measures. While this has provided a solid foundation for the literature regarding SRL skills within the population with ADHD, there are a few limitations that these measures posit. These limitations can addressed with a measurement called SRL microanalysis. The purpose of this study was to use SRL microanalysis to measure SRL differences between students with and without ADHD symptomatology during a mathematics word problems task. To do this, we recruited 127 seventh and eighth-graders. Students answered mathematics word problems and SRL microanalysis interview questions via an automated survey. Significant differences were found between diagnostic group regarding SRL strategic planning and attributions. Implications and limitations are discussed.

(46 pages)

PUBLIC ABSTRACT

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Self-regulated learning (SRL) is an essential skill for achievement and progress in several settings including academics. It is known that students with attention-deficit/hyperactivity disorder (ADHD) struggle with SRL skills. However, this knowledge has been acquired primarily from self-report measures. While this has provided a solid foundation within the literature regarding SRL skills within the population with ADHD, there are a few limitations that these measures posit. These limitations can addressed with a measurement called SRL microanalysis. The purpose of this study was to use SRL microanalysis to measure SRL differences between students with and without ADHD symptomatology during a mathematics word problems task. To do this, we recruited 127 seventh and eighth-graders. Students answered mathematics word problems and SRL microanalysis interview questions via an automated survey. Significant differences were found between diagnostic group regarding SRL strategic planning and attributions. Implications and limitations are discussed.

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CHAPTER I

INTRODUCTION

Self-regulated learning (SRL) is the extent to which individuals are actively engaged in their own learning through metacognitive, motivational, and behavioral processes (Zimmerman, 1994). SRL is often described as a cyclical feedback loop characterized by various subprocesses, such as goal-setting, planning, self-monitoring, using strategies, and reflecting that optimize learning in many diverse contexts of life. Consequently, utilizing SRL skills relates to positive academic outcomes such as increased participation in homework, the likelihood of graduating, higher grades, and classroom engagement (Caprara et al., 2008; Zimmerman & Kitsantas, 2005). On the other hand, deficits in SRL can lead to academic challenges (i.e., grade retention and lower grades; Bussing et al., 2010; Kent et al., 2011). SRL skills are important to a variety of learners including students in general education and those receiving special education services. Regarding special education populations, SRL deficits are evident among students with specific learning disabilities (Baird et al.,2009; Rosenzweig, et al., 2011), emotional disabilities (Hagaman, 2012), and of greatest interest to the current study, attention-deficit/hyperactivity disorder (ADHD; Lee & Zentall, 2017).

ADHD is a neurodevelopmental disorder characterized by symptoms of inattention, and hyperactivity/impulsivity to an extent that is disruptive to an individual's daily functioning and development (APA, 2013). ADHD is the most commonly diagnosed neurodevelopmental disorder and is very prevalent within the school setting. Many students with ADHD struggle academically due in part to SRL deficits (Sibley et al., 2019).

Prior research examining SRL differences between populations with and without ADHD has typically emphasized self-report questionnaires and teacher rating scales (Dinsmore et al., 2008; Hoza et al., 2002; Major et al., 2013). While self-report questionnaires and teacher rating scales tend to depict SRL as a stable construct, research indicates that students can and often do vary their use of SRL across academic domains (e.g., mathematics, reading, and writing) and even tasks within those domains (i.e., doing homework and preparing for tests; Hadwin et al., 2001; Winne, 2010). Thus, it is also relevant to use task-specific measures of SRL to identify if and how SRL skills vary across disability status for specific academic tasks such as mathematical problem-solving. One such measure to address this concern is a structured interview called SRL microanalysis. This structured interview measures SRL in a time-specific and contextual manner (Cleary & Callan, 2017).

The purpose of this project is to use SRL microanalysis to examine SRL differences between students with ADHD symptomology and their typically developing peers. To do so, we situated three SRL microanalysis measures (i.e., strategic planning, self-monitoring, and causal attributions) within a mathematical problem-solving task.

CHAPTER II

LITERATURE REVIEW

ADHD

ADHD is the most commonly diagnosed neurodevelopmental disorder and is characterized by several chronic symptoms including inattention and hyperactivity/impulsivity. These symptoms cause impairments in daily functioning for an estimated 5 to10 percent of all school-aged children in the United States (APA, 2013; Danielson et al., 2018; Perou et al., 2013; Polanczyk et al., 2007). ADHD is highly prevalent among students receiving special education services. Approximately 66% of students within the Other Health Impairment eligibility category of Individuals with Disabilities Education Improvement Act (IDEIA) have been diagnosed with ADHD. ADHD is also comorbid with students receiving special education services for specific learning disabilities (i.e., 20%) and emotional disabilities (i.e., 60%; Schnoes et al., 2006).

In school-aged children, ADHD is commonly linked to lower academic performance and higher disciplinary rates compared to their typically developing (TD) peers (Barkley, 2006; DuPaul & Stoner, 2003). Regarding academics, approximately 30% of school-aged children with ADHD perform at a lower level than would be expected for their IQ level or age (Frick & Lahey, 1991; Kamphaus & Frick, 1996) and while controlling social class, gender, and race, Fried et al., (2016) found that students with ADHD had a 25% probability rate of dropping out, compared to a mere 6% of their peers without ADHD.

Much of the existing literature has focused on links between ADHD and reading underachievement. However, mathematics subjects are also important to student success in school and after graduation. For example, mathematics skills are positively correlated with retention and positive opportunities in post-secondary education (Duncan et al., 2007). Research does support a negative association between ADHD and mathematical ability even when controlling for IQ, age, race, socioeconomic status, and medication (Tosto et al., 2015). Some of this academic underachievement is positively attributed to SRL skill deficits (Major et al., 2013; Sibley et al., 2019). For example, Sibley and colleagues (2019) found that students with ADHD were less likely to engage in SRL skills and that 23% of the variance in GPA could be attributed to SRL, when comparing students with (n = 18) and without (n = 32) ADHD.

Defining SRL

There are several models of SRL (Eflkides, 2011; Pintrich, 2000; Winne & Hadwin, 1998). One particular model (i.e., Zimmerman, 2000) is notable and is broadly used within intervention design and school-based applications (Cleary & Zimmerman, 2004; Harris & Graham, 2009). This model states that SRL is a cyclical process revolving around an individual's engagement in a task. Furthermore, this model consists of three phases: forethought, performance-control, and self-reflection.

SRL Forethought

The first phase, forethought, occurs before task-engagement and includes processes such as task analysis and motivational beliefs. Regarding task analysis, students can engage in goal-setting (i.e., deciding on an objective for one's performance or learning) and strategic planning (i.e., deciding on which are appropriate for the task of interest). Also, motivational beliefs are critical within the forethought phase because regulatory skills can only carry an individual’s performance so far if they are not motivated to use them (Zimmerman, 2000). Primary motivational beliefs include self-efficacy (i.e., one's belief in their ability to perform effectively concerning a specific task; Bandura, 1997), outcome expectations (i.e., an individual’s perception of outcomes derived from engaging in a task; Zimmerman, 2000), interest (i.e., intrinsic motivation or preference for the target task; Zimmerman, 2000), goal orientation (i.e., whether an individual’s goals specify process or achievement; Pintrich, 2000). Collectively, setting goals, planning, and holding adaptive motivation sets the stage for achievement and effective SRL during latter phases.

SRL Performance Control

After forethought is the performance-control phase, which occurs during task-engagement. The performance-control phase includes processes of self-control and self-observation. With self-control, individuals can engage in self-instruction (i.e., verbalizing to one’s self regarding how to engage in the task of interest; Zimmerman, 2000), imagery (i.e., utilizing mental imagery to enhance one's performance; Zimmerman 2000), attention focusing (i.e., strategies that an individual can use to improve their concentration; Zimmerman, 2000), and task strategies (i.e., ways that an individual can reorganize a task to assist their learning or improve their performance; Zimmerman, 2000). Regarding self-observation, students can self-record (i.e., when one traces their thoughts, behaviors, or emotions; Zimmerman, 2000), which often leads to self-experimentation (i.e., when one engages in actions to better understand the functions of their behaviors that are in question; Zimmerman, 2000).

SRL Self-Reflection

Self-reflection occurs after an individual has completed a task and includes processes such as self-judgment and self-reactions. Self-judgment includes sub-processes such as self-evaluation (i.e., comparing one's performance to a standard or goal; Zimmerman, 2000), and causal attributions (i.e., judgments regarding the cause of performance; Zimmerman, 2000). Self-reaction consists of satisfaction (i.e., approval or disapproval of performance; Zimmerman, 2000) and adaptive inferences (i.e., conclusions about how they can perform better on future attempts of the task of interest; Zimmerman, 2000). Self-reflection is critical to SRL because it presents an opportunity to self-correct by closing the feedback loop between self-reflection and forethought for the next task attempt.

Executive Functioning and SRL

Students with ADHD often struggle with executive functioning (EF) skills (Antshel, et al., 2014), which overlap significantly with SRL. EF has often been operationalized as functions that are controlled by the prefrontal cortex, and yield the ability to demonstrate behaviors that optimize success in situations that utilize various cognitive processes (Welsh & Pennington, 1988; Barkley 1997). These processes overlap significantly with SRL, for example, both EF and SRL literature emphasizes goal directedness and metacognitive activities such as planning, monitoring, and reflecting. Thus, many of the findings from these parallel fields can be considered interchangeable. However, some differences do exist. EF researchers tend to view and measure these processes as stable traits, whereas SRL researchers focus on aspects of these processes that are malleable.

SRL and ADHD

Students with ADHD often demonstrate SRL deficits (Sibley et al., 2019). These SRL deficits among students with ADHD pose a substantial risk for individuals with ADHD to fall behind their peers academically **(**Patel, et al., 2015). The following sections describe the interaction between deficits experienced by individuals with ADHD and the three phases of Zimmerman's (2000) model of SRL.

Research indicates that students with ADHD struggle with forethought processes including motivational beliefs, goal-setting, and planning. For example, Major and colleagues (2013) compared the self-efficacy of sixty-two adolescents with (n = 31) and without ADHD (n = 31). This study required participants to complete subtests from the Wechsler Abbreviated Scale of Intelligence and the Woodcock-Johnson Tests of Achievement to measure academic achievement, and the self-efficacy was measured using the Self-Efficacy for Learning Form (SELF; Zimmerman & Kitsantas, 2007). Results showed that youth with ADHD had lower self-efficacy levels than TD peers. Regarding goal-setting, Barron and colleagues (2006) conducted a study using a self-report questionnaire (i.e., Pattern of Adaptive Learning Scales) to examine goal-setting differences between students with (n = 50) and without ADHD (n = 42), and found that youth with ADHD had significantly more maladaptive goal orientations than the youth without ADHD.

Planning deficits are also well documented in children with ADHD while using SRL measures and EF measures (Tannock, 1998; Willcutt et al., 2005). Willcutt et al. (2005) conducted a meta-analysis review, which suggested that planning is among the most observed deficits in individuals with ADHD. Additionally, Nyman et al. (2010), conducted a study to examine the planning skills of children with ADHD using the Tower Test (NEPSY; Korkman et al., 1998) and found that children with ADHD (*n* = 30) struggled with the higher-order skills required for planning, whereas the TD children (*n* = 30) did not. Although this study was fundamentally a measure of EF, it is still relevant to consider within the scope of SRL planning as well, due to the overlap between the two constructs.

Students with ADHD are also known to struggle with SRL processes within the performance-control phase of SRL. More specifically, students with ADHD struggle with subprocesses such as self-monitoring and strategy use (Shue & Douglas, 1992; Lewandowski et al., 2015). Shue and Douglas (1992) found that students with ADHD (*n* = 24) struggled significantly with tasks that required self-monitoring skills compared to the TD comparison group (*n* = 24). Regarding strategy use, Lewandowski et al. (2015) compared the test-taking strategies of high school students with (*n* = 38) and without (*n* = 746) ADHD. Results showed that the students with ADHD, on average, used fewer strategies than their TD peers.

There is a need for more research on the self-reflection phase processes among students with ADHD (Reddy et al., 2018). This is especially true when considering that more quality time spent developing adaptive self-reflection can enhance forethought and performance-control processes (Cleary et al., 2006; Dignath & Büttner, 2008). However, students with ADHD do struggle with self-evaluations in comparison to their TD peers, and across multiple domains (Gresham, et al., 1998; Hoza et al., 1993; Owens & Hoza, 2001). For example, Hoza et al. (2001) conducted a study using a Likert style rating scale to measure participant self-evaluations and attributions. Results showed that boys with

ADHD (n = 83) were significantly less accurate regarding their academic competence compared to the boys in the non-ADHD comparison group (*n* = 66) and students with ADHD made less adaptive attributions (Hoza et al., 2001).

Measuring SRL

The knowledge basis regarding SRL and ADHD has traditionally been obtained through self-report questionnaires and teacher ratings (Dinsmore et al., 2008; Hoza et al., 2002; Major et al., 2013). While these measures have provided a strong foundation of knowledge regarding SRL, there are several caveats to consider when measuring SRL. For example, self-report questionnaires are completed retrospectively, which can result in memory errors (Schacter, 1999). Furthermore, self-report questionnaires and teacher ratings usually aggregate SRL across many tasks and contexts, but research indicates that SRL varies across tasks and contexts (Cleary & Chen, 2009; Hadwin et al., 2001).

As such, SRL researchers have recently used SRL microanalysis, which is a structured interview, that measures thoughts and behaviors during a specific task, within a specific setting (Callan & Cleary, 2018; Cleary, et al., 2012). SRL microanalysis utilizes targeted interview questions to identify SRL within forethought, performance-control, and self-reflection. SRL microanalysis interviews are typically administered in an individualized setting. However, given the time required to schedule and administer individual interviews, researchers have also begun to explore group administered microanalysis within intervention studies (Cleary et al., 2017) and predictive studies (Ridgley et al., in review).

Summary

Although self-report questionnaires and teacher ratings have shown that students with ADHD often have weaker SRL skills than their TD peers, it is also relevant to explore the gaps in the literature, including examining SRL differences in real-time within a single task (i.e., mathematical problem-solving). Moreover, many caveats of retrospective measures are resolved when SRL is measured in real-time. This includes addressing the temporal nature of SRL, and the memory errors that can occur when measuring SRL after the task has already concluded. Additionally, there is still much research needed to better understand differences in SRL processes, especially processes that are in the self-reflection phase, in relation to the population with ADHD.

Current Study

This study seeks to use SRL microanalysis interviews to examine the SRL of students with and without clinical levels of ADHD symptomology before, during, and after a set of mathematical word problems. In doing so, we address three specific research questions:

RQ1: Is ADHD symptomatology predictive of using forethought strategic planning?

RQ2: Do students in the ADHD or TD groups differ significantly regarding performance-control self-monitoring?

RQ3: Is ADHD symptomology predictive of using controllable self-reflection causal attributions?

CHAPTER III

METHOD

Participants

Students in 7th and 8th grade were recruited through various social media platforms and local schools within Northern Utah. Inclusion criteria included parent report of a third grade (or higher) reading level, because the measures included in this project were evaluated to be at a third-grade reading level (via the Flesch-Kincaid Grade Level Readability Formula; Flesch, 2007). Students were included in the ADHD group if they demonstrated clinical levels (i.e., greater than or equal to the 93rd percentile on the total raw score) of ADHD symptoms the ADHD Rating Scale – 5 and assigned to the TD group if they fell at or below the 85th percentile of the total raw score on the ADHD rating scale – 5. Students were excluded from the study if their parents reported that their students had a specific learning disability in math, because the primary task that students completed in this study was mathematics word problems. Students were also excluded if their parents did not indicate that they can read at or above a third-grade reading level. There were three attention check questions throughout the survey. Individuals who did do not answer at least two of the three questions correctly were not included in the study. A total of 127 students were included in this study, with most being White (n = 124) and male (n = 83). A few students were Hispanic or Latino/a/x (n = 2), and multiracial (n = 1). Seventy-three students were included in the ADHD group, and 54 students were included in the TD group. There were significant differences in grade and household income between diagnostic groups ($p < .05$). Additionally, only 4 students were medicated for ADHD at the time of this study. Additional participant demographic information can be found in Table 1.

Table 1
Participant demographics.

Characteristic	ADHD group (*n* = 73)		TD Group (*n* = 54)	
Gender	*n*	%	*n*	%
Female	21	28.8	33	61.1
Male	52	71.2	21	38.9
Grade*				
7	35	47.9	34	63
8	38	52.1	20	37
Race/Ethnicity				
White	71	97.3	52	96.3
Hispanic/Latin-x	2	2.7	1	1.9
Multi-Racial	0	0	1	1.9
Household Income*				
Below $30k/year	3	4.1	7	13.0
$31k-$60k/year	48	65.8	38	70.4
$61k-90k/year	21	28.8	8	14.8
$91k-120k/year	0	0	0	0
$121k-150k/year	0	0	0	0
Above $150k/year	1	1.4	1	1.9
	ADHD group (*n* = 73)	*M*(SD)	TD Group (*n* = 54)	*M*(SD)
Percentile on ADHD Rating Scale – 5		96.01 (2.0)		62.39 (20.5)
Strategic Planning		.10 (.30)		.48 (.50)
Self-Monitoring		.68 (.96)		.77 (1.25)
Causal Attributions		.46 (.50)		.75 (.43)
	ADHD group (*n* = 73)	% correct	TD group (*n* =54)	% correct
Mathematics Word Problem		86.3		79.6

Note: Only 4 students in the ADHD group were being medicated for ADHD at the time of this study.
*Denotes significant differences between the two diagnostic groups at p <.05

Measures

ADHD Rating Scale–5

The ADHD Rating Scale–5 (DuPaul et al., 2016) was completed by participants' parents to determine group affiliation for this study (ADHD, TD). The ADHD Rating Scale-5 is an 18-item rating scale that provides information about symptoms of ADHD in children and adolescents per the Diagnostic and Statistical Manual 5^{th} edition. (DSM-5; American Psychiatric Association, 2013). There are two symptom subscales (i.e., inattention and hyperactivity-impulsivity). Each subscale consists of nine items. Parents of participants provided their responses regarding the frequency of behavior on a 4-point Likert scale from 0 (never or rarely) to 4 (very often). We utilized the total score raw scores to convert percentile scores based on the child's sex and age.

Research has indicated that the ADHD rating Scale-5 displays high internal consistency reliability for Total, Inattention, and Hyperactivity-Impulsivity scores. The internal consistency alpha coefficients range from .89 to .96, and the test-retest reliability over 6 weeks across the three symptom factors ranged from .80 to .87. Prior research also indicates that the ADHD rating scale–5 effectively predicts diagnostic status and differentiates ADHD subtypes as well as individuals with and without ADHD. Moreover, the ADHD rating scale–5 has also demonstrated concurrent validity and factorial validity (DuPaul et al., 2016). In this study, this rating scale was utilized to identify which students would be excluded from the study, and which students would be included in the ADHD group versus the TD group.

Demographic Form

Following the completion of the ADHD rating scale – 5, parents completed a demographics form within a Qualtrics survey to determine students' gender, race/ethnicity, grade-level, special education status, special education identification, living setting (i.e., rural, suburban, and urban), social-economic status (SES), and pre-requisite reading level. SES was determined by identifying parental income levels. Participants had the option to refrain from answering any or all questions.

SRL microanalysis survey questions

This study utilized a Qualtrics survey. The survey was automated, and self-administered SRL microanalysis interview questions targeting SRL in relation to a mathematics-interview-task. The mathematics-interview-task consisted of three rate of change word problems. Both the students in the ADHD group and TD group completed these tasks. Three SRL microanalytic questions were completed by students to measure forethought (i.e., strategic planning), performance-control (i.e., self-monitoring), and a self-reflection process (i.e., causal attributions). The measurement wording and administration were based on prior microanalysis interviews (Callan & Cleary, 2018; Cleary et al., 2012); However, in contrast to most prior microanalysis research, the survey questions were integrated within a Qualtrics survey rather than being administered by an individual interviewer, because of COVID-19.

Strategic Planning. The strategic planning measure was completed prior to students' engagement in the mathematics-interview-task. On the Qualtrics form participants were prompted, "Do you have any plans for how to successfully complete these math problems?" On the following page, students were asked, "Is there anything else that you will do?" To code the open-ended response to this item we counted the number of mathematical strategic problem-solving strategies that participants indicated that they used to support their problem solving. Prior research has shown similar microanalytic measures to display high inter-rater reliability, as well a high ability in differentiating experts from non-experts (DiBenedetto & Zimmerman 2013) and predicting achievement (Callan & Cleary, 2018).

Self-monitoring. The self-monitoring measure evaluated the accuracy with which students evaluated their performance on the mathematics-interview-task. After each participant completed the mathematics-interview-task, they were prompted by the Qualtrics survey, “How likely is it that you answered this question correctly?” regarding the third problem in the mathematics-interview-task. Students responded on a 4-point Likert scale to identify whether they were felt (1) not at all sure, (2) somewhat sure, (3) pretty sure, or (4) very sure. The math problems were graded on a similar 4-point measurement system, to allow comparison between students’ responses on the self-monitoring interview question and their performance on the actual math word problems. This measure was adapted from prior research (Callan & Cleary, 2018; Zabrucky et al., 2009) examining participants’ ratings in relation to their actual performance on the three mathematics word problems.

Causal attributions. The causal attributions measure analyzed why students believed that they failed on a problem during the mathematics-interview task. Following the completion of all items on the mathematics-interview-task, the form displayed each of the math problems (one by one) on students' screens. The survey indicated, “If you got this problem wrong, why do you think you did?” Responses to this measure were coded to identify whether students listed controllable or uncontrollable attributions. Prior research using similar measures has shown high inter-rater reliability (Callan & Cleary, 2018). Additionally, similar measures reliably differentiated between achievement groups and predicted achievement in past research prior research using similar measures was predictive of achievement (Kitsantas & Zimmerman, 2002; Cleary et al. (2006; Cleary et al., 2015)

Procedures

This project was approved by the Utah State University Institutional Review Board. Participants were recruited from school districts in Northern Utah and on social media platforms which targeted northern Utah residents. Parent consent, student demographics, and an ADHD screener measure (i.e., the ADHD rating scale – 5) were collected from parents. At this point, parents were instructed to not help their child to complete the survey, and student assent was collected.

Students completed a total of ten mathematical word problems during the survey. First, they completed one mathematics problem (i.e., *the mathematics-introduction-task*) to orient them to the types of problems they were expected to complete. Students were asked to solve a rate-of-change word problem. Word problems with a rate-of-change format were selected because they apply to a wide range of grade levels, and can be solved in multiple ways. This was ideal for this study because the rate-of-change format optimized the number of opportunities for students to identify and use strategies. To solve the mathematics word problems, students needed to solve for the missing variable in the algebraic equation: $y = mx + b$. Students were not instructed to solve the problems in any specific way. For the introduction problem, the missing variable was x. There was no time limit for this problem, and students were not scored on the mathematics-introduction-task. For mathematics word problem examples for each missing variable, see Table 2.

Table 2.
Math word problem type examples

Problem type	Problem Example
Missing *x*	A tree grows at a rate of 1/3 inches per month. At this rate, how many months will it take for the tree to be 12 inches tall?
Missing *y*	It takes Austin 11 seconds to eat 1 doughnut. He needs to eat 12 doughnuts to win a prize. At this rate, how many seconds will it take Austin to eat 12 doughnuts?
Missing *m*	Malik went whale watching. He saw a whale but then it swam 48 feet away in 16 seconds. On average, how many feet did the whale swim per second?

Next, students responded to three SRL microanalytic interview questions before (i.e., strategic planning), during (i.e., self-monitoring), and after (i.e., causal attributions) the completion of three additional mathematical word problem (i.e., the *mathematics-session-task*). During the *mathematics-session-task*, students were prompted to solve the mathematical word problem. These problems contained either a missing *y, m,* or *x* variable. These problems mirrored the mathematics-introduction-task in format, content, and structure. The three problems selected for the study had no time limit.

The microanalysis sessions were completed entirely on an automated Qualtrics survey. Although there was no time limit, sessions lasted an average of 22 minutes. Students recorded their responses to both the SRL microanalytic interview questions and the mathematics word problems on the Qualtrics form. Upon completion, students (a) received a $15 gift card, and (b) were entered into a drawing for one of 10 gift cards valued at $25 for participation in this study.

Coding

Open-ended responses to the strategic planning and attribution microanalysis questions needed to be coded to translate qualitative data into quantitative data that could be examined statistically. A total of 33% of the open-ended data was dual coded, and percent agreement was 92.8%. If two coders did not agree on an item, they discussed until a consensus on the item was reached. Coding procedures were based upon prior microanalytic research (Cleary et al., 2012), prior research regarding microanalysis within mathematics (e.g., Callan & Cleary, 2018), and inductive examination of themes that coders identified within participant responses. The categories of responses are identified in Table 3. Following the identification and operationalization of response categories, point values were assigned to response categories with adaptive responses receiving positive points and maladaptive responses not being awarded points.

Table 3

Coding Categories, Examples, and Scoring

SRL process	Potential Response Types	Example	Received points?
Strategic Planning	Writing down key information	*"I will use my scratch paper."*	Yes
	Eliminate irrelevant information	*"I will cross out the information that is not helpful."*	
	Transform the problem	*"I will make an analogous problem with easier numbers first."* *"I will re-write the problem in my own words."*	Yes
	Using an equation or formula	*"I will use an equation to help me solve."*	Yes
	Drawing a picture	*"I will draw a picture to help me understand the problem"*	Yes
	Checking work	*"I will check to make sure I did the work correctly."* *"I will look for common errors."* *"I will do redundant math to double check my work."*	Yes
	Using a calculator	*"I will do the math with a calculator."*	No
	Stating that they would read the question	*"I'll read the problem."*	No
	Stating that they would solve the question	*"I'm just gonna do it."*	No

Attributions	Failed due to strategies chosen	*Any of the strategy categories listed above for strategic planning*	Yes
	Failed due to effort put towards the problem	*"I didn't try hard enough."*	Yes
	Failed due to a mistake	*"I made an error on my math."*	Yes
	Failed due to ability/difficulty of the problem	*"I'm not very good at math."*	No
	Denied failure on the item	*"I didn't get it wrong."*	No

Similar to prior microanalytic research (Cleary et al., 2012), Strategic planning was coded as the number of strategies that are listed. The following strategies received points: statements that described utilizing draft paper to solve the problem, the need to use an equation to complete computations, or the completion of computations necessary to solve the problem. Statements that did not identify adaptive strategic planning (e.g., simply stating they were going to solve it, stating they did not know what their plan was, or simply stating they were going to read the problem) were not assigned points.

Consistent with prior research (Callan & Cleary, 2018) self-monitoring was quantified as the absolute value which derived from students reported self-monitoring value (1 to 4) minus their actual performance on the item (1 meaning their answer was incorrect, 4 meaning their answer was correct).

Finally, causal attributions were coded by adding up the number of controllable attributions that students listed (Cleary et al., 2012) such as identifying the use of fallible strategies, making errors, and not investing sufficient effort. Students did not receive points for any uncontrollable factors that were reported (e.g., math ability or task difficulty). The method for coding the listed SRL processes is also shown in Table 4.

Table 4.
Coding Methods

SRL Process	Coding Method
Strategic planning	Count of the number of strategic planning items listed
Self-monitoring	The numeric value of listed self-monitoring minus student performance on the item.
Causal attributions	Adding up the number of strategy steps that participants list

Data Analysis

To address the first research question (RQ1) regarding strategic planning, we used Poisson regression analyses. The diagnostic group (i.e., ADHD or TD) was the independent variable (IV), and number of total strategies listed for the planning measure was the dependent variable (DV). Poisson regression was selected for this item due to the low variability in responses for the planning items, and because the planning outcome variable was a count variable rather than continuous. From the Poisson regression output, we interpreted the regression coefficient (*b*) to determine if the IV was a significant predictor of the DV. We also interpreted the incidence rate ratio (IRR) in order to identify the predicted change in the DV's incidence rate when comparing the IV (i.e., the two diagnostic groups).

To answer research question two (RQ2), we conducted a non-parametric t-test. In doing so, we compared differences in self-monitoring accuracy between the two diagnostic groups. A non-parametric t-test was selected because it allowed us to compare means without making assumptions regarding the distribution of the data. This was ideal for RQ2 because the self-monitoring variable data followed a distribution which disqualified it from several other analyses. The IV was diagnostic group, and the DV was accuracy in self-monitoring.

Finally, to answer research question three (RQ3), Poisson regression was utilized with diagnostic group as the independent variable and number of total strategic planning items listed as the dependent variable. Similar to RQ1, we interpreted the IRR and *b* to answer RQ3. Please see Table 1 for descriptive statistics regarding all three variables (i.e., strategic planning, self-monitoring, and causal attributions).

CHAPTER IV

RESULTS

Overall, there were significant findings for the strategic planning and causal attributions variables. The results addressing the three research questions are discussed below.

Strategic Planning

The Poisson regression model addressing strategic planning differences across diagnostic group showed that diagnostic group was a negative and significant predictor of using strategic planning (b = -1.614, SE = .42, p < .001). The regression coefficient suggests that students in the ADHD group listed a decreased log count of 1.614 strategic planning items compared to the students in the TD group. While log count cannot be interpreted in the same way as a regular integer, a negative log count does reflect a lower incidence of the DV, or strategic planning. Therefore, the students in the ADHD group were less likely to use strategies than the students in the TD group. The IRR suggests that for the ADHD group, the predicted rate of using strategic planning changes by a factor of .198. This means between the two diagnostic groups, students in the ADHD group are expected to use strategic planning at a rate of 80.2% less than students in the TD group.

Self-Monitoring

Regarding our second research question, there was no significant differences in self-monitoring across diagnostic groups (U = 1896, p = 0.671, two-tailed).

Causal Attributions

Our third research question addressed attributions across diagnostic group. Group membership was a negative and significant predictor of adaptive attributions (b = -0.499, SE = 0.24, p = .034). The Poisson regression coefficient suggests that students in the

ADHD group listed a decreased log count of 0.499 controllable attributions compared to the students in the TD group. Thus, students in the ADHD group were more likely to have lower incidence of adaptive attributions. The IRR suggests that for students who were in the ADHD symptomatology group, the predicted rate of endorsing controllable causal attributions was expected to decrease by a factor of 0.607. This means that when comparing the two groups, students in the ADHD group are expected to list controllable attributions at a rate of 39.3% less than the students in the TD group.

CHAPTER V

DISCUSSION

The primary objective of this study was to examine SRL processes across students with and without ADHD symptomatology. In contrast to prior research inquiries surrounding this topic, we assessed SRL with a task-specific measure called SRL microanalysis. In turn, this opened the door to better understand and explore SRL differences between the diagnostic groups, and specifically within math problem solving. This is vital because mathematics is a topic that is relevant for student achievement in school and success within the occupational realm (Duncan et al., 2007). Additionally, this subject can pose as a barrier for many students, so understanding specific differences in how this population (a) achieves in math, and (b) demonstrates essential SRL skills in relation to mathematics word problems is vital. This project also builds upon prior microanalytic research by utilizing an online, self-administered microanalysis protocol that contrasts the more traditional in-person microanalysis interviews that require an interviewer and interviewee.

This project was guided by Zimmerman's model of SRL and consistent with this model, we targeted at least one SRL process within each of the three phases of SRL that occur before, during, and after task-engagement. Specifically, we measured strategic planning, self-monitoring, and causal attributions. In general, we found that students with ADHD symptomatology were less likely to use strategic planning and controllable causal attributions, but there were no significant differences between the diagnostic groups regarding self-monitoring. Greater detail and analysis of these findings are provided below.

Strategic Planning

Overall, when strategic planning was measured with SRL microanalysis, students in the ADHD group were less likely to use strategic planning prior to mathematics word problems. These findings align with previous research that has relied on self-report measures (Boyer et al., 2018). However, it should be noted that students in general did not list many strategies ($M = .26$), with no one listing more than one strategy. This is concerning because prior research indicates that students achieve at higher levels when they consider more strategies during planning (Schoenfeld, 1985) and because strategic planning sets the stage for the actual deployment of strategies during task performance (Callan & Cleary, 2019; Cleary & Callan, 2017). Relating back to the mathematics word problems, it is also problematic if students are not able to generate high quality strategies for how to solve the problem. Mathematics word problems are complex, and often require that students use more than one strategy to solve them (Callan & Cleary, 2018). The results from this study suggest that students with and without ADHD symptomatology could benefit from repeated exposure to explicit strategies that they can use to solve these more complex math problems. Microanalytic measures, such as the measures used in this study, could be used as a manipulation check to determine if and when students have mastered a sufficient number of strategies or strategy steps. Future research should help researchers and educators better understand the most essential strategies and strategy steps or determine a “benchmark” of strategic mastery.

Self-Monitoring

Although there were no significant differences in self-monitoring accuracy across students with ADHD and without ADHD, there were a few interesting findings regarding the self-monitoring variable. Overall, the majority of students answered the mathematics problems correctly regardless of diagnostic status. Most students were also accurate in rating whether they answered the mathematics problem correctly or not, regardless of diagnostic status. Previous literature implies that students with ADHD struggle more significantly with accurate self-monitoring than typically developing students (Meltzer, 2007; Shue and Douglas 1992). However, the data from the current study did not align with previous research. Being that the majority of students regardless of diagnostic status answered the mathematics word problem correctly, it is possible that the math questions were simply not challenging enough for this sample. Another reason that our findings may be different from prior research is that we measured students SRL skills via an online survey. Research has also alluded to the idea that students with ADHD perform better when they are completing a task in a stimulating environment such as via computer learning (Alabdulakareem & Jamjoom, 2020). Perhaps the online nature of the task helped students in the ADHD group to be more engaged in the task so they could (a) achieve at higher levels on the math problem and (b) more accurately gauge their performance on the problem. However, additional studies are needed to follow up on whether there is a consistent trend regarding self-monitoring when measured with and without microanalysis both in-person and online.

Causal Attributions

The research regarding how students with ADHD engage in attributions has been slim. However, this study offers preliminary data that students with ADHD are less likely to attribute their failures to controllable factors in the context of mathematics word problems. This is concerning because it is more adaptive to attribute one's failure to factors that are controllable (e.g., strategies and effort; Cleary et al., 2015). For example, attributing one's failure to controllable factors allows one to make adaptations for future attempts at the task. Additionally, doing so helps to facilitate more adaptive processes within the forethought phase of SRL such as more adaptive motivational beliefs, goals, and strategic planning (Zimmerman, 2000). If an individual attributes failures to uncontrollable factors (e.g., ability, difficulty of the problem), then it is more difficult to improve for future attempts of the task and motivation can be hampered

Limitations and Future Directions

There are a few limitations of this study. This study used an online version of microanalysis, which may have presented some limitations. For example, an initial study does support the validity of completing microanalytic interview questions in an automated online format (Ridgley, 2019), but more research is needed to establish the validity and to intentionally and meticulously compare the measurement of SRL via SRL microanalysis as an online format and an in-person format. . While a few valuable findings emerged from this study, there are also limitations when considering the online formatting. Because the survey was completed completely autonomously, there is the possibility that parents did assist their children with the math problems. Although we attempted to address this during the initial screening processes, it was impossible to monitor parental interaction during the survey. Future studies could more strictly proctor online microanalysis surveys and compare SRL online responses to in-person responses.

There are also inherent limitations to survey research – specifically, selection bias (i.e., participants self-selected to participate). Additionally, in order to participate, participants needed to have to have access to the Internet, and appropriate technology.

Future researchers may consider randomized sampling and providing participants with the necessary materials to participate in the study to avoid such biases.

Additionally, while we used the ADHD Rating Scale-5 to determine students' ADHD symptomology levels and consequently create two diagnostic groups (i.e., ADHD, TD) we did not confirm diagnoses or use multiple informants for the screening process. This was due, in part, to COVID-19 regulations, as well as the number of participants that were required to answer the research questions of this study. It could be beneficial for future studies to confirm diagnoses or special education classification status. Additionally, future studies could identify differences in inattentive subtypes and hyperactive or combined subtypes of ADHD.

Limitations with this study also exist regarding the participants and data. The participants in this study represent a very homogenous sample, with most students being white. This can be attributed to the geographical location in which the study took place. In the surrounding area, there is not a wide range of ethnically and racially diverse students. Thus, our results should not be assumed to generalize to other racial/ethnic groups. While this study helps to close the literature gap regarding our understanding of SRL in relation to neurodiverse populations, it also contributes to the problem in research that exists regarding underrepresented minoritized populations (Morgan et al., 2014). However, future studies should target more diverse populations regarding racially and ethnically minoritized populations.

Conclusion

Overall, the findings of this study are relevant for personnel who interact with both typically developing students and students with ADHD symptomatology such as parents, general education teachers, school psychologists, special education teachers, and clinicians. Although the microanalytic data from this study is preliminary evidence, the notion that students with ADHD symptoms are less likely to engage in strategic planning and controllable attributions in relation to completing mathematics word problems is problematic. However, the low number of strategies used by all student populations was troubling as well. The importance of these skills in relation to mathematics word problems is magnified when one considers the literature regarding the importance of math skills in schools and occupational settings (Duncan et al., 2007). Thus, students both with and without ADHD may benefit from developing their skills to strategically plan and attribute their performances to controllable and strategic factors. For general guidelines on how facilitate some of these skills, readers can refer to Callan et al. (2021).

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