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Using a Self-Paced Reading Task to Examine the Comprehension Monitoring Abilities of Children with and without ADHD

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A thesis submitted in partial fulfillment of the requirements for the Master of Arts degree in Education
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Abstract

The current study examined how children with and without Attention Deficit Hyperactivity Disorder (ADHD) deployed their attention while reading and the cognitive processes thought to be related to successful comprehension. 42 children between 9 and 14 years of age read passages during a self-paced reading task. Half of the passages contained semantic inconsistencies. Of interest was the two groups of children's subsequent comprehension and the extent that they noticed the inconsistencies. The children's working memory, inferencing ability, verbal and non-verbal intelligence and decoding ability were also measured. Only the typically developing children's reading times were impacted by the passages' consistency. That is, the typically developing children spent longer reading the critical words in the inconsistent passages relative to the critical words in the consistent passages. Working memory, verbal and non-verbal intelligence, inferencing ability and decoding ability were all related to the children's comprehension. The implications of these findings are discussed.

Keywords

Reading comprehension, attention deficit hyperactivity disorder, cognitive psychology, comprehension monitoring, the Construction Integration model

Summary for Lay Audience

Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder that is characterized by inattention and/or hyperactivity. Although many children who have ADHD also have reading difficulties, the reasons for this phenomenon remain largely unknown. The aim of the current study was to better understand how children with and without ADHD monitored their comprehension while reading, the impact that their comprehension monitoring had on their subsequent comprehension and to further examine the cognitive processes that have previously been found to be related to reading comprehension. To learn more about these children's reading, 46 children with and without ADHD read short passages during an online reading task. Half of these passages had two sentences within them whose meanings were contradictory. Of interest was the extent that the two groups of children would notice these contradictory sentences and how they would perform on a true-false test and a text recall that followed the reading task. After completing these reading tasks, the children completed a few tasks that measured their memory, inferencing, intelligence and ability to decode words. The results suggested that whereas the children without ADHD seemed to notice the contradictory sentences, the children with ADHD did not. Additionally, in comparison to their non-ADHD counterparts, the children with ADHD remembered less information from the texts. While working memory, inferencing ability and decoding ability all had roles in the children's reading comprehension, the group differences found from the reading task might have been driven by group differences in verbal intelligence. This study adds to the existing body of knowledge pertaining to the relationship between reading, attention and comprehension monitoring.

Acknowledgments

First, I would like to give my thanks to my supervisor Dr. Deanna Friesen. Thank you, Deanna for helping me at every step of this thesis. Whether it was having a lack of participants or getting news of a building fire overseas, you have truly been a steady support these last two years. Your patience, quick edits, insight and encouragement have not gone unnoticed.

Another thank-you goes to Dr. Debra Jared. Without her, I would not have found my way into the Faculty of Education as a graduate student. I am glad to have had her as my undergraduate honours thesis supervisor, where I learned just how enjoyable answering a research question could be. From her lab, I would also like to thank Xuan Pan and Zian Chi for helping me navigate PsychoPy to design my thesis' major task during Covid-19.

The third set of thanks goes to my colleagues in the School and Applied Child Psychology program. Thank you to the individuals both old and new within Deanna's Reading Lab, who have given me advice and helped me with my project. I am also appreciative of the supportive women who have been a part of my MA cohort. I am lucky to have been this program alongside them, while snacking and/or watching the Bachelor. I look forward to seeing where the next four years take us.

And lastly, thank you to everyone who has asked what exactly I've been working on for the last two years (Yes, I'd imagine my explanations were confusing, but hopefully the layperson summary above helped). Thank you to my family scattered in Mississauga: My parents for believing in me, my sisters for providing comedic relief, my Granddad and Aunt D who showed their encouragement in their own unique ways. And to the

friends that I've had since starting here at Western almost seven years ago and have supported me ever since.

Table of Contents

Abstract ii

Summary for Lay Audience iii

Acknowledgments iv

Table of Contents vi

List of Tables viii

List of Figures ix

List of Appendices x

Chapter 1 1

1 Introduction 1

1.1 Theories of Reading Comprehension 3

1.2 ADHD and Reading Comprehension 9

ADHD, Attention and Memory 11

ADHD, Inferencing and Integration 13

1.3 The Present Study 17

Chapter 2 21

2 Method 21

2.1 Participants 21

2.2 Materials 23

Background Questionnaire 23

Reading Comprehension Task 23

Individual Difference Measures 27

2.3 Procedure 28

Chapter 3 31

3 Results 31

3.1 Individual Difference Measures 31

3.2 The Reading Comprehension Task 32

3.3 Correlation Analyses 35

Chapter 4 40

4 Discussion 40

4.1 Educational Implications 51

4.2 Limitations 52

4.3 Future Directions 55

4.4 Conclusions 56

References 57

Appendices 62

Curriculum Vitae 80

List of Tables

Table 1: Means and Standard Deviations (in brackets) of Demographic Information as a function of ADHD Status.. 22

Table 2: Means and Standard Deviations (in brackets) of Individual Difference Measures as a function of ADHD Status 32

Table 3: Means and Standard Deviations (in brackets) of Number of Units Recalled and True-False Test Accuracy as a function of ADHD Status and Passage Consistency 35

Table 4: Correlations between Reading Comprehension Task Performance and Individual Difference Measures 38

Table 5: Correlations between Reading Comprehension Task's Difference Scores and Individual Difference Measures... 39

List of Figures

Figure 1. Self-paced reading task schematic.. 25

Figure 2. Typically developing children's average word reading times (in ms) during self-paced reading task as a function of Word Position and Consistency................................ 33

Figure 3. Children with ADHD's average word reading times (in ms) during self-paced reading task as a function of Word Position and Consistency.. 34

List of Appendices

Appendix A: Parent/Guardian Questionnaire 62

Appendix B: Reading Passages List One.. 66

Appendix C: Reading Passages List Two 68

Appendix D: Reading Comprehension Task True-False Questions 70

Appendix E: Sentence Recognition Task (Oakhill, 1982) Example Story 71

Appendix F: Ethics Approval 72

Appendix G: Letter of Information and Consent Form 74

Appendix H: Children’s Assent Form 78

Appendix I: Debriefing Form 79

Chapter 1

1 Introduction

Reading comprehension is a valuable skill that children acquire throughout their education. As students progress, they gradually become more practiced readers and are increasingly expected to use their reading competence to their advantage (Rabiner & Coie, 2000). The ability to acquire new knowledge by reading plays an integral role in both academic and vocational success (Silva & Cain, 2015). Thus, because of its societal value, researchers have focused on better understanding the processes that underlie reading comprehension ability. For example, Jeanne Chall explains that in their early elementary school years, children gradually master the ability to decode words and simple sentences. Then, from grade four onwards, the expectation is that these students are able to read for meaning by extracting new knowledge (Indrisano & Chall, 1995); thus, reading comprehension becomes crucial for further learning and academic success (Friesen & Haigh, 2018).

Nonetheless, there is a subgroup of readers who are sufficient decoders but have difficulty understanding the texts they have read (e.g., Oakhill, 1993). This discrepancy between their decoding skill and their comprehension ability has piqued the interest of many researchers and educators. Specifically, it indicates that decoding ability is necessary but not sufficient for good reading comprehension and highlights the necessity of investigating the nature of this discrepancy. By determining the underlying mechanisms of comprehension and pinpointing ways in which less skilled comprehenders differ from their peers, we should be able to better address the needs of the former group. Identifying struggling readers as early as possible is crucial for implementing appropriate intervention strategies and minimizing the achievement gap between children who are skilled comprehenders and those who demonstrate difficulties in this domain (Munger & Blachman, 2013).

One such area that may differ between skilled and poor comprehenders is attention (e.g., Rabiner & Coie, 2000). Though researchers vary on how they define the term, there is a general consensus that attention refers to the ability to maintain one's focus on a given stimulus while minimizing the impact of other irrelevant, distracting stimuli in the environment (Kim, 2016). Arrington, Kulesz, Francis and Fletcher (2014) explain that attention has three components: sustained attention, response inhibition and cognitive inhibition. However, cognitive inhibition and sustained attention are especially important for reading comprehension. Cognitive inhibition refers to the need for individuals to supress irrelevant information such as context-irrelevant word meanings and thoughts. This, in turn allows the reader to engage in sustained attention, which helps them remain on task and continually update their mental representation of the text. Thus, in this manner sustained attention and cognitive inhibition operate in tandem and allow the reader to maintain their focus and consequently recall the text's information accurately (Arrington et al., 2014). It is possible that children with attention problems lag behind their peers because they have greater difficulty adopting the necessary behaviours to extract meaning from texts.

The present study had three goals. The first was to determine whether children with Attention Deficit Hyperactivity Disorder (ADHD) deployed their attention differently than their typically developing peers while reading. The second was to compare the information that the children retained from the texts and thereby examine the mental representations that the two groups of children formed. The final goal was to verify whether there were group differences in two cognitive processes previously found to be related to reading comprehension – working memory and inferencing – and their relationships with text processing and other cognitive processes.

This thesis will begin by describing two theories of reading comprehension: specifically, the Simple View of Reading (SVR; Gough & Tumner, 1986) and the Construction Integration Model (CI; Kintsch, 1998). The literature review will also discuss the cognitive processes that underlie reading comprehension with a focus on areas of difficulty for individuals with ADHD. Lastly, the thesis will conclude by describing a novel empirical study that considers ADHD, comprehension monitoring and their relationship with working memory, inferencing, intelligence and reading fluency.

1.1 Theories of Reading Comprehension

The Simple View of Reading (Gough & Tumner, 1986) and the Construction-Integration model (Kintsch, 1998) are two cognitive models that pertain to reading comprehension. Although they use different approaches, both have the capacity of informing our understanding of how students with poor comprehension might differ from their typically developing counterparts. On the one hand, the SVR model describes the prerequisite skills necessary for successful comprehension, whereas the CI model describes different levels of representation that are generated while individuals read and emphasizes the value of forming a coherent mental representation of a given text.

The SVR model proposes that comprehension is the product of word reading and language comprehension and implies that the absence of one component bars understanding texts (Gough & Tumner, 1986). It has been used to help researchers better understand reading disabilities such as dyslexia and hyperlexia and has informed educational policies and practices (Kirby & Savage, 2008; Lonigan, Burgess & Schatschneider, 2018; Nation, 2019). In this model, several low-level comprehension processes are thought to encompass word reading, such as decoding and phonological awareness (Kibby, Lee & Dyer, 2014; Lepola, Lynch, Kiuru, Laakkonen & Niemi, 2016). Decoding is the ability to decipher words in print (Gough & Tumner, 1986; Nation, 2019). It is reliant on phonological awareness: that is, one's knowledge of their language's sounds. Decoding necessitates that the individual understands that letters represent sounds and is able to combine those letters' sounds in order to read (Kibby et al., 2014).

In contrast, language comprehension is a broader term (Lonigan et al., 2018) as Gough and Tumner (1986) simply describe it as one's ability to understand and interpret words, sentences and discourse. In an attempt to further define the term, some researchers have sought to identify which skills comprise this component of the model. Lervåg, Hulme and Melby-Lervåg (2018) for example, propose that language comprehension encompasses vocabulary knowledge, inferencing ability and syntactic and morphological knowledge since these four oral language competences almost fully accounted for variance in their participants' language comprehension scores. Furthermore, Nation (2019) explains that listening comprehension tasks, which are often used to measure language comprehension subsume language processing ability and vocabulary and grammatical knowledge. Regardless, the aim of the SVR model is to provide a broad framework for understanding variation in reading comprehension performance at a given point in time; It is not intended to delve deeply into the cognitive processes that underlie it (Kirby & Savage, 2008; Nation, 2019).

Many studies have found evidence to support the SVR framework. For example, Tilstra, McMaster, Van den Broek, Kendeou and Rapp (2009), Lonigan et al. (2019) and Gustafson et al. (2013) all found evidence that decoding and language comprehension were significant independent predictors of reading comprehension among children. In all of these studies, decoding and language comprehension scores accounted for most of the variance in children's reading comprehension performance. Additionally, research indicates that as children advance through school and become more proficient in decoding, a developmental shift occurs; language comprehension accounts for an increasing amount of variance in children's reading comprehension, whereas the proportion of variance explained by decoding ability decreases (e.g., Gustafson et al., 2013; Lonigan et al., 2018; Tilstra et al., 2009).

However, other research has identified limitations to the SVR model. One limitation is that some studies have found additional predictors of reading comprehension which diverge from the two components indicated by the SVR. For example, Farnia and Geva (2013) reported that in addition to phonological awareness levels in grade one being a significant predictor for reading comprehension in grade six, working memory also behaved as a significant predictor. They and other researchers are in support of an augmented version of the SVR model, which acknowledges any unique contributions that memory and other general cognitive processes have on reading comprehension. A second limitation is that the SVR's ability to explain comprehension performance varies according to the child's age and reading skill. Tilstra et al. (2009) indicated that among their participants, whose grades ranged from four to nine, the proportion of variance in reading comprehension that was accounted for by word reading and language comprehension steadily decreased as grade level increased; By grade seven, less than half of the students' variance was explained by the SVR model's components. Similarly, Gustafson et al. (2013)'s study which compared children with and without reading difficulties indicated that the SVR model was less capable of explaining variance for the former group's comprehension performance. Thus, from a cognitive and developmental standpoint, the SVR fails to account for other important skills that are necessary for children's understanding of texts; however, the model does outline a few areas in which skilled and poor comprehenders may differ.

In contrast, the CI model describes the processes that occur while individuals read and how that incoming information is represented. This framework proposes that text comprehension occurs through the development of a coherent mental representation of the text, which is the product of the interplay of top-down and bottom-up cognitive processes. According to the model, there are three levels of mental representations that are generated as people read (Kintsch, 1998). The *surface form* is the text verbatim, whereas the *textbase* consists of propositions about the story's information. An individual's textbase of a haunted house story, for example, might consist of statements about the scary atmosphere. The situation model is the third component, and promotes recall by integrating the propositions together, establishing local and global coherence among them and incorporating the reader's background knowledge (Friesen & Haigh, 2018; Kim, 2016). Here, the reader would connect the story's information and relate it to their previous experiences. Accordingly, research indicates that individuals with poorer comprehension have difficulty forming a coherent representation of what they have read (Cain, 2010). Where the SVR describes the importance of the prerequisite reading skills that are necessary for reading (i.e., low-level skills such as decoding, phonological awareness and vocabulary knowledge), the CI model emphasizes the role of high-level comprehension skills: that is, skills that specifically help individuals understand texts (Rapp, van den Broek, McMaster, Kendeou & Espin, 2007). High-level comprehension skills enable the reader to create an appropriate situation model by activating the reader's background knowledge, connecting the words and sentences within a text and ensuring that the individual regularly monitors their comprehension. In this manner, the reader is able to extract meaning from the text (Li & D'Angelo, 2016).

High-level competences include comprehension monitoring ability and inferencing (Oakhill, 1993). These two processes' contributions towards reading comprehension are facilitated through a third high-level comprehension process called integration (Kim, 2016): that is, the ability to connect information such as propositions and background knowledge in a manner that creates a coherent situation model (Dixon & Bortolussi, 2013). Comprehension monitoring is a top-down process that refers to one's ability to assess the extent to which they understand what they have read (Kintsch, 2005). It also encompasses the individual's aptitude to detect and resolve inconsistencies and abnormalities in a manner that promotes their comprehension (Oakhill, Hartt & Samols, 2005). By verifying the appropriateness of the content and combining the information they have read, the reader is able to create an accurate situation model (Kintsch, 2005).

Inferencing on the other hand, pertains to the ability to extract information that is not explicitly stated (Daugaard, Cain & Elbro, 2017). The CI model explains that as individuals read, they form a variety of inferences that vary in their relevance to the text's overall message. Thus, to facilitate comprehension, a spreading activation process occurs, where the textbase's propositions strengthen the relevant inferences and the irrelevant ones are deactivated (Kintsch, 2005). From there, the reader is able to integrate their background knowledge with the text's propositions (Kim, 2016). Inferences play an increasingly large role in readers' subsequent comprehension of texts as they become more proficient. Daugaard et al. (2017) for example, observed that in addition to being positively correlated to reading comprehension, inference making ability fully mediated the relationship between vocabulary knowledge and reading comprehension among upper year elementary school students. The authors propose that at this stage, children are expected to deduce a variety of types of information from texts. As a result, their comprehension is reliant on their ability to do so.

Although they are not explicitly mentioned in either the SVR nor the CI models, working memory and attention are two other important cognitive processes that support successful reading comprehension (Castles, Rastle & Nation, 2018; Yuill, Oakhill & Parkin, 1989). These competences are considered more foundational to cognition than low and high-level comprehension skills and are necessary for a wide variety of tasks (Kim, 2016). Working memory refers to the system that temporarily maintains and integrates propositions that have been recently read and pulls relevant information such as background knowledge from long-term memory. The propositions and background knowledge are then integrated and used to generate a coherent representation of the text (Cain, Oakhill & Bryant, 2004). Kibby et al. (2014) demonstrated that working memory predicted comprehension among children between the ages of 8 and 12. Thus, it appears that working memory is an important element of successful reading comprehension.

In contrast, attention describes one's ability to allocate their focus onto an intended stimulus in the midst of other stimuli (Kintsch, 2005) and is necessary for learning a wide variety of tasks (Yildiz & Çetinkaya, 2017). With a longitudinal design, Rabiner and Coie (2000) demonstrated the value of screening for attention as a means of identifying children with reading difficulties. They studied reading comprehension among students in kindergarten until they reached grade five. A negative correlation between inattention scores on the Child Attention Problems Scale and reading achievement was found, implying that participants who were inattentive had difficulty understanding the texts provided. Additionally, inattention levels in Grade 1 was the most significant predictor for reading achievement in Grade 5. In sum, the existing reading research indicates that attention, working memory and inferencing are positively correlated with reading comprehension performance: providing insight on what cognitive processes may account for children's poor comprehension.

1.2 ADHD and Reading Comprehension

Attention Deficit Hyperactivity Disorder is a high-incidence neurodevelopmental disability that is characterized by executive functioning difficulties. It is estimated to affect 5% of school-aged children (Kofler et al., 2019). Its diagnosis is based on two symptom dimensions: hyperactivity and inattention (Öner, Vatanartiran & Karadeniz, 2019). Depending on the number and type of symptoms that the child exhibits, they are diagnosed with one of three ADHD subtypes; Individuals with fewer than six inattention symptoms and six or more hyperactivity symptoms have the primarily hyperactive subtype, individuals with fewer than six hyperactivity symptoms but more than six inattention symptoms have primarily inattentive ADHD and individuals with six or more inattention and hyperactive symptoms have the combined subtype of ADHD (Bernfeld, 2012). ADHD provides an interesting context for studying reading comprehension because it appears that students with ADHD demonstrate impairments in the cognitive processes known to be related to successful comprehension (e.g., Berthiaume, Lorch & Milich, 2010; Miller et al., 2013; Van Neste, Hayden, Lorch & Milich, 2015).

Many children with ADHD demonstrate academic difficulties (e.g., Deans, O'Laughlin, Brubaker, Gay & Krug, 2010; Van Neste et al., 2015). For instance, Öner et al., (2019) explain that up to 45% of children with ADHD have a learning disability, while Willcutt and Pennington et al. (2000) estimate that between 25% and 40% of individuals with ADHD also have a reading disability. However, the prevalence of these comorbidities seems to vary according to the individuals' ADHD subtype (e.g., Öner et al., 2019). For instance, Willcutt and Pennington (2000) considered reading disability and the two ADHD symptom dimensions and found that children with reading disabilities exhibited significantly more inattention symptoms than typically developing children. Meanwhile, Öner et al. (2019) indicated that in comparison to children without ADHD, children with the inattentive and combined ADHD subtypes had poorer reading comprehension performance. However, the comprehension of the children with the hyperactive subtype did not differ from that of their typically developing counterparts. Given the negative implications that children's ADHD symptoms may have on their academic trajectories (e.g., Van Neste et al., 2015), more research that investigates this complex disorder is warranted.

ADHD, attention and memory. Deploying attention is necessary for one's ability to later recall texts (Miller et al., 2013). In this manner, attention and memory operate interdependently to facilitate comprehension. Miller et al. (2013) conducted a study where children with and without ADHD read and recounted a story. The study reported three notable findings. First, although both groups of children recalled more central events (i.e., events that aid in one's overall comprehension of a story) than peripheral events; typically developing children demonstrated a stronger preference for the central events than peripheral events, in comparison to recall behaviours of the children with ADHD. Second, the proportion of central events that the full sample of children recalled was negatively correlated with the number of inattentive and hyperactive symptoms that they had. The third finding was that working memory completely mediated the negative relationship between the number of ADHD symptoms that the participants had and their ability to recall the texts' central events; that is, working memory fully accounted for the correlation between ADHD symptomology and event recall. These findings led the authors to conclude that working memory is necessary for continuously updating one's mental representations of texts and enhances their recall. Furthermore, because connecting the text's propositions was necessary for identifying the story's main events, they suggested that the situation models of the children with ADHD were less coherent than those of their typically developing counterparts.

Yeari, Vakil, Schifer and Schiff (2019) demonstrated a similar phenomenon with an eye tracking study that was implemented on adults with and without ADHD. The participants who had ADHD recalled fewer central events than the control group. This outcome occurred despite the adults with ADHD recognizing the events' importance and rereading the central events significantly longer than the peripheral ones, unlike their typically developing peers. However, there were no group differences in the other eye movement measures (i.e., total reading time, first-pass reading time, rereading occurrence). Thus, it appears that the two groups of readers deployed their attention to both types of events comparably but those with ADHD attempted to compensate for their memory deficits by spending more time rereading the important components. Given the nuanced approach that recording individuals' reading behaviours provides, it would be worthwhile to implement a comprehension monitoring study that has passages with inconsistencies and record how children with and without ADHD respond to the texts. The subsequent results could provide further insight on the text processing, attention and working memory of both groups.

Group differences in recall may be due in part to the cognitive load that reading may present to children with attentional difficulties. Tannock, Purvis and Schachar (1993) suggest that while reading, children with ADHD use greater cognitive resources to sustain their attention, which compromises their memory and subsequent recall. Their participants were children between the ages of 7 and 12, who either did or did not have ADHD. During the procedure, each child read a story and retold it. The students with ADHD made more errors: such as using semantically inappropriate word substitutions or providing incorrect information. However, interestingly, the two groups did not differ in their performance on the comprehension questions, which prompted them to recall factual and inferential information.

ADHD, inferencing and integration.

Inferencing. Besides attention and working memory, children with ADHD may have difficulty enacting higher-level reading processes; among them is making inferences. As discussed above, inferences are especially valuable for reading comprehension because they allow the reader to fill in information that is not explicitly mentioned in the text. Explanatory inferences are considered the most valuable for reading comprehension and help the reader understand a phenomenon by generating causal attributions. Elaborative inferences on the other hand, enhance the mental representation of the text by supplementing details and enabling the reader to form predictions (Van Neste et al., 2015).

Inferences are consolidated through integration, which connects the propositions and activates prior knowledge (Kim, 2016). According to the CI model, a lack of inferences should hinder the reader's formation of an appropriate textbase and situation model and negatively affect their text comprehension (Kintsch, 1998). Van Neste et al. (2015) demonstrated the value of inferences in their research, which compared children with and without ADHD. Participants' ages ranged from 7 to 11 years and they watched a television show, which was paused immediately before events critical to the story's plot. During this time, the children were required to describe their thoughts about the plot, which were then coded according to whether they were inferences. Afterwards, they recounted the television episode. Children with ADHD generated fewer plausible explanatory inferences than their typically developing peers. Furthermore, the number of plausible explanatory inferences that the children formed during the think-aloud procedure behaved as a mediator for the relationship between ADHD status and children's recall of the story's important events, and the relationship between ADHD status and children's recall of events on the causal chain. Plausible inferences also mediated group differences in the global coherence of the children's recall of the television episode. In all of these instances, the children's ability to form valuable inferences enhanced their mental representations of the television show and promoted their recall. Because children with ADHD had difficulty enacting this high-level comprehension skill, they exhibited recall that was poorer than that of their typically developing peers.

Similar to Van Neste et al. (2015), Berthiaume et al. (2010) used a think aloud procedure to investigate the importance of generating accurate inferences. Their participants were boys with and without ADHD, whose ages ranged from 7 to 12. Each one was read a story, where they were required to describe what they were thinking after hearing each sentence. The boys' inferences were then coded according to type (explanatory, elaborative or predictive) and further rated as either plausible or implausible. While both groups made a comparable number of plausible inferences, the children with ADHD made more implausible inferences than the control group. It is possible that their poorer quality inferences left these children with mental representations of the story that were inaccurate and/or incomplete.

In sum, both Van Neste et al. (2015) and Berthiaume et al. (2010)'s work highlighted group differences in generating the type of inference most important to reading comprehension. However, neither study explicitly considered reading comprehension. Further research is necessary to determine the role that inferencing has on the reading comprehension of children with and without ADHD. An effective way of studying this is by providing passages for the child to read and then examining the relationship between the children's comprehension performance and their inferencing abilities.

Integration of textual information. Generally speaking, various studies have investigated integration as a means of exploring group differences in reading and listening comprehension. However, apart from inferencing, no research has specifically considered children with ADHD and the impact that their ability to integrate textual units has on their reading comprehension. This area is worthy of attention because of these students' unique patterns of strengths and needs; Although they demonstrate difficulties in attention, working memory and inferencing (e.g., Miller et al., 2013; Rabiner & Coie, 2000; Yeari et al., 2019), individuals with ADHD can recognize important events in stories (Yeari et al., 2019) and they have been found to perform as well as their non-ADHD counterparts on comprehension questions which probe their recall of factual and inferential information (Tannock et al., 1993).

Although she did not expressly examine children with ADHD, Oakhill (1982) considered 7–8 year-old children who had either good or poor comprehension and created an innovative procedure that compared their ability to use inferences to integrate information. Eight three-sentence stories were read aloud to each child followed by a recognition task where the participant was presented with 32 sentences and was required to indicate whether they had heard each sentence before. Some of these recognition sentences were foils: half of which whose meanings were congruent with the information from one of the previous stories (i.e., its meaning could be inferred) whereas the others had a meaning that was incongruent. Supporting the CI model's assertion that integration is necessary for successful comprehension, both the good and poor comprehenders made more recognition errors when they encountered the semantically congruent foils than when they encountered the incongruent ones. This effect was larger for the good comprehenders indicating that although both groups were able to integrate the information they heard, the poorer comprehenders did so at a lesser extent. It would be advantageous to consider children with and without ADHD and pair the Oakhill (1982) procedure with a reading comprehension task to examine group differences in reading.

Another way of investigating how students integrate information is by providing them with reading passages. Oakhill et al. (2005) investigated the impact of comprehension monitoring and memory among skilled and less skilled comprehenders. The children were either 9 or 10 years old and were divided into two groups based on their comprehension score on the Neale Analysis of Reading Ability. Then the researchers used an error detection procedure, where the participants read passages that were six sentences long. Some of these passages had two sentences whose meanings were contradictory. These contradictory sentences were either adjacent or separated by a few other sentences. After reading each passage, the students were required to indicate whether the text was coherent or not. It was more difficult for the participants to detect inconsistencies that were farther apart than the close inconsistencies, and an interaction revealed that this effect was larger for the less-skilled readers than their counterparts. Lastly, the children’s ability to recognize the contradictory sentences was correlated with working memory and their comprehension scores. While this study effectively demonstrated the impact of skill, comprehension monitoring and memory, the procedure did not explicitly compare children who had ADHD with their typically developing peers.

To my knowledge, only one study has examined comprehension monitoring ability in students with ADHD, but a listening task was used. Berthiaume et al. (2010) investigated the impact of comprehension monitoring among 9 and 10-year old boys with and without ADHD. Similar to Oakhill et al. (2005), the researchers presented the participants with experimental passages which included two sentences whose meanings were contradictory. However, rather than manipulating the distance of the contradictory sentences, the contradictory sentences remained in the second and sixth sentence positions of the seven-sentence passages. After listening to each passage, the child was asked whether the paragraph made sense overall. In comparison to their typically-developing peers, the students with ADHD had more difficulty recognizing the paragraphs that were not internally consistent. These findings suggest that children with ADHD have poorer comprehension monitoring than their typically-developing peers and that the situation model they generate is inaccurate or missing information. Utilizing a self-paced reading task to examine how children with and without ADHD respond to inconsistencies would provide further information on how children with and without ADHD read texts and monitor their comprehension.

1.3 The Present Study

The present study investigated comprehension monitoring ability and the formation of mental representations in children with and without ADHD. Specifically, reading times to semantically inconsistent texts relative to semantically consistent texts were examined during a self-paced reading task, where the reading behaviours of children with and without ADHD were compared. Similar to the methodology used by Oakhill et al. (2005), contradictory sentences were embedded into reading passages. Given that observed group differences in Oakhill et al. (2005) were larger when the inconsistent sentences were presented further apart, the contradictory sentences in the present study were the second and sixth sentences. Additionally, working memory and inferencing ability were assessed as individual difference variables because they have been found to be related to the reading comprehension performance of children with ADHD (Miller et al., 2013; Van Neste et al., 2015). Working memory was assessed with a backwards digit span task, while Oakhill (1982)'s sentence recognition task measured inferencing ability. Given the importance placed on language and decoding skills in the SVR, the roles of word reading fluency and verbal and non-verbal intelligence were also investigated.

Initially, the plan was to assess children's comprehension monitoring behaviours with an eye tracking procedure. However, in response to the Covid-19 pandemic and federal/provincial social-distancing directives, an online self-paced reading procedure was used instead. Research indicates that self-paced reading tasks allow the individual to read texts in a manner that is comparable to how they would during more naturalistic methods of studying reading (e.g., eye tracking; Currie et al. 2021; Just, Carpenter & Wooley, 1982; van der Schoot, Vasbinder, Horsley, Reijntjes, & van Lieshout, 2009; Wassenburg, Beker, van den Broek & van der Schoot, 2015). Like eye tracking, self-paced reading provides a means of determining the processes that individuals use while reading. During this procedure, the participant reads a passage that is presented on a computer monitor. However, apart from the word or sentence that the individual is currently reading, the entire passage is masked by dashes. In order to advance through the passage, the participant must press a computer key which reveals the following word or sentence and masks the previous one (Just et al., 1982; van der Schoot, Reijntjes & van Lieshout, 2012). This is known as the moving-window method or paradigm (Just et al., 1982).

The current study used an anomaly detection paradigm: that is, it examined how participants responded to inconsistencies. This paradigm is often employed with self-paced reading tasks (Keating & Jegersky, 2015) because the procedure enables the researcher to measure the amount of time between the participants' key presses and consider their reading times in the passages' regions of interest (van der Schoot et al., 2012). This data can then be used to identify areas of processing ease and difficulty. Longer reading times can be found in regions where the reader is attempting to resolve an inconsistency (Currie et al., 2021; Keating & Jegerski, 2015; Just et al., 1982; van der Schoot et al., 2009). Since the current study's passages had one word (i.e., a critical word) that signaled an inconsistency within the text, the passages were presented word by word, rather than sentence by sentence. In addition to allowing the researcher to directly examine how children responded to this critical word, it also accommodated for possible spillover effects, where the critical word's impact on the children's reading times might not have been fully realized until a few words further (Keating & Jegersky, 2015). To my knowledge, there are no studies that have used self-paced reading to better understand how individuals with ADHD respond to semantic inconsistencies. Because of its utility, it was expected that this method would capture any processing differences between the two groups of children.

Since many children with ADHD demonstrate poor performance with regards to the cognitive processes associated with successful reading comprehension (e.g., Berthiaume et al., 2010; Van Neste et al., 2015), it was anticipated that they would retain less of the text's information while reading and would consequently have greater difficulty detecting the contradictory information. Specifically, when the sixth sentence contradicted the second sentence, the typically developing children would read it slower than when the sixth sentence did not contradict the second one. In contrast, no differences were expected in reading times of the children with ADHD as a function of whether the sixth and second sentences were contradictory or not.

In addition to considering both groups' text processing, the quality of their mental representations of the texts and their reading comprehension were also examined. Text recall followed each passage and asked the participant what they had learned after reading the text and what they already knew. These recalls were transcribed and coded for the number of correctly recalled units of information. Reading comprehension was also evaluated with a true-false test which was administered after the child read all the passages. Given previous research finding group differences in text recall (e.g., Van Neste et al., 2015; Yeari et al., 2019), it was expected that the children with ADHD would recall fewer units than their typically developing peers during the text recall and that the children with ADHD's performance on the true-false test would be poorer.

Chapter 2

2 Method

2.1 Participants

The children in the current study were recruited by advertising through social media (e.g., Facebook) and at two clinics in Western Ontario. Forty-six children participated. However, two participants were unable to open the self-paced reading task, one child had difficulty completing the reading task independently and one individual without ADHD had dyslexia. These children were removed resulting in a final sample of 42 children. Half of the children were typically developing (N = 21; females = 7) and their mean age was 11.19 years (*SD* = 1.50). The other half had ADHD (N = 21; females = 4) with a mean age of 11.62 years (*SD* = 1.28).

The mean age that the children with ADHD received their diagnosis was 8.15 years (*SD* = 1.95). Seven of the children had primarily inattentive ADHD, four had primarily hyperactive ADHD and nine had the combined type of ADHD. Those who were prescribed medication to address their attentional needs were asked to take their medications as prescribed on the day they were tested. Twelve children fell into this category and took one or more of the following medications on a regular basis: Vyvanse (5), Concerta (4), Intuniv (4), Biphentin (1), Risperidone (1), Trazodone (1).

The children's parents/guardians reported that their children were able to speak English fluently and read and understand English texts. Furthermore, parents reported the age that their children were first exposed to English, rated their child's reading ability and estimated the number of hours their child spent reading per week. No significant differences were found between groups, *t*s < 1.82, *ps* > .08, on these measures. The children's parents/guardians also demonstrated comparable educational attainment, $t(38) = 1.77$, $p > .05$, which was used as a proxy for socioeconomic status (SES) and was rated on a 5-point scale which ranged from 1 (*some high school*) to 5 (*professional or graduate degree*). Both groups' scores were equivalent to having a bachelor's degree. For a summary of the demographic information, please refer to Table 1.

Table 1

Means and Standard Deviations (in brackets) of Demographic Information as a function of ADHD Status

	ADHD	Typically Developing
Age (in years)	11.62 (1.28)	11.19 (1.50)
SES[1]	4.03 (0.80)	4.40 (0.50)
First Exposure to English (in years)	0.35 (1.57)	0.21 (0.92)
Hours Spent Reading in English per week	9.11 (7.72)	7.98 (7.01)
Parent's Rating of English Reading Ability[2]	4.30 (0.86)	4.70 (0.47)

Notes. 1. SES was the average of the children's parent/guardians' educational attainment, where 1 = *some high school* and 5 = *graduate or professional degree*.

2. Parent's Rating of (their child's) English Reading Ability was rated on a 5-point scale with 1 = *poor* and 5 = *excellent*.

2.2 Materials

Background questionnaire. An online questionnaire was created and administered to each participant's parent/guardian. The questionnaire asked the adult to indicate whether their child had an ADHD diagnosis, and if so, the child's age of diagnosis. It also had items that pertained to their child's language background, reading ability and the extent that they read at home. Additionally, the questionnaire asked about the adults' educational attainment, which was used as a proxy for SES. Relevant information from the questionnaire is reported in the participants' section. To view the full questionnaire, please refer to Appendix A.

Reading comprehension task. Six expository passages on animals were written for use in the current study's self-paced reading task. Each text was seven sentences long and between 92 to 102 words. The information about the animals came from a children's Encyclopedia Britannica book whose content was targeted towards children between the ages of three and six (Broderick, 2016) and the passages' format was based on the Oakhill et al. (2005) study. Additionally, the Flesch-Kincaid Calculator (Flesch, 1994) was used to estimate the passages' readability. The Grade Level formula considered the number of words, sentences and syllables in the passages and suggested that children would require an equivalent of 5.7 years in the American school system to comprehend the texts. Because the content, structure and readability were carefully considered during the passages' construction, it was anticipated that if there were any group differences in comprehension monitoring and integration ability, they would be captured.

Two versions of each passage were created. The differences between the two passages were found in the second sentence. In the inconsistent passages, the information in the second and sixth sentences was contradictory. In contrast, the second sentence in the consistent version did not contradict the sixth sentence. The sixth sentence was the same in each version and a priori, a disambiguating word was identified as the critical word within it. In the inconsistent condition, the critical word created the conflict with information found in the second sentence and it was here where it was expected that the reader would begin to notice that the sentences contradicted each other. Furthermore, identifying this critical word facilitated comparisons in reading times between the passage's two versions.

An example of both versions of a passage is provided below. Key differences between the consistent and the inconsistent versions are italicized for demonstrative purposes. The critical word is also bolded and italicized for this purpose.

Consistent passage example:

> Gorillas are social, clever animals that belong to a mammal category called primates. They can behave *peacefully*, so it is very *uncommon* to see them yelling and fighting with each other. Gorillas live in groups called troops and use their faces, bodies and mouths to communicate. They can help each other groom and feel sad when another gorilla is hurt. Together, gorillas make shelters in the forest and gather various fruits to share and eat. It is rare to see gorillas ***fighting*** because of their gentle and cooperative nature. Instead, they are usually calm but protect each other from predators when necessary.

Inconsistent passage example:

> Gorillas are social, clever animals that belong to a mammal category called primates. They can behave *aggressively*, so it is very *common* to see them yelling and fighting with each other. Gorillas live in groups called troops and use their faces, bodies and mouths to communicate. They can help each other groom and feel sad when another gorilla is hurt. Together, gorillas make shelters in the forest and gather various fruits to share and eat. It is rare to see gorillas ***fighting*** because of their gentle and cooperative nature. Instead, they are usually calm but protect each other from predators when necessary.

The passages were presented in a white Courier New font, on a grey background. Their font size was 30 pixels. An experiment building program called PsychoPy3 (Peirce

& MacAskil, 2018) was used to display the passages one word at a time. Thus, although the passages were presented in their entirety on the computer screen, all words except for the one that the participant was currently reading were masked by dashes. The participants advanced through each text by pressing the space bar, which in turn revealed the following word in the passage, while hiding the former one. For an image of how the self-paced reading task was displayed, please refer to Figure 1.

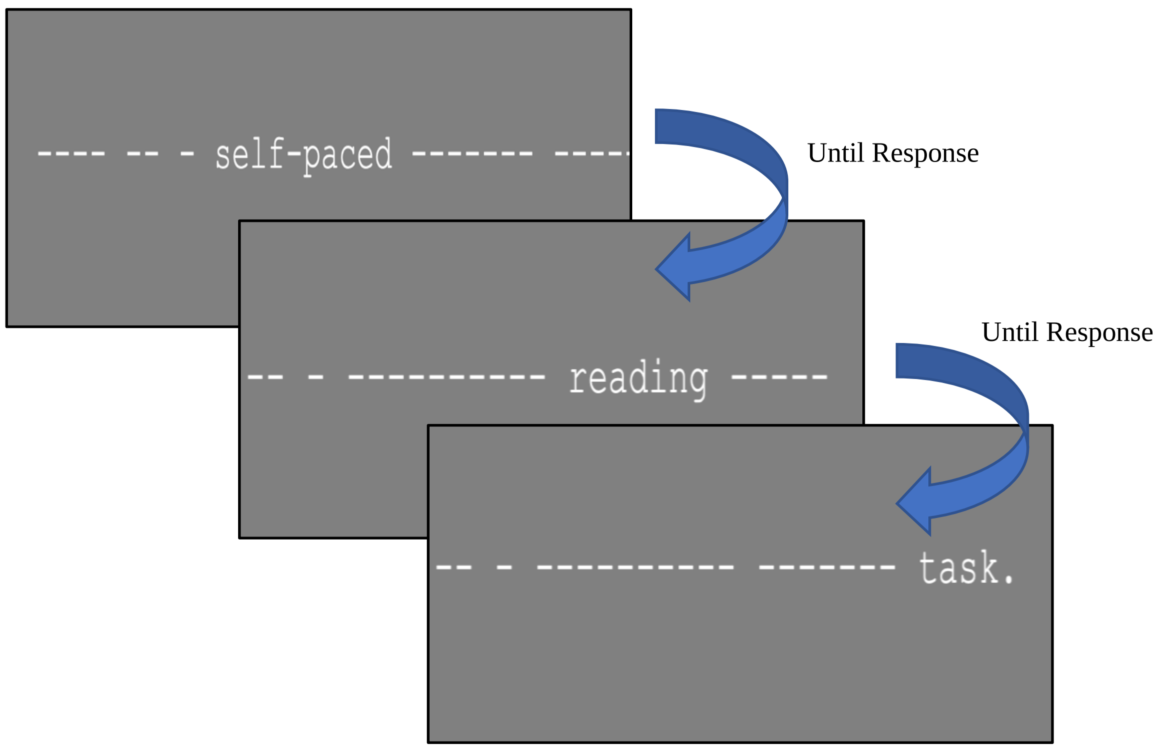

Figure 1. Self-paced reading task schematic.

Two lists of passages were made, where each one had three consistent passages and three inconsistent passages. The participants only read one version of each text and the lists were counterbalanced across the experiment. Please refer to Appendix B to see List One and Appendix C for List Two. The children were instructed to read the passages for meaning, because they would be asked to share what they learned after reading each text.

Since text recall was a dependent variable, four researchers counted the unique information units in each passage and met to reach consensus on the number of unique meaning units present in each passage. Since the second sentences varied according to the passage version, its meaning units were excluded. The passages' units ranged from 14 to 19. Since there were unequal numbers of meaning units across the passages, average proportions of total meaning units were used as the dependent variable. To capture text recall, the children were asked two questions. The first question was "What did you learn about this animal?" and the second was "What did you already know about this animal?" The participants' responses were audio recorded, transcribed and coded. Each question for each text was coded for the presence of unique meaning units. The total number of unique meaning units reported from the text that the participants correctly recalled while answering the two questions were converted into proportions and averaged across the three texts in each consistency condition. The rater was blind to the ADHD status of the participants.

After the self-paced reading component, a 24-item true-false test followed. At this time, the examiner read a list of statements aloud to the participant about all the animals. The participant was required to indicate whether the information was true or false according to the texts they had read. Because the participants varied in which consistent and inconsistent passages they read, the true-false questions did not address information that was found in the second and sixth sentences. However, the participants did receive separate accuracy scores (out of 12) for the different consistency conditions. To view the list of true-false questions, please refer to Appendix D.

Individual difference measures.

Inferencing. Inferencing was assessed with Oakhill (1982)'s sentence recognition task. This task consists of eight stories, each of which are three sentences long. Four recognition sentences accompany each text; two are identical to the sentences in the story, while the other two are not. The sentences in the latter group have one whose meaning can be inferred from the text's information, while the other has a meaning that is incompatible with the story's information. All of the stories are read aloud to the participant. Then, the examiner reads all of the recognition sentences to the individual, who is required to indicate whether they heard the sentence in any of the stories they were read. The task produced an overall accuracy score. Oakhill (1982) and Cain et al. (2004) found that this task established good discriminant validity among good versus poor comprehenders. To see an example of a story and its accompanying recognition sentences, please refer to Appendix E.

The KBIT-2. Verbal and non-verbal intelligence were measured with the second edition of the Kaufman Brief Intelligence Test (KBIT-2; Kaufman & Kaufman, 2004). Verbal intelligence was assessed by combining scores from the Verbal Knowledge and Riddles subtests. During the former subtest, the child is shown a page that has six pictures. The examiner says a word or phrase and the participant must identify which picture on the page best describes it. Meanwhile for Riddles, the child is required to answer a series of questions that consist of two or three clues and describe an object. The questions' answers rely on the child's vocabulary knowledge, verbal comprehension and reasoning skills. Non-verbal intelligence was measured with the Matrices subtest. This subtest has a multiple-choice format. For each item, the participant is shown an assortment of objects or shapes that are organized into a matrix. The child must select a picture which best completes the pattern depicted. The test manual provided standardized scores for each subtest which then produced a verbal score and a non-verbal score.

Working memory. Working memory was assessed with a backwards digit span memory task adapted from the fifth edition of the Wechsler Intelligence Scale for Children (WISC-V; Wechsler, 2014). This task measures both executive function and working memory (Daugaard et al., 2017). The examiner reads a number sequence aloud, and the participant must recite the digits in reverse order. The number of digits gradually increases, and testing ends when the participant fails two consecutive trials of a given number string length. A digit span score was produced by determining the highest number string length that the participant correctly recited backwards.

The TOWRE. The Test of Word Reading Efficiency (TOWRE; Rashotte, Torgesen & Wagner, 1999) measured the participants' phonemic decoding abilities and reading fluency. Each child was provided with a page that contained 104 English words, which were organized into columns. They then had 45 seconds to read as many of the words aloud, reading down each column starting at the first column. Afterwards, the task was repeated with 63 English non-words (i.e., items that were not English words but follow the language's grapheme-phoneme rules). The test manual was used to produce standardized scores for Sight Word Reading Efficiency (i.e., performance reading the English words) and Phonemic Decoding Efficiency (i.e., English non-words).

2.3 Procedure

Before the start of the study, ethics approval was acquired from Western University's non-medical research ethics board. To see a copy of the approval form, please refer to Appendix F. The children were recruited from two clinics affiliated with the University of Western Ontario and from the broader community using social media. Before participating, their parent/guardian was sent an online copy of the letter of information. The letter indicated that if they consented, their child would have their reading behaviours monitored during a reading comprehension task and would complete a few additional language and cognitive tasks. After consenting, the parent/guardian completed the background questionnaire. Then, at the start of their Zoom session, the child read an electronic version of an assent form to confirm that they agreed to participate. Similar to the letter of information, the child was informed that they would complete a reading task which would be followed by a few shorter activities. The session began after the parent/guardian virtually signed the consent form and the child provided their assent. Please refer to Appendix G to see a copy of the letter of information and consent form and Appendix H for the children's assent form.

Each child was tested individually during a single 75-minute synchronous Zoom session. In this manner, real-time video correspondence was used to communicate with the participant, present the tasks and provide instructions. The testing session was audio recorded and began with the Reading Comprehension Task. There, the participant was assigned one of the two versions of this task and was sent a link from Pavlovia (i.e., a website that allows researchers to share their experiments with participants; pavlovia.org) so that they could complete the task on their own computer. After the Reading Comprehension Task, the children performed the backwards digit span task, the sentence recognition task, the KBIT-2 and the TOWRE in this order. The session concluded once the children and parents were debriefed. The child also received their compensation (i.e., 20$ electronic gift card) at this time. The debriefing form can be found at Appendix I.

Chapter 3

3 Results

3.1 Individual Difference Measures

A Multivariate Analysis of Variance (MANOVA) was implemented on SPSS 27 to examine whether the children with ADHD differed from their typically developing counterparts on any of the Individual Difference measures. Group (ADHD, typically developing) was the independent variable and Working Memory (Backwards Digit Span), Inferencing (Sentence Recognition), Verbal Intelligence (KBIT-2), Non-Verbal Intelligence (KBIT-2), Sight Word Reading Efficiency (TOWRE) and Phonemic Decoding Efficiency (TOWRE) were the dependent variables. The main effect of group was significant, $F(1, 37) = 4.69$; $p < .05$; $\eta_p^2 = 0.11$, indicating that there was a significant difference between the two groups' scores on at least one of these dependent variables.

Table 2 reports the means and standard deviations for both groups' scores on the Individual Difference measures. The typically developing children's Verbal Intelligence scores were significantly higher than those of the children with ADHD, $F(1, 37) = 4.69$, $p < .05$, $\eta_p^2 = 0.11$.The difference between the two groups' scores on Phonemic Decoding Efficiency approached significance, $F\ (1, 37) = 3.43$, $p = .07$, $\eta_p^2 = 0.09$. No significant differences between groups were observed on Working Memory [$F(1, 37) = 0.51$, $p = .48$, $\eta_p^2 = .01$], Inferencing Ability [$F(1, 37) = 0.69$, $p = .41$, $\eta_p^2 = .02$], Sight Word Reading Efficiency [$F(1, 37) = 0.14$, $p = .72$, $\eta_p^2 = 0.00$] and Non-Verbal Intelligence [$F\ (1, 37) = 1.24$, $p = .27$, $\eta_p^2 = 0.03$].

Table 2

Means and Standard Deviations (in brackets) of Individual Difference Measures as a function of ADHD Status

	ADHD	Typically Developing
Backwards Digit Span	4.90 (1.41)	4.53 (1.84)
Inferencing Accuracy	0.74 (0.11)	0.77 (0.13)
Verbal IQ*	103.80 (15.27)	113.53 (12.58)
Non-Verbal IQ	111.95 (14.18)	116.74 (12.59)
Word Reading Fluency	101.80 (10.75)	100.58 (9.90)
Non-Word Reading Fluency	99.80 (10.93)	106.32 (11.06)

Note. * $p < .05$. Indicates that two groups' scores differed significantly.

3.2 The Reading Comprehension Task

Reading times. To view both groups' word reading times as a function of Word Position and Passage Consistency, please refer to Figures 2 and 3. A repeated measures ANOVA was conducted on the participants' reading times in the passages' sixth sentence. The repeated measure variables were Consistency (Consistent, Inconsistent) and Word Position, which ranged from n-2 to n+3, where n was the critical word. The dependent variable was word reading times in milliseconds, while Group (ADHD, typically developing) was the between groups variable. Although there was a main effect of Word Position [F(5, 200) = 6.14, $p < .05$, $\eta_p^2 = 0.13$], none of other main effects were significant [All Fs < 1, ps > 0.77]. The Word Position main effect was qualified by a Word Position x Consistency x Group interaction, F(5, 200) = 2.45, $p < .05$, $\eta_p^2 = 0.06$. A simple main effects analysis examined the reading behaviours of the typically developing and ADHD children separately. For the typically developing children, more time was spent reading the critical word (*n*) in the inconsistent passages (*M* = 770, *SD* = 430) than in the consistent passages (*M* = 660, *SD* = 270; F(1, 40) = 4.12, $p < .05$, $\eta_p^2 = 0.09$). In contrast, the children with ADHD spent a comparable amount of time reading the critical words in the consistent (*M* = 700, *SD* = 260) and inconsistent conditions (*M* = 650, *SD* = 210; F(1, 40) = 0.94, $p = .34$, $\eta_p^2 = 0.02$). No other significant differences were observed at any other word positions, [Fs < 1.55, ps > .22].

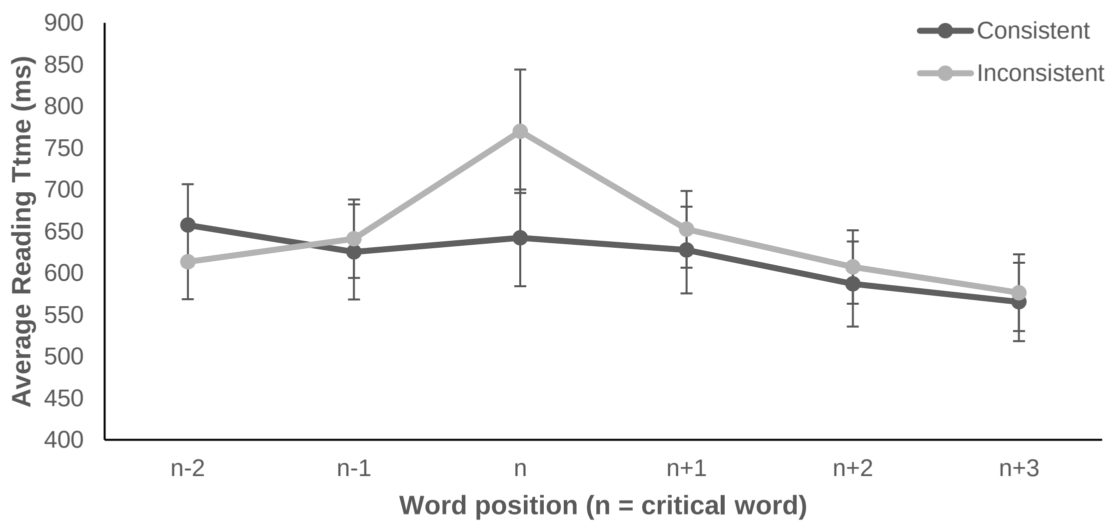

Figure 2. Typically developing children's average word reading times (in ms) during self-paced reading task as a function of Word Position and Consistency. Error bars represent standard error.

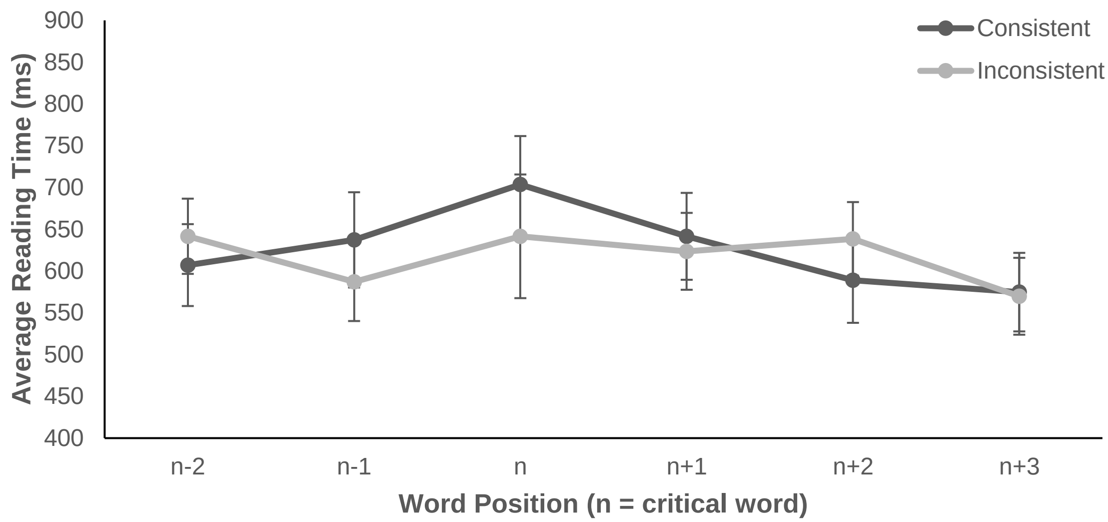

Figure 3. Children with ADHD’s average word reading times (in ms) during self-paced reading task as a function of Word Position and Consistency. Error bars represent standard error.

Text recalls. Table 3 reports the means and standard deviations for the number of units recalled as a function of Group and Consistency. A repeated measures ANOVA was used to compare the proportion of correctly recalled units of information that the children with and without ADHD produced during the Reading Comprehension Task. The repeated measure was Consistency (Consistent, Inconsistent); Group (ADHD, typically developing) was the between-subjects variable and the proportion of information that the children reported from the passages was the dependent variable. There was a main effect of Group, with the typically developing children recalling significantly more information (*M* = 0.40, *SE* = 0.03) than the children with ADHD (*M* = 0.31, *SE* = 0.03; $F(1, 38) = 4.86$, $p < .05$, $\eta_p^2 = 0.11$. However, there was no main effect for Consistency and no interaction between Group and Consistency [All *F*s < 1, *p*s > .63].

True-false test. The two groups’ performance on the true-false test was examined with another repeated measures ANOVA. The repeated measure variable was

Consistency (Consistent, Inconsistent) and the between groups variable was Group (ADHD, typically developing). The children's true-false accuracy score was the dependent variable. The main effects of Group and Consistency were not significant, all *F*s < 1, *p*s > .40. Furthermore, the interaction between Consistency and Group was also not significant, *F* < 1. Please refer to Table 3 to see the means and standard deviations of both groups' performance as a function of Consistency.

Table 3

Means and Standard Deviations (in brackets) of Number of Units Recalled and True-False Test Accuracy as a function of ADHD Status and Passage Consistency

	ADHD	Typically Developing
Text Recalls		
Consistent Passages	0.32 (0.13)	0.40 (0.15)
Inconsistent Passages	0.31 (0.14)	0.40 (0.11)
True-False Task		
Consistent Passages	0.88 (0.12)	0.90 (0.11)
Inconsistent Passages	0.88 (0.12)	0.90 (0.09)

3.3 Correlation Analyses

Bivariate Pearson correlations were calculated to identify significant relationships among the study's dependent variables. Participants' reading times on the critical word, true-false test overall scores, the number of units recalled, Working Memory (Backwards Digit Span), Inferencing Ability (Sentence Recognition), Verbal Intelligence (KBIT-2), Non-Verbal Intelligence (KBIT-2), Sight Word Reading Efficiency (TOWRE) and Phonemic Decoding Efficiency (TOWRE) were the included variables. Additionally, as part of the correlation analysis, the impact of consistency on Average Reading Time, True-False Overall Score and Average Story Units Recalled was also examined. This was effectuated by calculating difference scores. Difference scores for true-false accuracy and units recalled were calculated by subtracting the child's average score for the inconsistent passages from their average score for the consistent passages. Thus, higher scores signified better performance on the consistent texts. In contrast, difference scores for the children's reading times were obtained by subtracting the participants' average reading time for the consistent passages from their average reading time for the inconsistent passages. Again, higher scores signified more efficient processing of the consistent text. These difference scores were then entered into the correlation analysis with the other variables.

To see the correlations between the reading task's dependent measures and the children's performance on the background measures, please refer to Tables 4 and 5. Participants who had better scores on the true-false test recalled more story units (r = 0.39, $p < .05$) and had higher Verbal Intelligence (r = 0.34, $p < .05$) and Phonemic Decoding Efficiency scores (r = 0.43, $p < .01$). Children with shorter reading times demonstrated greater Inferencing Ability (r = -.40, $p < .01$). Children with larger difference scores for Reading Time had higher Verbal Intelligence scores (r = 0.30, $p < .05$), while participants with larger Text Recall Difference scores had higher digit spans (r = 0.39, $p < .05$).

With respect to the relationships between the background measures, participants with larger digit spans had higher Verbal Intelligence ($r = 0.34$, $p < .05$) and Phonemic Decoding Efficiency scores ($r = 0.39$, $p < .05$). Children who exhibited high Verbal Intelligence also demonstrated high Non-Verbal Intelligence ($r = 0.67$, $p < .01$) and high Sight Word Reading Efficiency scores ($r = 0.35$, $p < .05$). Moreover, the significant correlation between Sight Word Reading Efficiency and Phonemic Decoding Efficiency ($r = 0.46$, $p < .01$) indicated that participants who performed well on the former task also demonstrated superior performance on the latter one.

Table 4

Correlations between Reading Comprehension Task Performance and Individual Difference Measures

	1	2	3	4	5	6	7	8	9
	True-False Overall Score	Average Reading Time	Average Story Units Recalled	Digit Span	Average Inference Accuracy Score	KBIT-2 Verbal Standard Score	KBIT-2 Non-Verbal Standard Score	TOWRE Sight Word Reading Efficiency	TOWRE Phonemic Decoding Efficiency
True-False Overall Score	--	-0.02	0.39*	0.26	0.15	0.34*	0.34*	0.11	0.43**
Average Reading Time			0.15	-0.23	-0.40**	-0.13	0.05	-0.38*	-0.34*
Average Story Units Recalled				0.27	0.19	0.26	0.18	0.12	0.35*
Digit Span					0.17	0.34*	0.29	0.13	0.39*
Average Inference Accuracy Score						0.28	0.11	0.18	0.28
KBIT-2 Verbal Standard Score							0.66**	0.35*	0.31
KBIT-2 Non-Verbal Standard Score								0.23	0.37*
TOWRE Sight Word Reading Efficiency									0.46**
TOWRE Phonemic Decoding Efficiency									

Notes. *p < .05, **p < .01

Table 5

Correlations between Reading Comprehension Task's Difference Scores and Individual Difference Measures

	1	2	3	4	5	6	7	8	9
	True-False Difference	Reading Time Difference	Text Recall Difference	Digit Span	Average Inference Accuracy Score	KBIT-2 Verbal Standard Score	KBIT-2 Non-Verbal Standard Score	TOWRE Sight Word Reading Efficiency	TOWRE Phonemic Decoding Efficiency
True-False Difference	--	-0.09	-0.07	0.23	0.06	0.19	0.27	-0.05	0.04
Reading Time Difference			-0.05	-0.02	-0.11	0.30*	0.14	0.02	-0.06
Text Recall Difference				0.39*	-0.01	0.03	-0.24	-0.17	-0.12

Notes. 1. *$p < .05$

2. True False Difference = participants' average true-false score for consistent passages subtracted from participants' average true-false score for inconsistent passages

3. Text Recall Difference = average proportion of recalled units from consistent passages minus average proportion of recalled units from inconsistent passages

4. Reading Time Difference = participants' average reading time for inconsistent passages minus participants' average reading time for consistent passages

Chapter 4

4 Discussion

The present study had three goals. The first was to compare how children with and without ADHD deployed their attention while reading texts, the second was to examine the groups' mental representations of the texts and the third was to identify whether there were group differences in the cognitive processes known to be related to reading comprehension and then to examine the relationships between these variables. These objectives were examined with a self-paced reading task. Half of the passages that the children read had inconsistencies, and of interest was whether the groups would differ in how they responded to consistent and inconsistent passages. The children's responses to these texts were examined by considering their reading times for the critical words, their performance on a true-false test and the number of unique units of information that they recalled. Additionally, a backwards digit span memory task, Oakhill (1982)'s sentence recognition task, the KBIT-2 and the TOWRE were used to examine individual differences in working memory, inferencing, intelligence and reading fluency and to understand their relationships with each other and the reading task's dependent variables.

The current study found that the children with and without ADHD differed in their responses to the Reading Comprehension Task's inconsistencies. While the children with ADHD spent equal amounts of time reading the critical words in the consistent and inconsistent conditions, the typically developing children spent longer reading the inconsistent texts' critical words relative to those in the consistent texts. There was also evidence for group differences in the children's mental representations of the texts, as the children with ADHD recalled fewer units of information. Although the two groups' working memory and inferencing abilities were comparable, the typically developing children exhibited higher verbal intelligence. The correlations among the different tasks' dependent variables provided support for both the Simple View of Reading and the Construction Integration model: alluding to the important role that working memory, inferencing ability, intelligence and decoding ability have in successful reading comprehension performance.

The Reading Comprehension Task's results suggested that children with and without ADHD differed in how they deployed their attention while reading. Whereas the typically developing children read the critical words in the inconsistent passages slower than the critical words in the consistent passages, the children with ADHD's reading times did not differ as a function of the passages' consistency; they spent the same amounts of time processing the consistent and inconsistent passages' critical words. This finding suggests that the children with ADHD are overlooking information in texts, which depending on its importance could have the capacity of negatively affecting their mental text representations. Accordingly, the text recall data conveyed that the children with and without ADHD differed in the mental representations that they generated; Relative to the typically developing children, the children with ADHD recalled fewer units of information. However, while there were group differences in the children's recall, neither the children with or without ADHD's recall varied as a function of passage consistency. The true-false test's results indicated that the typically developing children and children with ADHD demonstrated comparable performance on this task. Similar to the text recalls, neither group's performance varied as a function of passage consistency.

Kintsch (1998) describes the difference between recall tasks and recognition tasks (e.g., true-false tests). Recognition tasks probe an individual's recognition memory and require the individual to compare the item's information with the propositions stored in their textbase. The individual then uses this comparison to make a similarity judgement and answer the question. Kintsch (1998) explains that relative to other types of memory tasks, people generally perform well on recognition ones. In contrast, individuals' performance on recall tasks is more contingent on the quality of their situation model and there is more room for error. Misinterpreting, oversimplifying, and/or failing to properly organize the incoming information negatively affects the individual's mental representation, which in turn has a negative impact on the quantity and quality of the information that the individual recalls (Kintsch, 1998). In sum, the divergent findings on the Text Recall and True-False comprehension tasks suggests that the quality of the children's textbases were similar but that their situation models' quality differed.

The finding that only the typically developing children differed in their responses to the consistent and inconsistent passages during the self-paced reading task align with the findings of Oakhill et al. (2005) and Berthiaume et al. (2010), who also investigated comprehension monitoring and how children responded to inconsistencies in texts. Recall that the Oakhill et al. (2005) and Berthiaume et al. (2010) studies both asked their participants whether each experimental passage made sense. The examiners in the Berthiaume et al. (2010) study read passages aloud to boys with and without ADHD and found that the boys with ADHD made more errors than the typically developing boys. In contrast, Oakhill et al. (2005) considered good and poor comprehenders who read the passages themselves (note that children with ADHD and children with comprehension difficulties both demonstrate difficulties in the domains of comprehension monitoring and inferencing [e.g., Berthiaume et al., 2010; Cain et al., 2004, Van Neste et al., 2015]). Oakhill et al. (2005)'s findings indicated that relative to the poor comprehenders, the good comprehenders demonstrated superior performance on the inconsistency detection task. With a self-paced reading task, the current study extended the findings above and demonstrated that typically developing children are able to detect inconsistencies without being warned about their presence beforehand.

The finding that the two groups differed in their performance on the Text Recalls is similar to the Yeari et al. (2019) and Tannock (1993) studies' results. Yeari et al. (2019) found group differences in their study's text recall component, as their adult participants with ADHD remembered fewer important events relative to the adults without ADHD. The children with ADHD in the Tannock (1993) study also recalled fewer events than their typically developing peers. Additionally, similar to the current study's findings for the true-false test performance, Tannock et al. (1993) found that the children with and without ADHD performed comparably on the comprehension questions that they provided. In sum, previous research and the current study provide converging evidence that children with and without ADHD differ in how they deploy their attention while reading and in the mental representations that they generate. However, the research also suggests that both groups of children have similar comprehension performance on measures that tap into recognition rather than recall.

Another aim of the current study was to determine whether there were group differences in the working memory and inferencing abilities of children with and without ADHD. Contrary to the prediction that relative to their non-ADHD counterparts, the children with ADHD would demonstrate poorer working memory and inferencing ability (Miller et al, 2013; Van Neste et al., 2015; Yeari et al., 2019) there were no group differences for either process. This information suggested that neither working memory or inferencing ability accounted for the groups' differing responses to the consistent and inconsistent passages' critical words.

The finding that working memory did not account for the groups' text processing conflicts with the findings of Yeari et al. (2019), who concluded that differences in working memory accounted for the adults with ADHD recalling fewer central events. Moreover, in their ADHD study, Van Neste et al. (2015) reported group differences in inferencing. However, their methodology differed from that of the current study, as their participants watched a television show and the researchers coded any spontaneous inferences that the children made during the show's pauses. The present study used the sentence recognition task designed by Oakhill (1982), which was intended for children between the ages of seven and eight years. This is considerably younger than the current study's participants, whose ages were between 9 to 14 years. Perhaps for the children on the upper end of this age range, performance on this task reflected their memory abilities for sentences rather than their inferencing abilities.

Verbal and Non-Verbal Intelligence, Sight Word Reading Efficiency and Phonemic Decoding Efficiency were also examined as individual difference measures. The results demonstrated that the typically developing children's Verbal Intelligence was higher than that of the children with ADHD but the groups' Non-Verbal Intelligence, Sight Word Reading Efficiency and Phonemic Decoding Efficiency were similar. The group differences in Verbal Intelligence align with Kaufman and Kaufman (2004)'s results;

while examining the KBIT-2's validity, they compared the performance of children with and without ADHD and found that the former group achieved lower scores on this measure. The participants with ADHD in the Van Neste (2015) study also had lower Verbal Intelligence scores. Because the KBIT-2's Verbal Intelligence measure encompasses the participant's vocabulary knowledge, reasoning ability and their ability to form concepts, it is possible that these two groups of participants differed in a meaningful way that contributed to their performance on the Reading Comprehension Task.

The KBIT-2's Verbal Intelligence score is produced from two subtests. Whereas the Verbal Knowledge subtest measured the participant's receptive vocabulary, the Riddles subtest has a greater emphasis on reasoning and inferencing. It is possible that the children's performance on the KBIT-2's Riddles subtest was a more age-appropriate proxy for Inferencing Ability than Oakhill (1982)'s sentence recognition task. Kaufman and Kaufman (2004) explained that this subtest was adapted from the Conceptual Inferencing test used by Kagan and Klein (1973), and that similar tasks have been used for executive function measures. Recall that during this task, the child is provided with two or three clues and must use this information and their reasoning skills to identify the object or concept that matches the description. A follow-up univariate ANOVA was conducted to determine whether the children with and without ADHD differed in their performance. ADHD status (ADHD, typically developing) was the between groups variable and the within groups variable was the children's raw scores on the subtest. Because the raw scores did not take age into account, age was entered as a covariate. The ADHD group's scores (M = 31.90, SD = 6.02) were lower than the typically developing children's scores (*M* = 34.67, *SD* = 6.54; $F(1, 39) = 3.96$, $p < .05$): suggesting that despite the absence of group differences for Oakhill (1982)'s sentence recognition task, the children's inferencing abilities did differ. Thus, the group differences in text processing were perhaps due in part to differences in inferencing ability.

The current study's third goal was to understand the relationships that the dependent variables had with each other. The number of information units that the children recalled from the texts, Verbal Intelligence and Phonemic Decoding Efficiency were all related to the children's performance on the Reading Comprehension Task's true-false test. The positive correlations that Verbal Intelligence, and Phonemic Decoding Efficiency had with the children's true-false scores reflect the importance of the prerequisite skills described in Gough and Tumner (1986)'s Simple View of Reading. Recall that the SVR model describes the prerequisite skills for reading comprehension and explains that it is the product of decoding ability and language comprehension. Whereas decoding refers to the ability to decipher words in print, the definition for language comprehension is broader but is believed to encompass one's ability to use language knowledge to understand the meanings of words and sentences (Gough & Tumner, 1986; Nation, 2019). In the current study, the TOWRE's Phonemic Decoding Efficiency subtest measured the participants' decoding abilities, and the KBIT-2's Vocabulary Knowledge and Riddles subtests assessed the children's language knowledge and produced a standardized score for Verbal Intelligence. Similar to the findings of Tilstra et al. (2009), Lonigan et al. (2019) and Gustafson et al. (2013), Verbal Intelligence and decoding were both related to the children's reading comprehension in the present study.

Additionally, the finding that the number of units that the children recalled from the texts was related to their true-false scores, align with Kintsch (1998)'s Construction Integration model and the importance of generating a coherent situation model (e.g., Kim, 2016). Recall that the CI model emphasizes the importance of connecting a text's words and sentences in a manner that creates a coherent mental representation of it. The current study's results indicate that as the number of units that the children recounted increased, their true-false scores also increased. The fact that these two different measures both described how participants understood the texts provides some evidence for construct validity.

Because an individual's ability to connect propositions and use their background knowledge to fill in any gaps of information is also thought to contribute to the quality of a reader's situation model (Kintsch, 2005), inferencing was anticipated to be related to the children's true-false scores. However, unlike the findings in the Daugaard et al. (2017) study, there was no association between the children's true-false scores and the children's performance on Oakhill (1982)'s sentence recognition task. It is possible that the difference in findings stem from methodological differences. Daugaard et al. (2017) provided open ended comprehension questions to their participants who read both expository and narrative texts. The authors also used open-ended questions to examine the children's propensity to make inferences. Thus, it is possible that the measures in the current study lacked the sensitivity necessary to fully examine the relationship between Inferencing Ability and reading comprehension.

Meanwhile, Inferencing Ability, Sight Word Reading Efficiency and Phonemic Decoding Efficiency were associated with the children's reading times. Given the importance that decoding ability has on children's reading, the negative correlations that sight word reading and decoding had with the amount of time that the children spent reading the critical words indicates that skilled decoders spend less time reading words than children who are less skilled. Once this skill is mastered, children can then divert their efforts towards reading comprehension (e.g., Indrisano & Chall, 1995; Tilstra et al. 2009). Moreover, the negative association between Inferencing Ability and Reading Times indicated that children with better memory for the presence of the recognition sentences spent less time reading the critical words. This relationship aligns with the findings of Kibby et al. (2014), who found that working memory predicted children's decoding ability and reading fluency. These authors suggest that by temporarily maintaining the text's sounds, words and sentences, memory helps promote smooth reading.

Phonemic Decoding Efficiency was related to the number of information units that the children recalled from the Reading Comprehension Task's texts. Again, decoding is one of the two components mentioned in the SVR model that promotes understanding of texts (Friesen & Haigh, 2018; Gough & Tumner, 1986; Gustafson et al., 2013). The relationship between decoding ability and recall in the current study underscores the importance of this low-level skill in children's reading comprehension. Moreover, the CI model emphasizes the importance of a coherent mental representation and how this situation model enables readers to understand what they have read. The finding that children who scored higher on Phonemic Decoding Efficiency also recalled more units of information suggests that the lower-level processes of children who develop good mental representations of texts are well instantiated (Kintsch, 1998).

Only two of the Reading Comprehension Task's difference score variables had a significant correlation with one of the individual difference measures. First, the story units difference score was correlated with the children's working memory. This association suggests that children with higher digit spans were more sensitive to the passages' consistency manipulation. Specifically, these participants' recalls for the inconsistent passages were poorer relative to their recalls for the consistent passages. The relationship between the story units difference score and working memory supports the research of Cain et al. (2004), who explain that the ability to maintain information that is recently read and establish connections allows readers to form a coherent mental representation of the text. Because the inconsistent passages contained contradictory information, the children with higher working memory capacities might have greater difficulty using their subsequent situation model to recount the passage's information. Moreover, it is possible that this larger working memory capacity interfered with the participants' ability to recall the inconsistent passages' information.

Second, the difference score for Average Reading Time was positively correlated with the children's Verbal Intelligence scores. Children with higher verbal intelligence were more sensitive to the consistency manipulation wherein there was a bigger difference in the amount of time spent on the critical words in the inconsistent condition relative to the consistent condition. Gustafson et al. (2013) described the importance of language comprehension in their study and explained that children with typical reading ability had better language comprehension (operationalized as word comprehension, listening comprehension and receptive grammar) than children with reading difficulties. Thus, the finding that the participants with high Verbal Intelligence's reading times were more sensitive to passage consistency conveys that due to their superior language comprehension, these children were better equipped to monitor their comprehension and detect inconsistencies.

The correlation between the children's difference scores for Average Reading Time and their Verbal Intelligence scores illuminates an important relationship between children's reading and language abilities. Recall that the Group x Consistency interaction for Reading Time indicated that only the typically developing children spent more time reading the inconsistent passages' critical words relative to the critical words in the consistent passages. Moreover, the typically developing children exhibited higher Verbal Intelligence scores in comparison to those of the children with ADHD. The correlation above provides a possible reason for the group differences found for the Reading Comprehension Task's self-paced reading component and the Text Recalls; Perhaps as a group, children with ADHD have poorer language comprehension. In addition to demonstrating lower performance on tasks measuring this skill, having poorer language comprehension might also have a negative impact on their text processing. This possibility is supported by the finding that the children with lower Verbal Intelligence had smaller difference scores for Average Reading Time, meaning that they were not as sensitive to the consistency manipulation and were perhaps overlooking the passages' information. In addition to providing a possible reason for why children with ADHD might be overlooking information in texts, this also reveals an area in which educators can intervene and support children who have this neurodevelopmental disorder.

4.1 Educational Implications

The study's findings provide a few manners in which educators can help their students achieve equitable outcomes at school. First, teachers should be aware of the differences that children with and without ADHD demonstrate in their text processing and recall. Students with ADHD may have trouble identifying key pieces of information and engaging in comprehension monitoring behaviours. Additionally, it is not only reading comprehension that is affected by attention but also listening comprehension (Berthiaume et al., 2010). Thus, to bolster ADHD children's comprehension monitoring abilities, teachers can teach these students how to use mental imagery or encourage them to use storyboards to keep track of texts' events (Cain et al., 2004). Since children with ADHD also experience difficulty in recalling information from texts, one suggestion is to encourage them to read strategically. This might help them better organize the incoming information into a coherent mental representation (Cain et al., 2004).

Second, teachers should also know what cognitive processes are related to text processing and whether children with ADHD experience difficulties in any of those areas. In the current study, the participants with ADHD demonstrated poorer inferencing ability (as measured by the KBIT-2's Riddles subtest) and lower verbal intelligence. Because inferencing has been found to aid with recall and the formation of a coherent mental representation (e.g., Van Neste et al., 2015), educators should help increase students with ADHD's propensity to infer by encouraging them to find "clues" that fill in gaps of information that are not explicitly mentioned in texts (Cain et al., 2004).

Moreover, given the group differences in Verbal Intelligence favouring the typically developing children, teachers could consult the SVR framework and use it to find ways to build their students with ADHD's language comprehension; The children's decoding ability was comparable to that of the typically developing children, thus the emphasis should be on language comprehension rather than the model's decoding component. Gustafson et al. (2013) and Lervåg et al. (2018) explain that targeting children's vocabulary knowledge and inferencing are two ways to build children's language comprehension. There are two reasons why augmenting children's inferencing ability and vocabulary knowledge might be beneficial. First, the children with ADHD's lower Verbal Intelligence scores on the KBIT-2, which measured their vocabulary and inferencing indicated that these two language comprehension skills are areas of need for these children. Second, the positive relationship between language comprehension (as measured by the KBIT-2's Verbal Intelligence score) and the Average Reading Time difference scores suggests that bolstering the children with ADHD's language comprehension might further enhance their comprehension monitoring abilities.

Although the current study did not find group differences in working memory, teachers should still be cognizant of its relationship with reading. The correlation between the children's digit spans and the number of units that they recalled from the stories for instance, indicates that the two skills are related. It might be beneficial for teachers to provide tools, accommodations or modifications where appropriate, to support their students who have poor memory.

4.2 Limitations

The current study has four main limitations. The first limitation is derived from the methodology. Due to the global Covid-19 pandemic and having to resort to online testing, a self-paced reading task was used to examine the children's text processing in lieu of eye tracking. Although several researchers explain that self-paced reading tasks allow the reader to read in a manner that is comparable to how they would for more naturalistic reading procedures (e.g., Currie et al. 2021; Just, et al., 1982; van der Schoot et al., 2009), this method prevented the participants from engaging in their full range of comprehension-repair strategies. For instance, the children in the current study were unable to revisit any words or sentences that they did not understand. Thus, the results do not capture the extent to which the participants rely on this behaviour in their everyday reading. Moreover in the Yeari et al. (2019) study, there were group differences in the adults' rereading behaviours and it is possible that the current study's groups would have differed in this regard. Additionally, the participants might have gotten into a rhythm while completing the self-paced reading task, where they pressed the space bar but were reading passively and not fully processing the text's information. The time between the participants' key presses was used as a proxy for their attention and text processing but it is likely that this operational definition does not fully encompass all that happened as the children read the texts. Nonetheless, the participants' high scores on the true-false test suggest that the children were indeed reading for meaning. Repeating this study with an eye-tracking procedure instead would help address the remaining gaps in knowledge.

Moreover, two limitations stem from the recruitment. The study relied on self-identification during the recruitment process, as the participants' parents or guardians reported that their child had or did not have ADHD. This self-report was the sole criterion used to sort the children into the ADHD and typically developing groups, since there was no measure within our procedure that verified the child's symptomology. Thus, although there would be little reason to be dishonest, it is possible that some parents described their child in a manner that did not depict their true abilities. Regardless, there were indeed group differences in how the children deployed their attention while reading and in the mental representations that they generated. These findings suggest that the parents were honest in their declarations.

A third limitation is that a selection bias might have occurred during the recruitment period. As a group, the children exhibited Verbal and Non-Verbal Intelligence scores that were higher than the norms established by Kaufman and Kaufman (2004). Meanwhile, the educational attainment of the participants' parents, which was used as a proxy for socioeconomic status was the equivalent of a bachelors' degree on average. Together the children's intelligence scores and the SES proxy suggests that parents whose children excel at school and/or were of a higher SES relative to the general population were more inclined to enroll their children in the study and that children with academic difficulties and/or were of a lower SES were underrepresented. Furthermore, factors such as having access to a computer with a reliable internet connection, the value that the parents placed on education and research and the extent to which the family had free time could represent meaningful differences that exist between the children who participated in this study and other children in the Canadian school system. A great deal of effort was put forth to ensure that the study was advertised to a variety of populations; however, because of the widespread impact of Covid-19, inclusionary criteria such as having a computer and internet access became necessary in order to effectuate the study.

Lastly, there was the impact of the children's medication. Since the children with ADHD were asked to take their medication on the day that they were tested, the full impact of their attentional needs on their Reading Comprehension Task performance and on the background measures might have been underestimated. Although other researchers have asked their ADHD participants to discontinue their medication usage up to 48 hours prior to the study (e.g., Miller et al., 2013; Tannock et al., 1993; Yeari et al., 2019), the decision to have the children use their medication as usual was made to increase the study's external validity. Because many children take ADHD medications to help them meet the demands of school, we wanted to examine the children's cognitive processes within this context and did our best to emulate it.

4.3 Future Directions

Future research should delve deeper within the domains of attention, reading comprehension and the cognitive processes related to successful reading comprehension. One way of doing so would be by using eye tracking. The procedure could be largely similar to the current study – with both consistent and inconsistent passages, the true-false test, the text recalls and the background measures – but the self-paced reading component could be replaced with an eye tracking procedure. Eye tracking provides a unique manner of studying reading comprehension because it records eye movements and is consequently able to monitor individuals' natural responses to the text and pinpoint where they are deploying their attention (Deans et al., 2010). Moreover, the procedure would allow the researchers to examine the participants' fixations, saccades and regressions into or out of a region of interest as the participants encountered the critical words in the consistent and inconsistent passages and their relationships with the individuals' performance on the other tasks. To my knowledge, there are no studies that have used eye tracking to better understand how individuals with ADHD respond to textual inconsistencies. Thus, using this methodology would contribute to further knowledge pertaining to the reading behaviours of children with and without ADHD. The study could also be replicated with adult participants. Comparing adults with and without ADHD would provide further information on the relationship between ADHD and reading comprehension, whether this relationship changes as individuals age and the long-term implications of having ADHD. Similar to the first suggestion, the study could be largely comparable to the current study.

4.4 Conclusions

The current study's aims were to examine how individuals with and without ADHD deployed their attention while reading, generated mental representations of texts and to identify the cognitive processes that underly reading comprehension. The children with ADHD's text processing did differ from that of their typically developing peers. They read the consistent and inconsistent passages comparably, unlike their typically developing counterparts. The children with ADHD also remembered less information from these texts. These group differences were perhaps driven by group differences in language comprehension ability. The children with ADHD had lower verbal intelligence, which might have made it more difficult for them to monitor their comprehension and to generate coherent mental representations. Attention, working memory, inferencing ability, intelligence and decoding ability were all related to the children's reading comprehension performance and provide support for the SVR and the CI model. Educators should recognize the unique needs that their students with ADHD might have. It would also be advantageous for them to support these children's reading by bolstering their comprehension monitoring, language comprehension and inferencing abilities.

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Appendices

Appendix A: Parent/Guardian Questionnaire

1. Participant's ID Code_______ (provided by the researcher)

2. Please select your relationship to the participant: Mother Father Other _____________

The following information refers to your <u>CHILD:</u>

3. Date of birth (day/month/year): _______________________________________

4. Gender:
   a. Male
   b. Female
   c. My child prefers another descriptor:______________

5. Grade: ___________________

6. Does your child have any difficulty with their vision? yes ☐ no ☐

   a. If so, does your child wear glasses? ________

7. Country of birth: _______________________________

8. Length of time in Canada (in years): _______________________

9. What is your child's first language?

English ☐ Another language(s) ☐ Both/All languages were learned at the same time ☐

10. At what age was your child first exposed to English? ________

11. How would you rate your child's reading in English?

Poor	Fair	Moderate	Good	Excellent
☐	☐	☐	☐	☐

12. Does your child ***understand*** any language other than English? yes ☐ no ☐

   a. **If yes**, at what age was your child first exposed to their other language?
   ____

13. Does your child ***read*** in any language other than English? yes ☐ no ☐

   a. If **yes**, how would you rate your child's reading in the other language?

Name other language(s)	Poor	Fair	Moderate	Good	Excellent
______________________________	☐	☐	☐	☐	☐

14. Approximately, how many hours a week does your child read in English at home?

   ____

15. Approximately, how many hours a week does your child read in another language?

   ____

16. Has your child been identified with Attention Deficit Hyperactivity Disorder?
yes ☐ no ☐

   If your child **has been identified with ADHD**:

   a. At what age were they diagnosed? __________
   b. At what age were their attention difficulties first noticed? ________
   c. What type of ADHD does your child have? Primarily Attention___; Primarily Hyperactivity___; Combined ____
   d. Does your child currently have a prescription for any medication for ADHD?

   yes ☐ no ☐

   If your child **is on medication for ADHD**:

      i. What medication? ____________________
      ii. Is your child currently taking their medication?
      ____
      iii. What is the medication dosage?
      ____
      iv. How long has your child been taking medication?
      ____

   e. If your child is **NOT** currently on medication, has your child ever been prescribed medication for ADHD? yes ☐ no ☐

IF YES:

i. For how long were they on medication?
ii. Why is your child no longer on medication?

____
____

17. Does your child have any other medical diagnoses? yes ☐ no ☐
18. If so, what are their other diagnoses?

____

19. Is your child on any other medications?

____

The following information refers to the <u>PARENTS:</u>

PARENT ONE:

20. Gender:
    a. Male
    b. Female
    c. Parent 1 prefers another descriptor: _______________

21. Country of birth of PARENT 1: ______________________________________

22. If not born in Canada, when did Parent 1 come to Canada (year)? - __________________

23. **List** the languages known by Parent 1, *in order of acquisition (first learned to last learned):*

____

24. **List** the languages known by Parent 1, *in order of fluency (best known to least known):*

____

25. Please place a check mark (√) next to Parent 1's highest level of Education:

____Some High School
____High School Graduate

____Some College or College Diploma
____Bachelor's Degree
____Graduate or Professional Degree

PARENT TWO (if applicable):

26. Gender:
    a. Male
    b. Female
    c. Parent 2 prefers another descriptor: ______________

31. Country of birth of PARENT 2: ______________________________________

32. If not born in Canada, when did Parent 2 come to Canada (year) __________________

33. List the languages known by Parent 2, *in order of acquisition (first learned to last learned):*

____

34. List the languages known by Parent 2, *in order of fluency (best known to least known*):

____

35. Please place a check mark (√) next to Parent 2's highest level of Education:

____Some High School
____High School Graduate
____Some College or College Diploma
____Bachelor's Degree
____Graduate or Professional Degree

Appendix B: Reading Passages List One

Gorillas
Gorillas are social, clever animals that belong to a mammal category called primates. They can behave peacefully, so it is very uncommon to see them yelling and fighting with each other. Gorillas live in groups called troops and use their faces, bodies and mouths to communicate. They can help each other groom and feel sad when another gorilla is hurt. Together, gorillas make shelters in the forest and gather various fruits to share and eat. **It is rare to see gorillas fighting because of their gentle and cooperative nature.** Instead, they are usually calm but protect each other from predators when necessary.

Otters
Otters are happy mammals that are found around the world. Their webbed feet and flat tails make swimming hard for them. They live near lakes and oceans. Even as adults, otters are very playful and enjoy sliding down riverbanks or on the snow. Otters like to eat different types of shellfish which they open by floating on their backs, putting a rock on their bellies and hitting the fish against it. **Otters are great swimmers because of the handy way their body parts are shaped.** They are nocturnal and prefer to be awake during the night and sleep during the day.

Bats
Bats are the only mammals that can truly fly. To find their food, they send out a cry that humans cannot hear. This sound bounces off objects and echoes back to the bat. The bat can then figure out the distance and size of the objects based on the returning sounds. Bats use this information to avoid flying into objects in their path and to find insects to eat. **People are not able to hear their cry because it is so high-pitched**. Bats sleep during the day and hang by their feet in large groups.

Rattlesnakes
Rattlesnakes belong to a group of poisonous snakes called pit vipers. Their tails make a rattling sound that encourages their prey to approach them. Rattlesnakes can be up to eight feet long. They identify targets by using heat-sensing organs that are found between each eye and nostril. Poison flows through their fangs and into their prey, which includes rodents, lizards and birds. **When prey hear the snake's tail rattle, they run away and try to escape.** Humans who are bitten by a rattlesnake can prevent the venom's effects by receiving prompt medical treatment.

Wolves
Wolves are highly intelligent animals that live in groups called packs. They are courageous hunters who usually hunt for their meals with other wolves. Wolf packs usually have between six and ten members and they howl to get each other's attention. Each pack typically has a male and female pair who are known as the alpha wolves and lead the group. Although they are not fast runners, their endurance is impressive. **They run long distances and hunt for food with their wolf pack, to find their next meal.** Their favourite foods are mice, deer, moose and squirrels.

Seals
Seals are large mammals that live in groups called bobs. Their hearing is good, and they use their eyes to make sure that predators are not nearby. Some seals have ears that are visible and stick out, while other seals have ears that are underneath their skin. Seals spend a great deal of their time in the water. A thick layer of fat keeps them warm and allows them to in cold climates. **Since their hearing is poor, seals have to rely on their vision to avoid predators.** They use their teeth and swim quickly to protect themselves.

Appendix C: Reading Passages List Two

Gorillas
Gorillas are social, clever animals that belong to a mammal category called primates. They can behave aggressively, so it is very common to see them yelling and fighting with each other. Gorillas live in groups called troops and use their faces, bodies and mouths to communicate. They can help each other groom and feel sad when another gorilla is hurt. Together, gorillas make shelters in the forest and gather various fruits to share and eat. **It is rare to see gorillas fighting because of their gentle and cooperative nature.** Instead, they are usually calm but protect each other from predators when necessary.

Otters
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Bats
Bats are the only mammals that can truly fly. To find their food, they send out a cry that humans can hear. This sound bounces off objects and echoes back to the bat. The bat can then figure out the distance and size of the objects based on the returning sounds. Bats use this information to avoid flying into objects in their path and to find insects to eat. **People are not able to hear their cry because it is so high-pitched.** Bats sleep during the day and hang by their feet in large groups.

Rattlesnakes
Rattlesnakes belong to a group of poisonous snakes called pit vipers. Their tails make a rattling sound that encourages their prey to run from them. Rattlesnakes can be up to eight feet long. They identify targets by using heat-sensing organs that are found between each eye and nostril. Poison flows through their fangs and into their prey, which includes rodents, lizards and birds. **When prey hear the snake's tail rattle, they run away and try to escape.** Humans who are bitten by a rattlesnake can prevent the venom's effects by receiving prompt medical treatment.

Wolves
Wolves are highly intelligent animals that live in groups called packs. They are courageous hunters who usually hunt for their meals without other wolves. Wolf packs usually have between six and ten members and they howl to get each other's attention. Each pack typically has a male and female pair who are known as the alpha wolves and lead the group. Although they are not fast runners, their endurance is impressive. **They run long distances and hunt for food with their wolf pack, to find their next meal.** Their favourite foods are mice, deer, moose and squirrels.

Seals

Seals are large mammals that live in groups called bobs. Their hearing is bad, and they use their eyes to make sure that predators are not nearby. Some seals have ears that are visible and stick out, while other seals have ears that are underneath their skin. Seals spend a great deal of their time in the water. A thick layer of fat keeps them warm and allows them to live in cold climates. **Since their hearing is poor, seals have to rely on their vision to avoid predators.** They use their teeth and swim quickly to protect themselves.

Appendix D: Reading Comprehension Task True-False Questions

Gorillas

1. Gorillas belong to a category of animals called primates. (T)
2. Gorillas feel sad when another gorilla is hurt. (T)
3. Gorillas build their shelters alone. (F)
4. A group of gorillas is called a squad. (F)

Wolves

1. Wolves can run long distances (T)
2. Wolves like to eat deer and mice (T)
3. Wolves sniff each other to communicate (F)
4. There are no leaders in wolf packs (F)

Bats

1. Bats are the only mammals that can fly (T)
2. Bats make a special sound to locate food (T)
3. Bats sleep during the night (F)
4. Bats have very good vision (F)

Rattlesnakes

1. Rattlesnakes have special sensors to help them find food (T)
2. Humans can recover from a rattlesnake bite (T)
3. Rattlesnakes do not eat birds (F)
4. Rattlesnakes can be up to 12 feet long (F)

Otters

1. Otters enjoy playing in the water (T)
2. Otters sleep in the daytime (T)
3. Otters do not eat shellfish (F)
4. Otters are grouchy animals (F)

Seals

1. Seals swim very fast to escape from predators (T)
2. A group of seals is called a bob (T)
3. Seals do not spend much time in the water (F)
4. Seals have fat on their bodies to cool them down (F)

Appendix E: Sentence Recognition Task (Oakhill, 1982) Example Story

Story:

1. The plane flew over the house.
2. The house was in Crawley.
3. The plane landed in a field.

Recognition Sentences:

1. The house was in Crawley.
2. The house was in a field.
3. The plane flew over Crawley.
4. The plane flew over the house.

Appendix F: Ethics Approval

Date: 2 September 2020

To: Dr. Deanna Friesen

Project ID: 116188

Study Title: Reading, Comprehension Monitoring and ADHD

Short Title: Reading Comprehension and ADHD

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: 02/Oct/2020

Date Approval Issued: 02/Sep/2020 21:18

REB Approval Expiry Date: 02/Sep/2021

Dear Dr. Deanna Friesen

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Oakhill (1982) Construction Integration Task	Other Data Collection Instruments		
TOWRE	Other Data Collection Instruments		
Backwards Digit Span	Other Data Collection Instruments	11/Sep/2018	
Adult Debriefing Form (20-06-2020)	Debriefing document	26/Jun/2020	
Child Debriefing Form (20-06-2020)	Debriefing document	26/Jun/2020	
KBIT-2 Verbal Knowledge Sample Plate	Other Data Collection Instruments		
Reading Passages_30_06_2020	Other Data Collection Instruments	30/Jun/2020	

True-False Recognition Test (30-06-2020)	Other Data Collection Instruments	30/Jun/2020	
Assent letter_(30_06_20)	Written Consent/Assent	30/Jun/2020	1
KBIT-2_Brief_Intelligence_Overview11	Other Data Collection Instruments		
Language Experience Questionnaire_Adult_Version (10_08_20)	Online Survey	10/Aug/2020	1
Language Experience Questionnaire_Child_Version (10_08_20)	Online Survey	10/Aug/2020	1
Social Media Blurb (13-08-2020)	Recruitment Materials	13/Aug/2020	1
Child and Youth Clinic Blurb (13-08-2020)	Recruitment Materials	13/Aug/2020	1
Qualtrics Child and Adult Language Experience Questionnaire Links (13_08_20)	Online Survey	13/Aug/2020	1
Qualtrics LOI, Consent and Assent Form Links (13_08_20)	Written Consent/Assent	13/Aug/2020	1
Adult_LOI_(02_09_20)	Written Consent/Assent	02/Sep/2020	
Child_LOI_(02_09_20)	Written Consent/Assent	02/Sep/2020	

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario
Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix G: Letter of Information and Consent Form

Project Title: Reading, Comprehension Monitoring and ADHD

Principal Investigator: Deanna Friesen, Ph.D., Education, Western University
Student Investigator: Olivia Ward, Education, Western University

Letter of Information

1. **Invitation to Participate**
   You and your child are being invited to participate in this research study on reading comprehension.
2. **Purpose of the Letter**
   The purpose of this letter is to provide you with information you need to make an informed decision about whether you and your child would like to participate.
3. **Purpose of this Study**

   The goal of this project is to better understand how children with and without Attention Deficit Hyperactivity Disorder (ADHD) comprehend texts by examining their reading behaviours.

4. **Inclusion Criteria**
   Students between 10 years old to 14 years old are invited to participate along with one of their parents. English must be your child's first language. You and your child must have access to the internet. For analysis purposes, you must agree to have your child's responses audio-recorded for them to participate.
5. **Exclusion Criteria**
   Students who have a first language other than English, are not in the age range and/or do not have internet access are not eligible to participate.
6. **Study Procedures**
   If you and your child agree to participate, you will complete a questionnaire about your family's language background (i.e., both parents' and the child's) as well as your child's cognitive background online via Qualtrics platform (approx. 5 minutes). A unique ID number will be assigned to you to include in the questionnaire to keep your family's data confidential. The rest of the study will be done entirely online through Zoom with your child and the researcher in this password protected session. The entire session should take approximately an hour and 15 minutes. During this time, your child will complete a reading task where they will read a series of short passages about animals and retell the stories. To keep your family's data confidential, your child will use the same ID number as the one that you used for the questionnaire. Your child will be sent a link to the reading task via the chat function on Zoom and they will be directed to an experiment sharing website called Pavlovia, which will enable them to complete the task online. After your child finishes the reading comprehension task, they will complete a few short language and cognitive tasks: a sentence

recognition task, a memory task, a vocabulary task, a reading fluency task and a non-verbal reasoning measure on Zoom with the researcher. The program Audacity will be used to record your child's audio responses.

7. **Possible Risks and Harms**
There are no known or anticipated risks or discomforts associated with participating in this study.

8. **Possible Benefits**
There are no direct benefits to you and your child in this study. However, it is anticipated that this study will help educators better understand the reading behaviours that are distinct to children with ADHD. The findings will contribute to the growing body of information surrounding the unique strengths and needs that children with ADHD demonstrate in the classroom. Ideally, this information can then be used to identify strategies to better support these children in their reading comprehension.

9. **Compensation**
Your child will be compensated with a $20.00 gift card to Indigo for participating in this research, regardless of whether they complete the session. The gift card will be sent to your email address, which will go through Indigo's online purchasing system in order to send your child's compensation. Thus we will provide the company with your name and email address.

10. **Voluntary Participation**
Participation in this study is voluntary. You and your child may decline to participate, refuse to answer any questions or withdraw from the study with no effect on their future education. You do not waive any legal rights by consenting to this study.

11. **Confidentiality**
Your family's participation in this study will be kept confidential. The researcher will keep any personal information in a secure and confidential location for a minimum of 7 years. The identifiable information (name, email address) will be collected to schedule the Zoom meeting. A master list will be used to link the unique ID with each participant's identifiers, and this list will be stored separately from the study data. No data will be collected/stored within Zoom. While we will do our best to protect your family's information, there is no guarantee that we will be able to do so. When the results are published, your names will not be used. Both aggregated data and quotes from the children's responses may be incorporated within a publication but will not be identifiable to you or your child. Representatives of The University of Western Ontario Non-Medical Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research. Your survey responses will be collected through a secure online survey platform called Qualtrics. Qualtrics uses encryption technology and restricted access authorizations to protect all data collected. In addition, Western's Qualtrics server is in Ireland, where privacy standards are maintained under the European Union safe harbor framework. The data will then be exported

from Qualtrics and securely stored on Western University's server. Your child's performance on the reading task will be collected using PsychoPy3 and pavlovia.org. PsychoPy3 is an experiment building program. This program will use your child's assigned ID number to keep your family's data confidential. Pavlovia.org is a secure online platform that allows researchers to put their experiments online. If you and your child agree to participate in the study, this third-party website may collect cookies and your family's IP address to ensure that the website is running smoothly. This personal data will not be accessible to the researchers nor will it be shared with any other parties. Pavlovia's server is located in the United Kingdom and uses encryption technology to protect all data. Your child's performance on the reading comprehension task will only be accessible to the researchers involved in this study.

12. Contacts for Further Information

If you and/or your child require any further information regarding this research project or you and/or your child's participation in the study you and/or your child may contact Olivia Ward or Dr. Deanna Friesen.

If you and/or your child have any questions about your rights as research participants or the conduct of this study, you and/or your child may contact The Office of Human Research Ethics.

13. Publication

If the results of the study are published, neither your nor your child's name will be used. If you and/or your child would like to receive a copy of any potential study results, please contact Olivia Ward.

14. Consent

Please ask your child if they would like to participate. If both you and your child agree, please sign the consent form.

This letter is yours to keep for future reference.

Consent Form

Project Title: Reading, Comprehension Monitoring and ADHD

Principal Investigator's Name: Dr. Deanna Friesen
Student Investigator's Name: Olivia Ward

I have read the Letter of Information and understand the nature of the study. I asked my child if they wish to participate and they agreed to participate. All questions have been answered to my satisfaction.

Child's Name: ____

Guardian's Name: ____

I agree to have my child participate in this study (please check box) ☐

I agree to have my email address shared with Indigo to receive compensation ☐

Appendix H: Children's Assent Form

Project Title: Reading, Comprehension Monitoring and ADHD

Assent Letter - Child

Principal Investigator: Dr. Deanna Friesen
Western Education

Student Investigator: Olivia Ward
Western Education

My name's Olivia and I am here to tell you about a study that looks at reading comprehension. I would like to see if you would like to be in this study. The reason you have been chosen is because we would like to see how students in elementary school understand stories.

We will only be meeting today over Zoom. To participate, your responses will be audio recorded. First, we will do a reading comprehension task. During this time, you will read a few paragraphs about animals. After each paragraph, you will be asked to talk about what you learned about the animal. Once you are done the reading comprehension task, you will do a few shorter tasks: a sentence recognition task, a memory task, a vocabulary task, a task that will measure your reading fluency and a task that will measure your reasoning abilities.

You do not have to be in the study. No one will be mad at you if you do not want to do this. If you do not want to be in the study, tell me or your parents. Even if you say yes, you can change your mind later. It is up to you. You can also skip any questions you would like. You can ask me questions at any time, now or later. You can also talk to your family.

Appendix I: Debriefing Form

DEBRIEFING FORM

Project Title: Reading, Comprehension Monitoring and ADHD

Principal Investigator: Deanna Friesen, Ph.D., Education, Western University
Student Investigator: Olivia Ward, Education, Western University

Thank you for participating in this study with your child. Our goal was to investigate the reading behaviours of children with and without Attention Deficit Hyperactivity Disorder (ADHD). To examine this, your child read a series of passages. Half of these passages had two sentences that contradicted each other and the other half of the passages did not contain any conflicting information. Of interest was whether your child would notice the contradictions. Based on previous research, we predicted that children with ADHD would be less likely to notice the contradictory information because they may have more difficulty linking information to form an understanding of the text.

In addition to attention, research indicates (e.g., Berthiaume et al., 2010; Miller et al., 2013) that working memory and inferencing also play a role in children's reading performance. For our study, we wanted to further investigate their role in comprehension and find out the possible impact that vocabulary knowledge, reading fluency and non-verbal reasoning have on reading performance. These abilities were assessed with the shorter cognitive tasks that your child completed.

If you have any questions about the study or its results, please contact Olivia Ward. If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Research Ethics.

Here are some references if you would like to read more about reading comprehension and ADHD. We can send you these papers if you would like.

Thank you,

Olivia Ward, Education, Western University
Deanna Friesen, Ph.D., Education, Western University

Curriculum Vitae

Name:	Olivia Ward
Post-secondary Education and Degrees:	The University of Western Ontario London, Ontario, Canada 2014-2018 B.A.
	The University of Western Ontario London, Ontario, Canada 2019-2021 M.A.
Honours and Awards:	John Dearness Memorial Award 2020-2021
Related Work Experience	Research Assistant The University of Western Ontario 2019-2021

Conference Presentations:

Friesen, D., **Ward, O.,** Bohnet, J., Cormier, P. & Jared, D. (2019, November). Early activation of cross-language meaning from phonology during sentence processing. Poster session presented at the annual meeting of the Psychonomic Society, Montreal, Canada

Friesen D., & **Ward, O.** (2021, June). Language experience drives differences in sentence repetition performance in bilingual children. Poster presented at the annual meeting of the Canadian Society for Brain, Behaviour and Cognitive Science, Montreal, Canada

Publications:

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