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The Association Between Sentence Repetition and Other Cognitive Abilities in School-Aged Children

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by

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in School-Aged Children

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ABSTRACT

The present study examined the association between sentence repetition and other cognitive abilities in 6- to 14-year-old children (*N* = 118; 60% female) recruited from schools in Windsor, Ontario. The effect of age and sex on children's SR was also examined. Children completed Benton's (1965) sentence repetition task, which required them to repeat a series of 26 verbally-presented sentences of increasing length. Language, auditory verbal memory, processing speed, fluid reasoning, and visual perception were measured with subtests from the Wechsler Intelligence Scale for Children (5th edition) and auditory nonverbal memory was assessed with the Seashore Rhythm Test. A multiple linear regression model including all independent variables significantly predicted SR performance. Only language abilities and auditory verbal memory significantly added to the prediction. Age was significantly and positively correlated to SR performance. Sex did not significantly affect SR performance. With the advantage of including the cognitive domains identified in previous studies within a single study, the findings support that SR is more than a measure of learning and memory. That SR taps multiple cognitive domains emphasizes the need to consider performance in the context of a comprehensive neuropsychological evaluation.

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CHAPTER I

INTRODUCTION

Sentence repetition (SR) tasks (also known as sentence recall, sentence memory, and sentence imitation tasks; Klem, Melby-Lervag, Hagtvet, Lyster, Gustafsson, & Hulme, 2015) are commonly used in child neuropsychological assessment batteries. Despite their popularity, the cognitive abilities measured by SR tasks are not well understood. In neuropsychology textbooks, SR tasks are conceptualized as tests of learning and memory (e.g., Anderson, Northam, Hendy, & Wrennall, 2011; Baron, 2018; Rourke, Fisk, & Strange, 1986), but empirical research indicates that the SR ability of typically-developing children is related to language (Klem et al., 2015; Marshall & Nation, 2003; Nag, Snowling, & Mirković, 2017; Polišenská, Chiat, & Roy, 2015) and auditory verbal memory (Nag et al., 2017; Poll, Miller, Mainela-Arnold, Adams, Misra, & Park, 2013; Willis & Gathercole, 2001). Prior research also indicates an indirect relation between processing speed and SR (Poll et al., 2013), and provides evidence against a relation between SR and nonverbal ability (Nag et al. 2017).

A methodological limitation of these studies is that none has examined these cognitive domains together. The first goal of the present study was to determine the extent to which language, auditory verbal memory, auditory nonverbal memory, processing speed, and nonverbal cognitive ability predict children's SR. This goal has implications for the construct validity of SR tasks and thereby to how neuropsychologists interpret SR scores.

SR improves dramatically throughout childhood (e.g., Archibald & Joanisse, 2009; Carmichael & MacDonald, 1984; Gaddes & Crockett, 1975; Spreen & Gaddes, 1969), but the effect of sex on children's SR performance is less well-established. Although some researchers have reported greater scores among males (Spreen & Gaddes, 1969) or females (Gaddes &

Crockett, 1975), other researchers have reported no sex differences (Carmichael & MacDonald, 1984). The second goal of the present study was to replicate the effect of age and to further examine the effect of sex on children's SR scores. This goal also has implications for how neuropsychologists normalize and interpret SR scores.

CHAPTER II

REVIEW OF LITERATURE

Sentence Repetition Tasks

In a typical SR task, the child listens to a series of sentences read by an examiner. Immediately following each sentence, the child is asked to repeat the sentence verbatim. The sentences gradually increase in length and the task is terminated when the child makes a predetermined number of consecutive errors. Performance is scored based on the number of correctly repeated sentences, which is often equivalent to the greatest number of correctly repeated syllables.

Several standardized measures of SR appear in the literature, including the Sentence Memory Test (Benton, 1965), the Sentence Repetition Test (Spreen & Benton, 1963), the Sentence Repetition subtest from the Spreen-Benton Aphasia Tests (Spreen & Benton, 1969), the Sentence Repetition Test (Spreen & Strauss, 1998), the Sentence Memory subtest of the Stanford-Binet (4th edition; Thorndike, Hagen, & Sattler, 1986), and the Sentence Imitation subtest of the Test of Language Development Primary (3rd edition; Newcomer & Hammill, 1997). Comprehensive descriptions of these tasks are not unanimously provided in the literature, but notable methodological differences include: presenting the sentences either orally by an examiner or electronically with an audio recording; incorporating a different number of sentences, ranging from 20 to 26; increasing the length of each successive sentences by one or more syllables or words; and terminating performance after three or five consecutive errors.

The studies reviewed in this chapter utilize a variety SR tasks. This approach was adopted because there is insufficient research on any one SR task.

Cognitive Abilities Associated with Sentence Repetition

Empirical research has examined the associations among SR and language abilities (e.g., Klem et al., 2015; Marshall & Nation, 2003; Nag et al., 2017; Polišenská et al., 2015), auditory verbal memory (e.g., Nag et al., 2017; Poll et al., 2013; Willis & Gathercole, 2001), processing speed (Poll et al., 2013), and nonverbal ability (Nag et al. 2017). A chronological summary of this body of research is provided below. Given the breadth of research on the former two associations, the reviewed literature is not exhaustive. Effort has been made to review articles that are representative of the larger body of research.

Willis and Gathercole (2001) examined the relation between SR, sentence structure, sentence comprehension, and auditory memory in a sample of English-speaking 4- and 5-year-olds (N = 61). SR was assessed with the Test for Reception of Grammar (Bishop, 1989), a task in which children are orally presented with 64 sentences with a mean length of 5.0 to 9.8 words. This task includes four sentences in each of 16 sentence structures, such as negative sentences (e.g., *The boy is not running*), embedded sentences (e.g., *The shoe the comb is on is blue*), and sentences containing plural pronouns (e.g., *They are sitting on the table*). After repeating each sentence, children's sentence comprehension was assessed. They were shown an array of four pictures and instructed to point to the picture that best depicts the meaning of the sentence. Auditory memory was assessed with two tasks: The Children's Test of Nonword Repetition (Gathercole & Baddeley, 1996), which required children to listen to and repeat 40 nonwords ranging in length from two to five syllables, and Auditory Digit Span (Gathercole, 1995), which required children to repeat a string of digits increasing in length from one to nine digits.

Willis and Gathercole (2001) divided children into two groups based on their performance on the auditory memory tasks. An ANOVA indicated that children's SR was significantly affected their auditory memory, such that children with high auditory memory recalled significantly more sentences than children with low auditory memory. SR performance was also significantly affected by sentence structure. Children demonstrated lower SR performance when sentences contained the not-only-X-but-also-Y structure (e.g., *Not only the bird but also the flower is blue*), the neither-X-nor-Y structure (e.g., *Neither the dog nor the ball is brown*), a relative clause (e.g., *The book is on the box that is red*), or an embedded sentence (e.g., *The shoe the comb is on is blue*). Children's sentence comprehension was significantly affected by sentence structure but not auditory memory. The authors concluded that auditory memory plays a greater role in children's SR than in sentence comprehension, refuting the notion that SR is "guided by access to conceptual, lexical, and syntactic representations" (p. 359).

Marshall and Nation (2003) examined the associations among SR and language skills in a sample of English-speaking 9- to 11-year-olds (*N* = 41). SR was assessed with the Recalling Sentences subtest from the Clinical Evaluation of Language Fundamentals (3rd UK edition - Revised; Semel, Wiig, & Secord, 2000), which required children to repeat 26 verbally-presented sentences of increasing length and difficulty. Reading comprehension and accuracy was assessed with the Neale Analysis of Reading Ability (Neale, 1997), which required children to read a series of short passages and answer questions to assess their understanding. Word decoding skills were assessed with the Phonemic Decoding Subtest of the Test of Word Reading Efficiency (Torgesen, Wagner & Rashotte, 1999), a timed task that required children to read a list of increasingly difficult pronounceable non-words.

Marshall and Nation (2003) divided children into two groups based on their performance on the latter two tasks. Children who scored at least one year below the mean for their chronological age were assigned to the 'poor comprehenders' group (*n* = 21) and children with average scores were assigned to the control group (n = 20). An ANOVA indicated that children's reading abilities significantly affected their SR score, such that children with below-average reading abilities recalled significantly fewer sentences than children with average reading abilities. Error analyses revealed that, compared to average readers, below-average readers made significantly more errors that changed the meaning of the sentence. The authors speculated that this may result from poor comprehension of the sentences from the outset or from poor encoding of the sentence content.

Poll and colleagues (2013) examined the relations among SR, auditory verbal memory, and processing speed in a sample of English-speaking 6- to 13-year-olds (N = 46). SR was assessed with the Recalling Sentences subtest of the Clinical Evaluation of Language Fundamentals (4th edition; Semel, Wiig, & Secord, 2003), which required children to repeat 27 orally sentences comprising 6 to 18 words. Auditory verbal memory and processing speed were measured with the Competing Language Processing Task (Gaulin & Campbell, 1994), which required children to listen to a series of sentences and say 'yes' to true statements and 'no' to false statements. Sentences were presented in sets of one to six sentences and children were also instructed to recall the last word of each sentence after each set. Processing speed was also measured with a rapid automatized letter naming task from the Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999), which required children to name lists of letters as quickly and accurately as possible. A regression analysis indicated that auditory verbal memory was a reliable predictor of SR. Processing speed was not a reliable predictor of SR, but indirectly effected SR through the mediation of working memory.

Klem et al. (2015) conducted a longitudinal study to examine the association between SR and language skills in a sample of Norwegian-speaking 4- to 6-year-olds (N = 216). SR was assessed with a task that required children to repeat 21 sentences of increasing length and complexity. Vocabulary was assessed with a Norwegian version of the British Picture Vocabulary Scale-II, which required children to select one of four drawings that best represents a spoken word, (Dunn, Dunn, Whetton & Burley, 1997). Grammatical knowledge was assessed with the Norwegian version of the Grammatic Closure subtest from the Illinois Test of Psycholinguistic Abilities (Kirk, McCarthy & Kirk, 1968). In this task, a series of pictures are briefly described and the child is instructed to fill in blanks in unfinished sentences. Structural equation modeling indicated that SR "is best seen as a reflection of an underlying language ability factor…[which] draws upon a wide range of language processing skills" (p. 146).

Polišenská, Chiat, and Roy (2015) examined the relation between SR and language skills in English-speaking (*n* = 50) and Czech-speaking (*n* = 50) 4- and 5-year-olds. SR was assessed in a novel task with seven conditions designed to manipulate morphology, phonology, semantics, and prosody. Each condition contained 32 sentences comprising 2 to 9 words (four sentences of each length). Multiple ANOVAs indicated that all four language skills significantly impacted children's SR, such that those with more advanced language skills achieved greater SR scores than those with less advanced language skills. This effect was seen across languages and ages.

Nag et al. (2017) examined the associations among SR and language, auditory memory, and nonverbal cognitive ability in a sample of Kannada-speaking 5- to 8-year-olds living in India (*N* = 135). SR was assessed with a novel task that required children to repeat 25 sentences designed to manipulate syntactic complexity and sentence length. Vocabulary was assessed with a task that required children to explain the meaning of words (Nag, 2008) and auditory memory was assessed with a novel nonword repetition task. General nonverbal ability was assessed with Raven's Coloured Progressive Matrices (Raven, Court, & Raven, 1995), which required children to complete a matrix of geometric designs. A regression analysis indicated that age, vocabulary, and auditory memory significantly predicted SR scores, whereas nonverbal ability did not.

Overall, the summarized literature indicates that the SR of typically-developing children is strongly related to language (Klem et al., 2015; Marshall & Nation, 2003; Nag et al., 2017; Polišenská et al., 2015) and auditory verbal memory (Nag et al., 2017; Poll et al., 2013; Willis & Gathercole, 2001). The literature also revealed an indirect relation between processing speed and SR (Poll et al., 2013), and provided evidence against a relation between SR and nonverbal ability (Nag et al. 2017).

Although the relation between SR and auditory nonverbal memory has not been examined in a non-clinical sample of children, Ebert (2014) examined this relation in English- and Spanish-speaking 5- to 11-year-olds with specific language impairment ($N = 47$). This study also examined the relation between SR and auditory memory. SR was assessed with the Recalling Sentences subtest from the Clinical Evaluation of Language Fundamentals (4^{th} edition; in English: Semel et al., 2003; in Spanish: Wiig et al., 2006), which required children to repeat sentences comprising 6 to 19 words. Auditory memory was assessed with a non-word repetition task (in English: Dollaghan & Campbell 1998; in Spanish: Ebert, Kalanek, Cordero, & Kohnert, 2008) and nonverbal working memory was assessed with a tonal pattern matching task that required children to listen to a series of tones and state whether they are the same or different. Children completed all measures in both languages. Ebert (2014) conducted a regression analyses and found that auditory nonverbal memory predicted SR, even after controlling for auditory memory. This result held across both administration languages. It is unclear, however, how these results would generalize to a non-clinical sample of children, a consideration relevant to the present study.

A methodological limitation of this body of research is that no study has examined these cognitive domains together in one sample. A regression analysis containing all these cognitive domains is important because a significant association between two variables may lose significance when a new variable is introduced to the model. A regression analysis would also indicate the extent to which these domains predict children's SR scores. The first goal of the present study was to conduct a regression analysis to examine the extent to which language, auditory verbal memory, auditory nonverbal memory, processing speed, and nonverbal ability uniquely predict the SR of school-aged children.

Effect of Age and Sex on Sentence Repetition

Examining the relation between demographic variables and SR is important to understanding which variables to control for when analyzing the cognitive factors associated with SR performance. The two demographic variables that are important to consider among child samples are age and sex. The effect of age on children's SR performance is undisputed, such that the number of sentences recalled by children increases dramatically throughout childhood (e.g., Archibald & Joanisse, 2009; Carmichael & MacDonald, 1984; Gaddes & Crockett, 1975; Spreen & Gaddes, 1969). Three studies have produced developmental norms for the SR performance of children (Carmichael & MacDonald, 1984; Gaddes & Crockett, 1975; Spreen & Gaddes, 1969), the findings of which support the external validity of the task. Table 1 shows the mean number of recalled sentences for 3- to 13-year-olds. By age 11- to 13 years, performance is approaching that of non-clinical adults, who remember an average of 15.0 to 24 sentences (See Table 2).

The effect of sex on children's SR is less well understood. Gaddes and Crockett (1975) observed a sex difference among 7-year-olds, such that females remembered one more sentence than males (on average). On the contrary, analyses conducted on Spreen and Gaddes' (1969) data revealed a sex difference among 9-year-olds, such that males remembered 1.5 more sentences than females (on average). Finally, Carmichael and MacDonald (1984) did not observe any sex differences. These discrepancies may be a result of small sample sizes or Type 1 error. The second aim of the present study is to further examine the effects of age and sex on the SR of typically-developing 6- to 14-year-old children.

Table 1

Mean Number of Sentences Recalled by Children on Sentence Repetition Tasks.

Age (in years)	*M*	*SD*
3	5.8[b]	2.9[b]
4	8.8[b]	1.9[b]
5	9.0[b]	2.7[b]
6	10.9[b], 9.3[c]	2.8[b], 1.6[c]
7	12.3[b], 10.0[c]	2.8[b], 2.0[c]
8	14.1[a], 13.3[b], 11.5[c]	3.6[a], 3.0[b], 1.3[c]
9	14.7[a], 14.6[b], 11.7[c]	2.3[a], 2.4[b], 2.0[c]
10	15.6[a], 14.5[b], 12.5[c]	2.2[a], 3.2[b], 1.5[c]
11	17.1[a], 15.8[b], 13.2[c]	1.8[a], 2.5[b], 1.7[c]
12	17.0[a], 16.8[b], 13.6[c]	1.9[a], 3.2[b], 1.9[c]
13	17.2[a], 13.8[c]	1.3[a], 1.4

Note. a = Spreen and Gaddes (1969); b = Carmichael and MacDonald (1984); c = Gaddes and Crockett (1975)

Note. The discrepancy between the means reported at an age is likely a result of the different SR tasks employed by these researchers; Spreen and Gaddes (1969) and Carmichael and MacDonald (1984) used a 26 sentence version in which each successive sentence increases by 1 syllable, whereas Gaddes and Crockett (1975) used a 22 sentence version in which each successive sentence increases by 1 to 3 syllables.

Table 2

Mean Number of Sentences Recalled by Adults on Sentence Repetition Tasks.

Article	*M*	*SD*
Meyers et al. (2000) – Study 1	15.0	1.65
Meyers et al. (2000) – Study 2	16.1	2.48
Spreen and Benton (1977)[a]	17.0	-
Benton et al. (1983)[a]	20.0	-
Williams (1965)	24.5	-

Note. a = as cited in Meyers et al., (2000)
Note. The large range of scores is likely a result of differences in the particular sentence repetition tasks used (see the Note in Table 1 for further explanation).

Clinical Utility of Sentence Repetition Tasks

Existing research provides some support for the clinical utility of SR tasks. Archibald and Joanisse (2009) demonstrated the clinical utility of SR tasks in pinpointing language and working memory deficits. They recruited a sample of typically-developing 5- to 9-year-old children (N = 88) to complete measures of SR, receptive language, expressive language, verbal working memory, and visual-spatial working memory. Children were grouped into either a low or average SR group. They found the following sensitivity and specificity statistics when examining the extent to which the following variables predicted group membership: language (96% and 76%, respectively), working memory (84% and 67%), and combined language and working memory (100% and 65%).

Plaza, Cohen, and Chevrie-Muller (2002) demonstrated the clinical utility of SR tasks in identifying dyslexia in children. They recruited a sample of children with dyslexia (n = 26), a control group consisting of age-matched typically-developing children (n = 26), and a control group consisting of typically-developing younger children (n = 26). The authors found that children with dyslexia obtained significantly lower SR scores than children in both control groups.

Conti-Ramsden, Botting, and Faragher (2001) demonstrated the clinical utility of SR tasks in identifying children with specific language impairment. They recruited a sample of 11-year-old children with a history of this condition (N = 160) and found high levels of sensitivity (90%) and specificity (85%).

Overall, the literature reviewed in this section provides support for the clinical utility of SR tasks. However, gaining a better understanding of which cognitive abilities uniquely predict SR performance and how demographic variables influence SR is important due to the frequent use of SR tasks in child neuropsychology assessment batteries (Klem et al., 2015). By addressing this gap in the literature, the present study can shed light on the construct validity of the SR task and thereby change how neuropsychologists interpret SR scores.

CHAPTER III

PRESENT STUDY

The purpose of the present study was twofold. The first goal was to investigate the extent to which language, auditory verbal memory, auditory nonverbal memory, processing speed, and nonverbal ability uniquely predict the SR of typically-developing children. Although empirical research has examined the associations among sentence repetition and language abilities (Klem et al., 2015; Marshall & Nation, 2003; Nag et al., 2017; Polišenská et al., 2015), auditory verbal memory (Nag et al., 2017; Poll et al., 2013; Willis & Gathercole, 2001), processing speed (Poll et al., 2013), and nonverbal ability (Nag et al. 2017), no study has examined these cognitive domains together within a single sample. No study has examined the association between SR and auditory nonverbal memory in a non-clinical child sample.

The second goal was to further examine the effect of age and sex on the SR of 6- to 14-year-old children. Existing research demonstrates that age significantly impacts children's SR (e.g., Archibald & Joanisse, 2009; Carmichael & MacDonald, 1984), but prior research on the effect of sex is inconclusive. Some research indicates a significant difference (Gaddes & Crockett, 1975; Spreen & Gaddes, 1969) whereas other research does not (Carmichael & MacDonald, 1984). This goal will shed light on whether normative data should be stratified by sex, in addition to age, and thereby has implication to how neuropsychologist interpret SR scores.

Hypotheses

Based on prior research, it was hypothesized that children's SR performance would be directly predicted by language (Klem et al., 2015; Marshall & Nation, 2003; Nag et al., 2017; Polišenská et al., 2015) and auditory verbal memory (Nag et al., 2017; Poll et al., 2013; Willis & Gathercole, 2001). It was also hypothesized that processing speed would indirectly effect SR through the mediation of auditory verbal memory (Poll et al., 2013). Children's nonverbal ability was not expected to predict their SR performance (Nag et al. 2017). A hypothesis pertaining to the association between SR and auditory nonverbal memory was not formulated since no prior study has examined this relation in a non-clinical child sample. It was also hypothesized that age would have a significant effect on SR performance whereas sex would not.

CHAPTER IV

DESIGN AND METHODOLOGY

This study was approved by the University of Windsor's Research Ethics Board and the Windsor-Essex Catholic District School Board.

Participants

This study included 118 6- to 14-year-old children (60% female) recruited from six schools in the Windsor-Essex Catholic District School Board during May and June of 2018. This age range was chosen since prior research has demonstrated significant development in SR over this period (e.g., Carmichael & MacDonald, 1984; Gaddes & Crockett, 1975). Eligibility requirements included English proficiency, normal or corrected-to-normal vision and hearing, and being between the ages of 6 and 14 years. All participants met these requirements and thus no one was excluded from participating.

The average estimated intelligence quotient of the sample was within the Average range (M = 104.3; SD = 12.5). Table 3 contains basic demographic information about the sample and, where applicable, comparative data from the 2016 Canadian Census. The sample was reasonably representative of the population. Most children were Caucasian, spoke English as their first and primary language, and had at least one parent who had attended college or university. Table 4 contains prevalence rates for common childhood psychological conditions, hearing impairments, and vision impairments within the sample and the population. The sample was reasonable representative of the population. The majority of children had never been diagnosed with a psychological condition, hearing impairment, or vision impairment.

Table 3

Sample and Population Demographic Statistics.

	Sample (N = 118)		Canadian Population
	N	%	%
Gender			
Male	47	39.8	51.3
Female	71	60.2	48.7
Ethnicity			
Caucasian	104	88.1	77.7
Aboriginal/First Nations	2	1.7	6.2
Asian	6	5.1	14.9
Hispanic/Latina	2	1.7	1.3
Middle Eastern	7	5.9	1.5
African American	3	2.5	3.5
No response	2	1.7	-
First Language			
English	117	99.2	74.8
Other	1	.8	24.0
Primary Language			
English	116	98.3	63.7
Other	2	1.7	31.5
Parent #1 Education			
Did not complete high school	2	1.7	18.3
High school graduate	11	9.3	26.5
Attended some college/university	13	11.0	2.8
College/university graduate	69	58.5	34.9
Graduate/Professional degree	23	19.5	17.5
Parent #2 Education			
Did not complete high school	2	1.7	18.3
High school graduate	20	16.9	26.5
Attended some college/university	14	11.9	2.8
College/university graduate	65	52.1	34.9
Graduate/Professional degree	12	10.2	17.5
No response	5	-	-

Note. Canadian population data from 2016 Canadian Census (Statistics Canada, 2016).
Note. Total percent for ethnicity does not equal 100% because some individuals identified with more than one category.

Table 4

Prevalence of Childhood Psychological Conditions, Hearing Impairments, and Vision Impairments in the Sample and Population

	Sample (N = 118)		Population Estimate
	N	%	%
Learning Disability	9	7.6	10.0[a]
Attention problems	11	9.3	5.0[a]
Autism Spectrum Disorder	3	2.5	1.0[a]
Oppositional Defiance Disorder/Conduct Disorder	1	.8	3.3[a]/4.0[a]
Speech-Language Disorder	6	5.1	7.7[b]
Hearing Impairment	2	1.7	8.0[c]
Vision Impairment	8	6.8	3.2[c]

Note. Data from: [a]Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (American Psychiatric Association, 2013); [b]Black, Vahratian, & Hoffman (2015). [c]Canadian Health Measures Survey (Statistics Canada, 2013; 2015)

Measures

Parents completed a brief demographic questionnaire and children completed the SR task as well as six other tasks that were chosen as measures of a particular cognitive ability. These included the Seashore Rhythm Test (Seashore, Lewis, & Saetveit, 1960) and a five subtest WISC-V short form (Wechsler, 2014). The WISC-V short form contains one primary subtest from each of the five Index scales, namely Vocabulary, Visual Puzzles, Figure Weights, Digit Span, and Coding. This short form was chosen because it includes the subtest with the greatest factor loading for each Index, and has strong reliability (r_{ss} = .95) and validity coefficients (r = .94; Sattler, Dumont, & Coalson, 2016).

Demographic questionnaire. Parents completed a brief demographic questionnaire (see Appendix A) designed to gather basic information about their child, including their name, gender, date of birth, racial/ethnic background, first/primary language, grade, and school.

Information was also gathered about parents' level of education and whether the child had been diagnosed with any of the following: learning disability, attention problems, autism-spectrum disorder, speech-language disorder, oppositional defiance disorder, conduct disorder, vision problems, and hearing problems. Additional items asked whether the child had ever been identified as having an exceptionality, had an individualized education plan, or received extra help inside or outside of school.

Sentence Memory Test (Benton, 1965; See Appendix B). In this task, children listened to a series of sentences read by a trained examiner. Immediately following each sentence, children were asked to repeat the sentence verbatim. The task consisted of 26 sentences. The first sentence contained one syllable, and sentences increased by one syllable thereafter. The test was discontinued when the child made an error on three consecutive sentences. As customary, this task was not timed. The total score was calculated by summing the number of correctly repeated sentences and range from zero to twenty-six.

Seashore Rhythm Test (Seashore et al., 1960). This task is a component of the Halstead-Reitan Neuropsychological Test Battery (Reitan, 1969; Reitan & Wolfson, 1989) and was selected as a measure of auditory nonverbal memory. The task included thirty pairs of tape-recorded nonverbal sounds and required children to indicate whether the two sounds were the same or different. Children marked their response on a paper answer sheet. The sounds were divided into three subsets, each with 10 sets of paired tones. The tones vary in length (5, 6, and 7 tones) and in rate of delivery. A total score was calculated by summing the number of correct items and ranged from zero to thirty. This test has acceptable reliability (r = .78; Charter & Webster, 1997).

Vocabulary. This untimed task is a primary subtest of the Verbal Comprehension Index (VCI) and was selected as a measure of language ability. Specifically, it is designed to assess lexical knowledge (Wechsler, 2014). It contains 29 words read aloud that a child is asked to define. The items could be repeated as much as necessary and unclear responses are queried for further elaboration. Correct answers are not acknowledged, and incorrect responses are corrected on some of the earlier test items to help the child understand the nature of the task. The starting item varies depending on the child's age, but earlier items may be administered if either of the first two test items is incorrectly answered. The task is terminated when the child makes three consecutive errors. Items are scored as 0, 1, or 2 and added to produce a total score (maximum 54). Full points are given on items prior to the child's first two test items with perfect scores. This task is reliable (r = .87; Sattler et al., 2016), and has moderate correlations with the FSIQ (r = .66) and the VCI (r = .68).

Visual Puzzles. This task is a primary subtest of the Visual Spatial Index (VSI) and was selected as a measure designed to assess nonverbal reasoning, visual-perceptual discrimination, and mental transformation (Wechsler, 2014). Children were presented with an array of six puzzle pieces and asked to select the three that fit together to complete the puzzle. One demonstration and one sample item were provided before the child was given 30 seconds to complete each of the 29 test trials. The starting item varied depending on the child's age, but earlier items were administered if either of the first two test items was incorrectly answered. The task was terminated when the child makes three consecutive errors. Items were scored as 0 or 1, and full points were given on items prior to the child's first two test items with perfect scores. A total score was calculated by summing the number of correct items and ranged from 0 to 29. This task has good reliability (*r* = .89; Sattler et al., 2016) as well as moderate correlations with the FSIQ (*r* = .65) and the VSI (*r* = .60).

Figure Weights. This task is a primary subtest of the Fluid Reasoning Index (FRI) and was selected as a measure of general sequential reasoning, quantitative reasoning, and nonverbal reasoning (Wechsler, 2014). Children were presented with a picture with one to three balance scales containing geometric shapes signifying weights. In each picture, one side of a scale is empty and the child is instructed to child select one of five weights to balance the scale. Two sample items were provided to ensure understanding before the child was given 20 seconds to complete each of the 34 test items. The starting item varied depending on the child's age, but earlier items were administered if either of the first two test items was incorrectly answered. The task was terminated when the child made three consecutive errors. Items were scored as either 0 or 1, and full points are given on items prior to the child's first two test items with perfect scores. A total score was calculated by summing the number of correct items and ranged from 0 to 34. This task is highly reliable (*r* = .94; Sattler et al., 2016), has moderate correlation with the FSIQ (*r* = .59), and a moderately low correlation with the FRI (*r* = .47).

Digit Span. This task is a subtest of the Working Memory Index (WMI) and was selected as a measure of auditory verbal memory. More specifically, it is designed to assess memory span, working memory, and rote learning (Wechsler, 2014). It comprised three task conditions that required children to repeat a series of digits. Children first repeated digits in forward order, then in backward order, and finally in ascending order. The series of digits increased in length from two to ten digits in Digit Span Forward, two to eight digits in Digit Span Backward, and two to nine digits in Digit Span Sequencing. One sample item was provided for each subtask and two items were administered at each sequence length. The items could not be repeated, and feedback was only given on the sample items. The task was terminated when the child made errors on both trials of an item. This task was not timed. Items were score as either 0 or 1. A total score was calculated by summing the number of correct items and ranged from 0 to 29 and ranged from 0 to 48. This task is highly reliable (*r* = .91) and has moderate correlations with the FSIQ (*r* = .59; Sattler et al., 2016) and the WMI (*r* = .51).

Coding. This task is a primary subtest of the Processing Speed Index (PSI) and was selected as a measure of processing speed. More specifically, it is designed to assess processing speed, visual-short term memory, and visual-motor coordination (Wechsler, 2014). It required children to copy symbols that were paired with other symbols (6- and 7-year-old children) or numbers (7- to 16-year-old children) in a legend. Younger children received two demonstration items and three sample items, before having 2 minutes to complete up to 75 test items. Older children received three demonstration items and six sample items, before having 2 minutes to complete up to 117 test items. One point was given for every correctly copied symbol. A total score was calculated by summing the number of correct items and ranged from 0 to 75 (younger children) or 117 (older children). This task is good reliability (*r* = .82; Sattler et al., 2016), has moderately low correlations with the FSIQ (*r* = .33), and has a moderate correlation with the PSI (*r* = .58).

Procedure

A script was used to recruit school principals via phone or email (See Appendix C). Once permission was obtained from the principal, presentations were conducted in all eligible classrooms to briefly outline the study's goals, measures, and registration process, as well as to answer students' questions and hand out recruitment flyers (See Appendix D). Flyers provided parents with a brief outline of the study's goals and measures, and presented the primary investigator's contact information. Upon contacting the primary investigator, parents were given more information about the study and how to register their child. Interested parents were sent an email containing a link to the online informed consent form (See Appendix E) and demographic questionnaire.

Registered children met with the primary investigator or one of two research assistants in a quiet office in the school. Verbal assent was attained (See Appendix F) and children were told that they could withdraw their participation at any time without penalty (this was done using child-friendly language). All children completed the tasks in one session, lasting 45 to 60 minutes. Tasks were administered in a fixed order: Sentence Memory Test, Vocabulary, Visual Puzzles, Figure Weights, Digit Span, Coding, and Seashore Rhythm Test. As compensation, children were entered in a draw to win one of four Indigo/Chapters gift cards valued at $50.00.

CHAPTER V

RESULTS

Participants

A total of 116 children completed all tasks. One girl did not complete the Sentence Memory Test because of examiner error and one girl did not complete the Seashore Rhythm Test as a result of terminating her participation prior to the completion of the task. These participants were excluded from each relevant analysis.

Data Preparation

Data were entered and analyzed in SPSS. Total scores were calculated for all tasks. Sentence Memory Test scores were converted to T-scores (M = 50; SD = 10) and the WISC-V subtest scores were converted to scaled scores (M = 10, SD = 3). Seashore Rhythm Test scores were converted to T-scores but normative data was only available for children aged 9 years and older. Younger children were excluded pairwise for each relevant analysis. Descriptive statistics for all measures are provided in Table 5.

Association Between Sentence Repetition and Cognitive Abilities

A multiple regression was run to predict children's SR from their performance on the Vocabulary, Visual Puzzles, Figure Weights, Digit Span, and Coding subtests. Preliminary analyses were first conducted to examine the suitability of a multiple linear regression. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.15. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. One studentized deleted residuals was greater than

Table 5

Descriptive Statistics for all Measures

	N	*M*	*SD*	*Range*
Sentence Memory Test (normed)	117	49.01	11.28	25 - 80
Sentence Memory Test (raw)	117	14.90	2.61	8 - 21
Seashore Rhythm Test (normed)	78	59.10	8.45	31 – 79
Vocabulary (normed)	118	11.53	2.77	5 - 17
Coding (normed)	118	9.43	3.03	2 - 18
Digit Span (normed)	118	10.85	2.66	2 - 19
Visual Puzzles (normed)	118	10.69	2.21	3 - 16
Figure Weights (normed)	118	10.52	3.29	1 - 18

±3 standard deviations, but no leverage values greater than 0.2 and no Cook's distance values greater than 1.0. Thus, all data points were retained. The assumption of normality was met, as assessed by a P-P Plot.

The multiple linear regression model containing all independent variables except Seashore Rhythm Test scores significantly predicted SR performance, $F(5,111) = 18.89$, $p < .001$, adj. $R^2 = .44$. Vocabulary and Digit Span significantly added to the prediction, $p < .001$, whereas Figure Weights, Visual Puzzles, and Coding did not. The percentages of variance accounted for by each variable were as follows: Digit Span (20.8%), Vocabulary (17.8%), Figure Weights (1.8%), Visual Puzzles (1.7%), Coding (0.9%). Regression coefficients and standard errors are presented in Table 6.

Table 6

Summary of Multiple Regression Analysis (N = 117)

	B	SE_B	*Beta*
Intercept	8.30	5.12	
Vocabulary (normed)	1.52	.32	.37*
Figure Weights (normed)	.12	.27	.03
Visual Puzzles (normed)	.16	.40	.03
Digit Span (normed)	1.82	.32	.43*
Coding (normed)	.06	.27	.02

Note. * $p < .01$; *B* = unstandardized regression coefficient; SE_B = standard error of the coefficient; *Beta* = standardized coefficient

A second multiple linear regression was run to predict children's SR from their performance on the Seashore Rhythm Test in addition to Vocabulary, Visual Puzzles, Figure Weights, Digit Span, and Coding subtests. This analysis only included children aged 9 years and older because normative data is not available for younger children's scores on the Seashore Rhythm Test. Preliminary analyses were first conducted to examine the suitability of a multiple linear regression. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.13. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and no

Cook's distance values greater than 1.0. Thus, all data points were retained. The assumption of normality was met, as assessed by a P-P Plot.

The multiple linear regression model was consistent with the one presented above. It significantly predicted SR performance, $F(6,70) = 9.83$, $p < .001$, adj. $R^2 = .41$, with only Vocabulary and Digit Span significantly adding to the prediction, $p < .001$. Figure Weights, Visual Puzzles, Coding, and SRT did not significantly add to the prediction. The percentages of variance accounted for by each variable were as follows: Digit Span (18.7%), Vocabulary (15.4%), Figure Weights (0.8%), Visual Puzzles (1.6%), Coding (0.2%), and Seashore Rhythm Test (6.5%). Regression coefficients and standard errors can be found in Table 7.

Table 7

Summary of Multiple Regression Analysis (N = 77)

	B	SE_B	*Beta*
Intercept	5.28	7.82	
Vocabulary (normed)	1.68	.39	.43*
Figure Weights (normed)	.01	.30	.00
Visual Puzzles (normed)	1.29	.38	.34
Digit Span (normed)	.06	.35	.02*
Coding (normed)	-.17	.51	-.04
Seashore Rhythm Test (normed)	.16	.12	.13

Note. * $p < .01$; *B* = unstandardized regression coefficient; SE_B = standard error of the coefficient; *Beta* = standardized coefficient

A mediation analysis was conducted to examine whether processing speed indirectly affects children's SR performance. This analysis investigated whether auditory verbal memory mediates the effect of processing speed on SR performance. Results indicated that processing speed was a significant predictor of auditory verbal memory, $\beta = 0.18$, $t(117) = 2.20$, $p = .03$, and that auditory verbal memory was a significant predictor of SR performance, $\beta = 2.34$, $t(117) = 6.97$, $p < 0.01$ (See Figure 1). Since both the a-path and b-path were significant, mediation analyses were tested using the bootstrapping method with bias-corrected confidence intervals (Preacher & Hayes, 2004). The 95% confidence interval of the indirect effects was obtained with 5000 boostrap re-samples (Preacher & Hayes, 2008). Processing speed was not a significant predictor of SR performance after controlling for the mediator, auditory verbal memory, $\beta = .20$, $t(117) = .67$, $p = .51$, consistent with full mediation. Approximately 32% of the variance in SR performance was accounted for by the predictors ($R^2 = 0.32$). The indirect coefficient was significant, $\beta = 0.41$, $SE = 0.22$, 95% CI = .04 to .92, $p = 0.04$, indicating that every point on the Coding subtest was associated with an approximately 0.41 point increase in SR score, as mediated by auditory verbal memory.

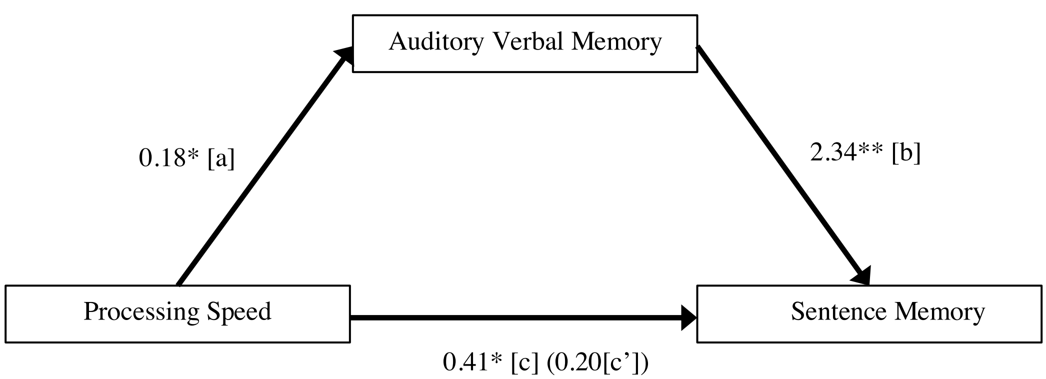

*Figure 1: Indirect effect of processing speed on sentence repetition performance through auditory verbal memory. *p < .05; ** p < 0.01*

Effect of Age and Sex on Sentence Repetition

Descriptive statistics for SR performance at each age cohort are presented in Table 8. A Pearson's product-moment correlation was run to assess the relation between children's SR score and age. Raw SR scores were used to avoid multicollinearity. Preliminary analyses showed the relationship to be linear with both variables normally distributed, as assessed by skewness and kurtosis statistics (< |2|), and there were no outliers. There was a moderate positive correlation between SR and age, $r(117) = .46$, $p < .001$ (see Figure 2), with age explaining 21.16% of the variation in raw SR scores. On average, children remembered 0.55 more sentences with every increasing year of age.

Table 8.

Descriptive Statistics for Raw Sentence Repetition Scores by Age Cohort

Age	*N*	*M*	*SD*
6	11	12.18	3.03
7	13	13.77	2.62
8	16	14.25	2.49
9	13	15.38	2.60
10	21	14.90	2.39
11	18	15.67	2.38
12	14	15.71	1.86
13	7	16.86	1.07
14	4	17.25	1.50

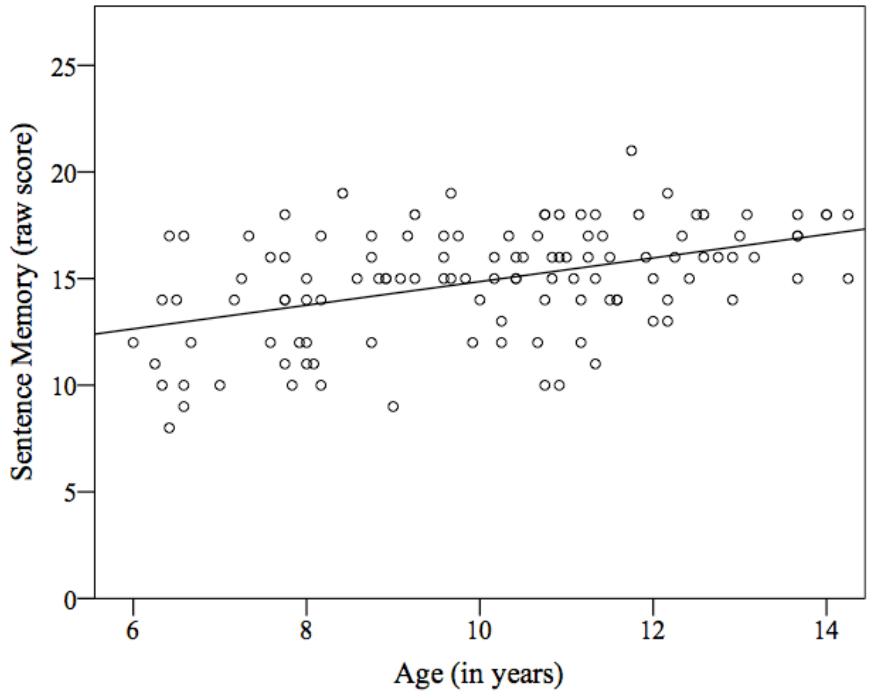

Figure 2: Relation between age in years and raw sentence repetition scores.

The equation for the line of best fit is Y = 9.32 + 0.55X.

An independent-samples t-test was conducted to determine if differences in SR scores between exist between males and females. There were five outliers in the data, as assessed by inspection of a boxplot, but they were retained because they did not change the outcome of the analysis. SR scores for each level of gender were normally distributed, as assessed by skewness and kurtosis statistics ($< |2|$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .87$). No significant difference was found between the SR of males ($M = 48.52$; $SD = 11.93$) and females ($M = 49.35$; $SD = 10.90$), $t(115) = .39$, $p = .70$.

Two additional independent-samples t-tests were conducted to determine if there were sex differences in SR scores of younger (e.g., 6- to 9-year-olds) and older children (e.g., 10- to 14-year-olds). No significant differences were found. Younger males and females, $t(51) = -.17$, $p = .86$, and older males and females, $t(62) = .34$, $p = .73$, demonstrated comparable SR performance.

CHAPTER VI

DISCUSSION

This study examined the association between SR and other cognitive abilities in 6- to 14-year-old children. This study also examined the effects of age and sex on children's SR performance. Children completed Benton's (1965) SR task, which required them to repeat a series of 26 verbally-presented sentences of increasing length. Language, auditory verbal memory, processing speed, fluid reasoning, and visual perception were measured with subtests from the Wechsler Intelligence Scale for Children (5^{th} edition) and auditory nonverbal memory was assessed with the Seashore Rhythm Test.

Association Between Sentence Repetition and Cognitive Abilities

It was hypothesized that children's SR would be directly predicted by measures of language ability and auditory verbal memory. This hypothesis was supported. Consistent with prior research, children's SR was directly predicted by measures of language ability (Klem et al., 2015; Marshall & Nation, 2003; Nag et al., 2017; Polišenská et al., 2015) and auditory verbal memory (Nag et al., 2017; Poll et al., 2013; Willis & Gathercole, 2001). Auditory verbal memory explained slightly more variance in children's SR performance than language abilities. Taken together, this suggests that successful SR performance can be attributed to the ability to store the sentence in memory temporarily *and* to employ language skills, such as knowledge of semantics and syntax, to infer the meaning of the sentence and chunk words together to lessen the cognitive load.

It was also hypothesized that processing speed would indirectly effect children's SR through their auditory verbal memory. This hypothesis was supported. This finding is consistent with prior research conducted by Poll et al. (2013), who suggested that children who move through a task more quickly demonstrate enhanced recall because they do not have to retain the information for as long. These children process information and formulate a response more quickly, resulting in less degradation of stored information.

It also hypothesized that children's SR would not be predicted by measures of their nonverbal abilities. This hypothesis was supported. Children's fluid reasoning and visuospatial processing does not impact their performance on SR tasks. This is consistent with prior research conducted by Nag et al.'s (2017), which demonstrated that children's nonverbal ability was unrelated to their SR performance.

The present study was the first to examine the relation between SR and auditory nonverbal memory. Auditory nonverbal memory did not significantly predict children's SR performance. This is contrary to Ebert's (2014) study that found auditory nonverbal memory to significantly predict the SR scores of 5- to 11-year-old children with specific language impairment. This discrepancy may suggest that children with specific language impairment utilize different abilities when completing SR tasks than typically-developing children. Alternatively, this discrepancy may suggest that the role of auditory nonverbal memory differs for younger (5- to 11-year-old) and older (9- to 14-year-old) children.

With the advantage of including cognitive domains identified in previous studies within a single study, the findings support that SR is more than a measure of learning and memory. Paramount to the interpretation of SR scores is that neuropsychology textbooks highlight the dual role of auditory verbal memory and language abilities, as well as the need to consider SR scores in the context of a comprehensive neuropsychological evaluation.

The findings from the present study are consistent with an unpublished thesis that examined the association between SR and cognitive abilities in 18- to 25-year-old undergraduate students

(*N* = 70; Bryan, 2018). This study, which also utilized Benton's (1965) SR task, conducted a multiple linear regression and found that language abilities and auditory verbal memory significantly predicted SR performance, whereas visuospatial processing and processing speed did not. This provides preliminary evidence of the stability of the latent cognitive abilities underlying SR tasks across childhood to young adulthood.

Effect of Age and Sex on Sentence Repetition

It was hypothesized that children's SR would be positively and significantly correlated to age. This hypothesis was supported, providing further evidence for the notion that children's SR increases dramatically throughout childhood and approaches that of adults by age 11 years (e.g., Archibald & Joanisse, 2009; Carmichael & MacDonald, 1984; Gaddes & Crockett, 1975; Spreen & Gaddes, 1969). This finding further supports the importance of considering age when interpreting children's SR scores.

It was also hypothesized that sex would not have a significant effect on children's SR. This hypothesis was supported; sex differences were not evident when examining the sample as a whole or separately for younger and older children. This finding is consistent with that of Carmichael and MacDonald (1984). Other researchers have found sex differences at some age cohorts (7 and 9-year-olds; Gaddes & Crockett, 1975; Spreen & Gaddes, 1969), but small sample sizes and Type 1 error may question the validity of these differences. The present study provides further support for the irrelevance of sex when interpreting children's SR scores.

Strengths of the Present Study

This study is merited for its large and representative sample. Consistent with 2016 Canadian Census data, the majority of participants were Caucasian, spoke English as their first and primary language, and had at least one parent who had attended college or university (See Table 3). The sample prevalence rates for childhood psychological conditions (see Table 4) in most instances approximated the rates found in the general population of children. The present study is also merited for examining the cognitive domains identified in previous studies within a single study, and for utilizing a regression analysis to examine the extent to which these domains predict children's SR.

Limitations of the Present Study

One limitation of the present study pertains to the validity of the descriptive statistics for the SR of 13- and 14-year-olds. These statistics may inaccurately represent the abilities of these cohorts because of small sample sizes (n = 7 and n = 4, respectively). It was evident during the classroom presentations that grade 7 and 8 students were particularly resistant to participating in research. A future study may benefit from offering greater incentive to these older children. It is also likely that recruitment was negatively affected by the time of year since students and their parents would have been busy wrapping up the school year. This effect may have been particularly evident among those approaching grade 8 graduation. Another limitation of the present study pertains to the use of the Seashore Rhythm Test. This task was chosen as a measure of auditory nonverbal memory without realizing that normative data was not available for children younger than 9 years of age. As a result, the association between auditory nonverbal memory and SR could not be examined in younger children, and the power of the regression analysis that included this measure was reduced by the smaller sample.

REFERENCES

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Anderson, V., Northam, E., Hendy, J., & Wrennall, J, (2001). *Developmental neuropsychology: A clinical approach.* New York, NY: Psychology Press/Taylor and Francis.

Archibald, L. M. D., & Joanisse, M. F. (2009). On the sensitivity and specificity of nonword repetition and sentence recall to language and memory impairments in children. *Journal of Speech, Language, and Hearing Research, 52*(4), 899-914.

Baron, S. (2018). *Neuropsychological evaluation of the child: Domains, Methods, & Case Studies, Edition 2*. New York, NY: Oxford.

Benton (1965). *Sentence Memory Test*. Iowa City, IA: Author.

Benton, A., Hamsher, K., Varney, N., & Spreen, O. (1983). *Contributions to Neuropsychological Assessment*. New York: Oxford University Press.

Bishop, D. (1989). *Test for reception of grammar*. United Kingdom Medical Research Council.

Black, L. I., Vahratian, A., & Hoffman, H. J. (2015). *Communication disorders and use of intervention services among children aged 3–17 years*. United States. Hyattsville, MD: National Center for Health Statistics.

Bryan, E. J. (2018). The Association between Sentence Repetition and Other Cognitive Abilities in an Undergraduate Population. Unpublished thesis.

Carmichael, J. A., & MacDonald, J. W. (1984). Developmental norms for the Sentence Repetition Test. *Journal of Consulting and Clinical Psychology, 52*(3), 476-477. doi:10.1037/0022-006X.52.3.476

Charter, R. A., & Webster, J. S. (1997). Psychometric structure of the Seashore Rhythm Test. *The Clinical Neuropsychologist*, *11*, 167–173.

Conti-Ramsden, G., Botting, N., & Faragher, B. (2001). Psycholinguistic markers for specific language impairment (SLI). *Journal of Child Psychology and Psychiatry, 42*, 741–748.

Dollaghan, C. & Campbell, T. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research*, *41*, 1136–1146.

Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, J. (1997). The British Picture Vocabulary Scale (Second ed.). London: GL Assessment. The Norwegian version by Lyster, S.-A. H., Horn, E., & Rygvold, A.-L. (2010).

Ebert, K. D. (2014). Role of auditory non-verbal working memory in sentence repetition for bilingual children with primary language impairment. *International Journal of Language & Communication Disorders, 49*(5), 631-636. http://dx.doi.org.ezproxy.uwindsor.ca/10.1111/1460-6984.12090

Ebert, K. D., Kalanek, J., Cordero, K. N. And Kohnert, K. (2008). Spanish nonword repetition: stimuli development and preliminary results. *Communication Disorders Quarterly, 29*, 67–74.

Gaddes, W. H., & Crockett, D. J. (1975). The Spreen-Benton Aphasia Tests, normative data as a measure of normal language development. *Brain and Language, 2*, 257-280. doi:10.1016/S0093-934X(75)80070-8

Gathercole, S.E. (1995). The assessment of phonological memory skills in preschool children. *British Journal of Educational Psychology, 65*, 155–164.

Gathercole, S.E., & Baddeley, A.D. (1996). *The Children's Test of Nonword Repetition*. London, UK: Psychological Corporation.

Gaulin, C. A., & Campbell, T. F. (1994). Procedure for assessing verbal working memory in school-age children: some preliminary data. *Perceptual and Motor Skills, 79*, 55–64.

Kirk, S. A., McCarthy, J. D., & Kirk, W. D. (1968). *Illinois Test of Psycholinguistic Abilities*. Urbana, IL: University of Illinois press. Norwegian version by Gjessing, H. J.&Nygaard, H. D. (1975).

Klem, M., Melby-Lervag, M., Hagtvet, B., Lyster, S.-A. H., Gustafsson, J.-E., & Hulme, C. (2015). Sentence repetition is a measure of children's language skills rather than working memory limitations. *Developmental Science*, *18*(1), 146-154. doi: 10.1111/desc.12202

Marshall, C. M. & Nation, K. (2003). Individual differences in semantic and structural errors in children's memory for sentences. *Educational and Child Psychology*, *20*, 123–140.

Meyers, J. E., Volkert, K., & Diep, A. (2000). Sentence Repetition Test: Updated norms and clinical utility. *Applied Neuropsychology, 7*(3), 154-159. doi:10.1207/S15324826AN0703_6

Nag, S. (2008). *Chili pili padabhandara* [Chili Pili Vocabulary Test]. Bangalore, India: Promise Foundation.

Nag, S., Snowling, M. J., & Mirković, J. (2017). The role of language production mechanisms in children's sentence repetition: Evidence from an inflectionally rich language. *Applied Psycholinguistics,* 1-23. doi:10.1017/S0142716417000200.

Neale, M. D. (1997). *Neale Analysis of Reading Ability – Second Revised British Edition*. Windsor: NFERNelson.

Newcomer, P. L., & Hammill, D. D. (1997). *Test of Language Development (3rd ed.)*. Austin, TX: Pro-Ed.

Plaza, M., Cohen, H., & Chevrie-Muller, C. (2002). Oral language deficits in dyslexic children: Weaknesses in working memory and verbal planning. *Brain and Cognition, 48,* 505–512.

Polišenská, K., Chiat, S., & Roy, P. (2015). Sentence repetition: What does the task measure? *International Journal of Language & Communication Disorders, 50*(1), 106-118. http://dx.doi.org.ezproxy.uwindsor.ca/10.1111/1460-6984.12126

Poll, G. H., Miller, C. A., Mainela-Arnold, E., Adams, K. D., Misra, M., & Park, J. S. (2013). Effects of children's working memory capacity and processing speed on their sentence imitation performance. *International Journal of Language & Communication Disorders, 48*(3), 329-342. http://dx.doi.org.ezproxy.uwindsor.ca/10.1111/1460-6984.12014

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, 40(3), 879-891. doi:10.3758/BRM.40.3.879

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. Behavior Research Methods, Instruments and Computers, 36, 717-731.

Raven, J. C., Court, J. H., & Raven, J. (1995). *Manual for Raven's Progressive Matrices and Vocabulary Scales*: *Section 2. The Coloured Progressive Matrices*. Oxford: Oxford Psychologists Press.

Reitan, R. (1969). *Manual for Administration of Neuropsychological Test Batteries for Adults and Children*. Unpublished manuscript.

Reitan, R., & Wolfson, D. (1989). The Seashore Rhythm Test and brain functions. *The Clinical Neuropsychologist*, *3*, 70–77.

Rourke, B. P., Fisk, J. L., & Strange, J. D. (1986). *Neuropsychological assessment of children: A treatment-oriented approach*. New York, NY: The Guilford Press.

Sattler, J. M., Dumont, R., & Coalson, D. L. (2016). *Assessment of Children: WISC-V and WPPSI-IV*. La Mesa, California: Jerome M. Sattler.

Seashore, C. E., Lewis, D., & Saetveit, D. L. (1960). *Seashore measures of musical talent*. New York: The Psychological Corporation.

Semel, E., Wiig, E. H. & Secord, W. (2000). *Clinical evaluation of language fundamentals*, *Revised, Third UK Edition*. The Psychological Corporation, London, UK.

Semel, E., Wiig, E. H. & Secord, W. (2003). *Clinical Evaluation of Language Fundamentals, Fourth Edition*. Psychological Corporation, San Antonio, TX.

Spreen, O., & Benton, A. (1977). *Neurosensory Center Comprehensive Examination for Aphasia* (2nd ed.). Victoria, Canada: University of Victoria.

Spreen, O., & Benton, A. L. (1963). *Sentence Repetition Test: Administration, Scoring, and Preliminary norms*. Unpublished manuscript, University of Iowa.

Spreen, O., & Benton, A. L., (1969). *Neurosensory Center Comprehensive Examination for Aphasia*, *Edition A*. *Manual of Instructions*. Victoria: Neuropsychology Laboratory, University of Victoria.

Spreen, O., & Gaddes, W. H. (1969). Developmental norms for 15 neuropsychological tests age 6 to 15. *Cortex*, *5*, 171-191.

Spreen, O., & Strauss, E. (1998). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary* (2nd ed.). New York: Oxford University Press.

Statistics Canada (2013). *Canadian Health Measures Survey*.

Statistics Canada (2015). *Canadian Health Measures Survey*.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Stanford-Binet Intelligence Scale, 4th Edition*. Riverside, Chicago, IL.

Torgesen, J. K., Wagner, R. K. & Rashotte, C. A. (1999). *Test of Word Reading Efficiency*. Austin, Texas: Pro-Ed.

Wagner, R. K., Torgesen, J. K. & Rashotte, C. A. (1999). *Comprehensive Test of Phonological Processing*. Austin, TX: PRO-ED.

Wechsler, D. (2014). *WISC-V: Administration and scoring manual*. San Antonio, TX: Pearson.

Wiig, E. H., Secord, W. A. & Semel, E. (2006). *Clinical Evaluation of Language Fundamentals, 4th Spanish Edition*. San Antonio, TX: Psychological Corporation.

Williams, M. (1965). *Mental Testing in Clinical Practice*. London: Pergamon.

Willis, C. S., & Gathercole, S. E. (2001). Phonological short-term memory contributions to sentence processing in young children. *Memory, 9*, 349–363.

APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE

Q1. Parent's First Name: ____

Q2. Parent's Email Address: ____

Q3. Your Relationship to Child
❍ Mother
❍ Father
❍ Legal Guardian
❍ Other, please specify: ____

Q4. Child's First & Last Name: ____

Q5. Child's Grade
❍ SK
❍ Grade 1
❍ Grade 2
❍ Grade 3
❍ Grade 4
❍ Grade 5
❍ Grade 6
❍ Grade 7
❍ Grade 8

Q6. Name of Child's School: ____

Q7. Child's Gender: ____

Q8. Child's Date of Birth: ____

Q9. Child's Racial / Ethnic Background (please select all that apply)
❑ Aboriginal/First Nations
❑ Asian descent
❑ Black/African descent
❑ Hispanic/Latina
❑ Middle Eastern/Arab descent
❑ White/Caucasian
❑ Other, please specify: ____
Q10. Child's First Language
❍ English
❍ French
❍ Other, please specify: ____

Q11. Mother's First Language
❍ English
❍ French
❍ Other, please specify: ____________________

Q12. Father's First Language
❍ English
❍ French
❍ Other, please specify: ____________________

Q13. Child's Primary Language Spoken at Home
❍ English
❍ French
❍ Other, please specify: ____________________

Q14. Highest Level of Education Completed by Parent #1
❍ Did not complete high school
❍ High school graduate
❍ Attended some college
❍ College graduate
❍ Attended some university
❍ University graduate
❍ Graduate/Professional Degree

Q15. Highest Level of Education Completed by Parent #2
❍ Did not complete high school
❍ High school graduate
❍ Attended some college
❍ College graduate
❍ Attended some university
❍ University graduate
❍ Graduate/Professional Degree

Q16. Has your child ever been diagnosed with one of the following... (select all that apply)
❑ Attention problems (e.g., ADHD)
❑ Autism-spectrum disorder
❑ Hearing problems
❑ Speech-language disorder
❑ Oppositional defiance disorder (ODD) and/or Conduct disorder
❑ Vision problems
❑ NO - none apply

Q17. Please elaborate on your selections, if applicable.

____

____

Q18. Has your child ever been diagnosed with a learning disability?
❍ Yes
❍ No

Q19. If yes, what type? (please select all that apply)
❑ Reading
❑ Mathematics
❑ Written Expression
❑ Learning skills (or Executive Dysfunction)

Q20. If yes, was this diagnosis based on a psychological assessment?
❍ Yes
❍ No

Q21. Has an extended family member of the child ever been diagnosed with a reading disability? (sometimes referred to as dyslexia)
❍ Yes
❍ No

Q22. If yes, please select all that apply...
❑ Sibling
❑ Parent
❑ Grandparent
❑ Aunt/Uncle
❑ Cousin

Q23. Has the child ever been identified by the school system as having an exceptionality?
❍ Yes
❍ No

Q24. Does the child have an Individualized Education Plan (IEP)?
❍ Yes
❍ No

Q25. If yes, what is it for? (please select all that apply)
❑ Reading
❑ Writing
❑ Math
❑ Learning skills

Q26. Has the child ever received any special help at school? (e.g., special class placement, tutoring, speech-language therapy, etc).
❍ Yes
❍ No

Q27. If yes, please elaborate as you see necessary.

Q28. Has the child ever received any additional (outside school) reading instruction, tutoring, or extra help? (e.g., Kumon, Oxford, Sylvan)

❍ Yes
❍ No

Q29. If yes, please elaborate as you see necessary.

APPENDIX B

SENTENCE MEMORY TEST (Benton, 1965)

Child's Name: Date:

Examiner's Name: Total Score:

Instructions: *I will say some sentences. Listen carefully and when I have finished, repeat the sentence back exactly as I have said it. Remember, do not begin until I have given you the whole sentence*. Answer any questions. Discontinue after 3 consecutive failures. (Instructions from Spreen & Strauss [1998] and adapted by Meyers et al. [2000])

		Score (0/1)
1	Look.	
2	Come here.	
3	Help yourself.	
4	Bring the table.	
5	Summer is coming.	
6	The iron was quite hot.	
7	The birds were singing all day.	
8	The paper was under the chair.	
9	The sun was shining throughout the day.	
10	He entered about eight o'clock that night.	
11	The pretty house on the mountain seemed empty.	
12	She wrote the letter to her brother in college.	
13	The lady followed the path down the hill toward(s) home.	
14	The market was full of people buying all kinds of things.	
15	The island in the ocean was first noticed by the young boy.	
16	In the future he will finish work quite early in the morning.	
17	The distance between these two cities is too far to travel by car.	
18	He listened to the teacher telling the story of the war to the class.	
19	A judge here knows the law better than those people who must appear before him.	

20	There is a new method in making steel which is far better than that used before.	
21	The nation has a good government which gives us many freedoms not known in time past.	
22	The friendly man told us the directions to the modern building where we could find the club.	
23	The kind knew how to rule his country so that his people would show respect for his government.	
24	Yesterday he said he would be near the village station before it was time for the train to come.	
25	His interest in the problem increased each time that he looked at the report which lay on the table.	
26	Riding his black horse, the general came to the scene of the battle and began shouting at his brave men.	

APPENDIX C

PHONE SCRIPT FOR SCHOOL PRINCIPALS

My name is Alicia and I am a Master's student at the University of Windsor in the Clinical Psychology program. I am currently conducting a study to look at sentence memory in school-aged children and Dr. Erin Picard mentioned that you might be interested in having your school participate. Is this something you'd be interested in hearing more about?

This study has received clearance from the University of Windsor Research Ethics Board. As part of the study, each child will meet with me, or a trained research assistant, for 45 to 60 minutes during a pre-arranged school day to complete a number of activities related to language, thinking, memory, and processing speed. Testing dates and times will be arranged with the classroom teacher to limit any disruptions to the children's learning. To be eligible, children must be between the age of 6 and 14 years. Do you think you would be interested in having your school participate in this study?

[If no]: Thank you very much for calling/your time.

[If Yes]: Thank you very much. If you could provide me with your email address, I can send you additional information *[advertisement, parental consent, assent]* about the study. To begin recruiting participants, I would like to schedule a brief class presentation in each eligible grade to explain the study and deliver advertisements. Advertisements can be sent home with students in their planner and/or posted by the classroom teacher to the class virtual communication tool with parents. Parents of students who are interested in the study will be asked to contact the researcher via email or phone to determine eligibility and to receive the parent survey, including parental consent form. Children will also provide informed consent on the day of the study.

EMAIL SCRIPT FOR SCHOOL PRINCIPALS

Dr. Erin Picard mentioned that you might be interested in having your school participate in our research study, which has received clearance from the University of Windsor's Research Ethics Board. My name is Alicia and I am a Master's student at the University of Windsor in the Clinical Psychology program. The purpose of this study is to look at sentence memory in school-aged children. As part of the study, each child will meet with me, or a trained research assistant, for 45 to 60 minutes during a pre-arranged school day to complete a number of activities related to language, thinking, memory, and processing speed. Testing dates and times will be arranged with the classroom teacher to limit any disruptions to the children's learning. To be eligible, children must be between the age of 6 and 14 years (please note that we are no longer recruiting 5-year-olds, despite stating so on our official documents). Additional information about the study is attached in Letter of Information for Consent to Participate in Research.

If you would like to participate in this study, I would like to schedule a brief class presentation in each eligible grade to explain the study and deliver advertisements. Advertisements (attached) can be sent home with students in their planner and/or posted by the classroom teacher to the class virtual communication tool with parents. Parents of students who are interested in the study will be asked to contact the researcher via email or phone to determine eligibility and to receive the parent survey, including parental consent form. Children will also provide informed consent (attached) on the day of the study.

APPENDIX D

RECRUITMENT FLYER

WINDSOR-ESSEX CATHOLIC DISTRICT SCHOOL BOARD
"Learning together in faith and service"

University of Windsor

**RECRUITING STUDENTS IN GRADES SK TO 8
FOR A MEMORY STUDY**

We are seeking students between the age of 5 and 14 years to participate in a research study about memory.

All research will occur at the student's school during school hours!

If you, the parent, choose to participate, you will be asked to complete the following:

1. Electronic consent form
2. Brief electronic demographic questionnaire regarding your child's history

Your child will be asked to complete approximately 45 minutes of activities related to memory and other cognitive abilities.

As compensation for participating, your child will be entered in a draw to win 1 of 4 giftcards to Indigo/Chapters worth $50 each.

If you are interested in participating, or would like some more information, please contact **Alicia Bartlett by email (uofwmemorystudy2018@gmail.com) or phone (519-253-3000 ext. 3506).**

**This study has been approved by the University of Windsor Research Ethics Board*

APPENDIX E

INFORMED CONSENT

Title of Study: Examining the Associations Among Sentence Repetition and Other Cognitive Abilities in School-Aged Children

You and your child are asked to participate in a research study conducted by Alicia Bartlett (graduate student) and Dr. Joseph Casey (faculty supervisor) from the Psychology Department at the University of Windsor. This study has received clearance from the University of Windsor Research Ethics Board. The results of this study will contribute to Alicia Bartlett's master's thesis project.

If you have any questions or concerns about the research, please feel to contact Alicia Bartlett at 519-253-3000, ext. 3506 (uofwmemorystudy2018@gmail.com) or Dr. Joseph Casey at 519-253-3000, ext. 2220.

PURPOSE OF THE STUDY

The purpose of the study is to examine sentence memory in school-aged children (students in JK to Grade 8) using a task that requires students to repeat sentences of increasing length. Performance on this task will then be compared to the student's performance across standardized measures of related cognitive skills.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

- Complete an online questionnaire sent via email to provide informed consent and to gather basic demographic information about your child.

If you provide consent for your child to participate in the study:

- Your child will meet with the researcher in an office at their school for approximately 45 minutes to complete the following tasks:
    - Two measures of verbal working memory (Sentence Memory Test & WISC-V Digit Span; 10 minutes). Your child will be asked to repeat sentences or number strings of increasing length until two or three consecutive errors are made.
    - Two measures of nonverbal reasoning (WISC-V Visual Puzzles and Figure Weights; 10 minutes). Your child will be asked to select three pictures that sum to create a larger picture, and to select a weight to balance a scale, until three consecutive errors are made.
    - A measure of verbal comprehension (WISC-V Vocabulary; 5 minutes). Your child will be asked to define words until three consecutive errors are made.
    - A measure of processing speed (WISC-V Coding; 2 minutes). Your child will be asked to copy symbols as quickly as possible.
    - A measure of nonverbal working memory (Seashore Rhythm Test; 5 minutes). Your child will be asked to listen to pairs of nonverbal sounds and indicate whether they are the same of different.

Please note that your child will be providing their own assent to participate in the study at the time of participation and may choose to not participate despite your consent. Your child is free to withdraw from the study at any time despite your consent.

POTENTIAL RISKS AND DISCOMFORTS

There is no foreseeable risk or discomfort associated with your participating in this study. Although unlikely to occur, if you experience any distress while completing the online survey, please discuss your concerns with Dr. Joseph Casey, C.Psych., (519-253-3000, ext. 2220).

There is no foreseeable risk or discomfort associated with your child participating in this study. Most children will find these tasks similar to ones they complete in school (e.g., remembering, writing), and therefore should be familiar with the task requirements. If your child refuses to participate on the day of the assessment, they can withdraw their participation or the appointment can be rescheduled.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

The main purpose of the study is to gain a better understanding of the underlying cognitive abilities associated with sentence memory in elementary school-aged children. Clinicians may benefit from the results of this study in that they will have a better understanding of how to interpret children's scores on sentence repetition tasks. Participants interested in scientific research may also gain useful information about different methods used to conduct research and may also feel intrinsic rewards for contributing to scientific knowledge to benefit others.

COMPENSATION FOR PARTICIPATION

Child participants will be entered into a draw for the opportunity to win 1 of 4 giftcards to Indigo/Chapters worth $50. Parents will be sent an email following the completion of data collection to inform them whether or not their child was the successful winner. Electronic giftcards will then be sent via email to the email address provided by the child's parent.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you and your child will remain confidential and will be disclosed only with your permission. Classroom teachers and peers will know which students participated when your child leaves class to complete the study. Otherwise, all demographic and research data collected will be de-identified, meaning that it will be coded with a randomly assigned identification number rather than displaying your name. If this study results in publication within a scientific journal, only aggregated data will be presented and your individual information will not be identified. All of your identifying, demographic, and research data will be stored in separate encrypted files and physically stored within a secure (locked) location. Only Dr. Casey will have access to your personal identifying information once it is stored. Personal identifying information will be destroyed 2 years after the completion of the study, and destruction will be carried out in a manner to preserve your confidentiality.

PARTICIPATION AND WITHDRAWAL

You and your child can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time during the experiment without consequences of any kind.

You may also refuse to answer any questions you don't want to answer or your child may refuse to perform any tasks they don't want to perform and still remain in the study. The investigator may withdraw you from this research if circumstances arise that warrant doing so. Your child will be eligible for the draw even if withdrawal occurs. After your child has participated in the study, data may still be withdrawn following written instructions from a parent or guardian. Data can no longer be withdrawn after August 31, 2018 once data analysis has occurred.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

When this study is finished, it is the aim of the research team to publish the results in a peer-reviewed scientific journal so that other researchers and clinicians may benefit from its findings. Results of the present study will be posted on the Child Neuropsychology Research Group website. Results will be available by October 1, 2018.
Web address: www.uwindsor.ca/reb
Date when results are available: October 1, 2018

SUBSEQUENT USE OF DATA

These data may be used in subsequent studies, in publications and in presentations.

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights as a research participant, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I understand the information provided for the study "Examining the Associations Among Sentence Repetition and Other Cognitive Abilities in School-Aged Children" as described herein. My questions have been answered to my satisfaction, and I agree to allow my child to participate in this study. I have been given a copy of this form.

____________________________	____________________________
Name of Parent	Signature of Parent
____________________________	____________________________
Name of Participant (child)	Date

____

SIGNATURE OF INVESTIGATOR
These are the terms under which I will conduct research.

April 5, 2018
Date

APPENDIX F

CHILD ASSENT FORM

Child Assent Form – Sentence Memory Study

I am a student researcher, and I am doing a project on memory in kids. I would like to ask you to complete some activities with me that involve working with a pencil, repeating numbers and sentences, or answering questions.

When I am finished working with all the kids who agree to be in my study, I will write a report on what I have learned. My teachers will read it, and it might be put in a book, but no one will know who the kids are that completed my activities.

I want you to know that I will not be telling your teachers or parents or any other kids how you do. Your mom and/or dad have said it is okay for you to complete my activities. Do you think that you would like to do them? You won't get into any trouble if you say no.

If you decide to start the activities you can stop them at any time, and you don't have to answer any question you do not want to answer. It's entirely up to you. As a thank-you for participating, you will be entered into a draw to win 1 of 4 gift cards to Indigo/Chapters worth $50. You will be entered into the draw even if you decide not to finish all of my activities.

Would you like to help with my project and try completing the activities?

I understand what I am being asked to do to be in this study, and I agree to be in this study.

______________________________ ________________________

Signature Date

VITA AUCTORIS

NAME	Alicia Nicole Bartlett
PLACE OF BIRTH	Newport, Wales
YEAR OF BIRTH	1991
EDUCATION	Elmwood School, Ottawa, ON, 2009
	Carleton University, HBA, Ottawa, ON, 2014
	Carleton University, MA, Ottawa, ON, 2016