Sex, executive function, and story learning from shared reading of digital books: An online participatory study

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Table of Contents

Abstract 7

Résumé 9

Acknowledgements 12

Dedication 15

Acknowledgement of Funding 16

Contribution to Original Knowledge 17

Preface and Statement of Contributions 19

List of Tables 20

List of Figures 21

Chapter 1: Introduction 22

Importance of Literacy 23

Boys and Literacy Achievement 24

A Controversial Topic 27

Younger Children: Fewer Studies, More Inconsistent Results 28

Theoretical Explanations for Sex Differences in Literacy Achievement 34

Biological Factors 34

Socio-Environmental Factors 37

Cognitive-Linguistic Factors 39

Chapter 2: Emergent Literacy Development and Support Mechanisms 44

Executive Function 47

Shared Storybook Reading 53

The Present Study: Shared Reading With Digital Books in a Remote Context 58

Purpose of the Current Study 58

Study Goals and Hypotheses 59

Chapter 3: Methodology 61

Participants 61

Recruitment 61

Inclusionary and Exclusionary Criteria 62

Online Information Session 63

Study Sample 64

Study Design 69

Technical 69

Procedure 71

Session 1: Emergent Literacy Skills - Measures and Materials 71

Session 2: Executive Function Skills - Measures and Materials 76

Session 3: Online Shared Reading of a Digital Story 81

Session 4: Story Learning Outcomes - Measures and Materials 93

Study Variables and Analytic Strategies for Study Hypotheses 97

Data Transformation 99

Predictor Variables 99

Outcome Variables 106

Analytic Strategy 1 108

Analytic Strategy 2 110

Missing Data 114

Chapter 4: Results 116

Hypothesis 1: Sex Differences in Story Learning 118

Hypothesis 2: Executive Function and Story Learning 120

Hypothesis 3: Emergent Literacy Skills and Story Learning 122

Hypothesis 4: Joint Effects of Emergent Literacy and Executive Function Skills 126

Summary of Results 128

Chapter 5: Executive Functioning During Shared Reading of a Digital Book Online 129

Behavioural Coding Scheme 130

Executive Functioning Variables 137

Analytic Strategies 139

Analytic Strategy 1 139

Analytic Strategy 2 142

Results 146

Hypothesis 1: Sex Differences in Executive Functioning During Shared Reading 146

Hypothesis 2: Executive Functioning During Shared Reading and Story Learning 148

Hypothesis 3: Task-Based Versus Observational Measures of Executive Function 151

Summary of Results 154

Chapter 6: Discussion 155

Sex and Story Learning From Shared Reading of a Digital Book Online 156

Emergent Literacy Skills and Story Learning From Online Shared Reading 161

The Role of Executive Function in Children's Learning From Digital Books 164

Clinical and Pedagogical Implications 171

Study Strengths and Limitations 173

Directions for Future Research 174

Conclusion 176

References 179

Appendices 214

Appendix 1: Study Consent Form 214

Appendix 2: Study Consent Electronic Signature Page 221

Appendix 3: Study Background Questionnaire 225

Appendix 4: Session 2 Pathway 233

Appendix 5: Story Coding Scheme 234

Appendix 6: Sample Pre-Test Stories 238

Appendix 7: Sample Task-Based Executive Function Responses 243

Appendix 8: Sample Story Retells 248

Appendix 9: Sample Story Comprehension Response 254

Appendix 10: Sample Word Recognition Response 256

Abstract

This dissertation is based on the ongoing concern surrounding boys' underperformance in literacy. One explanatory framework suggests that boys have poorer literacy outcomes than girls due to a slower development of emergent literacy skills. However, the possible origins of sex differences in the development of foundational literacy skills remain a matter of question. One hypothesis is that boys have a weaker development of executive function—cognitive processing skills such as response inhibition, attentional inhibition, and working memory. Within the present thesis study, I sought to examine the contributions of sex, emergent literacy skills, and executive function to preschool children's learning from a digital storybook online, an emerging area of research. Thirty English-speaking children (12 boys, 18 girls) between the ages of 4 and 5 years completed pre-test measures of emergent literacy and executive function skills, a single read of a digital storybook, and post-test measures of story learning performance, all online. The findings revealed there were no statistically significant differences between boys and girls in story learning, as measured using story retelling, story comprehension and word recognition tasks. Additionally, there was no effect of emergent literacy skills on children's story learning outcomes. I present possible explanations for these non-significant findings. The results from the regression analyses showed that differences in executive function accounted for some variance in children's learning from the online shared reading experience. More specifically, the task-based measures explained 16% of the variation in children's story learning performance (p = .02). Although the observational measures did not contribute to a significant increase in the proportion of variance explained ($\Delta R^2 = .04$, $p = .12$), they provide us with important information about preschool children's executive function development within a digital learning context. The results from this online thesis study do not support existing research evidence of a gap in literacy skills between boys and girls. And they are in contrast to prior studies of school-aged children where sex had a direct and indirect effect on learning from digital reading contexts. Despite a small and homogenous sample, the findings do provide some support for the framework that executive function may explain some variation in children's learning from digital contexts, independent of sex. I discuss the implications of the study findings and highlight the importance of examining children's executive function using different situations and investigating different strategies to support executive functioning during digital reading contexts. It is possible that the use of techniques such as turn-taking, which was used in the present study may help to scaffold children's executive functioning during shared reading of digital books. Thereby supporting their learning outcomes from this context. Alternatively, it is possible that it may be more effective if the expert reader (parent, teacher, clinician) allows the child to take control of the literacy learning activity and follows their lead instead.

Keywords: sex, emergent literacy, executive function, shared reading, digital books, online learning

Résumé

Cette thèse est fondée sur la préoccupation constante concernant les faibles résultats en littératie chez les garçons. Les résultats inférieurs des garçons comparativement aux filles sont souvent expliqués par un développement plus lent des compétences en littératie émergente. Cependant les origines possibles des différences entre les filles et les garçons dans le développement des compétences en littératie émergente restent à éclaircir. Un développement plus lent des fonctions exécutives chez les garçons, c’est-à-dire des fonctions cognitives telles que les capacités d’inhibition de réponse, d’inhibition de l’attention, et la mémoire de travail, pourrait expliquer ces différences. Dans cette thèse, je visais à examiner la contribution du sexe, des compétences en littératie émergente et des fonctions exécutives sur les capacités d’apprentissage des enfants préscolaires lors de la lecture d’un livre d’histoire numérique en ligne, un contexte peu étudié. Trente enfants anglophones (12 garçons, 18 filles) âgés de quatre et cinq ans ont effectués des tests de compétences en littératie émergente et de fonctions exécutives. Ils ont participé à la lecture partagée d'une histoire numérique et à des mesures post-intervention d’apprentissage, le tout réalisé en ligne. Les résultats n’ont montré aucune différence statistiquement significative d’apprentissage entre les filles et les garçons dans ce contexte. Ces apprentissages ont été évalués par la capacité à raconter une histoire, à comprendre une histoire et au moyen d’une tâche de reconnaissance de mots. De plus, des compétences en littératie émergente n’ont pas eu d’effet sur l’apprentissage réalisé. Je présente des explications possibles pour ces résultats non significatifs. Les résultats des analyses de régression ont montré que les fonctions exécutives expliquaient en partie les apprentissages effectués par les enfants d’âge préscolaire lors de la lecture partagée d’une histoire numérique. Plus précisément, les mesures standardisées des fonctions exécutives

expliquaient 16% de la variance dans l'apprentissage réalisé (p = 0,02). Les mesures d'observation n'ont pas contribué de façon significative à augmenter la proportion de variance expliquée (ΔR^2 = 0,04 , p = 0,12). Néanmoins, elles fournissent des informations importantes sur le développement des fonctions exécutives des enfants préscolaires dans le contexte de l'apprentissage numérique. Les résultats de cette thèse divergent des connaissances scientifiques actuelles qui documentent un écart entre les garçons et les filles en littératie. Les résultats obtenus contrastent également avec des études menées auprès d'enfants d'âge scolaire dans lesquelles le sexe avait un effet direct et indirect sur l'apprentissage réalisé dans les contextes numérique. Malgré un échantillon petit et homogène, les résultats soutiennent l'hypothèse que les capacités exécutives pourraient expliquer des différences de compétence en littératie émergente entre les enfants d'âge préscolaire, indépendamment du sexe de l'enfant. Je discute les implications des résultats de thèse et souligne l'importance d'examiner les fonctions exécutives des enfants dans différentes situations et d'examiner des différentes stratégies pour soutenir le développement de leurs fonctions exécutives dans un contexte d'apprentissage numérique. Si le lecteur expert (parent, enseignant, clinicien) utilise des techniques telles que le tour de rôle pendant la lecture partagée d'histoire numérique, comme c'était le cas dans cette étude, ces techniques pourraient soutenir le développement des fonctions exécutives des enfants lors de l'apprentissage en ligne et pourraient améliorer leurs apprentissages. Par ailleurs, si le lecteur expert permet à l'enfant de prendre le contrôle et suit les initiatives de l'enfant, ces stratégies pourraient permettre un meilleur développement des fonctions exécutives, particulièrement dans les contextes d'apprentissage en ligne.

Mots-clés : sexe, littératie émergente, fonctions exécutives, lecture partagée, histoires numériques, apprentissage en ligne

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Dedication

To mummy, who gave me my love for reading and encouraged me to ask “why?”

To my nieces and nephews, you are forever my reason(s) why.

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Contribution to Original Knowledge

This dissertation extends the current literature on sex differences in literacy and shared reading by examining factors that explain preschool children's learning from digital books in an online environment. Preschool children's learning in a remote learning environment is an area that has not received much attention; therefore, the challenges are not fully understood. As such, the present online thesis study and its findings contribute to this limited area of research. The outcomes from this thesis study suggest that preschool children can learn from a fully remote learning context and learning outcomes do not differ by sex, especially among children who share similar background characteristics.

This research also extends the current literature on shared reading of digital books by examining the role of executive function in preschool children's learning from a digital book online. Of the three complex factors that were examined, it was executive function that explained preschool children's learning from a digital reading context. Although there are concerns that children may learn less from digital reading contexts possibly due to increased cognitive load requirements, few experimental studies have addressed the role of executive function in preschool children's learning from digital contexts. Therefore, this thesis study contributes both to the limited research examining the role of executive function in preschool children's learning from digital contexts and to the broader literature examining the contribution of executive function to literacy development.

A distinct contribution of the present study was in the use of different approaches to examine children's executive function. Although it is recommended that different approaches are used to examine children's executive function to get a more global perspective of their development, studies that use both direct and indirect measures to assess preschool children's executive function skills are rare. Even more limited are studies that use objective measures to examine children's executive functioning in a (literacy) learning context. Therefore, this work aligns with research recommendations and advances the use of both standard measures in isolation and measures of observation in context to examine children's executive function development. Moreover, the observational measures that were designed and used within the present thesis study to examine preschool children's executive functioning during a literacy learning context represent a contribution to research methodology. These measures provide a structured tool that could be replicated within other studies to advance the use of objective measures of observation and to improve consistency in research tools for observing children's executive functioning in a literacy learning context.

The findings from this research were presented at the Social Sciences and Humanities Research Council (SSHRC) Ensuring Full Literacy 2022 Annual General Meeting in Toronto (Ontario) and at the 2022 American Speech-Language Hearing Association in New Orleans (Louisiana).

Preface and Statement of Contributions

This thesis study was conceptualised and designed by me, Dahlia Marie Thompson, with oversight from Professor Susan Rvachew, Professor Laura Gonnerman, Professor Elin Thordardottir, and Dr. Tanya Matthews. I prepared the submission to the McGill University Institutional Review Board to seek ethics approval, with oversight from Professor Rvachew and Dr. Matthews. I also designed and set-up the behavioural experiment online using LimeSurvey and jsPsych plug-ins, working in close collaboration with Mohammad Anas Shahid and Tory Lackman. Mohammad set up the New React App to display the digital storybook in a web browser and Tory created the original pathways in Microsoft Word.

Recruitment for this thesis study was carried out by me, Mr. Carlos Pérez Valle, and Dr. Matthews. I conducted all the online information sessions with the parents who expressed interest and all the study sessions with the participating children. Dr. Matthews provided oversight by attending information sessions with some parents, providing feedback for improvement after watching video recordings of early study sessions, and reviewing my scoring of some children's pre-test and post-test measures. Mr. Pérez Valle carried out the reliability for oral narrative coding. I also created the behavioural coding scheme for the video data and was supported by Ms. Jessy Burdman-Villa and Ms. Yanran Mou, who carried out the coding and reliability of the shared reading observations. I conducted the statistical analyses and wrote this dissertation, with close guidance from Professor Rvachew.

List of Tables

Table 1 Selected Background Characteristics of Enrolled Participants 67

Table 2 Digital Story Text and Discussion Prompts 86

Table 3 Chi-Square Results of Associations Between Sex and Background Variables 101

Table 4 Correlations for Study Predictor Variables 104

Table 5 Correlations for Study Outcome Variables 107

Table 6 Shapiro-Wilk Test of Normality for Story Learning Variable 109

Table 7 Collinearity Statistics for Study Data 113

Table 8 Number of Participants Completing Each Session 115

Table 9 Descriptive Statistics and Correlations for Study Variables 117

Table 10 Regression of Association Between Executive Function and Story Learning 121

Table 11 Regression of Association Between Emergent Literacy and Story Learning 123

Table 12 Joint Effects of Emergent Literacy and Executive Function on Story Learning 127

Table 13 Overview of Executive Functioning Variables 138

Table 14 Shapiro-Wilk Test of Normality for Executive Functioning Variables 140

Table 15 Regression of Association Between Executive Functioning and Story Learning....... 149

Table 16 Joint Effects of Task-Based and Observational Measures of Executive Function 152

List of Figures

Figure 1 Storytelling Four-Panel Stimulus 73

Figure 2 Images of Sun (left) and Moon (right) Used in Day-Night Task 77

Figure 3 Images of Bear (left) and Lion (right) Used in Bear-Lion Task 79

Figure 4 Illustration of Screen Display During Online Shared Reading 84

Figure 5 Story Word Recognition Pair fly-Frank 96

Figure 6 Visual Summary of Study Hypotheses 98

Figure 7 Scatterplot Matrix for Testing Assumption of Linearity 111

Figure 8 Boxplots for Children's Story Learning Performance by Sex 119

Figure 9 Relationship Between Intake Story Tell Quality and Story Learning Performance.... 124

Figure 10 Relationship Between Intake Letter Knowledge and Story Learning Performance.. 125

Figure 11 Sample Visualization of Participant's Event Log During Online Shared Reading... 134

Figure 12 Scatterplot of Standardized Residuals With Standardized Predicted Values 143

Figure 13 Normal P-P Plot of Regression Standardized Residual 145

Figure 14 Executive Functioning During Story Learning by Sex 147

Figure 15 Association Between Executive Functioning and Story Learning Performance....... 150

Chapter 1: Introduction

To successfully navigate today's knowledge-based society, individuals need strong literacy skills. More specifically, today's literate individuals need to be able to identify, understand, evaluate, create, communicate and compute using print and digital materials that are associated with varying contexts (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2022; Yousif, 2003). Unfortunately, achieving strong literacy skills remains a challenge for many. Globally, an estimated 773 million adults and youths reportedly have low literacy skills, and an estimated 250 million children are failing to acquire foundational literacy skills (UNESCO, 2022). Having strong literacy skills has always been important (reviewed in the next section), but increasingly so in our time of workforce transition, economic recovery, and digital learning.

There is some research evidence to suggest that boys acquire literacy skills at a slower rate than girls (e.g., Below et al., 2010; Borgonovi et al., 2018; Bornstein et al., 2004; Brandlistuen et al., 2021; Phillips et al., 2002). This sex difference in literacy skills is the primary focus of this thesis. Within the literature, the term "gender difference" is also used to describe differences between boys and girls in literacy abilities. Throughout this thesis, the term "sex difference" is used. However, there are instances where the term "gender" is retained, such as when describing the findings from a study that used that specific term. Within this chapter, I will explore boys' and girls' literacy achievement, beginning with older children and then discussing literacy skills in elementary school children. Some hypotheses to explain sex differences in literacy skills will also be posited, along with supporting evidence.

The origins of sex differences in literacy will be found in the emergent literacy or pre-literacy period. Literacy acquisition is built from a range of cognitive skills that develop long before children are introduced to conventional literacy learning at compulsory school entry (Muter et al., 2004; Whitehurst & Lonigan, 1998). The second chapter will cover emergent literacy skills and discuss the possible origins of sex differences in these early cognitive linguistic precursors for reading. Chapter 2: Emergent Literacy Development and Support Mechanisms, will also motivate the hypotheses and methods for the thesis research to be presented in subsequent chapters.

Importance of Literacy

Literacy is a transversal life skill that has a multiplier effect, for adults and children alike. For adults, the effects of low literacy skills are felt at the individual and societal levels, with long-term health, social, and economic costs. Individuals with lower literacy skills find it increasingly challenging to organize information, make sense of what they are reading, follow a line of reasoning, and participate fully in society (DeWalt et al., 2004; Jones et al., 2006; Stromquist, 2008). This hinders their ability to discern the accuracy of information, perform everyday tasks such as understanding instructions on prescription drug labels, complete job applications, help their child with homework, and participate fully in democracy.

Low literacy skills affect an individual's participation in society and hamper economic growth. The findings from recent analyses of international adult literacy data suggest that literacy levels are a stronger predictor of the long-term growth of a country's gross domestic product than overall educational attainment (Schwerdt et al., 2020). It is posited that a one percent increase in literacy skills in the overall workforce could in the long run result in a three percent increase in gross domestic product. The results also suggest that the proportion of adults with lower literacy skills have a stronger (negative) impact on a country's growth rates, than individuals with higher literacy skills. Prior to the onset of the global coronavirus pandemic in

2020, 1 in 6 Canadian adults or an estimated 40% of the Canadian workforce reportedly did not have the literacy levels necessary to learn new skills effectively and to be highly productive in their jobs (Scerbina et al., 2013). More specifically, many Canadians were failing to achieve a minimum level of reading proficiency.

Children with low literacy skills are of particular concern. Literacy skills have long been observed to be an important determinant of school success and mandatory school completion (Carlson, 2010). Children with weaker literacy skills find it increasingly challenging to navigate all areas of the learning curriculum, as reading ability plays a fundamental role in school success by facilitating learning in other content areas (Conti-Ramsden et al., 2009; Reed et al., 2017). Additionally, there is existing research evidence linking poor literacy skills to secondary school dropout rates (Hernandez, 2011). Boys particularly have been observed to consistently demonstrate lower literacy performance across grade levels as well as lower mandatory school completion rates (Borgna & Struffolino, 2017; Greene & Winters, 2006; Homsy & Savard, 2018). Although poor literacy skills may not be a direct determinant of crime and delinquency, there is some research evidence to suggest a strong link between poor literacy skills and young adult crime (e.g., Duncan et al., 2009), with aggregate data showing boys are 2 to 3 times more likely than girls to be accused of a criminal act (e.g., Savage, 2019), regardless of violation type.

Boys and Literacy Achievement

The topic of lower literacy performance among boys is not a recent phenomenon. Published findings of children’s literacy skills and overall academic achievement dating back more than one hundred and twenty years show that relative to girls, boys as a group persistently demonstrate poorer literacy scores during the formal learning years (e.g., Ayres, 1909; meta-analysis by Hedges & Nowell, 1995; meta-analysis by Lietz, 2006; Mullis et al., 2017b;

Organisation for Economic Cooperation and Development [OECD], 2019a; meta-analysis by Voyer & Voyer, 2014). More specifically, evidence from reading studies, teacher-assigned scores, school-based assessments, and international tests of reading performance show that on average school-aged boys are 1.5 to 2 times more likely than girls to be low performers in reading or to receive a score that is below the reading proficiency baseline.

For example, results from the most recent Programme for International Student Assessment (PISA), which measures 15-year-old children's scholastic performance every three years, show that more boys than girls—28% compared to 18%—did not achieve a Level 2 reading proficiency (OECD, 2019a). Of the eight levels of reading proficiency in the recent 2018 PISA, Level 2 is considered the baseline or minimum reading proficiency level, with readers at this level being able to identify the central idea in a text that is of moderate length and to understand limited information when the text includes some distracting information (OECD, 2019a).

This consistent sex difference in reading attainment reflects differences between boys and girls in overall mastery (Education Quality and Accountability Office [EQAO], 2018a, 2018b; Klecker, 2006, 2014; Ministry of Education & Information, 2018) as well as in the achievement of broad-based processes of reading comprehension. This can be illustrated by the results from the most recent Progress in International Reading Literacy Study (PIRLS) framework, where Grade 4 boys obtained significantly lower scores on tasks assessing broad-based processes of reading comprehension (Mullis et al., 2017b). More specifically, the results showed that in 47 of the 50 countries sitting PIRLS, boys had a lower international average score than girls on retrieving and straightforward inferencing tasks—503 (SE 0.5): 520 (SE 0.4). Additionally, boys had a significantly lower average score than girls in interpreting, integrating, and evaluating information—500 (SE 0.5): 520 (SE 0.5)—in 48 of the 50 countries.

Whereas differences between boys and girls in science and mathematics have narrowed to negligible gaps over time, the average and substantial sex differences in reading and writing have not changed (Stoet & Geary, 2013). These trends have been observed regardless of geographical location, country socio-economic status, and language, and despite evident improvements in both boys' and girls' reading performance in recent years (Giguère et al., 2012; Klecker, 2014; Lietz, 2006; Mullis et al., 2017b; OECD, 2019a; Stoet & Geary, 2015). Across grade levels, most low performing and struggling readers are males, with current international test data showing that a large proportion of secondary school boys are approximately half a reading proficiency level behind girls (Chiu & McBride-Chang, 2006; OECD, 2019a); the equivalent of an average school year's progress.

Historically, most data on literacy performance have been from paper-based assessments, delivered in physical print format and traditionally carried out using paper and pencil. However, the way we read and write has long been changing, with people increasingly reading and learning using diverse digital tools, such as smartphones, tablets, and laptop computers. In recent years, reading literacy frameworks have been adapting to the changing way in which people read, with reading measures now requiring children to construct meaning in online environments, namely to integrate information across texts to generate inferences as well as to handle conflict across sources in a digital environment (OECD 2011; 2019b). Within these frameworks, there is a greater emphasis on multiple-source texts and the reading passages may contain different types of visual information, such as photographs as well as dynamic features, including pop-ups and animations (Mullis & Martin, 2019). Additionally, with the on-screen delivery of reading literacy tests, students are also required to use navigational tools to move between passages of text. There is research evidence from computer-based versions of international measures of reading performance of elementary and secondary school children (Mullis et al., 2017a; OECD, 2011), as well as from retrieval tests measuring reading outcomes from electronic book reading (e.g., Huang et al., 2013; Kanniainen et al., 2019) to suggest that boys also underperform in digital reading environments.

A Controversial Topic

Despite evidence of a persistent sex difference in literacy, it is still a very controversial topic, with some educational policy analysts (e.g., Mead, 2006) and researchers (e.g., Siegel & Smythe, 2005; White, 2007) contending that the sex difference in reading is weak and of little practical consequence. The results from prior meta-analyses have shown that the difference between boys and girls in reading-related abilities has been stable across time and developmental levels, yet it has generally been small (Hedges & Nowell, 1995; Hyde & Linn, 1988). To illustrate, in their meta-analysis of studies that included a broad range of participants from toddlers to adults, Hyde and Linn (1988) reported a weighted mean effect size of $d = 0.14$ in favour of girls in vocabulary and reading comprehension; $d = 0.11$ when the Scholastic Aptitude Test (SAT) verbal results were removed. Subsequent meta-analyses of international reading performance data suggest there is a developmental progression in the literacy gap between boys and girls, with the effect size being small ($d = 0.23$) among 10 and 11-year-olds but notably medium ($d = 0.42$) among 15-year-olds (Lynn & Mikk, 2009). Findings of smaller effect sizes, especially among younger children should not be viewed as inconsequential.

The viewpoint that a stable yet small sex difference in literacy abilities during the mandatory learning years is of little practical consequence may have a sociological basis. Global data reveal that employment rates among adults is persistently higher among males and there is a stable sex difference in median annual earnings over time, also in favour of men (OECD, 2022; Pelletier et al., 2019). These findings appear to suggest that in the long run, boys do better than girls financially, despite having weaker literacy skills across the mandatory learning years and despite a higher propensity to drop out of secondary school. The latter, which may partially be explained by greater employment opportunities in certain sectors of the labor market (Borgna & Struffolino, 2017). Indeed, global data confirm that there is an ongoing over-representation of men in higher-paying sectors—construction, mining, quarrying, science, technology, engineering, oil and gas extraction—and an ongoing over-representation of women in lower-paying sectors (e.g., Pelletier et al., 2019). Even when women were employed in similar occupational sectors and categories as men, and worked similar hours per week, they still had lower median weekly earnings (e.g., US Bureau of Labor Statistics, 2015). These findings point to a global systemic issue that needs to be addressed, but they do not negate the findings of a pervasive tendency for young males to achieve lower outcomes on a vital life skill during the mandatory learning years—putting one too many at a disadvantage. Nor do they negate research evidence showing that boys are more represented on the caseload of children with language impairment and literacy delays (Quinn, 2018; Rutter et al., 2004; Snowling et al., 2016), regardless of referral method type.

Younger Children: Fewer Studies, More Inconsistent Results

Most of the empirical evidence to support a small to medium yet pervasive weaker performance in literacy by boys has been from the later school years. Sex differences in literacy skills during the younger years has received far less attention than the later school years. The research evidence from studies that have examined literacy abilities in younger children has been less consistent and more complex. As many studies have reported girls having a tendency to perform better than boys in literacy (e.g., Below et al., 2010; Brandlistuen et al., 2021), as have not (e.g., Adams & Simmons, 2018; Matthews et al., 2009).

There is research evidence from large diverse samples to suggest that girls tend to perform significantly better than boys in literacy during elementary school and even prior to compulsory school entry when reading precursors are being developed. For example, the results from a large scale cross-sectional study by Below et al. (2010), showed that girls significantly outperformed boys in oral reading fluency in kindergarten and fourth grade, notwithstanding equivalent performance at first, second, third, and fifth grades. Additionally, boys have been observed to demonstrate weaker performance on core emergent literacy skills, namely expressive vocabulary (Bornstein & Cote, 2005), oral narrative (Gardner-Neblett, 2015), letter knowledge (Deasley et al., 2018), and phonological awareness (Lundberg et al., 2012) skills.

The evidence from longitudinal studies, such as Bornstein et al. (2004) suggest that relative to girls, boys consistently underperform on subjective and objective measures of expressive and receptive language from the age of 2 through to the age of 5. The findings for vocabulary from their 5-year-old children contradict those from the Law et al. (2013) study, where logistic regression models were used to examine the association of gender with language and literacy skills at age 5 and 34 years. The findings from Law et al. (2013) revealed that 5-year-old English boys performed marginally better than girls on receptive vocabulary skills ($p < .001$, $d = 0.20$), notwithstanding significantly poorer ($p < .01$, $d = 0.10$) word reading skills. Moreover, boys but not girls who had a parent who was a poor reader were more likely to not be reading at age 5.

Studies reporting significant differences between boys and girls in early literacy abilities have not been restricted to monolingual English-speaking children, as similar findings have been found in other linguistic and cultural communities. For example, Eriksson et al. (2012) investigated differences between boys and girls in emerging language skills in over thirteen thousand infants and toddlers from 10 non-English language European communities. The results of their cross-linguistic and cross-cultural study showed that relative to girls, boys had a slower development of word comprehension and word production. Similarly, Brandlistuen et al. (2021) found that among a large sample of Norwegian children who have not yet experienced formal reading or writing instruction, girls (n = 3723) outperformed boys (n = 3744) on a wide range of emergent literacy skills. More specifically, a higher proportion of 5 and 6-year-old girls were able to read words relative to 5 and 6-year-old boys, with the gap increasing with age.

It has been suggested that this early gap in literacy abilities decreases with age, even disappearing by school entry. In the previously mentioned longitudinal study carried out by Bornstein et al. (2004), girls had significantly better oral language performance from ages 2 through 5, but the results did not reveal any significant differences between boys and girls when they were 6-years-old. There are many cross-sectional studies in which boys and girls were observed to achieve similar literacy test scores at school entry and the early elementary school years. For example, the results from an opportunity sample carried out with over 100 children from the United Kingdom showed that while boys aged 5:0 to 6:7 years (60 to 79 months) reported lower writing development, they did not differ significantly from girls in vocabulary, letter knowledge or phonological processing skills (Adams & Simmons, 2018). Similarly, Matthews et al. (2009) found that kindergarten boys and girls in the United States performed similarly in single word naming, letter-word identification, and sound awareness. Likewise, the results from a study of over three 300 Australian primary (elementary) school children did not reveal any significant sex differences on code-related measures of reading abilities (Limbrick et al., 2012). More specifically, boys and girls in Year 1 and 2 had similar performance in single word reading, non-word reading, word-identification fluency, and oral reading fluency.

Collectively, these findings appear to support a common conclusion that boys may demonstrate weaker emergent literacy skills, but they do catch up to girls by school entry, where they are exposed to conventional literacy learning. However, the findings from other studies have demonstrated that this difference between boys and girls in early literacy abilities does not necessarily disappear by compulsory school entry and it is stable up to the end of elementary school. For example, in their longitudinal study of over 400 Norwegian children, Sigmundsson et al. (2017) found that 5- and 6-year-old boys had a significantly weaker performance in the naming of upper-case and lower-case letters and their associated sounds. This significant sex difference in letter knowledge persisted across their first year of elementary school (Sigmundsson et al., 2018). Likewise, the findings from the previously-mentioned study by Brandlistuen et al. (2021), which used questionnaire data from preschool teachers, showed that the gap in early literacy skills increased rather than decreased as children entered their last year of preschool. In relation to children’s early word reading skills, the results showed that at 61 months of age, 38% of the girls relative to 25% of the boys reportedly were able to read words. A year later, both boys and girls had improved in their word reading abilities. However, the results showed that relative to girls, the percentage of 72-month-old boys who were able to read words was markedly lower than girls. More specifically, the results showed that 71% of 6-year-old girls were able to read words, relative to 48% of the boys.

This longitudinal disadvantage for boys may be heightened in at-risk social environments. For instance, Chatterji (2006) controlled for ethnicity and poverty when describing the trajectory of oral language and code-related skills development over the kindergarten and grade one years. The sex difference in literacy precursors that existed between American boys and girls at kindergarten entry was increased from a gap of −0.168 *SD* units to −0.313 *SD* units. The results from this and similar longitudinal studies comprising children from grade one through six (e.g., Phillips et al., 2002), suggest that not only is a gap present at school entry, it either remains constant or increases over time as reading and writing skills develop, with the lowest achieving boys consistently losing ground across years (Husain & Millimet, 2009; Ready et al., 2005).

Differences in Study Characteristics. It is possible that differences in study characteristics may explain the inconsistent results from reading studies of younger children. In addition to differences in study design (i.e., cross-sectional versus longitudinal), other factors may further explain inconsistent results. For example, the period of year tested (e.g., beginning of the school year at school entry in Below et al., 2010; versus spring of kindergarten in Herbert & Stipek, 2005), differences in sample selection and aspect of literacy measured (e.g., Bornstein et al., 2004; versus Law et al., 2013), and the complexity of the task used to assess the literacy skill at certain developmental levels (e.g., Burt et al., 1999; versus Deasley et al., 2018).

To illustrate, in the afore-mentioned cross-sectional study by Below et al. (2010), the results showed significant differences between American boys and girls in kindergarten but not in the early grades. The lack of significant differences between boys and girls in the early grades could be attributed to different reasons. One mitigating factor could have been the task that was used to measure children’s literacy abilities. It is possible that some tasks—such as phoneme segmentation and nonsense word—may have been more discriminative at identifying significant performance differences between boys and girls when their literacy skills were developing, rather than when the literacy skill was more developed and automatized. Within the literature, researchers have proposed similar theories in relation to other literacy tasks. For example, some researchers have questioned the efficacy of using tasks such as alliteration (e.g., as used in Burt et al., 1999) rather than rhyming or word recognition (e.g., as used in Morais, 1991; Puente et al., 2016) to measure phonological awareness in preschool-aged children

There is enough research evidence from diverse measures of literacy and from diverse samples of children to suggest that across time and developmental levels, boys demonstrate weaker literacy skills than girls, and boys as a group generally do not display an advantage in literacy abilities over girls. A review of the literature has shown that relative to girls, boys not only started school with weaker foundational literacy skills they also had lower literacy gains over the course of the school year and across grade levels (Chatterji, 2006; Husain & Millimet, 2009; Phillips et al., 2002; Ready et al., 2005; Sigmundsson et al., 2018), as the change in oral language and decoding demands shifted. Moreover, this difference in literacy abilities has been observed across different socioeconomic groups (Lundberg et al., 2012), and even when boys and girls share similar additional risk factors, such as lower socioeconomic status and lower maternal education level (e.g., Entwisle et al., 2007; Lee & Al Otaiba, 2015).

Gaps in early literacy development are of particular concern. Literacy development is hierarchical in nature (Storch & Whitehurst, 2002) with strong literacy skills cumulatively built from a diverse range of foundational cognitive skills that are laid during the first six years of life (Lonigan et al., 2008; Spencer & Cutting, 2021). There is vast research evidence to suggest that early delays on core precursors to literacy have the potential to compound children's later learning (Cobb-Clark & Moschion, 2017; Hart & Risley, 2003; Hawa & Spanoudis, 2014; Limbrick et al., 2012), both when they are initially learning to read formally in the early grades and during the later grades when they are required to use literacy skills to learn other content or curriculum areas. Understanding sex differences in early literacy development is therefore of ongoing importance, as this has implications for early reading intervention and curriculum design.

Theoretical Explanations for Sex Differences in Literacy Achievement

A review of the extant literature revealed that diverse theoretical frameworks have been proposed for differences between boys and girls in literacy abilities. In addition to a range of biological factors that underpin oral language development, most explanatory factors have focused on either socio-environmental factors related to boys' experience of the literacy learning environment or boys' preparedness to learn literacy when they begin school (Logan & Johnston, 2010). In general, these different frameworks have been shown to be associated with boys' acquisition of literacy and outcomes at certain points of development. However, no one framework fully explains the ongoing reading variance between boys and girls. Each framework will be addressed in relation to the emergent literacy period, when foundational skills that underpin later literacy abilities are developing.

Biological Factors

The first explanatory framework suggests that the impact of sex hormones and sex dimorphism of language lateralization in the brain may explain differences between boys and girls in early oral language development. Children's early oral language skills critically support developing and later language and literacy skills, either directly or indirectly (Lee, 2011; Storch & Whitehurst, 2002). Therefore, it is instrumental to understand what factors influence early language growth and whether these factors possibly explain resulting differences in literacy skills between boys and girls.

There is research evidence to suggest that hormonal surges during infancy may potentially influence early vocal and language development (Quast, 2021). To illustrate, in a longitudinal study carried out by Kung et al. (2016), a negative correlation was found between salivary testosterone level measured at 1 to 3 months of age and expressive vocabulary size reported by parents at 18 to 30 months of age. However, the results showed that the negative effect of salivary testosterone levels during the mini-puberty stage was not restricted to boys, as higher levels of testosterone were also associated with smaller vocabulary sizes in girls.

These results are consistent with an earlier longitudinal study investigating the association between sex hormones during infancy and sentence comprehension abilities at preschool. Within this study, Schaadt et al. (2015) measured twenty children's estradiol and testosterone concentrations from blood samples at 5 months old, then assessed their early sentence comprehension abilities using a standardized verbal test when they were 4-5 years old. The findings showed a similar correlation between sex hormones and language abilities, with lower testosterone and higher estradiol levels at 5 months being associated with better sentence comprehension at 4-5 years of age. Similar to Kung et al. (2016), they also observed that the effect of sex hormone concentrations on language development was independent of sex. Based on the raw scores presented within the study, boys and girls had similar comprehension scores.

In relation to sex dimorphism of language lateralization in the brain, most studies investigating sex differences in brain organization for language functions have been carried out with either adult populations (e.g., Shaywitz et al., 1995) or children with brain damage (e.g., Frith & Vargha-Khadem, 2001). However, the findings from emerging neuroimaging studies carried out with typically developing children between the ages of 4 and 18 years suggest that there are early functional differences between boys and girls in language-associated regions of the brain. For example, the results from two recent studies (Burman et al., 2008; Yu et al., 2014), which used different neuroimaging technologies showed that during spelling, rhyming, and verb generation tasks, girls and boys displayed different patterns of activation of the language network. More specifically, the results from functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) showed that girls demonstrated a more bilateral activation pattern in their frontal and temporal regions of interest during the early years, whereas boys showed a more left-hemisphere dominance. Although left hemisphere lateralization has typically been associated with more mature language processing (Yu et al., 2014), the results from the overt visual verb generation task do not suggest that boys benefitted from an early emergence of left hemisphere language lateralization. Additionally, the results showed that the striking differences in pattern of laterality that were observed during early childhood, such as at age 4, did not appear to persist across developmental levels. Rather, these early differences between boys and girls became similar with increasing age, such that by the adolescent years, girls were showing a similar pattern of left hemisphere lateralization to boys. It is a matter of question whether girls benefitted from the bilateral activation in the frontal language-related areas during early childhood.

The emerging findings on post-natal sex hormones and brain organization from populations of children are intriguing, however they should be interpreted with caution. It is challenging to draw causal links from observations of post-natal hormonal concentrations to resulting sex differences in cognitive linguistic performance. Likewise, it is challenging to draw causal links from differences in brain pattern activation when performing different tasks to sex differences in literacy. Furthermore, the findings to date such as on the effect of post-natal hormonal concentrations on literacy abilities have been independent of sex. Alloway and Gilbert (2002) similarly caution against biological factors as an explanatory factor for sex differences in early literacy, as this approach may be limiting. They contend that such a line of inquiry may not necessarily produce educational practices that would be constructive. Moreover, the findings from studies examining the contribution of diverse factors on oral language and literacy development in twin pairs and non-twins (e.g., Grasby et al., 2016; Van Hulle et al., 2004) suggest that environmental or socio-environmental influences should be considered when investigating differences between boys and girls in early literacy abilities.

Socio-Environmental Factors

The second explanatory framework suggests that diverse socio-environmental factors such as gender stereotyping (Plante et al., 2019; Wolter et al., 2015) or differences in reading engagement (OECD, 2002) may explain some of the variance between boys and girls in literacy outcomes. Historically, literacy activities, such as reading books have often been viewed as being feminine in nature, with boys not expected to perform as well as girls. It has been suggested that gendered expectations or socio-cultural norms surrounding literacy, such as the notion of literacy activities being feminine (Wolter et al., 2015) or boys not being expected to do as well as girls in literacy (Pansu et al., 2016) may translate into reduced interest or engagement in reading; thereby affecting boys' success in literacy (Hartley & Sutton, 2013). For example, Wolter et al. (2015) found that preschool teachers who endorsed gender stereotypes regarding literacy had a negative impact on preschool boys' motivation to learn to read but not girls'. The results further showed that preschool motivation to read was a significant predictor of children's later literacy skills in elementary school. However, the effect was found to be independent of gender, with boys' and girls' literacy skills in first grade similarly impacted by motivation to learn to read in preschool.

Lower reading engagement, which possibly results from gender stereotyping has been observed to be strongly correlated with children's motivation to read (Chiu & McBride-Chang, 2006) and to be a stronger predictor of literacy achievement than socio-economic status (OECD, 2002)**.** Accordingly, strategies are increasingly being proposed to improve boys' engagement in reading. These include lowering gender stereotyping both in the home and school environments, and adapting teaching strategies and literacy materials (OECD, 2012; Plante et al., 2019). Prior results from student questionnaires have shown that whereas girls reported reading more fiction, boys reported reading newspapers, magazines and comics more frequently than books (OECD, 2002). The results from studies focusing on strategies to improve children's engagement in reading have been promising. For example, a National Literacy Trust study in the United Kingdom investigating reading motivation and reading skills in children reported that strategies such as the use of digital books were positively correlated with a change in boys' engagement in reading (Picton & Clark, 2015).

There is some research evidence documenting lower engagement in literacy-related activities by boys. On average, girls reportedly spent more time reading (books) than boys and were more highly diversified in the kind of content they read (OECD, 2002). However, the findings have primarily been from studies of school-aged children and based on subjective measures of reading engagement and interest, such as self-reporting by child (e.g., Marinak & Gambrell, 2010; OECD, 2002; Wigfield & Guthrie, 1997). In studies where sensitive measures of engagement have been used, no difference in reading engagement was found between boys and girls. For example, when verbal and non-verbal observational measures of engagement have been used (e.g., Rvachew et al., 2019), kindergarten boys and girls were observed to be similarly engaged in literacy activities.

More notably, the results from preschool populations have not revealed any significant differences between boys' and girls' engagement in literacy activities. For example, Deasley et al. (2018) reported that boys and girls between the ages of 45 and 58 months were similarly engaged during shared and independent reading of print and digital books; notwithstanding weaker letter naming and letter sound association scores by boys at intake. Likewise, in a prior study by Baroody and Diamond (2013), observer reports of children's literacy engagement did not reveal any significant differences between 4-and 5-year-old boys and girls during free play or large group literacy activities, such as book reading. Based on the use of sensitive measures, the existing research evidence does not support lower reading engagement as a robust explanatory factor for sex differences in literacy abilities, especially among emergent readers.

Cognitive-Linguistic Factors

The third explanatory framework suggests that boys have weaker literacy outcomes because they start school with weaker oral language and decoding skills. Prior to the start of mandatory schooling, a typically developing child undergoes rapid cognitive-linguistic growth that forms the foundation for the acquisition of literacy after formal instruction begins (Snow et al., 2001). Among reading researchers, it has largely been acknowledged that these foundational skills are inter-related. More notably, oral language and decoding—emergent literacy—skills have been observed to develop concurrently during the early years and to have a continuous bi-directional relationship across time (Ouellette, 2006; Storch & Whitehurst, 2002). In a cross-sectional study of over two hundred preschool and primary (elementary) school Greek children, Ralli et al. (2021) found that children's oral language and decoding skills worked together to help support their story retelling abilities. Among older preschool children, vocabulary skills were found to indirectly predict their story retelling abilities through their phonological awareness and morphological skills.

Based on the simple view of reading proposed by Hoover and Gough (1990) from their longitudinal sample of English-Spanish bilingual children, oral language and decoding skills have long been observed to explain significant variation in children's literacy outcomes. Of the broad range of oral language and decoding skills that young children acquire before they are introduced to conventional literacy learning in school, expressive vocabulary, narrative skills, implicit phonological awareness, and letter knowledge have consistently been shown to be robust predictors of later reading and writing ability (Lonigan et al., 2008; Rvachew & Savage, 2006). For example, the results from an eight year longitudinal study by Song et al. (2015) found a strong correlation between the size and growth of preschool vocabulary and comprehensive reading ability at age 11. Another longitudinal study found a similar predictive relationship between preschool children's oral narrative competence and their later writing abilities. The results from this longitudinal study that was carried out by Bigozzi and Vettori (2016) showed that in a sample of preschoolers with no spelling difficulties, those who told stories that were well-structured, cohesive, and consistent also wrote stories of similar quality in first grade. Similarly, the results from another longitudinal study suggest that word reading ability at age 7 may be mediated by the phonological skills that children had at age 5. Within their study, Russell et al. (2018) found that phonological skills at 5-years-old accounted for approximately 50% to 80% of the variance in word reading ability at 7-years-old. Male gender was also observed to be independently associated with children's word reading ability.

There is empirical data showing that boys develop oral language and code-related precursors of literacy slower than girls. In relation to oral language precursors, research evidence suggests that relative to girls, boys are three times more likely to be late talkers at 24 months (Zubrick et al., 2007) and tend to have smaller expressive vocabularies between the ages of 2 and 5 (Bornstein et al., 2004). Notwithstanding a small effect size, there is evidence from a sample of French-Canadian children to suggest a gap on expressive language development is present as early as 18 months of age (Bouchard et al., 2009). The findings from Rodriguez and Tamis-LeMonda (2011) who examined children's oral language and code-related literacy skills at 15, 25, 37, and 63 months of age suggest timing is a key factor in the development of emergent literacy skills in pre-kindergarten children. Regarding oral language precursors of literacy, there is evidence to suggest that amount of talk and vocabulary growth are well established in children by 36 months of age (Hart & Risley, 2003). The findings from this longitudinal study further suggest that it is the vocabulary use and rate of vocabulary growth at 36 months that was strongly associated with and equally predictive of children's reading performances in grade three.

Additionally, boys have also been observed to have poorer narrative skills during the preschool period. As an example, the results from a longitudinal study of oral narrative skills among African American children found that 4-year-old girls demonstrated stronger storytelling abilities than boys (Gardner-Neblett & Sideris, 2018). More specifically, the stories girls told included more story grammar elements and were better organized than the stories boys told. The results from this study also showed that preschool narrative skills had a differential impact on boys' and girls' reading scores from grade one to six. While girls demonstrated stronger narrative skills than boys, their narrative skills did not moderate changes in their reading skills. However, as preschool boys' narrative skills increased, so did their reading skills over time.

Researchers have also found that boys demonstrate weaker performance on code-related precursors of literacy, namely letter (naming and sound) knowledge and phonological awareness skills. In the afore-mentioned book reading study carried out with 4 and 5-year-old Canadian children, Deasley et al. (2018) found that at intake boys knew significantly fewer letter names than girls and more boys than girls reported knowing no letter sounds. Additionally, boys were observed to demonstrate less overt literacy-related behaviours such as pointing at or touching letters when they were independently looking at complex alphabet books. Similar sex differences in decoding abilities have been observed in state-wide early literacy screenings (e.g., Justice et al., 2005). The screening results from over two thousand American children from diverse ethnicities revealed that 4-and 5-year-old boys were significantly behind girls on 6 of the 7 early literacy tasks administered, including alphabet knowledge (d = 0.27), and beginning sound awareness (d = 0.11).

In summary, there is ongoing research evidence to support a robust link between emergent literacy skills and later literacy achievement. There is also ample research evidence to suggest that relative to girls, boys are late talkers, and they demonstrate a slower development of oral language and decoding skills. This slower development of foundational literacy skills has been observed despite boys being similarly engaged as girls with literacy learning practices. The possible origins of sex differences in the development of oral language and code-related precursors of literacy remain a matter of question. The results from a secondary analysis of the large-scale Early Childhood Longitudinal Study (ECLS-K 2011) dataset suggest that children's cognitive development and performance in kindergarten, in areas such as literacy, may be influenced by both cognitive linguistic knowledge as well as cognitive non-linguistic abilities (Byrnes et al., 2019). Cognitive non-linguistic abilities as an explanatory factor for sex differences in emergent literacy skills provide the rationale and focus of this thesis study.

Chapter 2: Emergent Literacy Development and Support Mechanisms

Early childhood is characterised by the onset and rapid development of a range of foundational skills. During the preschool period, prior to the start of mandatory school, children's emergent literacy skills rapidly develop (Neuman & Dickinson, 2001). There are diverse frameworks on the emergent literacy stage. One framework, proposed by Storch and Whitehurst (2002) characterizes the critical cognitive linguistic knowledge that children develop during this time. Namely, oral language and decoding skills that lay the foundation for formal literacy learning at school entry. There is ongoing evidence to suggest that a delay in language development during the preschool period is a particular risk factor for later literacy problems (McLeod et al., 2019). Another framework, proposed by Wasik and Hendrickson (2004), addresses diverse environmental and child factors that may influence children's early cognitive linguistic growth. Such as, early (maternal) language exposure and child characteristics such as attention. Collectively, these two frameworks suggest that the acquisition and development of literacy is an intricate process, and the trajectory of early literacy development in typically developing children may be influenced by diverse factors.

To better understand the diverse sources and mechanisms that influence children's early literacy development, reading researchers have long been investigating the role of diverse risk factors (Bus et al., 1995; Roberts et al., 2005; Shaul & Schwartz, 2014; Soto-Calvo et al., 2020). One of the key environmental supports that has consistently been shown to influence the trajectory of early literacy development and later literacy skills during school is early language input during parent-child interactions (Hart & Risley, 1995; Rowe, 2012; Vernon-Feagans et al., 2022). During these interactions, children are exposed to elaborated conversations and scaffolding, which provide rich opportunities for growth in oral vocabulary and implicit phonological awareness skills.

There is increasing evidence from studies carried out using diverse measures of language input showing a robust correlation between early language exposure and variability in children's cognitive linguistic outcomes. For example, the results from a study of 24 to 48-month old Parisian children by Le Normand et al. (2008) showed that the amount of language exposure recorded during a 20-minute play session was significantly correlated with differences in lexical diversity and productivity. Likewise, a systematic review of studies investigating language input in the child's environment using wearable digital recorders found a positive association between adult word content and children's early cognitive linguistic abilities (Wang et al., 2017).

The results from longitudinal studies investigating children's literacy trajectories are particularly informative. Vernon-Feagans et al. (2022), who investigated children's linguistic development from pre-kindergarten through to elementary found that the contribution of early maternal language input to later literacy outcomes was enduring. The results from their large sample of socio-economically diverse families revealed that maternal language input correlated with children's language development at 36 months and their subsequent word recognition and reading comprehension skills, up to grade five. Notably, this contribution of early maternal input—captured during mother-child book sharing—to children's later literacy outcomes was found to be over and above classroom instructional quality.

The results from some behavioural studies (e.g., Clearfield & Nelson, 2006; Johnson et al., 2014) suggest there are gender differences in verbal aspects of early parent-child interaction. More specifically, mothers—who provided most of the adult-child interactions relative to fathers—were observed to respond preferentially to girls over boys during infancy. Prior findings from a meta-analysis by Leaper et al. (1998) revealed that mothers talk less to boys than girls ($d = .29$) and use less supportive speech with boys than girls ($d = .22$) across childhood. These differences in the frequency and quality of mother-child interactions potentially resulting in variability in early language acquisition and subsequent differences between boys and girls in the development of emergent literacy skills. Therefore, one explanatory framework for differences between boys and girls in early literacy acquisition is differences in (maternal) language input during the early years. However, many other studies investigating the sources of variability in children's language development (e.g., Galsworthy et al., 2000; Huttenlocher et al., 1991; Huttenlocher et al., 2010) have not found any difference in the amount of adult speech input that boys received relative to girls.

In recent decades, researchers have been investigating the role of other mechanisms that support emergent literacy development. Particularly, child characteristics that have been shown to be associated with early development and general school functioning when they transitioned to a conventional learning environment (Best et al., 2011; Blair, 2016; Gibb et al., 2008; Ready et al., 2005). One child factor that has been gaining traction in reading research is executive function (Alfonso & Lonigan, 2021; Cartwright, 2012). Executive function has been observed to develop concurrently with children's cognitive linguistic skills and is believed to play a critical support role in the development of early oral language and decoding skills. Prior findings from the National Institute of Child Health and Human Development (2003) suggest preschool executive function may even be a significant mediator of the relationship between the home environment and diverse language-related outcomes, as well as letter knowledge.

Executive Function

Executive function is an umbrella term used to identify a set of inter-related cognitive processing skills that strongly support all forms of cognitive performance during childhood and beyond (Ahmed et al., 2021; Blair & Razza, 2007; McClelland et al., 2013; Miyake et al., 2000). Although executive function is fundamental to task achievement throughout everyday life, it is a complex construct to define and measure. The number of skills that are included under the umbrella of executive function, the name by which the different skills are identified, and sensitive measures that are best-suited to assess their development often differ across cognitive neuroscience and reading studies (Anderson & Reidy, 2012; Carlson, 2005; Cartwright, 2012). Within the literature, the term cognitive control mechanisms has also been used to describe executive function (e.g., see Davidse et al., 2011).

Most of the earlier work on executive function was carried out with adults or college students (e.g., see work by Miyake et al., 2000), and included cognitive processing skills such as inhibition, updating, and shifting. In developmental frameworks, three or four core skills are normally listed, albeit with differences in the skills identified. For example, the framework originally proposed by Diamond (2006) identified three core cognitive processing skills, namely inhibition, working memory, and cognitive flexibility. This model was later revised in response to ongoing findings that suggest inhibition may be a multidimensional process comprising at least two distinct dimensions (Diamond, 2013a); specifically, a response inhibition dimension operating at the behavioural level and an interference suppression dimension operating at the level of attention. Within the literature, interference suppression or interference control is also referred to as attentional inhibition (Howard et al., 2014; Traverso et al., 2022). Within this thesis study, the term attentional inhibition will be applied.

An earlier developmental model of executive function proposed by Anderson (2002) included four cognitive processing skills operating in an integrative manner: attentional control, cognitive flexibility, goal setting, and information process. Each of these distinct domains subsequently listed a range of different sub-skills. For example, inhibition was listed under the domain of attentional control rather than as a unique domain in itself. A list curated by Cartwright (2012), which combined the work of diverse researchers identified a total of eleven executive function skills, including self-regulation. Within the literature, the definition of executive function and self-regulation, as in behavioural not emotional regulation, often overlap (for example, see Fuhs et al., 2014; Skibbe et al., 2019). This is understandable, as core executive function skills such as response inhibition are the key constructs that underlie goal-directed behaviours, such as the ability to control or regulate one's behaviour during a task to achieve goals (Anderson, 2002; Banfield et al., 2004; Skibbe et al., 2019).

Within this thesis study, I will adopt the more commonly used developmental framework of executive function proposed by Diamond (2006) and subsequently updated to reflect the multi-dimensional facet of inhibition (Diamond, 2013a). This framework identifies the components that have often been postulated as the core executive function skills that are present during the emergent literacy years, the period of interest within this thesis. According to this model, the core executive function skills comprise: (i) *response inhibition* or the ability to resist acting impulsively; (ii) *interference control* (henceforth attentional inhibition) or the ability to ignore distraction and stay focused (iii) *working memory* or the ability to hold information in mind and manipulate it; and (iv) *cognitive flexibility* or the ability to flexibly switch perspectives or adapt to changed circumstances (Diamond, 2013a). These core processes are posited to support higher level cognitive skills such as reasoning, planning, and problem-solving.

Although executive function continues to develop across the lifespan and improves with age, the early years have been observed to be especially crucial. During this period, the pre-frontal cortex, the primary brain region supporting executive function growth undergoes rapid development (Cartwright, 2012; Diamond, 2002, 2006). This anterior portion of the frontal lobe is characterized by a very long period of development, requiring approximately twenty years to reach full maturity in humans. Based on anatomical changes to the frontal lobe and development of executive function, one framework classified the trajectory of typical executive function development into four distinct periods of growth spurts: (i) birth to 1 year, (ii) 1 to 3 years, (iii) 3 to 7 years, and (iv) 7 years through to early adulthood (Diamond, 2002).

This thesis study focuses on the first half of the third growth period, or the preschool period. The results from developmentally sensitive measures of executive function suggests that the preschool period is characterised by rapid growth in executive function skills (Diamond, 2013a; Hoehl et al., 2008). Notably, children’s ability to flexibly switch under more complex conditions emerges during the third year of life, with development continuing during later childhood and into adolescence (Best & Miller, 2010). Additionally, children’s ability to coordinate their executive function skills to manage their behaviour start to show marked improvement from the third year of life onward (Garon et al., 2008; Hendry et al., 2016; Zelazo et al., 2003). The research evidence suggests that inhibition and attention in particular begin to show noticeable development around age four (Friend & Bates, 2014).

This marked development of executive function skills during the preschool period has been observed to occur concurrently with the development of core literacy precursors, such as oral narrative development (Friend & Bates, 2014). The results from studies in cognitive neuroscience suggest that executive function plays a crucial role in children’s cognitive performance from preschool throughout the formal school years (Allan et al., 2014; Cartwright, 2012) and beyond (Ahmed et al., 2021; McClelland et al., 2013). There is research evidence to suggest that the growth in executive function taking place during the preschool period is more susceptible to experiential factors and has more predictive power than later growth (Best & Miller, 2010; Diamond, 2016). For example, McClelland et al. (2013) found that parental ratings of children's ability to attend to relevant information at age 4 significantly predicted their academic achievement at age 21 and the odds of completing college by age 25. In relation to reading achievement levels at age 21, the total effect of preschool ability to attend to relevant information ($\beta = 0.14$, $p = .009$) was found to be both direct and indirect through reading skill at age 7, and beyond background covariates such as vocabulary at age 4, gender, and maternal education level.

Likewise, the results from a longitudinal study by Ahmed et al. (2021) revealed that executive function measured at 54 months of age was significantly correlated with adult educational attainment ($r = .36$, $p < .01$), and impulse control ($r = .11$, $p = .01$) at age 26. More notably, the results further showed that executive function measured during preschool and childhood explained variance in both adult educational attainment and impulse control, over and above that which was explained by executive function measured during the teenage years.

There is robust evidence from longitudinal studies carried out with diverse populations to suggest there is a reciprocal and predictive association between preschool executive function and diverse early literacy outcomes (e.g., Blair & Razza, 2007; Gandolfi et al., 2021; Howard & Vasseleu, 2020; Shaul & Schwartz, 2014; Traverso et al., 2022; Weiland et al., 2014). For example, the results from Blair and Razza (2007) showed that preschool inhibitory control, assessed directly using a peg-tapping task was significantly associated with letter knowledge skills in kindergarten. Weiland et al. (2014) also found that inhibitory control measured at the start of the preschool year using the Pencil Tapping task was significantly associated with children's receptive vocabulary growth at the end of the preschool year, over and above their beginning vocabulary skills. Likewise, the results from hierarchical linear regression analyses conducted by Gandolfi et al. (2021) showed a significant relationship between children's ability to ignore distraction and stay focused and their performance on measures of orthographic knowledge and phonological awareness.

Most studies that have examined the influence of executive function on children's emergent literacy skills have focused primarily on aspects of phonological awareness and vocabulary. Fewer studies have examined the relationship between executive function and applied literacy tasks such as oral narrative ability in young children. However, there is some evidence to suggest there is also a unique predictive and bi-directional relationship between preschool executive function and oral narrative development. In particular, the findings from a cross-lagged design by Friend and Bates (2014) revealed that children's ability to resist distraction and focus attention at age 4 predicted their ability to produce a causally coherent narrative at age 5, over and above growth in language development. The results further showed that improvements in oral narrative development at age 4 predicted children's ability to follow and implement new rules at age 5.

The influence of executive function on children's cognitive linguistic development is further illustrated by studies where significant deficits in executive function skills have been observed in children who were identified as having language difficulties at an early age, at risk for repeated learning difficulties, or who were later diagnosed with developmental language disorders (Morgan et al., 2019; Peng et al., 2013; Snowling et al., 2019). Furthermore, preschool children who have been identified as advanced learners have been observed to also have advanced executive function, relative to their peers (Howard & Vasseleu, 2020).

Although there are marked differences in children's executive function development as a function of age (Garon et al., 2008), there is also research evidence to suggest that individual child differences within age may be related to other factors. More notably, there is research evidence from developmental studies to suggest that child sex may be a contributory factor. Longitudinal studies have been particularly informative in this regard. Mileva-Seitz et al. (2015) showed that 52-month-old boys scored significantly lower than girls on a developmentally appropriate measure of inhibition. Similarly, Ready et al. (2005), found that girls not only started kindergarten with stronger literacy skills than boys, but girls also displayed more attentional inhibition than boys. It is posited that this ability for better attentional control among girls explained a large portion of the variance in literacy learning and gains between boys and girls in kindergarten.

Given the concurrent development of executive function and emergent literacy, the significant relationship between these skills, and findings of sex differences in aspects of both skills, it is possible that differences in executive function may explain why some boys have a slower development of emergent literacy skills. This thesis study therefore seeks to describe and explain the role of executive function in sex differences in emergent literacy skills.

In children, executive function is typically assessed using either task-based or informant-based measures, or a combination of approaches (Anderson & Reidy, 2012; Carlson, 2005; Diamond, 2016). It is widely acknowledged that each approach provides a different perspective on executive function development. Whereas task-based measures are believed to tap into specific executive function skills, informant-based measures such as reporting using rating inventories are believed to provide a more global perspective of the child’s executive functioning (Garon et al., 2008; Wallisch et al., 2017). On the one hand, task-based measures are believed to provide a more objective assessment of children’s abilities. However, these measures often differ in complexity, take place in structured contexts that may not necessarily mimic everyday functioning, and may be subject to task impurities and ceiling effects. On the other hand, informant-based measures such as questionnaires are routinely subject to bias and measurement errors. However, it is largely acknowledged that reporting by these measures may provide greater insight into children’s use of executive function skills in everyday contexts and over a longer duration of time than structured tasks administered in isolation. Consequently, to provide a more composite measure of children’s executive function, a standardized executive function questionnaire with strong psychometric properties paired with a developmentally appropriate task or battery of observational tasks may be required (Wallisch et al., 2017).

Given that direct and indirect measures may provide different perspectives into children’s executive functioning, this thesis study included both task-based measures of executive function in isolation as well as observational measures of executive function in context. Specifically, children’s ability to resist acting impulsively (response inhibition) and to ignore distraction and stay focused (attentional inhibition) were observed during participation in an everyday activity, namely shared storybook reading.

Shared Storybook Reading

Shared storybook reading is a well-known literacy practice that has consistently been observed to provide children with a unique opportunity to nurture and develop their foundational literacy skills (Holdaway, 1982; Justice & Pullen, 2003; Lever & Sénéchal, 2011; Roberts et al., 2005). There is ongoing research evidence to suggest that shared storybook reading has significant benefits for children's readiness for conventional literacy learning at school entry (Anderson et al., 2018; Ezell & Justice, 2005; Rhyner, 2009). These benefits were found when children were actively engaged, their specific interest catered to, and explicit scaffolding strategies were used to heighten their awareness of oral language and decoding skills during shared reading interactions. Additionally, there is research evidence to suggest that preschool children's exposure to books and their storybook knowledge mediated the relationship between the home literacy environment and developing literacy skills (Davidse et al., 2011). The results also showed that (short-term) memory predicted children's vocabulary skills, over and above exposure to storybooks at home. No similar results were found for letter knowledge and no similar relationships were found for their measures of inhibition and attention.

Increasingly, young children are learning emergent literacy skills from shared storybook reading carried out across different modalities, namely print and diverse digital tools such as smartphones and tablets (Courage, 2019; Furenes et al., 2021; Rideout, 2017). There is some research evidence showing that young children were more engaged when digital stories were shared relative to when print stories were shared. For example, Richter and Courage (2017) found that during shared reading preschool children were more attentive and engaged when a story was shared on a tablet compared to when it was shared in printed format. Within this study, the digital book that was shared included multimedia content and interactive features that activated story-related information. Deasley et al. (2018), who examined sex differences in emergent literacy and reading behaviour found that 4 and 5-year-old boys and girls (N = 128) were similarly engaged when listening to and interacting independently with print and digital books; notwithstanding boys having lower scores than girls in letter knowledge at intake.

The research findings from studies comparing preschool children's emergent literacy outcomes from traditional print books and digital books have been inconclusive. Some studies have reported no differences in outcomes. Such as, Richter and Courage (2017) who examined preschool children's (*N* = 79) interaction and story learning following shared reading of comparable print and digital stories. The results of their study revealed that although children were more attentive and engaged during digital storybook reading, their recall of story content from the print and digital stories was similar.

There are studies that have reported better outcomes in emergent literacy skills, such as phonological awareness and word recognition when children shared digital books relative to when they shared print books. In one such study, Korat and Segal-Drori (2015) examined preschool children's storybook reading under different contexts—specifically, shared reading with a parent as well as independent reading. Their findings showed that joint sharing of well-designed digital books, namely those that contained story congruent interactive features—such as clickable words with pronunciation at the syllabic and sub-syllabic levels, and dynamic visuals—resulted in marked progress in children's phonological awareness and word reading skills. O'Toole and Kannass (2018) similarly found that 4-year-old children (*N* = 100) learned more words from a tablet book relative to a traditional print book. In contrast, Parish-Morris et al. (2013) found that preschoolers' narrative comprehension from digital books was weaker relative to the print format, when they examined interactive shared reading experiences in 165 parent-child dyads. For example, the results showed that were no differences between 3-year-old children in character or event identification based on book format. However, 3-year-old children who shared digital books recalled less story content and told stories that were less sequenced than 3-year-old children who shared traditional print books.

Variability in the emergent literacy skill measured from shared reading of traditional print and digital books may explain some of the inconsistencies in research findings. Furthermore, it is possible that the interactive features in digital stories that contributed to higher engagement and positive learning outcomes in some children challenged other children’s ability to attend to the shared reading task (Russo-Johnson et al., 2017; Rvachew et al., 2020). Thereby, resulting in poorer learning from digital shared reading experiences. In the afore-mentioned study by Richter and Courage (2017), preschool children’s executive function was found to be a stronger predictor of their ability to recall story content from a tablet book than their age and language comprehension alone.

Shared reading of digital books is different from shared reading of traditional print books in important respects. Particularly, in the demand for the use of various navigation tools and the presence of interactive features (Bus et al., 2015). These interactive features, which allow user engagement may place unique selective attention and task switching demands on the user (OECD, 2011). The need to assess relevance and disregard distractors may be more challenging for young children, whose executive function skills are still developing (e.g., see Parish-Morris et al., 2013). The sharing of digital stories with preschoolers represents a unique and potentially more challenging literacy learning context than the sharing of traditional print books, as there are diverse factors that may compete for the emergent reader’s cognitive resources. These include the reader who is sharing the story text, the story text that needs to be processed, the device or the medium being used to share the story, as well as the multimedia and interactive features of the storybook. Therefore, there is a probability that executive function skills, which are rapidly developing yet still immature in preschool children (Diamond, 2013a) may play a unique role in their learning from digital shared reading contexts.

Children with poorer executive function may be particularly at risk during digital book reading environments. More specifically, children who have a poorer ability to hold information in mind during a task (working memory), to control their impulses (response inhibition), and to ignore distraction and attend to a task (attentional inhibition) relative to their peers, may be more challenged by digital book reading experiences. It is possible that they may find it harder to coordinate their cognitive resources effectively, thereby benefitting less from the learning task. It is also possible that relative to girls, boys may be especially challenged within digital book reading environments.

The results from studies carried out with emerging readers suggest there are sex differences in executive function development. More specifically, the results from some studies suggest that boys have weaker attentional inhibition (Ready et al., 2005) and inhibitory control (Mileva-Seitz et al., 2015) relative to girls. Therefore, children with weaker executive function skills, particularly boys may be more at risk for poorer learning outcomes from shared reading with digital books. There is some research evidence of boys having lower literacy outcomes than girls from digital book reading contexts, such as weaker information retrieval (e.g., Huang et al., 2013) and poorer comprehension (e.g., Kanniainen et al., 2019). However, this research evidence to support sex differences in digital book reading environments is from studies of older children where digital reading was carried out independently by mature readers and not jointly with an adult, as is usually the case with emerging readers. Therefore, it remains a question of whether sex differences in literacy outcomes from a digital book reading context would also be found among emerging readers.

The Present Study: Shared Reading With Digital Books in a Remote Context

Purpose of the Current Study

The present thesis study seeks to understand the contributions of sex, emergent literacy skills, and executive function to preschool children's learning from shared reading of a digital book in a novel context; online. The study was conducted online within the context of the coronavirus (COVID-19) pandemic, when in-person studies were cancelled, and many people were working and learning remotely from home. During this period, remote learning became more ubiquitous, thereby providing a unique opportunity to examine young children's learning from shared reading of digital books in a fully remote learning environment. Prior work on shared reading of digital books have largely been conducted using tablets and in person. In some instances, the researcher and the child were physically present in the same room and jointly shared the physical device (e.g., Richter & Courage, 2017). In other instances, the researcher (i.e., the reader) was online, while the child and a research assistant were present together in a physical study room (e.g., Gaudreau et al., 2020).

The sharing of a digital book in a fully remote learning context—with both the researcher and the emergent reader online—adds an additional layer of complexity and the challenges remain largely unknown. For many emergent readers, learning online is a novel experience and represents a particularly complex learning environment, as they would be required to coordinate their cognitive resources among diverse factors. These factors include: (i) the digital book on a shared screen display, including its interactive features, images, and text; (ii) the expert reader's voice; (iii) the web camera displays showing their image as well as the reader's image; and (iv) processing the instructions to navigate learning online. It also required them to manage potentially added distractors in their remote learning environment, which would be different from a controlled laboratory setting. Examples of these potential distractors include other family members working and learning from home, younger siblings playing nearby, a dog barking, or even easy access to toys and books that were not related to the literacy learning task. In sum, to attend to the task of learning from shared reading of a digital book online, emergent readers would be required to manage a range of distractors—in their environment as well as that of the expert reader's—as well as the novelty of learning online.

Study Goals and Hypotheses

The primary goal of the present thesis study was to describe and explain sex differences in emergent literacy skills. In this thesis study, children participated in an online shared reading experience with the researcher, during which they listened to a story, answered questions about the pictures, and interacted with the digital book on a shared screen. Subsequently, their learning from the online shared reading experience was measured to reveal their story retell expressive vocabulary, story retell quality, story comprehension, and word recognition.

The hypotheses for the outcomes of the shared reading experience were as follows:

1. Boys will learn less than girls from the digital story. Story learning performance will be measured with three tasks administered after the shared reading experience: an independent story retell task scored for use of unique content words (expressive vocabulary) and quality; story comprehension by means of strict criterion questions; and word recognition assessed with a 2-alternative pointing task.
2. Story learning performance will be correlated with executive function, as assessed at pre-test with standard tasks of attentional inhibition, response inhibition, and phonological working memory.

3. Story learning performance will also be correlated with emergent literacy skills as assessed at pre-test with measures of story telling and letter knowledge.
4. Any sex difference in story learning performance will be explained by executive function after first accounting for the children's emergent literacy skills.

To further examine the relationship between executive function and story learning performance, children's executive functioning during the online shared reading experience was also observed. Specifically, I coded the everyday performance of children's ability to resist acting impulsively (response inhibition) and to ignore distraction and stay focused (attentional inhibition) when the researcher was reading the story text. To examine the insight provided by children's executive functioning behaviours during the online story learning task, I proposed three additional hypotheses. It was hypothesized that:

1. Boys would exhibit poorer executive functioning than girls during the story learning task.
2. Story learning outcomes would be correlated with children's executive functioning during shared reading, as assessed using observational measures of response inhibition and attentional inhibition.
3. Observational measures of executive functioning would explain additional variation in story learning, over and above what was explained by task-based measures of executive function that were administered in isolation at pre-test.

Chapter 3: Methodology

This thesis study was conducted according to the ethical principles of the World Medical Association Declaration of Helsinki (2013). I received ethics approval from the McGill University Institutional Review Board (Ethics Certificate A11-B80-20A_20-10-016) and followed a process of informed consent and assent for the study. Each parent attended an information session online, after which they provided consent for their child to participate in the study. Subsequently, each parent received a signed portable document format (PDF) copy of their consent form. Each participating child was video recorded providing assent at the start of their first study session, and their assent was monitored throughout the sessions.

Participants

Recruitment

Recruitment for the present thesis study was done through three primary methods. The first method was a call for participants in a local newsletter that was distributed online and in print to families across Montréal (Québec). The second method was a telephone campaign with local Montréal daycares and preschools, who catered to anglophone or bilingual children with English as a dominant language. A call was placed to each establishment to request assistance from the director or school administrator to share a copy of the study flyer with their parents. The third method was an email campaign with elementary schools that had a pre-kindergarten component. Following approval from the Sir Wilfrid Laurier School Board, I contacted elementary school principals to request their assistance in sharing my study flyer with their parents. The study flyer included an overview of the study, researcher contact details, as well as a hyperlink to access a copy of the study consent form online.

A total of 49 parents responded to these recruitment efforts, which took place over a period of 12 months, between Spring 2021 and Spring 2022. Of the forty-nine parents who expressed initial interest and provided their email addresses, 35 attended their scheduled information sessions. Repeated email follow ups were carried out with the other parents. To respect parent's privacy and right not to participate, I limited my follow-up emails to parents to three, including the initial contact. Parents and children who completed the study received a $20 Amazon Gift card, with a list of recommendations for age-appropriate print books, digital books, and strategy learning games.

Inclusionary and Exclusionary Criteria

Children were eligible to participate in the present thesis study if they were between the ages of 4 and 5 years, and they could communicate using English. The language of the study was English. Therefore, children were eligible to participate if they were monolingual or bi- (multi-) lingual speakers of English. Findings from prior studies of preschool children (e.g., Brandeker & Thordardottir, 2015; Thordardottir, 2014) suggest bilingual or multilingual children with 40% exposure or more in the language environment had comparable vocabulary acquisition and grammar to their monolingual peers. Based on the perceived complexity of the language used within the study activities, the bilingual or multilingual criterion for this thesis study was set to a minimum of 60% exposure to English, with exposure being defined as global through parental input at home and preschool or daycare.

Children with low to average language skills and residual or persistent speech errors following language therapy were also eligible to participate in the present study. Additionally, children who presented with developmental difficulties that are common in preschool classrooms, such as suspected attention deficit, concerns about literacy acquisition, clumsiness, corrected vision, and other concerns as reported by parents could participate in the study. Within this thesis study, there were no sex, gender, ethnic, or socio-economic status restrictions to participation.

Given the variables of interest in this study, children with a diagnosed sensory, motor, or cognitive impairment were precluded from participating in the assessment procedures. This included children with a confirmed visual or hearing impairment, cerebral palsy, Down Syndrome, and autism.

Online Information Session

Each parent attended a thirty-minute online information session, which I conducted using Cisco Webex or Zoom. Zoom was used to facilitate those parents who explicitly expressed preference for this software. Some parents shared that they already had Zoom on their devices for remote work and learning, they were more familiar with the platform, or they were using a work-assigned device that did not allow them to install new programs. Within the information session, I provided an overview of the study and invited parents to ask questions. Once the parents' questions had been answered to their satisfaction, I provided the hyperlink to the consent form signature page and invited them to sign the digital study consent form by providing a simple electronic signature. According to Part 2 of the *Personal Information Protection and Electronic Documents Act ("Personal Information Protection and Electronic Documents Act," 2019)*, in Canada, an electronic signature is defined as "a signature that consists of one or more letters, characters, numbers or other symbols in digital form incorporated in, attached to or associated with an electronic document". Parents were thus asked to type their names using letters and characters in a designated signature text box to indicate their consent. After providing consent, parents completed a background questionnaire and chose session dates based on their availabilities. Using the online questionnaire, parents reported on socio-demographic factors, their children's birth, health, and developmental history, as well as their children's home literacy activities and use of digital tools. I created the digital consent form, consent form signature page, and background questionnaire using LimeSurvey version 3, which was hosted by McGill University. Copies of the consent form, signature page, and background questionnaire are provided in Appendices 1 through 3, respectively.

Study Sample

A total of thirty-five children (16 boys, 19 girls) were enrolled in my online thesis study, but 5 withdrew leaving 30 who completed all components. The age of the enrolled participants ranged from 4 years (*n* = 21) to 5 years (*n* = 14), with an average age of 4 years 10 months or 58.06 months (*SD* = 6.49 months). At intake, I assigned each participant a 12-digit alphanumeric identification number containing 6 distinct components. For example, GDL1M1ETL000, where **GDL** was the internal reference name of the thesis study: Gender Differences in Literacy; **1** represented this thesis study, the first sub-project in the project series covered by the grant that provided primary funding for this study in the form of a graduate student stipend; **M** represented child biological sex or sex at birth as reported by parents, with options being either M (male) or F (female); **1** represented the cohort (i.e., the term of intake) with options being 1 - Summer2021, 2 - Fall2021, 3 - Winter2022, 4 - Spring2022, and 5 - Summer2022; **ETL** representing the language group with options including ETL - English Typical Language, FTL - French Typical Language, ELD - English Language Delay, and FLD - French Language Delay; and **000** representing the 3-digit participant number in order of enrollment, regardless of language group.

Based on parental reporting, 15 of the enrolled children were bilingual-multilingual speakers of English. These bilingual-multilingual children spoke a combination of English and another language or languages, including French, Italian, Jamaican Creole, Mandarin, and Spanish. Parental reporting also revealed that one enrolled participant (boy) had language delay. Within this study, children were categorised as having language delay or late language emergence if they were reported as not having any two-word combinations by 24 months of age (Paul, 1991; Rescorla, 1989; Rice et al., 2008). Additionally, eight of the enrolled children reportedly had a family history of speech, language, or reading problems. These children were evenly distributed across boys and girls.

In general, the children who participated in this thesis study were from middle to high socio-economic backgrounds, as determined by the occupation and education levels of their parents. The average Hollingshead Four Factor Socioeconomic Status social strata for the study sample was 4.86 out of a maximum of 5, with 1 referring to unskilled labourers or menial service workers and 5 referring to executives, proprietors, or major professionals (Hollingshead, 1975). Parents' education ranged from partial college to graduate level training. Of the 35 enrolled participants, 32 belonged to a two-parent household, with 88.6% of the primary caregivers (mothers) educated at either the college or university level. At the time of the study, parents' occupation sectors ranged from manufacturing to upper management, with three mothers reporting they were unemployed. Of these three mothers, one had a partial college education and two had a university level education.

Based on the Statistics Canada 2021 classification structure (Statistics Canada, 2021), participants' ethnic and racial backgrounds as reported by their parents are as follows: North American origins = (5.71%); European origins = (42.86 %); Caribbean origins = (8.57 %); Latin, Central and South American origins = (2.86 %); African origins (0 %); Asian origins = (14.29

%); Oceanian origins (0 %); Other ethnic and cultural origins = (25.71 %). A summary of selected background characteristics of the enrolled study participants is provided in Table 1.

Table 1

Selected Background Characteristics of Enrolled Participants

Variable	All	Boys	Girls
Participant	35	16	19
Age range (months)	48-71	50-71	48-69
Average age (months)	58.06	58.50	57.68
	(6.49)	(7.10)	(6.10)
Average birth weight (grams)	3345.29	3170.59	3492.41
	(926.73)	(781.74)	(1031.01)
Low birth weight [a]	3	2	1
Pre-term birth	1	1	0
English Monolingual	20	8	12
English Bilingual-Multilingual	15	8	7
Hollingshead Child-SES Score [b]	52.97	54.21	51.92
	(9.32)	(9.40)	(9.38)
Family history of speech, language, or reading problems			
Yes	8	4	4
No	27	12	15
Language delay [c]			
Yes	1	1	0
No	32	15	17
Unknown	2	1	1
Weekly digital media (hours)	10.68	10.56	10.79
	(9.39)	(9.41)	(9.62)

Note. Standard deviations appear in parentheses next to means. SES = socio-economic status.

[a] Birth weight under 2500 grams, regardless of gestational weeks. [b] Weighted score ranging from 8 to 66 based on the education and occupation of parent and averaged for families with multiple caretakers. [c] No two-word combinations by age 24 months.

Study Design

To examine the contributions of sex, executive function, and emergent literacy skills to children's learning from shared reading of a digital book online, a pre-post study design was used. This thesis study consisted of 4 sessions and lasted for three weeks, on average. Participating children completed two pre-test sessions, one shared reading session, and one post-test session. Children attended one session per week, however the shared reading and post-test sessions were conducted on the same day. Based on parents' schedules, I conducted study sessions either weekday daytime, weekday evening, or on Saturdays. All the study sessions for my thesis study were conducted remotely using video conferencing software and desktop screen sharing to display all stimuli. All the sessions were video recorded with recordings saved to a McGill University-approved cloud storage.

Each child completed the sessions and the activities in the same order. At the outset of each session, children were provided with a pathway showing the list of activities and task order. A sample pathway is provided in Appendix 4. After completing each session, the researcher and the child played a game, as a reward. For example, after session two we created a car online and took it for a spin. After the post-test session, we drew a frog by hand. Each session lasted approximately twenty minutes, not including the game time. All information and study sessions were carried out by me, the primary researcher for my thesis study.

Technical

For my thesis study, I created and set-up the pre-test and post-test stimuli using various jsPsych plugins. jsPsych is a JavaScript framework for creating and running behavioural experiments in a web browser (de Leeuw, 2015). A New React App was created to set up the digital storybook as a single page application for interactive shared use in a desktop web browser

(React). Each part of the study was set up as individual components with unique HyperText Markup Language (.html) and JavaScript (.js) files. Then, I packaged all the study assets into a single JavaScript zipped (.jzip) file and imported it into a Just Another Tool for Online Studies (JATOS) server (Lange et al., 2015). The study file was hosted on a McGill University-approved integrated online testing platform running JATOS version 3.6.1 (BRAMS, 2022). The remote study sessions were conducted using Cisco Webex, with Microsoft Teams or Zoom as a back-up in the event of technical difficulties with Webex.

Procedure

Session 1: Emergent Literacy Skills - Measures and Materials

In the first session, children's emergent literacy skills were assessed using story telling (oral language) and letter knowledge (code-related) measures. These measures have been shown to be strong predictors of later reading and writing outcomes and are commonly used in studies of emerging readers (e.g., Cabell et al., 2011; Deasley et al., 2018; Sigmundsson et al., 2017). The letter knowledge measure consisted of two tasks: letter naming and letter-sound association. The order of task presentation for session one was letter naming, letter-sound, and story telling.

Letter Naming Task. For the letter naming task, children were shown 10 high frequency letters of the English alphabet on the screen and asked to say the name of each letter. The use of high frequency letters followed a prior procedure used in a longitudinal study by Sénéchal et al. (1998) and Sénéchal and LeFevre (2002) when examining complex relations among young children's early home literacy experiences, subsequent language and decoding skills, and their later reading achievement. The letters were shown in sequence and consisted of a practice trial of 3 items, followed by 10 test items: 6 upper case and 4 lower case letters. The practice items were "A, L, a". The test items were "F, K, T, I, N, E, h, w, r, b". Between the appearance of each letter, there was a wait sign; the image of an open hand with palm facing up and fingers spread out. During the practice trial, children received feedback to ensure they understood the task. There was no feedback during the test portion. Children received 1 point for each correct test item, with maximum points of 10.

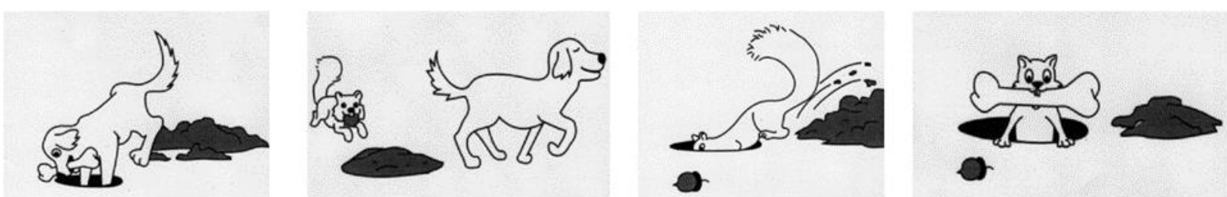
Letter-Sound Association Task. The procedure for the letter-sound association task was similar to the letter naming task, except children were required to say the sound the high frequency letter makes. In the letter-sound task, children saw a tiger holding a letter on the screen. The letters were shown in sequence and consisted of a practice trial of 3 items, followed by 10 test items: 6 upper case and 4 lower case letters. The same 3 letters (A, L, a) were used for the letter naming and letter-sound practice trials. The letter-sound test items were "M, O, S, K, T, F, v, p, b, r". During the practice trial, children received feedback to ensure they understood the task. No feedback was provided during the test portion of the task. Children received 1 point for each correct test item, with maximum points of 10.

Storytelling Task. To elicit oral narratives, a black and white wordless stimulus was used. Wordless picture sequences are often used for oral narrative tasks with preschool-aged children (e.g., see Kornev & Balčiuniene, 2017). With respect to the present thesis study, I showed children a black and white stimulus that had a set of four pictures and asked them to tell me a story. Specifically, I told children, "I will show you four pictures together on the screen. Look at the pictures and tell me your best story. You can make your story as long as you want." Children were shown the four pictures together, rather than individually in sequence. This was done to minimise any undue influence on children's ability to independently generate a story that was well-ordered or sequenced. To encourage independent storytelling, children were provided with three generic prompts: (1) I repeated the last thing the child said and waited for approximately five seconds, (2) "Tell me more", and (3) "Did anything else happen?" All children received the same three prompts in the same order, up to a maximum of 3 times, unless the child clearly indicated they had finished telling their story by saying "done", "the end", or a similar utterance indicating completion.

The 4-panel stimulus that was used for the storytelling task was from the 7th Edition of the Basic Reading Inventory (Johns, 1997). As shown in Figure 1, the first picture in the panel displays a dog with a bone digging a hole. The second picture in the panel shows the dog walking away and a squirrel (or chipmunk, or cat, or kitty based on children's productions) with a nut in its mouth approaching the covered hole. The third picture in the panel shows the squirrel burrowing in the same hole with the nut off to the side. The fourth picture in the panel shows the squirrel inside the hole with the (dog's) bone in his mouth. The story panel was chosen as it was developmentally appropriate, it would accommodate the generation of a narrative with one or more complete episodes, and it had been used in prior reading studies within my laboratory. Based on the date of publication, it was highly unlikely that the 4 and 5-year-old children participating in this thesis study would have had prior knowledge of the panel, thereby influencing the quality of the story they produced.

Figure 1

Storytelling Four-Panel Stimulus



Note. Four unique panels collated and presented together as one image during storytelling task.

Story Transcription and Coding. A review of the literature revealed that researchers examining oral narrative development in emerging readers often evaluate children's stories using diverse measures of microstructure and/or macrostructure elements (e.g., Gardner-Neblett & Sideris, 2018; Kornev & Balčiuniene, 2017; Ralli et al., 2021; Schneider et al., 2005). In general, young children's stories are often scored using individual measures of story productivity, lexical diversity, syntactic complexity, story grammar, cohesion, structure, or sequencing. Based on the review of the literature for best practices and measures that are commonly used with emerging readers, children's stories within this thesis study were first transcribed orthographically then scored for (1) story words produced and (2) story quality.

Regarding story words produced, all unique appearances of content words (i.e., nouns, verbs, adjectives, and adverbs) in children's productions were counted, and a single score of expressive vocabulary was retained. Only story-related utterances were counted. For example, when the child paused to show their new princess dress or fidget toy, those words were not counted as part of the story telling. Character names were excluded, and compound words were counted as one word.

Regarding story quality, this was measured as an aggregate of two distinct elements, namely story grammar units and story organization. The story panel used within this study did not have its own scoring scheme and normative data. Therefore, I created a coding scheme to assess the presence of relevant story grammar units and the overall organization of the narrative. The coding scheme included best practices for scoring story grammar elements from prior research with similarly aged children (e.g., Gardner-Neblett & Sideris, 2018; Petersen et al., 2008 Index of Narrative Complexity; Schneider et al., 2005 Edmonton Narrative Norms Instrument) and an organizational scale.

Regarding story grammar, children received points for mention of 8 units comprising a complete story episode: character, setting, initiating event, internal response, plan to resolve, action to resolve, complication, and resolution or ending. The story grammar units were coded 0, 1, 2. Children received 2 points when they mentioned both characters (the dog and the squirrel) and when they provided story anchoring units such as initiating event, action to resolve, and ending. Children received 1 point for mention of only one main character and for the other story grammar units. The maximum score for a one-episode story was 12 points.

Regarding the organization of the narrative, children's stories were subjectively rated using a 5-point Likert scale, with 0 - Completely off topic, 1 - Not Organized, 2 - Slightly Organized, 3 - Somewhat Organized, 4 - Organized, 5 - Very Organized. The organization ratings considered whether the story events were sequenced, whether cause and effect were introduced, the complexity of the language used to sequence events (e.g., use of higher order conjunctions, such as "after that"), and overall coherence. A detailed explanation of the items that should be present for each scale point to be applied was prepared to guide uniform scoring. A copy of the story coding scheme is provided in Appendix 5 with samples of the stories that children told provided in Appendix 6.

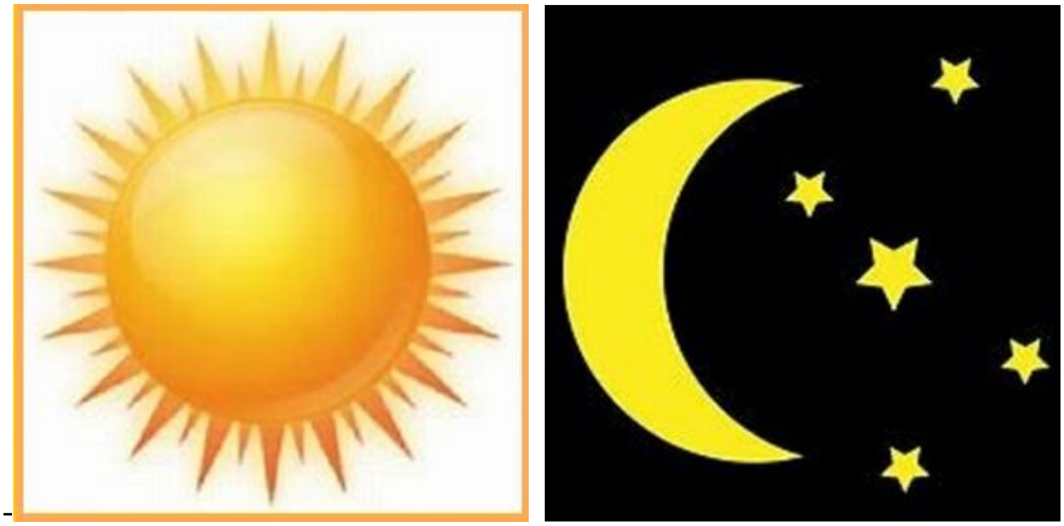
Session 2: Executive Function Skills - Measures and Materials

In the second session, children's executive function was assessed using standard measures of attentional inhibition, response inhibition, and phonological working memory.

Measure of Attentional Inhibition. To assess children's ability to ignore distraction and stay focused, Day-Night, a Stroop like verbal task was used. Day-Night is a widely used measure of interference control in children between the ages of 3 and 7 (see review by Montgomery & Koeltzow, 2010). Task administration and scoring were done according to the procedure outlined in Gerstadt et al. (1994), where a semi-random order was used to display the stimuli on screen during testing. During this task, I told children that they were going to play the *Opposite Game.* First, I showed them a picture of the sun on the screen and asked them to repeat the word "day". Then, I showed them a picture of the moon with some stars and asked them to repeat the word "night". The images of the sun and moon that were used within the *Opposite Game* are provided in Figure 2. After ensuring children understood the concept of the game and could say the words, "day" and "night" independently, I instructed children to say the opposite word when they were shown each picture. Namely, children were instructed to say "day" when the picture of the moon with the stars was shown and to say "night" when the picture of the sun was shown. Each child received a practice trial of 4 items followed by 16 test items. The practice items and test items were distributed evenly across day-night stimulus. During the practice trial, I provided children with feedback where necessary, however I did not provide any feedback during the test portion. For each test item, children received a score of 1 for each correct answer, 0 for an incorrect answer, and NR for non-responses. The maximum score for this task was 16 points. A sample of a completed response sheet for this task is provided in Appendix 7.

Figure 2

Images of Sun (left) and Moon (right) Used in Day-Night Task

-

Note. The images of the sun and the moon with stars are stock photos that were available online at the time of the thesis study. Images were presented in colour during task.

Measure of Response Inhibition. To assess children's ability to resist acting impulsively, Bear-Lion, a commonly used non-verbal measure of complex response inhibition was used (see meta-analysis by Petersen et al., 2016). Bear-Lion, a simplified version of the Simon Says task, is also referred to as Bear-Dragon in the literature (e.g., see Marshall & Drew, 2014; Sabbagh et al., 2006). There is sometimes inconsistency in the task procedure across studies and many studies do not provide a complete overview of the administration and scoring of the task. Within this thesis study, task administration and scoring were done according to the procedure outlined in Sabbagh et al. (2006), which was similar to the earlier procedure outlined in Kochanska et al. (1996). For this task, I told children they were going to play the *Bear Lion* game. First, I practiced four gestures with the child, after which I showed them a picture of a bear followed by a picture of a lion (refer to Figure 3 for images). During this game, I told children that sometimes they would see the bear and sometimes the lion, who would give them a command. I informed children that they should perform the gesture when the bear gave the command but to resist performing the gesture when the lion gave the command. The task consisted of a practice trial of 4 items followed by 10 test items, evenly distributed across stimulus and in alternating order. I provided children with feedback only during the practice trial.

Figure 3

Images of Bear (left) and Lion (right) Used in Bear-Lion Task

Note. The images of the bear and the lion are stock photos that were available online at the time of the study. Images were presented in colour during task.

The gestures used within this task were chosen strategically. Specifically, based on what part of the children's torso would always be visible in the camera and based on adherence to early COVID-19 related health recommendations advising us not to touch certain parts of the face, such as the mouth and the eyes. The prompts were recorded using the voice of another researcher and embedded within the image files to create audio-visual stimuli. Therefore, during the practice and test items, the children saw the image and heard the prompt at the same time, from an unfamiliar researcher.

As shown in Figure 3, the images chosen for both animals appeared friendly, and the recorded voice quality was neutral. This was in contrast to prior research where one animal (Bear) is depicted as friendly with a gentle voice and the other animal (Lion) is depicted as mean with a gruff voice (e.g., see Sabbagh et al., 2006). The decision to present both animals as friendly with neutral voice quality was to minimise the effect of external influences such as visual appearance and difference in voice quality on the children's memory and subsequent performance. For the Bear (activation or do movement) portion of the task, children received a score of 0 if they failed to move as expected, 1 for a wrong movement, 2 for a partial movement, and 3 for a full and correct movement. For the Lion (inhibition of movement) portion, children received a score of 0 for full movement, 1 for wrong movement, 2 for partial movement, and 3 for full inhibition of movement. The maximum score for this task was 30 points. A sample of a completed response sheet for this task is provided in Appendix 7.

Measure of Phonological Working Memory. To assess children's ability to hold and manipulate information in mind, a nonword repetition task was used. Within this study, the Syllable Repetition Task (Shriberg et al., 2009), a dynamic measure of phonological working memory, speech perception, phonological assembly, and short-term memory was used. For this task, I told children that they were going to play *Silly Words.* First, I showed children the image of an ear on the screen and told them that they were going to hear a silly word so they should listen carefully. Then, I showed children the image of a mouth on the screen and told them that whenever they saw the mouth, they should repeat the silly word they just heard. The original procedure for this task does not include a practice trial, therefore I recorded a two-syllable practice item (baba) for the present thesis study. I repeated the practice item twice and provided feedback to ensure children understood the task. After the practice trial, children heard 18 test items in sequential order, according to the protocol, namely eight 2-syllable items, six 3-syllable items, and four 4-syllable items. The 2-syllable test items were "bada, dama, bama, mada, naba, daba, nada, maba." The 3-syllable test items were "bamana, dabama, madaba, nabada, bamada, manaba." The 4-syllable test items were "bamadana, danabama, manabada, nadamada." Children's production of each target item was coded for the number of consonants produced correctly, within-class manner substitutions, additions, and omissions to derive overall scores for competency and processing (memory, encoding, and transcoding). The memory scores from the processing component were abstracted. A sample of a completed response sheet for this task is provided in Appendix 7.

Session 3: Online Shared Reading of a Digital Story

In the third session, I told children that we would be reading a story about an interesting character. Within this thesis study, the reading procedures were constrained by the online nature of the shared reading sessions. Therefore, the reading sessions were very structured. There is research evidence to suggest the use of strategic and structured prompts during shared reading is positively correlated with children's overall engagement in this literacy learning activity and their learning outcomes (Lever & Sénéchal, 2011). I read the digital story once to each child using a pre-defined script to guide the dialogue.

At the outset of the shared reading activity, I established a predictable read-talk-play, turn-taking routine, with an estimated shared reading time of 15 minutes. First, I told the child that our story had words, pictures, and some secret sounds hidden on the pages. Then, I told the child that to read the story, we would take turns. First, I would read the story text, expecting the child to listen and attend to pictures and the text (reader's turn). Next, I would ask the child questions using the pre-defined script, expecting verbal responses from the child (story talk). Finally, the child would take their turn and independently search for the 3 hidden sounds on the page (child's turn). If the child had difficulty finding all three secret sounds on the page despite numerous clicks, I would encourage exploration while not providing explicit instructions, such as "how about ...". I moved to the next page of the story after the child had found all three hotspots. This turn-taking procedure was followed for each story page.

Digital Story. Regarding the digital story shared, the commercially available iPad book, *A Frog Thing* by Drachman and Muscarello (2012) was used. This story was chosen as it met specific criteria that were relevant to the present research objectives. Specifically, the story was age appropriate, colourful with sharp illustrations, of optimal reading length, used minimal amounts of text per screen, and had a good episodic structure with relevant story grammar items. Additionally, this story has been shown to be engaging for similarly aged children in prior research (Richter & Courage, 2017).

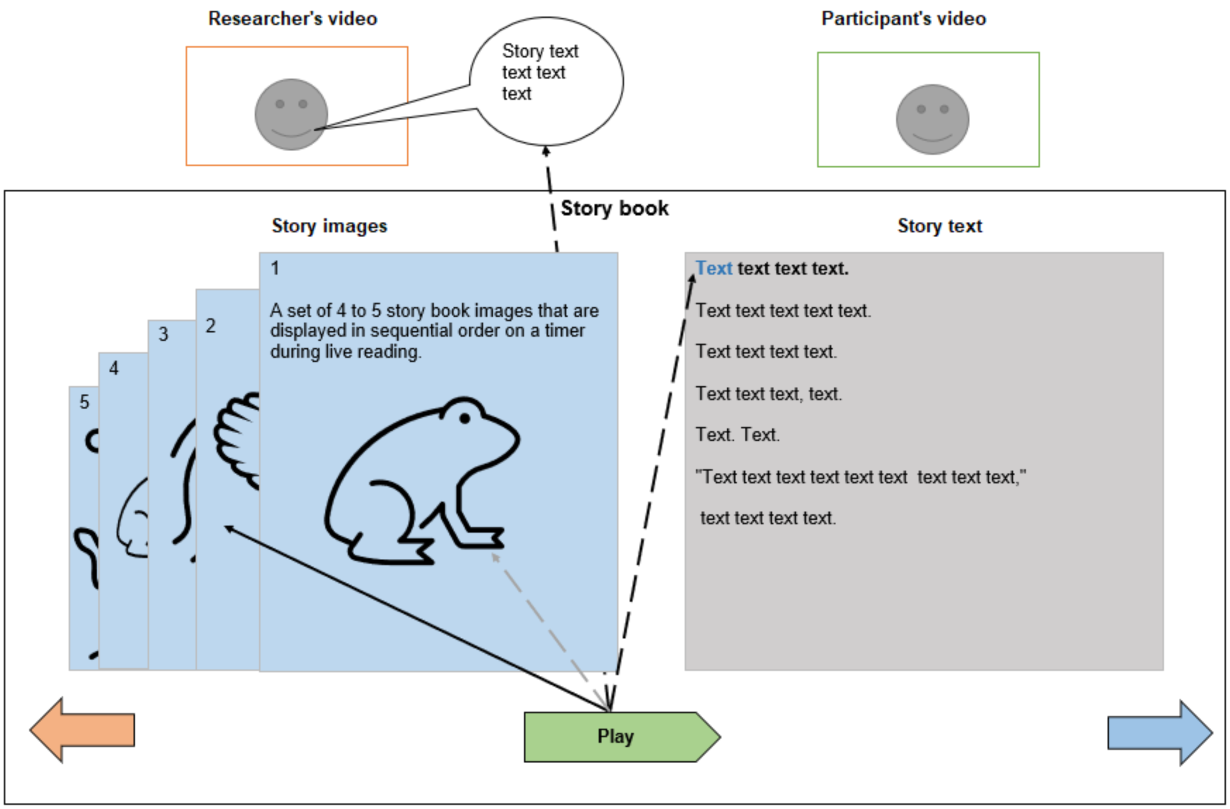
There are three episodes in this story, which tells the tale of a frog named Frank, who wanted to fly. Frank tried to fly by himself, but he was not successful, leaving him quite sad. Although it made him even sadder when his parents told him to try doing something that frogs normally do instead of trying to fly, he was determined not to give up. One day, he used his swimming skills to save a baby bird from drowning and received an amazing gift from the mother bird and her friend. By holding onto a stick carried by the birds, Frank got to soar in the sky, and was very happy to have his dream come true.

This thesis study was carried out online and done remotely with the researcher and the child in different physical locations—their respective homes. Therefore, the iPad version of the storybook had to be modified to allow the researcher and the child to share and access the story text and its interactive features via a desktop web browser and video conferencing. I edited the cover and the pictures on each screen of the storybook to remove overlaying text, recorded new sounds to align with learning goals, and modified the overall presentation of the book. In addition to the cover, the modified web browser version had 11 story screens or read sequences. The original iPad version had 48 individual screens, including the cover. The set up of the modified storybook as a single page interactive application for shared use in a desktop web browser was done using React (React).

I read the story live to each child once. During online shared reading, both the researcher and the child could see the storybook and actively engage with the text and interactive features of the digital storybook on the screen at the same time. As illustrated in Figure 4, the researcher's and participant's videos were displayed at the top of the screen with the desktop version of the digital storybook displayed below the videos. The display of the digital storybook consisted of a block on the left with a story congruent arrangement of images on a timer, a block on the right containing the story text, and a multimedia block at the bottom with play/pause, next and back buttons.

Figure 4

Illustration of Screen Display During Online Shared Reading



Note. The actual story text and images are not displayed due to copyright.

When the screen is loaded, the first image in the arrangement and the complete story text for that specific page are always visible. The story text always contained one hotspot in blue. The last image in the arrangement always contained two hotspots.

At the start of the live reading, the researcher pressed the play button. Upon play, the researcher began reading the story text and the line of story text that was being read was highlighted in bold, in synchrony with the researcher's voice. The story image that was on display on the screen was eventually replaced by the next one in the arrangement. For each story page, there were between four and five images in each arrangement, with the appearance of each image based on a pre-defined timer. As the next line of story text was read out loud by the researcher it was highlighted in bold and the previous line of story text was no longer bolded. By the end of the reading of the story text on the screen, the last image in the arrangement was on display and only the last line(s) of text remained in bold. This process occurred during each story page or read sequence.

For each read sequence, one of the secret sounds was always presented in the story text in blue colour and two were always hidden in the image that appeared last in the arrangement of story images. The last appearing image in the arrangement always remained visible to the child for the "play" or interaction segment. For example, in read sequence 1 when the word "Frank" was touched, the child heard its pronunciation; when the image of Frank was touched, the child heard a frog sound; and when the image of Frank's parents was touched, the child heard them say, "You can do whatever you set your mind to, Frankie." The original story text was retained. The story text and discussion prompts used during shared reading are presented in Table 2.

Table 2

Digital Story Text and Discussion Prompts

Read Sequence	**Images from iPad**	**Original Story Text from iPad**	**Discussion Prompts**
0	1(cover)	A Frog Thing by Eric Drachman Illustrated by James Muscarello	What do you think the story is about? [any response]
1	2 – 6	Frank wanted to fly. But he was a frog. And frogs can't fly. Frank was different, though. Special. Aerodynamic. “You can do whatever you set your mind to, Frankie,” his parents had promised.	What did Frank want to do? [expect a response] That's a funny idea, isn't it?
2	7 – 10	So, Frank set his mind to flying … but it was more like falling than flying. And everyone laughed at him. Tired and discouraged, Frank buried his head in his big webbed feet. And that's how Frank's parents found him.	Poor Frank, he is discouraged. Why is he discouraged? [expect a response] Yes, that's right. He tried so hard, but he just couldn't fly.

Read Sequence	Images from iPad	Original Story Text from iPad	Discussion Prompts
3	11 – 15	Frank explained his problem … and there was a long silence as they thought about how to respond. “Frankie …” started Frank's dad finally, “when we said you could do anything you set your mind to, we meant any … FROG THING. See flying is a ... BIRD THING ... just like staying underwater forever is a FISH THING.” “Yes, you should find a frog thing,” said mom.	Frank's parents told him to find a frog thing. Do you know some frog things? [expect a response] - If child says don't know or something similar, help with “How about flying? Is flying a frog thing?” [response] or “How about swimming? Is swimming a frog thing?” [response] - Follow with, “Let's find out some frog things!”
4	16 - 18	“But I want to fly!” “I'm sorry kiddo, but frogs can't fly,” explained dad. “No,” agreed Mom, “we swim and we hop, but we don't fly.” “They don't understand,” he thought.	Frank is feeling [expect a response]. Follow with, “Do you think Frank will fly?” [expect a response] Let's find out.

Read Sequence	Images from iPad	Original Story Text from iPad	Discussion Prompts
		“We understand,” they said and patted Frank's shoulder.	
5	19 -24	Frank sat in the dark, still sad, but growing more determined. “I'll show them,” he thought. “I'll learn to fly, and I'll fly right over the pond!” He jumped and ran and leaped and dove. He flapped and flapped and flapped. And finally, just flopped on top of a leaf to rest. He soaked his sore feet and hung his heavy head until … … SPLASH	Wow, I wonder what made the splash. [any or no response] Let's find out.

Read Sequence	**Images from iPad**	**Original Story Text from iPad**	**Discussion Prompts**
6	25 - 28	Something crashed into the water and started to sink. Frank leapt into action. “It’s a baby bird!” he thought. He swooped down, swept her up, and swam her back to shore. The nervous mother bird hugged her baby tight. Her baby coughed, then wheezed, then opened her eyes … safe and warm in her mother's wings. The mother bird turned and kissed Frank right on the cheek. He was very surprised and a little embarrassed. “Thank you, thank you!” She chirped.	What made the splash? [expect a response] Yes, and Frank saved the baby bird.
7	29 - 34	“What a great swimmer you are! How can I ever repay you?” “Oh, it was nothing, Ma'am,” said Frank, for he was a very polite and modest frog.	Hmm, the mother bird says she will be right back. I wonder what her plan is to help Frank with his dream. [any or no

Read Sequence	**Images from iPad**	**Original Story Text from iPad**	**Discussion Prompts**
		"Please, I want to do something for you. Anything." "Well …" suggested Frank, "I really really want to fly." "But, frogs don't fly," said the mother bird. "I know," admitted Frank. "And you still want to fly?" Frank shrugged. "I've set my mind to it." She looked in his eyes … then flew off in a flutter. "Wait here," she cried. "I'll be right back!"	response] Let's see what happens next.
8	35 - 39	And she did come back - with another bird and a twig between them. "Grab on!" she called. Before he knew it, they were high above the trees. The morning sun streamed through the sky, and the wind whistled	Wow! Frank's dream came true. How did Frank's dream come true? [expect a response]

Read Sequence	Images from iPad	Original Story Text from iPad	Discussion Prompts
		over Frank’s slick green skin. It was a little scary at first, but soon he relaxed, as they glided and rose and swooped and dove. Everyone hurried to see Frank fly. They watched from the bank as he and the birds passed high overhead. “This is no ordinary frog thing!” observed Frank's mom.	
9	40 - 42	When their flight was finished, the mother bird pulled Frank close. “You are a very special frog,” she said, and with a whoosh of her wings, flew back to her nest. Breathless, Frank waved, “Thank you! Thank you so much.” Frank hopped home somehow lighter than before.	Frank's dream came true. Now, he is feeling [expect a response]

Read Sequence	Images from iPad	Original Story Text from iPad	Discussion Prompts
10	43 - 46	On his way, he met his folks. “Frankie, we saw you up there!” Mom beamed. “Fantastic!” croaked Dad. “You can do anything you set your mind to!” “Anything,” agreed Mom. “Well ... any frog thing, maybe,” Frank explained. “The birds were the ones flying. I was just holding on.” “But I do think I could be one of the great swimmers!” His parents smiled proudly as Frank joined his friends in the pond.	From now on, Frank is going to become [expect a response]
11	47 - 48	Frank had wanted to fly. But he was a frog. And frogs can't fly … … but they sure can swim!	The end. Did you enjoy our story? [any or no response] So, what is Frank really good at in the end? [expect a response]

Session 4: Story Learning Outcomes - Measures and Materials

In the fourth session, children's learning from the online shared reading experience was measured. To assess children's learning, three measures were used: (1) story retelling to assess unique content words and quality of the story retold, (2) story comprehension to assess understanding of the story, and (3) word recognition to assess ability to correctly identify words used frequently in the story. The three tasks were administered immediately following the shared reading session. All the children received their post-test measures on the same day, except for one child who completed their post-test on a separate day due to fatigue.

Story Retelling Task. The story retelling task followed a similar procedure to the pre-test storytelling task, previously described. Children were provided with one visual prompt, in this case the cover of the digital book and asked to retell the story they had just shared. Within the literature, story retelling options include retelling to a familiar hearer (the researcher who read the story) or to an unknown hearer—another researcher (e.g., Gardner-Neblett & Sideris, 2018; Kornev & Balčiuniene, 2017; Ralli et al., 2021; Schneider et al., 2005). In the case of this thesis study, children were invited to independently retell the story to the researcher with whom they had just shared the book. Immediately after sharing the story interactively with the child, I invited them to tell me the story. Specifically, I told children, "Let's see how much of the story you remembered. Tell me the story of *A Frog Thing*. You can make your story as long as you want. Go ahead."

Children were provided with three generic prompts: (1) I repeated the last thing the child said and waited, (2) "Tell me more", and (3) "What happened next?" All children received the same three recall prompts and in the same sequence, up to a maximum of 3 times, unless the child clearly indicated they had finished retelling the story. The coding and scoring procedure for the story retelling task were the same as described for the pre-test storytelling task (see Appendix 5 for a copy of the coding scheme). Children's story retells were scored for unique content words (expressive vocabulary) and quality; the latter measured as an aggregate of story grammar units and organization. Regarding story grammar, the digital story had three complete episodes and points were awarded for grammar units provided, with a maximum score of 30 points. Regarding organization, children's stories were rated using the 5-point Likert scale for overall structure and coherence previously described for the storytelling task. The maximum score for retell quality was therefore 35 points.

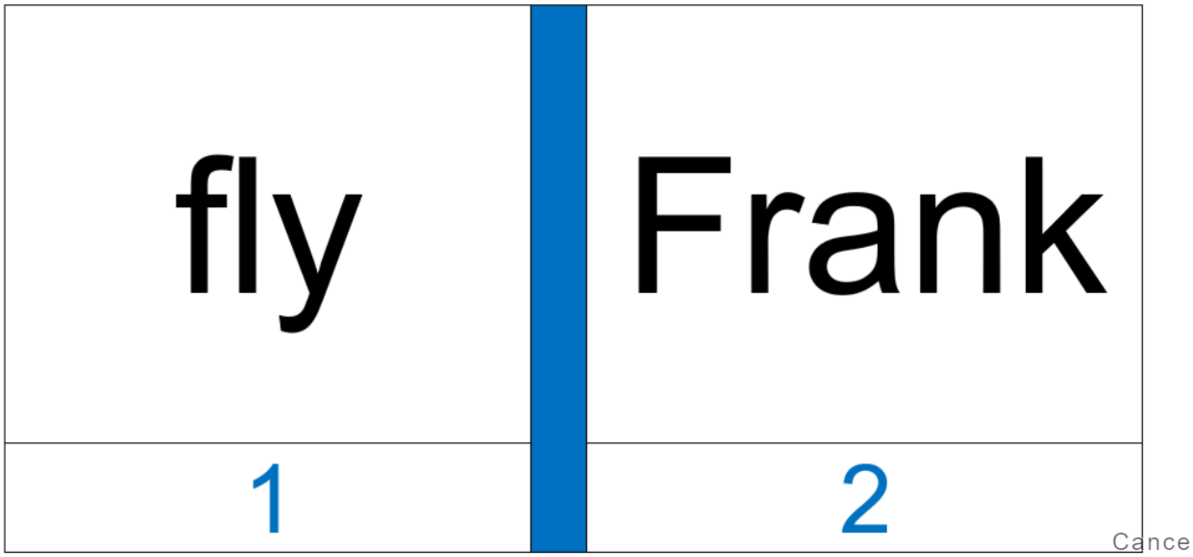
The story retells were scored twice, first by the primary researcher then independently by another researcher. The second coder was not present during the post-test sessions and did not know the identities of the children. I trained the second coder on the story scoring scheme, then provided them with the orthographic transcription and a blank scoring profile for each participant. An analysis of variance two-factor without replication was conducted for each item of interest. The intraclass correlation coefficient (ICC) was *0.95* for unique content words and *0.90* for retell quality, indicating good inter-rater reliability (Koo & Li, 2016). Samples of children's story retells are provided in Appendix 8.

Story Comprehension Task. Children's understanding of the story was measured using four questions. Each question was preceded by a visual prompt from the story. Children were told to look at the picture and then asked: Question 1 - "What does Frank want to do?"; Question 2 - "Why does Frank look so discouraged?"; Question 3 - "What made the splash in the water?"; and Question 4 - "How did the birds help Frank make his dream come true?" The pictures used were Question 1 - Frank sitting on a lily pad staring at the birds in the sky; Question 2 - Frank lying on a rock with his feet on his head and his parents looking on; Question 3 - Frank sitting on a lily pad, staring at the splash in the water; Question 4 - Frank flying between the birds (only Mother Bird visible), holding onto a twig (or stick). Children's responses were transcribed orthographically then scored for accuracy, with NR for non-response, 0 for incorrect response, 1 for partial correct response, and 2 for a complete correct response. For example, in response to Question 4, children who mentioned the birds and the twig received a score of 2, whereas children who mentioned the birds but not the twig received as score of 1. The maximum score for this task was 8 points. An example of a completed story comprehension response sheet is provided in Appendix 9.

Word Recognition Task. Regarding the word recognition task, children were shown four pairs of words that occurred frequently in the story and asked to identify the word said out loud by the researcher. All the target words started with "f", a frequently occurring letter in the story. The word pairs were: 1– "fly, Frank"; 2 – "frog, feet"; 3 – "fly, frog"; and 4 – "folks, feet". Children were asked to identify the words "Frank, frog, fly, and feet", respectively. Given the remote context in which the study was conducted, the presentation of the pairs also included the numbers 1 and 2 appearing below each word for better identification. This is further illustrated in Figure 5 using the first word pair. Children responded with variants of "the first one" or "the number one" to indicate they had chosen the first word in the pair and received a score NR for non-response, 0 for an incorrect response, and 2 for a correct response. The maximum score for this task was 8 points. An example of a completed word recognition response sheet is provided in Appendix 10.

Figure 5

Story Word Recognition Pair fly-Frank

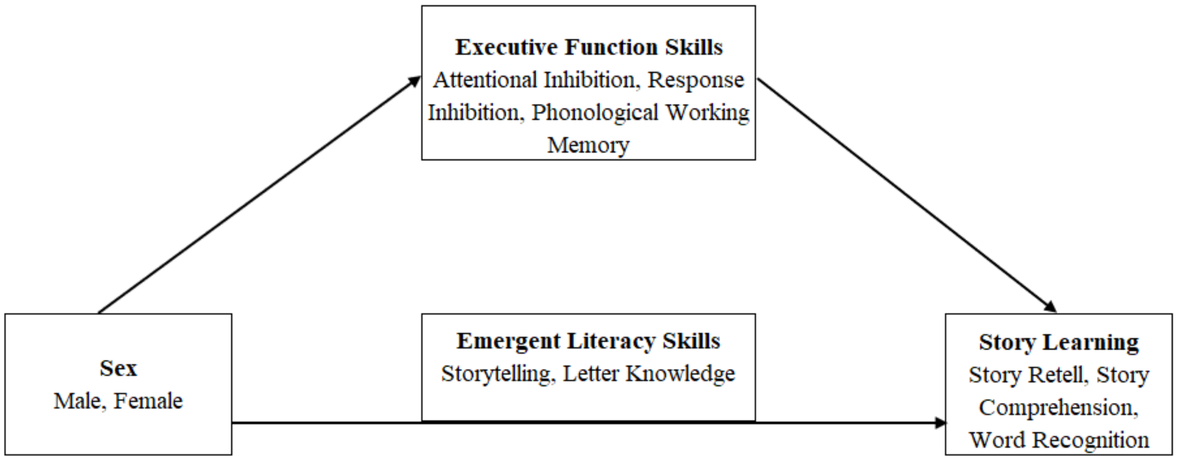


Study Variables and Analytic Strategies for Study Hypotheses

There are two sets of study hypotheses to be tested, as listed in Chapter 2 (Emergent Literacy Development and Support Mechanisms) and illustrated in Figure 6. The analyses to test the first set of hypotheses are based on the pre-test and post-read measures that I have just described in the preceding section. The assessment of the hypotheses to examine executive functioning during shared reading online will be covered in Chapter 5: Executive Functioning During Shared Reading of a Digital Book Online.

Figure 6

Visual Summary of Study Hypotheses



To conduct the analyses to assess the effects of sex, executive function, emergent literacy, and the joint effects of emergent literacy and executive function skills requires some processing of all the data that were collected during the post-read assessment. In this section this data processing will be presented along with a justification for decisions about data transformations and aggregation. The analytic strategies will also be outlined.

Data Transformation

The study variables were based on different measurements that used different scales. As such, the first step was to standardize the raw score values from each pre- and post-test measure into z-scores to place the study dataset on a common scale.

Predictor Variables

Potential Confounds. A review of the literature on studies carried out with children revealed diverse language, biological, and environmental factors that may potentially serve as confounders in the analysis of sex differences in story learning performance (e.g., see Ackerman & Friedman-Krauss, 2017; Fuhs & Day, 2011; Hammer et al., 2017; Law et al., 2013). Accordingly, background information reported by parents at study intake were gathered from the study questionnaire and examined. Specifically, study participants' age, socio-economic status (SES), weekly digital media time, birth weight, pre-term birth, English language background, family history of speech, language and reading difficulties, and language delay were examined.

Independent Samples *t* Test and Chi-Square Test of Independence were used to assess the relationship between sex and the background variables collected from the study questionnaire. The results of the *t* Test showed that there were no significant differences between boys and girls in age, SES, weekly digital media time, and birth weight ($p > .05$). Similarly, the results of the Chi-Square Test of Independence (summarized in Table 3) revealed there were no significant differences between boys and girls in English language background, family history of speech, language and reading difficulties, and language delay ($p > .05$). Based on the results of these two tests, none of the background variables reported by parents were retained for study analyses.

Table 3

Chi-Square Results of Associations Between Sex and Background Variables

Variable	*df*	χ^2	*p*
Pre-term birth	1	1.22	.269
English language background	1	0.61	.433
Family history	1	0.07	.782
Language delay	2	0.87	.646

Note. *N* = 35.

Aggregation of Predictor Variables. The next decision concerns the executive function variables—three measures administered during pre-test—and whether they could be considered as separate variables or they could be aggregated to create one composite variable for study analyses. The results from some studies that have conducted factor analyses suggest executive function skills are best characterised as a unitary construct, particularly during the preschool and early elementary period (e.g., Wiebe et al., 2011). Other studies that have reported higher correlations among younger children relative to older children suggest executive function skills become more divergent with development and are best characterised as distinct yet related factors during the preschool period (e.g., Lerner & Lonigan, 2014).

In line with the theoretical framework and to determine the efficiency of the number of predictor variables used, I conducted a bi-variate correlational analysis to examine the relationships among the three executive function measures as (i) separate variables and (ii) as a composite variable. Given the small sample size for this study, a Principal Component Analysis (PCA) was not possible. The results of the correlational analyses (presented in Table 4) showed there was a strong positive correlation between the response inhibition and phonological working memory variables ($r = .54$, $p < .01$). The results also showed that the composite executive function variable—aggregate of the three variables—was significantly correlated with the individual executive function variables, with moderate to strong correlations ($r = .36$ to .96). I, therefore, retained the composite executive function variable for study analyses.

A similar consideration was also made in relation to the emergent literacy variables. I also considered whether it would be more efficient to aggregate the oral language and decoding measures into one composite emergent literacy variable for study analyses or to retain them as separate variables. The results of a bi-variate correlational analysis, also presented in Table 4, revealed there were strong correlations between the two oral language variables—pre-test story unique content words and story quality ($r = .84$, $p < .01$). As such, I created a composite oral language variable, measured as an aggregate of unique content words and intake story quality, and examined the relationship with each oral language variable. This composite story tell variable was significantly correlated with each oral language variable. However, the individual and composite oral language variables were not significantly correlated with letter knowledge. Oral language and code-related skills are known to be closely related yet unique in their contribution to literacy and reading comprehension (Storch & Whitehurst, 2002). I therefore retained one oral language (story tell quality) and one code-related (letter knowledge) variable to be used as emergent literacy predictors for study analyses.

Table 4

Correlations for Study Predictor Variables

Variable	1	2	3	4	5	6	7	8
1. Intake Unique Words	-	**.84****	.25	**.96****	.18	-.20	-.17	-.02
2. Intake Story Quality [a]	**.84****	-	.15	**.96****	.05	-.26	-.25	-.16
3. Letter Knowledge [b]	.25	.15	-	.21	.35	-.29	-.02	.16
4. Story Tell Quality [c]	**.96****	**.96****	.21	-	.12	-.24	-.22	-.09
5. Attentional Inhibition	.18	.05	.35	.12	-	.24	-.10	**.36***
6. Response Inhibition	-.20	-.26	-.29	-.24	.24	-	**.54****	**.49****
7. Phonological Working Memory	-.17	-.25	-.02	-.22	-.10	**.54****	-	**.96****
8. Executive Function [d]	-.02	-.16	.16	-.09	**.36***	**.49****	**.96****	-

Note. N=30. Missing values excluded pairwise. Significant correlations in bold.

[a] Aggregate of story grammar and structure. [b] Aggregate of letter naming and letter sound.

[c] Aggregate of unique content words, story grammar, and structure. [d] Aggregate of attentional inhibition, response inhibition, and phonological working memory.

*$p < 0.05$. ** $p < 0.01$.

Outcome Variables

Aggregation of Outcome Variables. I also examined the associations among the different measures of story learning performance to determine the efficiency of the outcome variables for study analyses; if they should be retained as separate variables or aggregated into a composite story learning variable. The results of a bi-variate correlational analysis (presented in Table 5) revealed that there was a strong correlation between story retell unique content words and story retell quality ($r = .83$, $p < .01$) and between story comprehension and word recognition ($r = .42$, $p < .05$). The results also showed that there were strong positive correlations between the composite story learning variable—measured as an aggregate of the four outcome variables—and each story learning variable. I subsequently retained the composite story learning variable for study analyses.

Table 5

Correlations for Study Outcome Variables

Variable	1	2	3	4	5
1. Unique Content Words	-	**.83****	.01	.18	**.73****
2. Retell Quality [a]	**.83****	-	.11	.26	**.80****
3. Story Comprehension	.17	.11	-	**.42***	**.56****
4. Word Recognition	.18	.26	**.42***	-	**.67****
5. Story Learning [b]	**.73****	**.80****	**.56****	**.67****	-

Note. N = 30. Missing values excluded pairwise. Significant correlations in bold.

[a] Aggregate of retell grammar and structure. [b] Aggregate of retell unique content words, retell quality, story comprehension, and word recognition.

*$p < 0.05$. ** $p < 0.01$.

Analytic Strategy 1

In the first set of analyses, I examined sex differences in children's learning from shared reading of a digital book online, with child sex as the predictor variable and story learning performance as the outcome variable. The outcome variable was measured as an aggregate of retell unique content words, retell quality, story comprehension, and word recognition. To determine the most appropriate statistical test for analyzing the data, first an assessment of normality was performed (Livingston, 2004; Rochon et al., 2012). Given the sample size, the Shapiro-Wilk Test of Normality was used. The results of the Shapiro-Wilk Test, presented in Table 6, showed that the sampling distribution was normally distributed. Accordingly, a parametric test—Independent Samples *t* Test—was used to examine differences between boys and girls in story learning performance.

Table 6

Shapiro-Wilk Test of Normality for Story Learning Variable

Variable		Shapiro-Wilk		
		W	df	*p*
Story Learning [a]	Boys	.894	12	.133
	Girls	.929	18	.186

Note. [a] Aggregate of retell unique words, retell quality, story comprehension, word recognition.

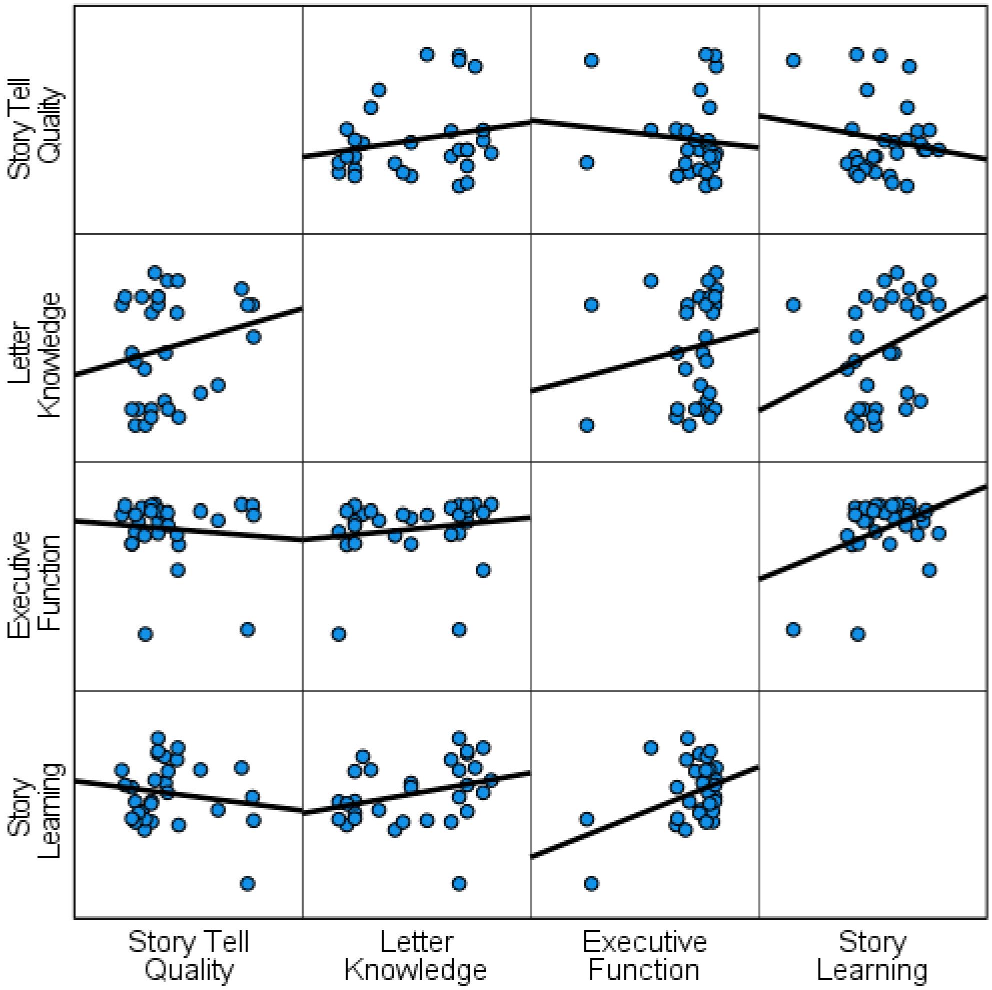
Analytic Strategy 2

In the second set of analyses, I used linear regression analyses to model the relationships between (1) executive function and story learning, (2) emergent literacy and story learning, and (3) executive function, emergent literacy, and story learning. To align with best practices for conducting linear regression analyses, tests for assumptions were first carried out to determine if the data met the necessary requirements (Osborne & Waters, 2002; Sevier, 1957; Tabachnick & Fidell, 2013).

First, I produced scatterplots to test for the assumption of a linear relationship between the predictor variables and story learning. An examination of the scatterplots (matrix presented in Figure 7) revealed the assumption had been met.

Figure 7

Scatterplot Matrix for Testing Assumption of Linearity



Note. Fit line shows straight-line relationship between predictor and outcome variables.

Next, I carried out analyses of standard residuals, which showed that the data did not contain any outliers (Std. Residual Min = -2.77, Std. Residual Max = 2.09). Similarly, tests to see if the data met the assumption of collinearity indicated that multi-collinearity was not a concern and is summarized in Table 7.

Finally, I carried out tests for assumption of independent errors and homoscedasticity. An examination of the Durbin Watson values, which can vary from 0 to 4, revealed that the residuals were not correlated (Durbin-Watson values = 2.00, 2.02). Likewise, an inspection of the scatterplots of standardized residuals revealed that the variance of errors was constant across variables, thereby meeting the assumption of homoscedasticity. More specifically, the data points that were plotted appeared to be random with no obvious indications of funnelling.

Table 7

Collinearity Statistics for Study Data

Variable	Tolerance	VIF
Story Tell Quality	.956	1.046
Letter Knowledge	.956	1.046
Executive Function [a]	1.000	1.000

Note. [a] Aggregate of attentional inhibition, response inhibition, and phonological working memory.

Missing Data

Of the 35 children who were enrolled in the present online thesis study, 4 boys and 1 girl did not complete all the study sessions. Therefore, post-read data are only available for 30 children. A descriptive summary of participation by session is provided in Table 8. The results presented within this thesis are based on analyses that used listwise exclusion of observations with missing values. Within this thesis study, missing data for study variables were coded using a discrete value of 2000.

Table 8

Number of Participants Completing Each Session

Session	All	Boys	Girls
1	33	15	18
2	32	14	18
3	31	13	18
4	30	12	18

Note. Enrolled *N* = 35. Session 1 = Pre-test measures of Emergent Literacy. Session 2 = Pre-test measures of Executive Function. Session 3 = Shared reading of a digital story. Session 4 = Post-test measures of Story Learning.

Chapter 4: Results

This chapter presents the results of my thesis study examining sex differences in story learning from shared reading of a digital book online, and the effects of executive function and emergent literacy skills on children's story learning performance. The results from this online shared reading experience are based on a sample of thirty 4- and 5-year-old children (12 boys, 18 girls) who completed the post-read measures, which were carried out immediately after the shared reading activity. All the analyses for the present thesis study were conducted using the International Business Machines' Statistical Package for the Social Sciences (IBM SPSS) software, version 27 (IBM Corp, 2020), with a significance level of 5% or $p = 0.05$, and confidence interval of 95% in all cases. Descriptive information for the study variables is presented in Table 9, followed by the results for the first set of study hypotheses.

Table 9

Descriptive Statistics and Correlations for Study Variables

Variable	Min	Max	*M*	*SD*	1	2	3	4
1. Story Tell Quality [a]	-2.32	4.28	0.00	1.92	-	.21	-.09	-.15
Boys	-2.32	3.97	0.28	2.18				
Girls	-1.82	4.28	-0.19	1.76				
2. Letter Knowledge [b]	-1.45	1.40	0.00	1.00	.21	-	.16	.29
Boys	-1.30	1.40	0.23	0.97				
Girls	-1.45	1.25	-0.15	1.00				
3. Executive Function [c]	-3.30	0.74	0.00	1.00	-.09	.16	-	**.40***
Boys	-3.16	0.74	0.15	1.09				
Girls	-3.30	0.70	-0.10	0.94				
4. Story Learning [d]	-7.95	4.81	0.00	2.77	-.15	.29	**.40***	-
Boys	-7.95	3.68	-0.11	3.31				
Girls	-3.23	4.81	0.07	2.44				

Note. $N = 30$. Boys = 12, Girls = 18. Values reflect z-scores computed for study data raw scores. Significant correlations in bold.

[a] Aggregate of story tell unique content words and quality. [b] Aggregate of letter naming and letter-sound association. [c] Aggregate of attentional inhibition, response inhibition, and phonological working memory. [d] Aggregate of retell unique content words, retell quality, story comprehension, word recognition.

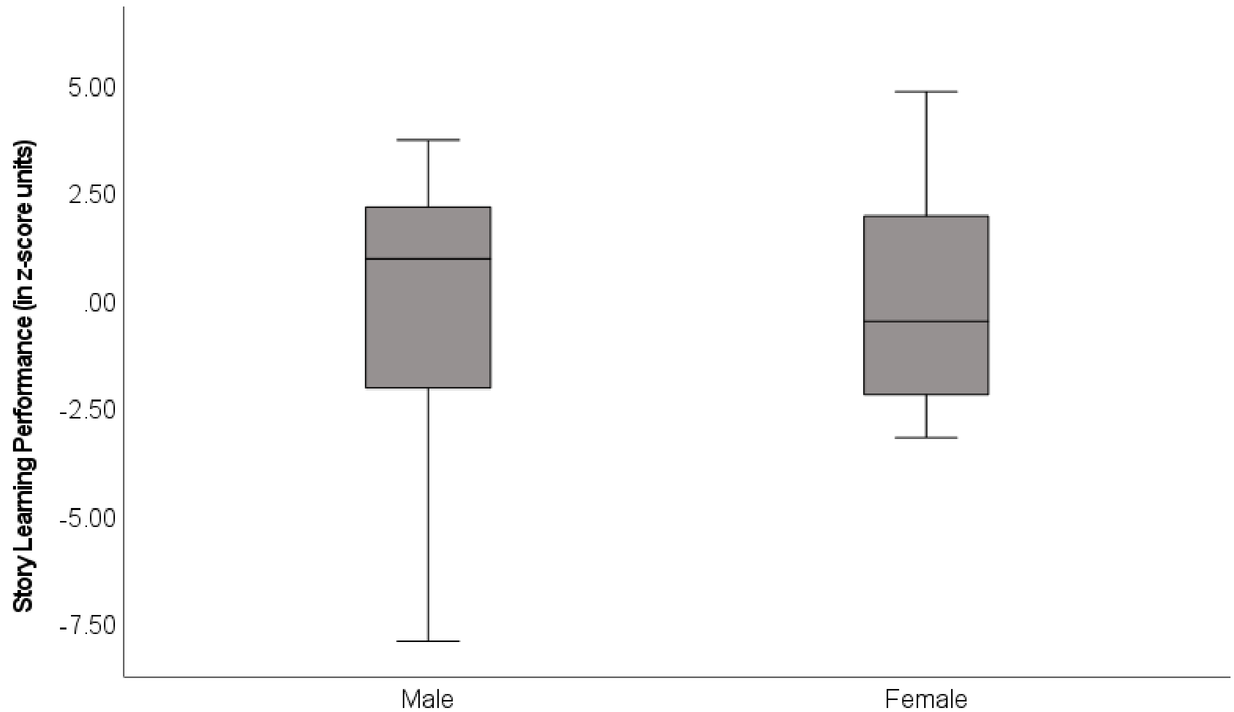
*$p < 0.05$.

Hypothesis 1: Sex Differences in Story Learning

It was hypothesized that boys would learn less than girls from shared reading of a digital story online**.** To explore whether the means for story learning performance were significantly different for boys and girls, I conducted an Independent Samples *t* Test. The *t*-test results showed that on average, boys and girls had similar story learning performance, $t(28) = -0.182$, $p = .85$, $d = -0.06$, 95% CI [-0.79, 0.66]. Based on the results of the analysis, which are further visualized in Figure 8, the evidence does not support my study hypothesis. I therefore conclude that there is no sex difference in story learning performance, measured as an aggregate of retell unique content words, retell quality, story comprehension, and word recognition. Given that there was no sex difference in story learning from shared reading of a digital book online, the data were collapsed across sex in all subsequent analyses.

Figure 8

Boxplots for Children's Story Learning Performance by Sex



Note. Story Learning performance measured as an aggregate of retell unique content words, retell quality, story comprehension, and word recognition. As indicated by the length of the boxes, males and females have reasonably similar interquartile ranges; although the overall range for story learning scores was greater among males, with the whiskers extending to almost the same length as the interquartile range. The male dataset suggests there were potential outlier story learning values, which warranted a closer look at the data set. The removal of the potential outlier did not change the results of a non-significant sex difference.

Hypothesis 2: Executive Function and Story Learning

It was hypothesized that children's story learning performance would be correlated with their executive function skills as measured using performance-based tasks in isolation at pre-test. To explore the relationship between executive function and children's learning from shared reading of a digital book online, a simple linear regression analysis of the study sample was conducted. The predictor used in the model was a composite executive function variable (aggregate of attentional inhibition, response inhibition, and phonological working memory), and the outcome variable was a composite story learning variable (aggregate of retell unique content words, retell quality, story comprehension, and word recognition).

The results of the simple linear regression revealed that 16% of the overall variation in story learning could be explained by executive function and the model was a significant predictor of children's story learning performance, $F(1, 28) = 5.35$, $p = .02$, $R^2 = .16$, R^2 adjusted = .13. The regression co-efficient, presented in Table 10, suggested there was a positive relationship between executive function and story learning, such that an increase in executive function score corresponded to an increase in story learning performance by 1.11 points, on average. In conclusion, the results from the analysis support the study hypothesis, as executive function predicted children's story learning from shared reading of a digital book online.

Table 10

Regression of Association Between Executive Function and Story Learning

Variable	*B*	*SE*	*β*	*t*	*p*	95% CI
Constant	-2.44	0.47		0.00	1.00	[-0.96, 0.96]
Story Learning	1.11	0.48	.40	2.31	.028	[0.12, 2.09]

Note. CI = confidence interval.

Hypothesis 3: Emergent Literacy Skills and Story Learning

It was hypothesized that children's story learning performance would be correlated with their existing emergent literacy skills. To investigate the relationship between children's emergent literacy—oral language and decoding—skills and their story learning from shared reading of a digital book online, a multiple linear regression analysis was carried out. The model comprised story tell quality and letter knowledge as the predictor variables, and story learning as the outcome variable. Story learning being measured as an aggregate of retell unique content words, retell quality, story comprehension, and word recognition.

The results of the multiple linear regression revealed that children's oral language and decoding skills did not predict their story learning performance, $F(2, 27) = 2.20$, $p = .13$, $R^2 = .14$, R^2 adjusted = .07. As summarized in Table 11 and further visualized in Figures 9 and 10, the regression coefficients suggested there was a positive relationship between the emergent literacy variables and story learning performance. On average, a decrease in children's story tell quality score corresponded to a decrease in their story learning performance by 0.33 points. Likewise, the results showed that an increase in children's letter knowledge score corresponded to an increase in their story learning performance by 0.96 points, on average. However, neither story tell nor letter knowledge was a significant predictor in the model ($p > .05$).

In conclusion, the results from the multiple linear regression do not provide support for the study hypothesis, as children's emergent literacy skills did not predict their learning from the online shared reading experience.

Table 11

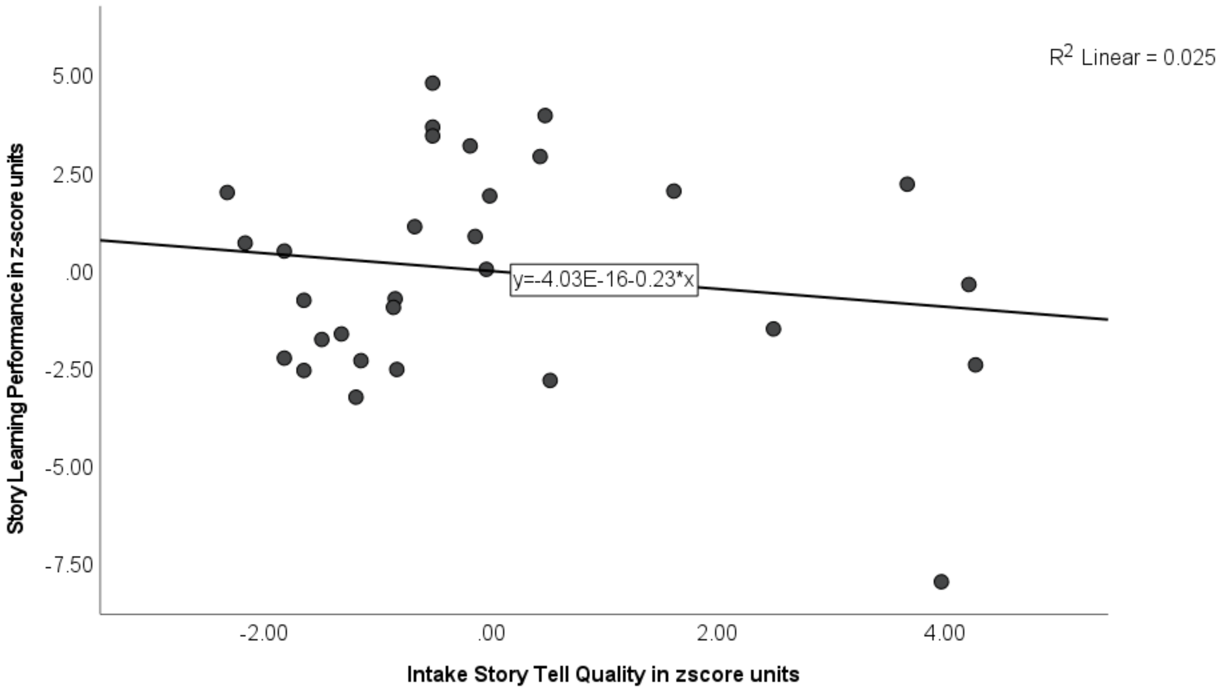
Regression of Association Between Emergent Literacy and Story Learning

Variable	*B*	*SE*	*β*	*t*	*p*	95% CI
Constant	-3.19	0.48		0.00	1.00	[-0.99, 0.99]
Story Tell Quality	-0.33	0.26	-0.23	-1.26	.216	[-0.87, 0.20]
Letter Knowledge	0.96	0.50	0.34	1.90	.067	[-0.07, 2.00]

Note. CI = confidence interval.

Figure 9

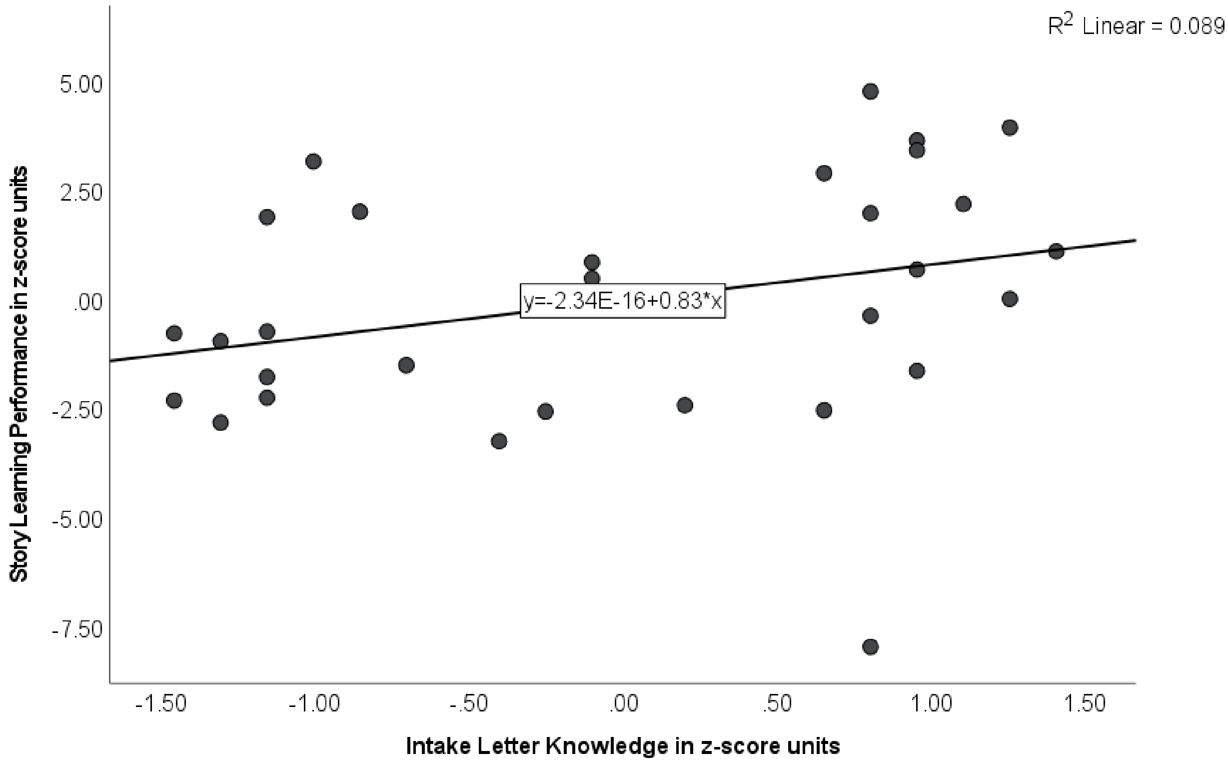
Relationship Between Intake Story Tell Quality and Story Learning Performance



Note. From the data points, we can observe a positive relationship between intake storytelling quality and children's story learning performance. There is also an outlier present in the data. However, the removal of the outlier did not change the relationship between the variables.

Figure 10

Relationship Between Intake Letter Knowledge and Story Learning Performance



Note. From the data points, we can observe a positive relationship between intake letter knowledge and children's story learning performance. There is also an outlier present in the data. However, the removal of the outlier did not change the relationship between the variables.

Hypothesis 4: Joint Effects of Emergent Literacy and Executive Function Skills

It was hypothesized that any sex difference in story learning performance would be explained by children's executive function after first accounting for their emergent literacy skills. As demonstrated previously, the results of the analysis carried out for Hypothesis 1 revealed that there were no significant differences between boys and girls in their story learning performance (*M* -0.11, *SD* 3.31 *: M* 0.07, *SD* 2.44, $p > .05$). Therefore, all subsequent analyses ignored sex as a predictor variable.

To examine the joint effects of emergent literacy and executive function on children's story learning performance, a hierarchical multiple regression analysis using enter method was carried out. The results of the regression indicated that emergent literacy and executive function jointly explained 24.9% of the variance in story learning performance, $F(3, 26) = 2.86$, $p = .05$, $R^2 = .24$, R^2 adjusted =.16. As summarized in Table 12, the regression coefficients suggested there was a positive relationship between the predictor and outcome variables. The individual predictors were further examined and while executive function contributed significantly to the model ($p < .05$), whether entered first or second, emergent literacy skills did not. In conclusion, the results from the hierarchical multiple regression showed that executive function but not emergent literacy skills was the significant predictor of preschool children's story learning from shared reading of a digital book online.

Table 12

Joint Effects of Emergent Literacy and Executive Function on Story Learning

Variable	*B*	95% CI for *B*		*SE B*	*β*	R^2	ΔR^2
		LL	*UL*				
Step 1						.16	**.16***
Constant	-2.44	-0.96	0.96	0.47			
Executive Function	1.11	0.12	2.09	0.48	**0.40***		
Step 2						.24	.08
Constant	-1.92	-0.95	0.95	0.46			
Executive Function	0.93	-0.05	1.92	0.48	0.33		
Intake Story Quality	-0.26	-0.78	0.25	0.25	-0.18		
Letter Knowledge	0.78	-0.22	1.79	0.49	0.28		

Note. Significant correlations in bold. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

*p < .05 (2-tailed).

Summary of Results

Within this thesis study, I examined the roles of sex, executive function, and emergent literacy skills in preschool children's learning from shared reading of a digital book within a remote learning environment. The results from the analyses revealed that there were no differences between preschool boys and girls in story learning performance. Therefore, the findings from this thesis study do not provide any support for existing research evidence of a gap between boys and girls in literacy abilities. Likewise, the findings also showed that emergent literacy skills as measured at pre-test were not correlated with children's story learning outcomes. Whereas sex and emergent literacy skills failed to explain significant variation in children's story learning outcomes, executive function did. The relationship between executive function and story learning was positive, with children's story learning scores increasing as their executive function scores increased, on average. In summary, the results from this online remote study are consistent with hypotheses that suggest variation in children's learning may be associated with their existing executive function skills. More specifically, executive function skills may explain differences in children's learning from shared reading of digital books.

The findings from the present online thesis study, which revealed a significant relationship between executive function and story learning from a digital book, were based on the use of direct measures of executive function. A review of the literature had suggested that direct and indirect measures could provide different perspectives into children's executive function development (Garon et al., 2008; Wallisch et al., 2017). Accordingly, the question of whether indirect measures of executive function would provide any insight into children's behaviour during learning and account for additional variation in story learning was subsequently examined, with the results presented in the next chapter.

Chapter 5: Executive Functioning During Shared Reading of a Digital Book Online

The present chapter further examines the role of executive function in story learning from shared reading of a digital book online. Within the previous chapter, I presented results demonstrating a significant relationship between children's executive function and their story learning performance. This relationship was based on the use of direct measures of executive function that were administered in isolation at pre-test. It is possible that the use of indirect measures might provide a different perspective into children's executive function development relative to the use of direct measures (Garon et al., 2008; Wallisch et al., 2017). Therefore, we may gain additional insight into the relationship between executive function and story learning within this thesis study by also using indirect measures to examine children's executive function.

To explore what additional insight we could gain, this thesis study used measures of observation to describe and examine children's executive functioning during the story learning task, with three hypotheses being proposed. First, it was hypothesized that there would be significant differences between boys and girls in executive functioning during the story learning task. Given research findings that suggest boys have a slower development of executive function skills (e.g., Mileva-Seitz et al., 2015; Ready et al., 2005), I expected that boys would demonstrate poorer executive functioning than girls during the story learning task. Second, it was hypothesized that children's executive functioning during shared reading would influence their story learning outcomes. Third, it was hypothesized that observational measures of executive functioning would explain additional variation in children's story learning outcomes, over and above the task-based measures that were administered at pre-test.

Behavioural Coding Scheme

Subsequent to the completion of my thesis study, I created a behavioural observation coding scheme to describe children's executive functioning while they were participating in the online story learning task. Recall that the online shared reading session was delivered using a predictable "read-talk-play" turn-taking routine, which was defined at the outset of the story learning task. To recap, at the outset of the story learning task, children were told that they would be sharing a story with the researcher. I told children that to share the story we would take turns. First, I would read the story text on the screen (i.e., researcher's turn), then we would talk a little about the story together (i.e., joint turn using a pre-defined script), after which the child would handle the digital book on the screen to find the three hidden sounds (i.e., participant's turn). It was expected that while the researcher was taking their turn to read the story text, children would listen, attend to the story text and pictures, and not handle the book on the screen. It was also expected that children would not verbally interrupt or speak over the researcher while they were reading the story text. In other words, it was expected that the participant would demonstrate their executive function capabilities by following the instructions and allowing the researcher to take their turn. This "read-talk-play" turn-taking routine was repeated for each story page (12 in total) and resulted in a shared reading session that lasted for 20 minutes, on average.

Within the observational coding scheme, I defined four mutually exclusive behaviours to describe the everyday performance of children's ability to (1) follow rules and resist acting impulsively or out of turn and (2) to ignore distractions and stay focused during a learning task, in order to achieve a learning goal—story learning. The display of these behaviours represents response inhibition and attentional inhibition (interference control), respectively; two of the executive function skills that were assessed at pre-test using structured tasks. The four behaviours that were defined in the observational coding scheme are as follows:

1. **Handle**: Describes children's manipulation of the book on the shared screen display while the researcher was reading the story text. Children were coded for two handle events, namely whether they handled or did not handle the digital book—based on their cursor visibly moving across the screen—while the researcher was reading. If the child handled the digital book while the researcher was reading the story text, then this was considered as not attending to the reading task, a negative behaviour.
2. **Verbal**: Describes whether children verbally interrupted or spoke over the researcher while they were reading the story text. Children were coded for two verbal events, namely whether they verbally interrupted the researcher or not while they were reading. If the child verbally interrupted the researcher while they were taking their turn to read the story text, then this was considered as not attending to the reading task, a negative behaviour.
3. **Gaze**: Describes the direction of the child's gaze (i.e., eyes) while the researcher was reading the story text. Children were coded for two gaze events, namely whether they were looking toward or away from the screen (i.e., digital book and reader) while the researcher was reading. If the child's gaze was turned away from the screen during the reading of the story text, then this was considered as not attending to the reading task, a negative behaviour.
4. **Posture**: Describes the orientation of the child's trunk (visible on the camera) relative to the researcher, while they were reading the story text. Children were coded for three posture events, namely whether they were fully facing the screen, turned away from the

screen, or had their backs turned to the screen (i.e., at a 180-degree angle) while the researcher was reading the story. If the child's trunk was angled away from the screen or their back was turned to the screen while the researcher was reading the story text, then this was considered as not attending to the reading task, a negative behaviour.

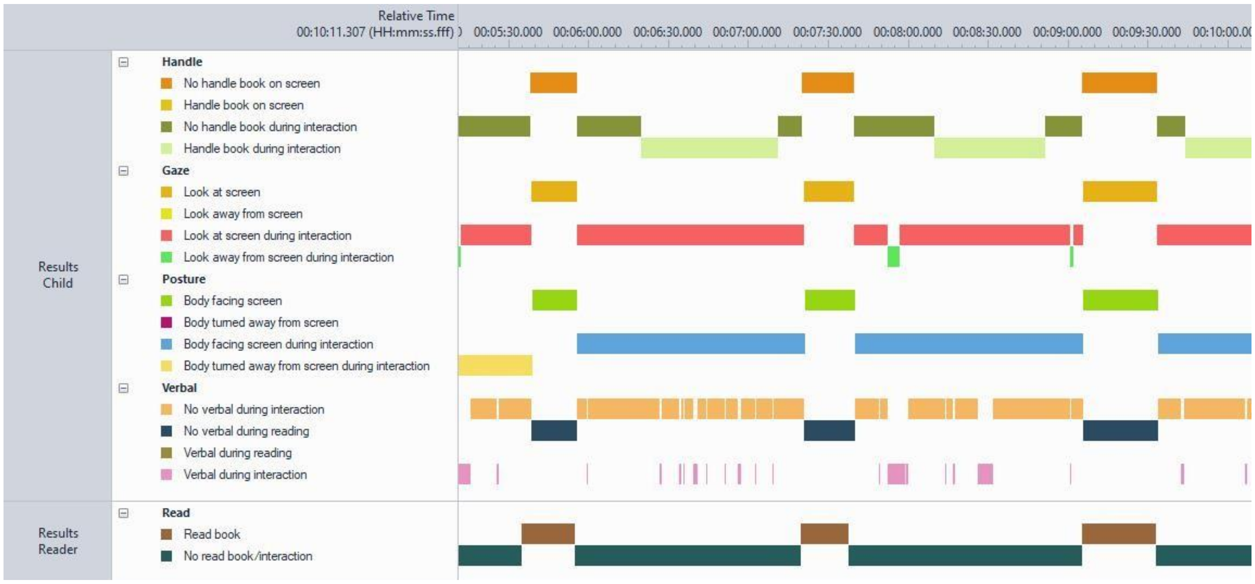
The attending and non-attending behaviours were applied to the video recordings of the online shared reading sessions. Given the "read-talk-play" routine that was carried out for each story page, the entire shared reading observation was coded. More specifically, I coded the read portions where I was taking my turn to read the story text, as well as the no-read portions where we talked about the story and the child took their turn to engage with the digital book and its features on the shared screen display. If the behaviours just described were observed when I was reading the story text, they were coded under "Read Book". Otherwise, if the behaviours were observed when the child and I were interacting or the child was engaging with the digital book on the screen, they were coded under "No Read Book/Interaction". Within this study, each "Read Book" occurrence is considered a read episode event; defined as the start of the reading of the story text to the end of the reading of the story text on the page and the behaviours observed during the reading. In total, there were 12 read episode events.

The attending and non-attending behaviours were sampled continuously during each Read Book and No Read Book/Interaction occurrence. The duration of each Read Book and No Read Book/Interaction segment differed across story page screens and from child to child. For example, there were instances where the reading of the story text lasted for approximately 20 seconds and other instances where it lasted for approximately 45 seconds, based on the amount of story text present on the page. Additionally, there were instances during the No Read

Book/Interaction segments where one child found the 3 secret sounds on the story page in less time than another child. The coding scheme also included an “unable to code” event for each behaviour. For example, “unable to code gaze” was applied when the child may have lowered their head and their eyes were not fully visible in the camera, thereby making it impossible to accurately code the direction of the child’s gaze. In Figure 11, an extract from one participant’s data stream is provided to show the application of the behavioural coding scheme just described during the online shared reading task.

Figure 11

Sample Visualization of Participant's Event Log During Online Shared Reading



Note. Colour-coded data stream extract showing a participant's attending and non-attending behaviours during Read Book (read episode) and No Read Book/Interaction (engagement) events. The behavioural codes—represented in the block, Results Child—are listed in alphabetical order: handle, gaze, posture, and verbal. Based on the data stream extract, this participant was attending to the story learning task during each of the three read episodes depicted. More specifically, when the researcher was reading the story text, this participant was coded as demonstrating positive response inhibition (no handle book on screen and no verbal) and positive attentional inhibition (gaze and posture toward or facing screen).

Children's executive functioning during the story learning task considers only the behaviours that were observed while the researcher was reading the story text, i.e., during the Read Book segments. The occurrence of the behaviours that were sampled during the No Read Book/Interaction segments—where children were expected to and encouraged to handle the book and its features on the screen to find the hidden sounds, and to verbally engage with me in story talk—are not considered within this present study. The No Read Book /Interaction segments are outside the scope of the present study hypotheses, which focus on children's executive functioning—ability to follow instructions, to resist acting impulsively and out of turn, and to ignore distractions and remain focused—during learning to achieve a goal, not engagement.

The video data were coded by two independent research assistants using Observer XT 11.5 (Noldus Information Technology, 2013), a professional behaviour research software for observational data. This software allows video data to be imported and coded in ".mp4" or ".avi" formats. The research assistants were provided with video data files that were saved using the unique 12-digit participant identifier. The two research assistants (i.e., Coder 1 and Coder 2) had limited knowledge of the study rationale and no prior experience with the study participants. Additionally, they were not present during any of the study sessions and did not know the identities of the children. The research assistants only became familiar with children's first names during coding, as I often addressed each child by their first name during shared reading. As the primary researcher, I designed the coding scheme and worked closely with each research assistant, training them individually on the behavioural coding scheme. I also completed one video data coding with each research assistant as practice, providing ample feedback on operational definitions and interpretations to ensure understanding. Following training, each research assistant was given the chance to practice and apply the coding scheme independently on the practice video data. Any discrepancies were subsequently discussed and resolved.

Of the 31 shared reading videos (observations) that were available, 3 were excluded. Of these three, one observation was excluded as the participant (boy) did not complete the fourth session. Hence, there was no post-read data. The other two observations (girls) were excluded due to technical difficulties and resulting poor video recording quality, which made them impossible to code. Therefore, the analyses and results presented within this chapter are based on twenty-eight observations (12 boys, 16 girls), all of whom had corresponding post-read data. Given the small sample size of the present thesis study, I decided to code all the observations twice for reliability purposes, rather than a proportion. The first research assistant (Coder 1) coded the observations from a list of participants in sequential order. The second research assistant (Coder 2) coded the observations from a list of participants organized in random order. The randomised list was prepared by me, the primary researcher using List Randomizer, an online tool (Random.Org, 2022).

Once all the observations had been coded, I subsequently performed an inter-observer reliability of the video data coding using a duration-sequence method of comparison. This method compares the durations across all the attending and non-attending behavioural events that were recorded by Coder 1 and Coder 2 for each observation (shared reading video). It also took into consideration the gap between the behavioural events during coding. I also manually examined data outputs of behavioural events that were recorded by each coder for different read episodes and for different participants. The observer agreement achieved between Coder 1 and Coder 2 was between 0.79 and 0.94 across the 28 observations. The Pearson correlation coefficient was 0.93, an indicator of good agreement between the two coders (Koo & Li, 2016).

Executive Functioning Variables

From the four behaviours measured, 2 executive functioning variables were abstracted: a response inhibition variable and an attentional inhibition variable. Children's response inhibition was measured by their handling and verbal behaviours during each read episode. Children's attentional inhibition was measured by their gaze and posture (trunk orientation) behaviours during each read episode. As described in Table 13, children's executive functioning performance was subsequently scored based on the display of their behaviours during reading.

Regarding response inhibition, children received a score of 1 or 0 for each read episode. More specifically, children received a score of 1 if both "No handle book on screen" and "No verbal" behavioural events were present during the read episode. However, if either a "Handle book on screen" or "Verbal" behavioural event was present, children received a score of 0 for that read episode. The maximum response inhibition score was 12.

Regarding attentional inhibition, children also received a score of 1 or 0 for each read episode. More specifically, children received a score of 1 if both "Look on screen" and "Body facing screen" behavioural events were present during the read episode. However, if either a "Look away from screen" or "Body turned away from screen" or "Back turned to screen" behavioural event was present, children received a score of 0 for that read episode. The maximum attentional inhibition score was 12.

Table 13

Overview of Executive Functioning Variables

Response Inhibition During Read Episode		Attentional Inhibition During Read Episode	
Attending	**Non-Attending**	**Attending**	**Non-Attending**
No handle book on screen **AND** No verbal (no interrupt reader)	Handle book on screen **OR** Verbal (interrupt reader)	Look on screen **AND** Body toward or facing screen	Look away from screen **OR** Body turned away from screen **OR** Back turned to screen

Note. For each read episode, if both attending behaviours were present, then this was considered as positive executive functioning and a score of 1. If any non-attending behaviour was present, then this was considered as negative executive functioning and a score of 0.

Analytic Strategies

To address the hypotheses proposed for the observational data, two sets of analyses were conducted. All statistical tests were two-tailed with a p value of .05. Prior to conducting the analyses, I examined the relationship between the observational measures to determine the efficiency of the executive functioning variables for study analysis. This examination of variables is similar to the one I previously conducted in Chapter 3: Methodology, where I examined the efficiency of the task-based measures of executive function as predictor variables. The results of a bi-variate correlational analysis revealed that the observational measures of response inhibition and attentional inhibition were not significantly correlated ($r = .30$, $p = .11$) and could be retained as separate variables for study analyses. All data are represented in z-score units.

Analytic Strategy 1

In the first set of analyses, I examined sex differences in executive functioning during story learning, with child sex as the predictor variable and the observational measures of response inhibition and attentional inhibition as the outcome variables. To determine the most appropriate statistical test for analyzing the data, I first carried out a Shapiro-Wilk Test of Normality (Livingston, 2004; Rochon et al., 2012). As outlined in Table 14, the results of the Shapiro-Wilk Test suggested that the attentional inhibition data was normally distributed but the response inhibition data was not. Given that the response inhibition data significantly deviated from a normal distribution, I subsequently used a Mann-Whitney U-Test to test if there was a significant difference between boys and girls in executive functioning during story learning.

Table 14

Shapiro-Wilk Test of Normality for Executive Functioning Variables

Variable		Shapiro-Wilk		
		W	df	*p*
Response Inhibition [a]	Boys	.846	12	.033
	Girls	.883	16	.044
Attentional Inhibition [b]	Boys	.949	12	.629
	Girls	.960	16	.663

Note. $N = 28$.

[a] Measured by child’s book handling and verbal interruption behaviours during reading.

[b] Measured by child’s gaze direction and posture (trunk orientation) behaviours during reading.

To determine how to interpret the results of the Mann-Whitney U-Test, histograms of the executive functioning variables were subsequently generated to examine the distribution of the scores for boys and girls. A review of the diagrams revealed that there was much variation in response inhibition and attentional inhibition behaviours within the two groups, however boys and girls did not have a similar distribution of scores for the outcome variables. Therefore, the results for this analysis are interpreted in relation to mean ranks rather than medians.

Analytic Strategy 2

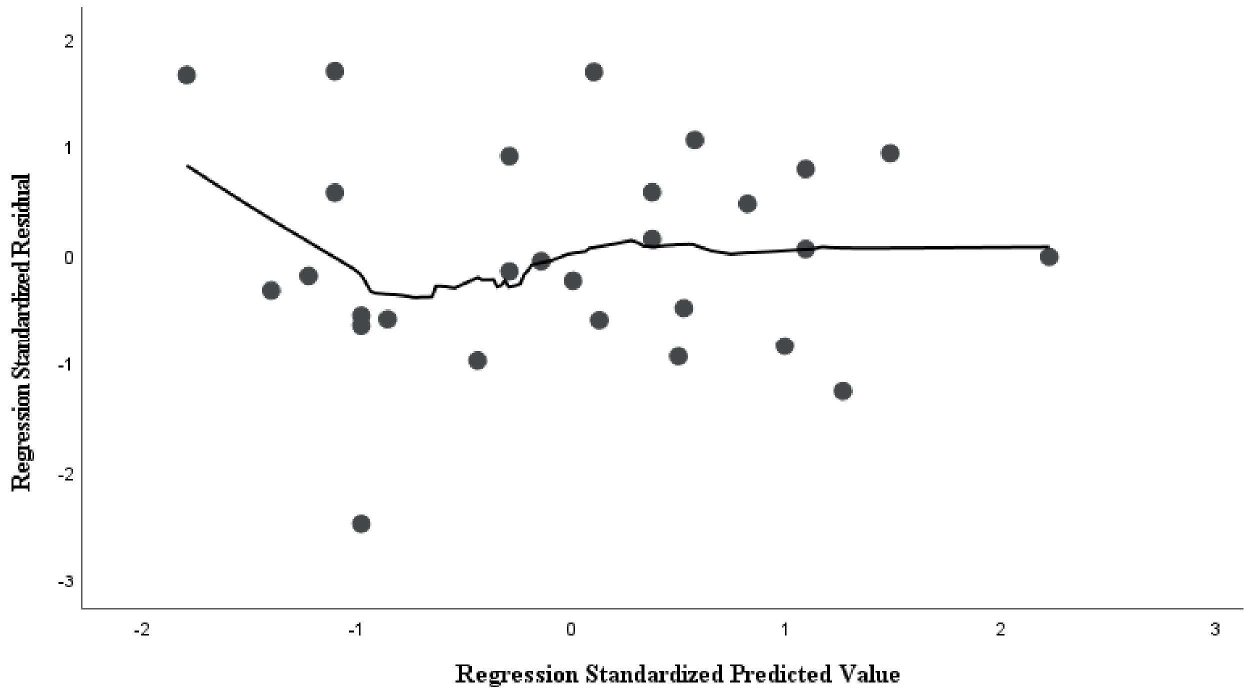
In the second set of analyses, I used regression analyses to examine the contribution of children's executive functioning during shared reading to their learning outcomes. Specifically, I modelled (1) the relationship between children's response and attentional inhibition behaviours during shared reading and their story learning outcomes, and (2) the joint effects of task-based and observational measures of executive function on children's story learning performance.

Tests for Assumptions for Regression Analyses. To align with best practices for conducting regression analyses, I first carried out the relevant tests for assumptions to verify that the observational data met the necessary requirements (Osborne & Waters, 2002; Sevier, 1957; Tabachnick & Fidell, 2013). Specifically, tests for linearity of data, outliers, collinearity of data, independence of errors, and homoscedasticity were carried out, and are hereby summarized.

As presented in Figure 12, the scatterplot of the standardized residuals with the standardized predicted values showed that the data met the assumption of linearity. Similarly, the analysis of standard residuals suggested that the data did not contain any outliers (Std. Residual Min = -2.48, Std. Residual Max = 1.69).

Figure 12

Scatterplot of Standardized Residuals With Standardized Predicted Values

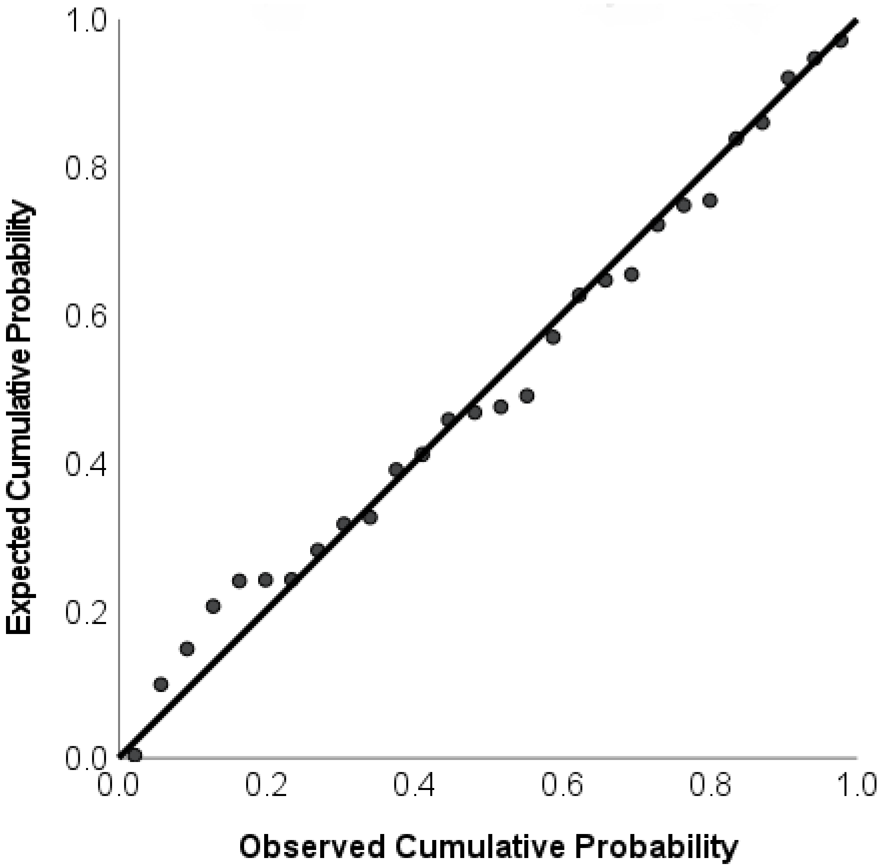


Note. Scatterplot with Loess curve fitted through it. Residuals appear to be randomly scattered around zero, suggesting the relationship between predictor and outcome variables is zero.

The results of the test to see if the observational data met the assumption of collinearity indicated multi-collinearity was not a concern, as the collinearity statistics were all within acceptable limits (Response inhibition: Tolerance =.90, VIF = 1.10; Attentional inhibition: Tolerance =.90, VIF = 1.10). Likewise, the data met the assumption of independence of errors (Durbin-Watson value = 2.11) and the errors were normally distributed, as illustrated by the probability-probability plot in Figure 13.

Figure 13

Normal P-P Plot of Regression Standardized Residual



Note. The observed cumulative probabilities of the residuals are generally close to the diagonal (normal distribution) line, suggesting the distribution of the residuals is close to a normal distribution.

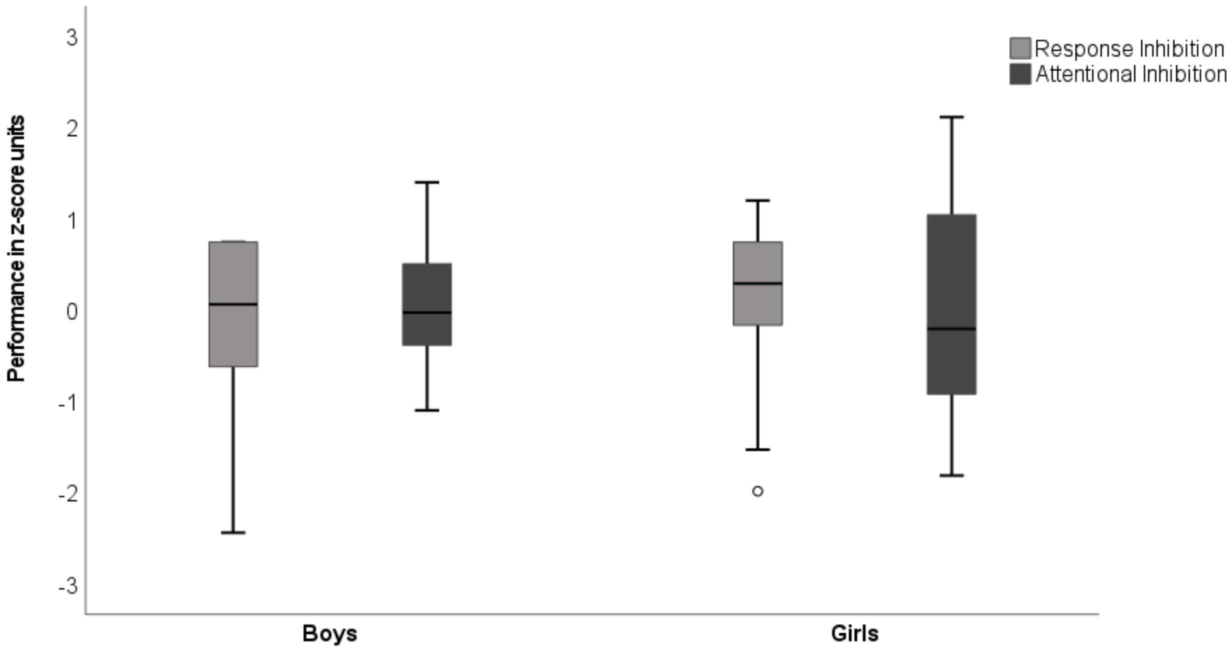
Results

Hypothesis 1: Sex Differences in Executive Functioning During Shared Reading

It was hypothesized that boys would demonstrate poorer executive functioning than girls during the story learning task**.** To compare the differences between boys' and girls' response inhibition and attentional inhibition behaviours while the researcher was reading the story text, a Mann-Whitney U-Test was carried out. In relation to response inhibition, boys had a slightly lower value than girls, with a mean rank of 12.46 for boys compared to 16.03 for girls. However, the results of the Mann-Whitney U-Test showed that this difference in response inhibition behaviour was not statistically significant ($U = 71.50$, $p = .26$, $r = 0.041$). The Mann-Whitney U-Test also revealed that boys and girls demonstrated similar attentional inhibition behaviour during story learning ($U = 94.00$, $p = .94$, $r = 0.003$), with mean ranks of 14.67 and 14.38, respectively. Figure 14 provides a visual summary of boys' and girls' response inhibition and attentional inhibition behaviours during shared reading of a digital book online.

Figure 14

Executive Functioning During Story Learning by Sex



Note. Within the samples of boys and girls, there is an overall spread of response inhibition (left) and attentional inhibition (right) scores, and differences in box lengths. The distribution range of attentional inhibition scores is wider for girls (n = 16) than boys (n = 12). Both samples are also skewed but there are no significant differences between the two groups, as indicated by location of the medians. When the potential outlier that is present in girls' response inhibition performance is considered, the overall range extends to mirror the left skew present among boys.

Hypothesis 2: Executive Functioning During Shared Reading and Story Learning

It was hypothesized that children's response and attentional inhibition behaviours during shared reading would influence their story learning performance. To explore whether children's executive functioning behaviour during shared reading was correlated with their learning outcomes, a multiple regression analysis was conducted. The predictors used in the model included a response inhibition variable and an attentional inhibition variable. The outcome variable was children's story learning performance; the same composite story learning variable previously described in Chapter 3: Methodology (i.e., aggregate of retell unique content words, retell quality, story comprehension, and word recognition).

The results of the multiple linear regression revealed that children's response inhibition and attentional inhibition behaviours during shared reading of a digital book were not correlated with their story learning performance, $F(2, 25) = 1.53$, $p = .23$, $R^2 = .10$, R^2 adjusted = .03. As summarized in Table 15, the regression equation suggested there was a positive relationship between children's response and attentional inhibition behaviours during shared reading and their story learning performance, however this relationship was not found to be significant ($p > .05$). This relationship between executive functioning during online shared reading and story learning performance is further visualized in Figure 15.

Table 15

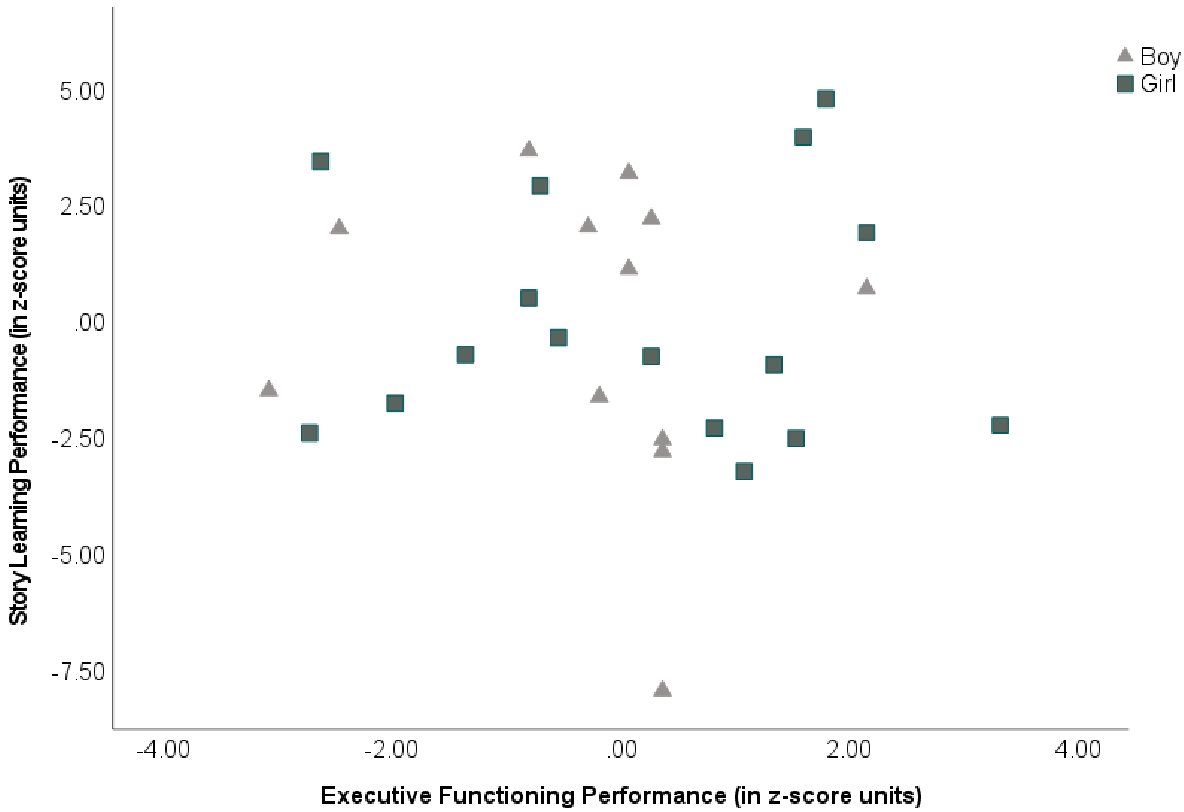
Regression of Association Between Executive Functioning and Story Learning

Variable	*B*	*SE*	*β*	*t*	*p*	95% CI
Step 1						
Constant	-0.03	0.53		-0.06	.951	[-1.13, 1.07]
Response Inhibition	-0.65	0.54	-0.22	-1.19	.242	[-1.78, 0.47]
Step 2						
Constant	-0.03	0.53		-0.06	.951	[-1.12, 1.06]
Response Inhibition	-0.87	0.56	-0.30	-1.53	.137	[-2.04, 0.29]
Attentional Inhibition	0.71	0.56	0.25	1.26	.217	[-0.45, 1.88]

Note. CI = confidence interval.

Figure 15

Association Between Executive Functioning and Story Learning Performance



Note. The scatterplot is defined by child biological sex, with triangles representing boys and squares representing girls. From the data points, we can observe much variation in executive functioning performance and a positive relationship between children's behaviours during shared reading and their story learning outcomes. We can also observe an outlier (Cook's Distance 0.293), a boy whose data point demonstrated a unique relationship and which warranted further investigation. The removal of the outlier did not change the relationship between the variables.

Hypothesis 3: Task-Based Versus Observational Measures of Executive Function

It was hypothesized that observational measures of executive functioning would account for additional variation in children's story learning performance, over and above the variation explained by task-based measures of executive function administered in isolation at pre-test. A two-stage hierarchical multiple regression using enter method was conducted, with story learning as the outcome variable. The composite task-based executive function variable (aggregate of attentional inhibition, response inhibition, and phonological working memory) was entered in stage one of the model, to control for executive function as measured at pre-test. The two observational measures of executive functioning (response inhibition and attentional inhibition) were entered in stage two of the model.

The results of the hierarchical multiple regression revealed that the task-based and observational measures of executive function jointly explained 20.8% of the variation in children's story learning performance. The task-based measures of executive function accounted for 16% of the variation in children's story learning performance, $F(1, 26) = 4.94$, $p = .03$, $R^2 = .16$, R^2 adjusted = .12. When the observational measures of executive functioning were introduced into the model, they accounted for an additional 4.8% of the variation in children's story learning. However, the observational measures of executive function did not contribute to a significant increase in the proportion of variance explained, $\mathrm{F}(3, 24) = 2.09$, $p = .12$, $\mathrm{R}^2 = .20$, R^2 adjusted = .10. As summarized in Table 16, the relationship between executive function and story learning performance was positive, regardless of the type of executive functioning measure (task-based or observation). However, only the task-based measures of executive function contributed significantly to the model and explained variation in children's story learning outcomes ($p < .05$).

Table 16

Joint Effects of Task-Based and Observational Measures of Executive Function

Variable	*B*	95% CI for *B*		*SE B*	*β*	R^2	ΔR^2
		LL	*UL*				
Step 1						.16	**.16***
Constant	0.00	-1.04	1.04	0.50			
Task-based Executive Function	1.11	0.08	2.14	0.50	0.40*		
Step 2						.20	.04
Constant	-0.00	-1.06	1.05	0.51			
Task-based Executive Function	0.94	-0.18	2.06	0.54	0.33		
Observational Response Inhibition	-0.49	-1.70	0.72	0.58	-0.17		
Observational Attentional Inhibition	0.60	-0.53	1.74	0.55	0.21		

Note. Significant associations in bold. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

*$p < .05$ (2-tailed).

Summary of Results

Within this thesis study, I also examined the everyday performance of children's executive function. More specifically, I designed a behavioural coding scheme to describe children's response inhibition and attentional inhibition behaviours and examined the display of these behaviours while I was taking my turn to read the story text. The results of the analyses examining children's response inhibition and attentional inhibition behaviours during story reading revealed that there was much variation in executive functioning performance within the two samples of boys and girls. However, boys and girls behaved similarly in their ability to resist handling the book on the screen and to refrain from verbally interrupting (speaking over) the researcher while they were taking their turn to read the story text. Boys and girls also demonstrated similar performance in their ability to control distractions and focus their attention during shared reading in a remote learning environment. Although the amount of variation in story learning increased when the observational measures of executive function were considered, the findings showed that it was the task-based measures of executive function that were the predictors of importance.

Chapter 6: Discussion

Within the current thesis study, I examined the contributions of sex, emergent literacy skills, and executive function to preschoolers' learning from shared reading of a digital book online, an emerging area of research. The motivation for this study stemmed from ongoing reports of a small but persistent sex difference in literacy performance, in favour of girls—even during the preschool years when foundational literacy skills are rapidly developing. In my case, I was particularly interested in children's learning to read in a digital context, because we can imagine that this type of learning environment would be more complex and would require a higher level of cognitive demand (Bus et al., 2015; Courage, 2019; Furenes et al., 2021). It is possible that children with poorer executive function—cognitive processing skills would be especially challenged in these contexts.

This online thesis study and its findings contribute to three distinct bodies of literature, namely sex differences in literacy, shared reading with digital books, and measures of executive function development. The findings revealed that sex did not explain preschool children's learning from shared reading of a digital book online. Additionally, the results showed that children's existing emergent literacy skills were not correlated with their learning from the online shared reading experience. Instead, it was executive function that explained a certain variance in boys' and girls' learning from shared reading of a digital book online. Interestingly, there was an increase in the amount of variance accounted for by executive function when both task-based and observational measures of executive function were jointly considered. Moreover, there were differences in the distribution of children's executive function scores based on the type of measure. These changes confirm that there is added insight to be gained from using different situations to measure children's executive function, especially in learning contexts. I will discuss these findings within the context of the existing literature along with their implications, before making recommendations for future research.

Sex and Story Learning From Shared Reading of a Digital Book Online

Based on prior research evidence showing boys have weaker emergent literacy skills than girls (e.g., Brandlistuen et al., 2021; Deasley et al., 2018; Gardner-Neblett & Sideris, 2018; Sigmundsson et al., 2017), I expected that boys would demonstrate poorer story learning outcomes than girls from the online shared reading experience. The results showed that there was much variation in story learning outcomes within both groups, the highest performing child was a girl, and the lowest performing child was a boy. However, contrary to my expectations, boys and girls had similar story learning performance. Further exploration of children's story learning performance in relation to the sex variable revealed that sex accounted for less than 1% of the variation in learning outcomes from online shared reading. This amount is in line with documented research, such as the large-scale twin study by Galsworthy et al. (2000). The results showed that there were differences between boys and girls in early cognitive abilities, however sex (gender) only accounted for 1% to 3% of the variance in learning outcomes.

The literacy skills examined within the present thesis study are similar to those examined within other studies that have found preschool boys have poorer foundational literacy skills than girls, in areas such as oral narrative (e.g., Gardner-Neblett & Sideris, 2018) and early word reading (e.g., Law et al., 2013). However, my results are not consistent with these existing research findings. Based on the findings from the present thesis study, there are two possible conclusions. The first is that sex does not play a role in preschool children's learning from digital reading contexts, unlike prior studies of school-aged children where sex had a direct and indirect effect on children's literacy outcomes from digital reading contexts (e.g., Huang et al., 2013;

Kanniainen et al., 2019). Studies examining sex differences in children's learning from digital contexts have mostly been carried out with school-aged children. Therefore, the present results contribute to the findings for the preschool population, among whom the use of digital technologies is increasingly being used for diverse activities, such as literacy learning (Kılıç et al., 2018; Rideout, 2017). Alternatively, it is possible that sex may play a role in preschool children's learning from digital reading contexts, however several factors not adequately captured by the present thesis study may explain why a sex difference was not found.

Within the reading literature, when no difference has been found between preschool boys and girls, it is possible that differences in aspects of methodology, such as sample selection and the literacy skill measured may have contributed to the disparate findings across studies. Within the present thesis study, one possible explanation for the lack of a sex difference in story learning outcomes is the homogeneity of the sample, specifically in relation to the socio-economic status of the participants. Based on parental reporting, the 30 preschoolers who completed this thesis study were ethnically diverse. However, they were mostly from high socio-economic backgrounds, as measured by the occupation and education levels of their parents. It is possible that if my study sample were more socio-economically diverse and thus more representative of the population of children who are getting ready for conventional literacy learning, significant differences could have been detected between boys and girls in their story learning performance. This thesis study was a remote study that was conducted online during the height of the coronavirus pandemic. Therefore, it required that participants had reliable access to the internet as well as their own computer with a working camera. It is possible that these requirements inadvertently biased the types of households who could participate in my study.

There have been consistent findings from studies carried out with large diverse samples of children to suggest that socio-economic status (SES) is correlated with children's foundational literacy skills. The findings also suggest that the effect of SES on beginning reading skills may be moderated by sex. For example, the findings from a large-scale study by Lee and Al Otaiba (2015) revealed that both boys and girls from high poverty households—children eligible for free or reduced-price lunch—had significantly poorer literacy skills than girls from low poverty households. Importantly, the results from this study revealed a crucial difference between the boys and girls who were eligible for free or reduced-price lunch, as the boys within this group showed significantly poorer foundational literacy skills than the girls.

The findings to support the hypothesis that sex has a moderating effect on the relationship between socio-economic status and foundational literacy skills have been consistent within the literature. For example, Entwisle et al. (2007) and Barbu et al. (2015) also found that boys from lower socio-economic backgrounds—defined based on being a meal subsidy recipient or parental occupation level—were more disadvantaged in their emergent reading skills than girls from comparable backgrounds. Similar to Lee and Al Otaiba (2015), both researchers also found that among children who were not from high poverty households, boys and girls had similar oral language and decoding skills. The findings from the present online thesis study revealed that there were no significant differences between boys and girls in their socio-economic status—which was mostly high based on parental education and occupation levels—and there were no differences between boys and girls in story learning from online shared reading. Therefore, these results contribute to existing research evidence by demonstrating that preschool boys who are not disadvantaged socio-economically perform just about the same as girls in literacy, even when the learning context is more complex.

Another possible explanation for the lack of a significant difference between boys and girls in story learning performance is the sample size. There are strengths as well as limitations related to studies with smaller sample sizes (Hackshaw, 2008). For example, smaller studies can be conducted within a shorter timeframe than larger studies. However, it may not be possible to always observe a true effect or an absolute difference between two groups within a smaller study. Compared to smaller studies, larger studies tend to produce more narrow confidence intervals, and hence more precise results. This limitation is especially relevant if the magnitude of the difference that has normally been observed between two groups has generally been small.

Within the literature, where a gap in literacy performance has been observed among younger children, the effect size has generally been small. For example, the findings from meta-analyses conducted by Hyde and Linn (1988) and Lynn and Mikk (2009) suggest that the weighted effect size of the sex difference is generally between $d = 0.11$ and $d = 0.23$ in younger children. Additionally, as illustrated by the studies that I reviewed in Chapter 1: Introduction (e.g., Bornstein et al., 2004; Brandlistuen et al., 2021; Lange et al., 2016), these small effect sizes have generally been from studies carried out with large groups of children. My online thesis study consisted of only 30 children, of whom 18 were girls. The results achieved from the present thesis study indicated that the p level was high ($p = .85$), the effect size was negligible ($d = -0.06$), and the confidence intervals were wide [-0.79, 0.66]. It is highly possible that the sample size was not adequate and thus the study data lacked sufficient power to detect significant differences between boys and girls in story learning from online shared reading of a digital book.

Researchers do not generally agree on whether post hoc power calculations are useful, as these calculations are generally reliant on the significance level and could possibly be misleading (Althouse, 2021). To illustrate, using the results I achieved from the present thesis study and keeping the significance level fixed at $\alpha = .05$, I obtained a post hoc power of .053. Nevertheless, it is possible that with at least 70 children (sample size in Gardner-Neblett & Sideris, 2018), the statistical power could have increased, thereby being more sufficient to detect a small but significant difference between boys and girls in story learning performance. Although an increase in sample size is not a guarantee of meaningful differences, when I increased my sample size to 72 (38 girls, 34 boys) and set the parameters to reflect the means and standard deviations reported by Gardner-Neblett and Sideris (2018)—where 4-year-old boys demonstrated lower narrative skills than girls—the post-hoc power was .588. Thereby, possibly lending credence to the consideration that sample size may have been a limitation within my thesis study.

Within the literature, research studies have not always been consistent regarding the findings of a sex difference in literacy performance across mandatory schooling and particularly during the preschool years—where fewer studies have been conducted. The results from the present thesis study, which examined preschool children's learning online, add to the inconsistency in findings for the preschool population. Despite the lack of a significant sex difference in story learning from online shared reading—possibly due to a homogenous and small sample—understanding why some boys demonstrate weaker literacy skills relative to girls on diverse measures of literacy remains relevant. Particularly, if the gaps are being observed during the foundational years (McLeod et al., 2019).

It is possible that the sex gap in literacy outcomes is more nuanced than we think, particularly during the emergent literacy stage of development. It is possible that a multitude of factors not adequately captured by the sample size and the socio-demographic of the participants within the present study underpin boys' performance in literacy. Therefore, ongoing investigation in boys' performance in literacy is warranted. Given that the boys and girls within this thesis study, who have not yet experienced conventional literacy learning had similar story learning outcomes, it remains a matter of question whether the similarity in literacy performance within this cohort remains stable across mandatory schooling.

Emergent Literacy Skills and Story Learning From Online Shared Reading

The findings from the present thesis study showed that sex did not explain preschool children’s learning from the online shared reading experience, and neither did their existing emergent literacy skills. This finding does not support the existing research evidence showing an association between oral language skills and learning from a digital reading context. Such as Strouse and Ganea (2016), who found that preschool children’s vocabulary skills were correlated with their answers to a predatory-prey situation following shared reading of a digital book. More specifically, their results showed that within a researcher-read condition, children with higher receptive vocabulary skills used better camouflage reasoning to explain their answers than children with lower vocabulary skills.

The results from the present thesis study were also surprising in light of the vast evidence from the existing literature showing the strong correlation between children’s oral language and decoding skills (e.g., Hipfner-Boucher et al., 2014; Ralli et al., 2021; Storch & Whitehurst, 2002). The large-scale longitudinal study carried out by Storch and Whitehurst (2002) is a well-cited study that demonstrates the robust relationship between children’s emergent literacy skills during the preschool period. For example, their findings showed that preschool children’s oral language skills accounted for approximately 48% of the variance in their decoding skills. One potential reason for my non-significant finding may be in relation to methodology, specifically the design and measures used within the present thesis study.

Within my thesis study, I measured children's existing emergent literacy skills at pre-test using storytelling and letter-knowledge tasks. Following the shared reading experience, I measured children's learning from the storybook using oral language (story retell, story comprehension) and code-related (word recognition) tasks. The emergent literacy—oral language and decoding—predictor variables were kept separate. However, based on the high correlations between the post-read oral language and decoding measures, I subsequently aggregated them to form one composite story learning variable, as this was considered more efficient for study analyses. It is possible that a significant relationship may exist between children's emergent literacy skills and their learning from shared reading of digital books, as demonstrated by previous research (Strouse & Ganea, 2016). However, this relationship may only be present when learning outcomes are based on single measures of oral language and decoding skills and not a composite variable, as was the case in the present thesis study. It is possible that by aggregating the highly correlated oral language and decoding outcome measures rather than keeping them separate, I failed to isolate the possible effects of emergent literacy skills on children's story learning performance.

The type of measure used within the present thesis study may also have contributed to the non-significant finding. A large portion of the studies examining the association between emergent literacy skills and diverse literacy outcomes have done so in relation to oral language measures of vocabulary and decoding measures, such as phonological awareness tasks (e.g., Hipfner-Boucher et al., 2014; Ralli et al., 2021; Storch & Whitehurst, 2002). A smaller body of studies have examined this association using language comprehension type measures similar to those used within the present thesis study. Nonetheless, the finding from the present thesis study is not congruent with these other studies that have used story retelling or similar complex language measures.

To illustrate, Lynch et al. (2008) examined the relationship between 4-year-old children's story comprehension (using recall and comprehension tasks) and their decoding abilities. They found a small but significant association between preschooler's responses to story comprehension questions and their decoding skills, using a measure of initial sound recognition. Likewise, Hipfner-Boucher et al. (2014) examined the relationship between emergent literacy skills within a sample of 4- to 6-year-olds using narrative story structure and found a significant relationship between children's oral language and phonological awareness skills—blending and elision. More recently, in a large scale developmental study that used structural equation modelling to examine children's ability to retell a story, Ralli et al. (2021) found that there was a significant relationship between oral language and story retelling skills in both preschool and kindergarten children.

Differences in study design may account for the disparate findings between my thesis study and this limited body of research. Closer reading of the three studies just mentioned showed that all of the data were collected at a single point in time, rather than within the context of a pre-post study design with a shared reading experience, as in the case of the present thesis study. As previously mentioned, I also found significant correlations between the single measures of story retell, story comprehension, and word recognition that were collected concurrently at post-test, hence my rationale for aggregating them into one composite story learning variable. However, the concurrent associations between the oral language and decoding measures that were administered at post-test to evaluate story learning performance was not the scope of the present thesis study. Researchers who have used a pre-post study design to examine children's emergent literacy skills using oral narrative tasks include Piasta et al. (2018). However, their finding of a predictive relationship between preschool children's oral narrative and early literacy skills was based on single measures of decoding skills administered when children were 6 years old; two years after their narrative skills had been assessed.

It is possible that a significant relationship may exist between children's emergent literacy skills and their learning from digital reading contexts. However, this relationship may only be evident when learning outcomes are based on single measures of oral language and decoding skills, and not a composite measure of learning, as was the case in the present thesis study. The use of a composite variable to assess preschool children's learning, particularly when outcome measures are highly correlated, should be explored in other studies. Alternatively, it is possible that within digital reading contexts, emergent literacy skills may contribute less to learning outcomes, particularly when children do not have socio-demographic risk factors.

The Role of Executive Function in Children's Learning From Digital Books

The results from the present online thesis study suggest that among boys and girls of similar socio-demographic characteristics, variation in story learning performance was explained by differences in executive function. Currently, the way in which executive function skills contribute to children's learning is a hot topic. Children's executive function skills develop rapidly and concurrently with their emergent literacy skills during the preschool years (Diamond, 2013a; Neuman & Dickinson, 2001) and researchers generally agree that executive function skills are important to children's readiness for school (Blair & Razza, 2007; Diamond, 2016). As such, there has been growing research examining the contribution of executive function skills to children's school readiness, in areas such as literacy and mathematics (e.g., Allan et al., 2014;

Escolano-Pérez et al., 2017; Howard & Vasseleu, 2020; O'Toole & Kannass, 2018; Traverso et al., 2022; Vitiello & Greenfield, 2017).

The use of digital media to share stories with children who are getting ready for conventional literacy learning has been increasing (meta-analysis by Furenes et al., 2021). And there have been some concerns that children’s learning from digital reading contexts may be poorer than traditional story reading contexts, due to the need for increased cognitive processing (Bus et al., 2015). However, studies examining the unique contribution of cognitive processing skills—executive function—to preschool children’s learning from digital reading contexts are limited. The limited body of evidence include Strouse and Ganea (2016) and Richter and Courage (2017), who examined the role of executive function in preschool children’s conceptual learning and recall of story information from digital and paper books, respectively. As such, the finding from the present thesis study demonstrating an association between executive function and children’s learning from an online shared reading experience is a distinct contribution to an emerging body of research.

The results from the present online thesis study are congruent with the findings from both Strouse and Ganea (2016) and Richter and Courage (2017), who found that executive function was correlated with preschool children’s learning from a digital reading context, carried out in person. Additionally, the finding from the present study supports the broader literature examining the contribution of executive function to children’s readiness for conventional literacy learning (e.g., Chung & McBride-Chang, 2011; Gandolfi et al., 2021; Jabłłoński, 2013; Shaul & Schwartz, 2014; Traverso et al., 2022). In addition to supporting the existing literature, the present thesis study also makes two distinct contributions. The first being the use of a complex language event to examine the relationship between executive function and literacy, and the second being the use of both direct and indirect measures to examine children's executive function development.

Executive function (Diamond, 2016) and oral narratives (Schick & Melzi, 2010) are both considered to be constructs of high importance during the pre-reading years. Yet, studies examining the relationship between executive function and children's learning using meaning-related measures, such as story retelling are rare in typically developing preschool populations. One exception is a longitudinal in-person study of 42 preschoolers carried out by Friend and Bates (2014), where the relationship was examined using a (wordless picture) storytelling task. In the digital book reading study by Richter and Courage (2017), the relationship was measured using strict-criterion comprehension questions.

The production or retelling of a story is a complex language event that requires the integration of diverse skills, such as the ability to sequence and organize events coherently (Schick & Melzi, 2010). Factor analyses carried out by Cannizzaro and Coelho (2013) showed that both executive function and story structure demonstrated constructs of output-fluidity and organizational-efficiency in neuro-typical adult populations. It is possible that executive function and oral narrative skills are distinct yet complimentary constructs (Friend & Bates, 2014) that engage similar processes. Namely, the ability to focus, to organize, and to keep relevant information in mind to complete a task. This hypothesis of executive function and oral narrative skills tapping into similar cognitive processes may explain the significant relationship found between executive function and story learning performance within the present thesis study. The results showed that children's scores on the direct measures of executive function were high, on average. Additionally, children's story retells were generally sequenced and included the relevant story grammar elements (e.g., characters, initiating event, and ending); notwithstanding differences in the length of the stories retold. It is possible that boys' and girls' ability to retell a complete, coherent, and well-structured story after sharing a digital story online once was supported by their ability to control their impulses (i.e., not handle the digital book out of turn); to resist distractions (i.e., features in the digital book and within their remote learning environment); and to recall pertinent information (i.e., story words, story grammar units), despite distractions. This relationship between executive function and oral narratives should be further examined within the preschool population, especially in digital book reading contexts.

In addition to using oral narratives to examine children's learning from the online shared reading experience, the present thesis study was also distinct in the use of different situations to examine children's executive function. Within the existing literature, preschool children's executive function skills are often assessed using either direct measures in isolation or indirect measures, such as informant reporting by a parent or teacher (Anderson & Reidy, 2012; Carlson, 2005; Diamond, 2016). It is a widely held belief that direct and indirect approaches may provide differential insight into children's executive function development (Wallisch et al., 2017). However, it is exceedingly rare for both direct and indirect measures to be incorporated within research studies that are carried out with preschool children. In those instances, performance-based tasks were paired with behavioural questionnaires and rating scales to subjectively report on children's abilities (e.g., Ruffini et al., 2021).

The use of objective measures to examine the critical processes that are associated with children's executive function in an everyday context is less common. Even less common is the use of objective measures that do not rely on factors such as child's response time or time to complete a given task (e.g., Yamamoto & Imai-Matsumura, 2019). With the exception of an in-person longitudinal study by Escolano-Pérez et al. (2017), the present thesis study is one of the few studies to examine preschool children's executive functioning using objective measures that do not rely on factors related to speed. It is also one of the few studies to examine children's executive functioning during a literacy learning activity. The results showed that there was a generally positive trend between children's response inhibition and attentional inhibition behaviours during online shared reading and their story learning performance. And the measures of observation accounted for additional variance in story learning, above and beyond the performance-based measures. However, in contrast to Escolano-Pérez et al. (2017), who found a significant relationship between children's executive functioning during structured play and their literacy levels, the present thesis study did not.

Although Escolano-Pérez et al. (2017) used measures of observation to examine preschool children's executive functioning, literacy outcomes were only measured in the first year of compulsory schooling and not during preschool. Additionally, children's executive functioning was observed within the context of structured play, not literacy learning. Play, including symbolic and physical play, has been observed to contribute to both children's executive function development and literacy development (Diamond, 2013b). It remains a matter of question what was the role of play in the significant relationship between executive functioning and literacy outcomes in first grade that Escolano-Pérez et al. (2017) found. Future work examining the everyday performance of executive function abilities in preschool children would need to consider both the measure and the context.

Notwithstanding a non-significant relationship between children's executive functioning during story learning and their learning outcomes, there were interesting takeaways from the use of indirect measures. Interestingly, there were differences in the overall distribution of executive function performance scores during story learning relative to the performance scores from the task-based measures used at pre-test. Most children were at or near ceiling for the direct measures that were administered in isolation at pre-test. However, the distribution of scores was broader for the observational measures. There were notable differences in some children's response inhibition and attentional inhibition behaviours during story learning. It possible that most children benefited from the guided and iterative nature of the brief measures that were administered at pre-test, in isolation of a learning context. However, when they were within a learning context, some children may have found it more challenging to independently manage their executive function abilities over a longer period of time to attend to the learning task.

Another interesting takeaway from using different approaches to examine children's executive functioning is in relation to sex differences. There is some evidence to suggest that boys not only have poorer literacy skills (not supported by the results from the present thesis study), but they also have poorer attentional inhibition and response inhibition skills than girls. However, the research evidence to support sex differences in executive functioning has largely been based on subjective measures of reporting by parent or teacher (e.g., Ready et al., 2005) or from children's performance on structured tasks independent of a learning context (Mileva-Seitz et al., 2015). Research studies using measures of observation to assess preschool children executive function skills are emerging and only a handful have examined sex differences in executive functioning while carrying out a task. The limited body of evidence includes Escolano-Pérez et al. (2017), who examined Spanish-speaking boys' and girls' executive functioning during play, and Yamamoto and Imai-Matsumura (2019), who examined Japanese boys' and girls' clean-up time in response to their teacher's instructions. Therefore, the present thesis findings represent a significant contribution to the limited body of research examining sex differences in executive function development using objective measures, more so within a literacy learning context.

As demonstrated by the present thesis study, there was much variation in response inhibition and attentional inhibition behaviours within the sample, but there were no significant differences between boys and girls. These findings are congruent with Escolano-Pérez et al. (2017) and Yamamoto and Imai-Matsumura (2019), who examined sex differences using game play and clean-up time, respectively. Collectively, the findings from these two studies and the present online thesis study suggest that poorer executive function development among preschool boys relative to preschool girls may be the result of the construct that is used to measure children's abilities.

Alternatively, other reasons may explain why the boys and girls within the present thesis study did not differ in executive functioning during online shared reading. There are many complex child and environmental factors that influence executive function development in preschool children (Ackerman & Friedman-Krauss, 2017; Diamond, 2016). Whereas some factors such as play are considered positive contributors, others are negative and thus more detrimental to children's foundational growth. These negative influencers may include low birth weight and socio-demographic risk factors, such as poverty (Ackerman & Friedman-Krauss, 2017; Diamond, 2016); the effects of which may present differently in boys and girls. Within the present thesis study, the participating boys and girls were from diverse cultural and ethnic backgrounds. However, they were mostly typically developing with normal birth weight, on average, and presented with no socio-demographic risk factors such as poverty—as suggested by their high socio-economic status, on average. They also came from well-educated households and presented with typical language development. These positive contributors and so-called protective factors across boys and girls within the present thesis study may explain the lack of a sex difference in executive functioning during online shared reading. To understand the effects of these factors on boys' and girls' executive functioning during literacy learning contexts and their subsequent outcomes, future research should consider a more diverse sample, specifically in relation to socio-economic status, birth weight, and language development.

Clinical and Pedagogical Implications

The findings from the present thesis study suggest that executive function may play a significant role in preschool children's learning from digital contexts, independent of sex. The use of digital tools among young children has long been increasing, with tools being used for a variety of purposes, such as literacy learning (Kılıç et al., 2018; Rideout, 2017). Additionally, there has been an uptake in the use of telepractice to deliver speech-language pathology interventions virtually, as a result of the coronavirus pandemic (Macoir et al., 2021). Therefore, understanding what factors may prevent children from benefitting from these contexts has both clinical and pedagogical implications, particularly in relation to literacy learning using digital books and the delivery of reading interventions in a virtual context.

If, therefore, some boys and girls are reporting lower outcomes when learning or interventions take place in a digital context, it is important for clinicians and educators to consider whether poorer executive function may be playing a role. This could be done by incorporating easy to administer measures within clinical assessments and literacy interventions. The present findings revealed that children's performance on task-based measures in isolation and their ability to demonstrate their abilities during a literacy learning activity accounted for separate amounts of variance in learning outcomes. Therefore, as suggested within the literature (Garon et al., 2008; Wallisch et al., 2017), and as demonstrated by the present thesis findings, clinicians should consider the use of both performance-based tasks and objective measures of observation to obtain a more global overview of children's executive function development.

Regarding direct measures, clinicians could use standard executive function measures that are brief, engaging, cost-effective, and easy to administer, even within an online context. Such as, the digital versions of the Day-Night, Bear-Lion, and Syllable Repetition Task that were used to measure children's core executive function skills within the present thesis study. These three measures, which have long been used in traditional paper-based environments were set up for digital use, with the total administration time between 10 to 15 minutes per child, on average. Within the present thesis study, the tasks were set up for online display using open-source software that required some technical knowledge. However, it is possible to use alternative digital tools that require less technical knowledge, such as Microsoft PowerPoint slides, as outlined in Strouse and Ganea (2016).

Regarding indirect measures, it is common for subjective measures to be used to examine children's executive functioning over a period of time. Such as, parental or teacher reporting of the child's behaviour using a questionnaire or behavioural rating scales (Ruffini et al., 2021). As demonstrated within the present thesis study, it is also possible to examine children's executive functioning using measures that do not rely on informant reporting or even response time to gain a more objective understanding of children's everyday abilities over a longer period. As shown by Escolano-Pérez et al. (2017), children's abilities could be observed in a game-like setting. Alternatively, as revealed within the current thesis study, children's behaviour could be measured objectively while they are performing an everyday learning task, such as shared reading of a digital book, using a behavioural coding scheme or checklist.

It is important to understand not only what factors may contribute to children's learning from digital contexts, but also how to support their learning within these environments. Therefore, an understanding of effective strategies to support children's executive functioning during digital learning contexts would also be beneficial to clinicians and educators. Parents too can benefit from learning how to better support children's executive functioning during story time, especially when digital tools are used.

Study Strengths and Limitations

This thesis study is one of the few studies to examine sex differences in literacy skills within a sample of 4-and 5-year-old children in an entirely online environment. Moreover, the current thesis study also has methodological strengths. These include the design of the digital book to allow for co-operative use in a remote learning context, the use of oral narratives, and the assessment of children's executive function skills using both direct tasks in isolation and measures of observation in context.

Although the findings from the present online thesis study extend prior research on sex differences in literacy, shared reading with digital books, and the use of different situations to measure executive function, there are some limitations. As discussed previously, the sample size for this online study was small, and the participants were ethnically but not socio-economically diverse. Therefore, the non-significant findings for sex and emergent literacy skills, and the significant finding for executive function may not generalize to a larger and more diverse sample. Additionally, only one experimental condition was used.

Within this thesis study, all children experienced the same reading condition and there was no control group. The experimental condition was structured and incorporated the use of a turn-taking strategy that was introduced at the outset of the shared reading activity. It is possible that embedding this turn-taking strategy into the story learning task positively influenced children's executive functioning during reading, thereby contributing to their learning outcomes. Since only one reading condition was used, this turn-taking strategy was not adequately controlled for, and it is unclear if children would have performed differently if they had been exposed to a similar reading condition but without the use of appropriate turn-taking.

It should also be mentioned that the digital book that was used within this study was carefully chosen in relation to the theme and its clear narrative structure. Although the digital book was modified to include the display of a sequential list of story images on a timer during live reading, in general the multimedia features were congruent with the literacy learning task. There is ample research evidence from diverse samples of young children showing that a carefully designed digital book with proper scaffolding may increase reader attention, and language and literacy learning outcomes (Bus et al., 2015; Courage, 2019; Furenes et al., 2021). Therefore, it is possible that the careful design of the digital book that was used within this thesis study—the considerate frequency of sounds and animations, and the close match between the interactive features and the story learning goal—did not adequately or adversely challenge children's executive functioning; thus, warranting further study.

Directions for Future Research

Notwithstanding a small and homogenous sample, the results from the present thesis study demonstrate that executive function predicted preschool children's story learning from an online shared reading experience. Therefore, it is important for future research to actively consider the role of preschoolers' existing executive function skills when digital books are used for learning or when learning is carried out online. More specifically, this role should be examined using different experimental conditions that could potentially challenge children's executive functions in unique ways. Furthermore, it is recommended that literacy studies incorporate both structured tasks in isolation and objective measures of observation in context, as this may provide better insight into the contribution of executive function to children's learning from digital contexts.

Not only should future research continue to examine the contribution of executive function to children's learning from digital books, but future work should also consider how best to operationalize shared reading using digital books. There are recommendations to guide effective shared reading using traditional paper books (Ezell & Justice, 2005; Lever & Sénéchal, 2011; Rhyner, 2009). However, the question of what strategies are more appropriate or beneficial when shared reading is carried out using digital books needs to be further explored. Therefore, future studies should examine what strategies can be integrated into digital book reading contexts to support children's executive functioning and the differences in learning outcomes based on the strategy used.

Within the present study, a "read-talk-play" turn-taking routine was established at the outset of the online shared reading task and it was maintained consistently throughout the experience. Turn-taking, also referred to as reciprocity or synchrony, has been observed to be associated with better children's outcomes from joint interactions (systematic review by Leclère et al., 2014). Moreover, it has been suggested that turn-taking and consistency might support children's executive functioning (Binns et al., 2019). Therefore, it is possible that the consistent use of a turn-taking routine within the present thesis study scaffolded children's executive functioning and contributed to their learning outcomes from the digital book reading context.

However, the efficacy of the turn-taking procedure in relation to children's executive functioning during online shared reading and their learning outcomes could not be validated within the current study, as all children received the same learning condition. The examination of turn-taking procedures or synchrony between adult and child within digital book reading contexts is an emerging area of research. However, the research to date has largely focused on aspects such as the changes in interaction or the impact of joint media engagement on parent-child interactions during reading (systematic review by Ewin et al., 2020). Therefore, the effects of turn-taking procedures on children's executive functioning during digital reading contexts and subsequently their learning from these contexts are largely unknown and warrant further investigation.

Alternatively, it is possible that if the expert reader—parent, clinician, teacher—allows the child to take control of the literacy learning activity and follows their lead as they explore the digital book (in contrast to the present thesis study), children's executive function development may be better supported. Following the child's lead has also been posited as another strategy for supporting children's executive function development (Binns et al., 2019). The effect of either or both strategies on children's executive functioning during shared reading with digital books and their subsequent learning outcomes should be further explored.

Conclusion

The preschool years are categorised by the rapid development of diverse foundational skills with robust evidence demonstrating the predictive relationship between preschool development and later learning outcomes. Therefore, it is of ongoing importance to know what skills may influence young children's learning and how best to support the development of these skills. Moreover, the way we learn has long been changing, with exposure to digital learning contexts increasing. The factors that contribute to learning from digital contexts are not fully understood, particularly in relation to preschool children. Therefore, the present thesis study where preschoolers participated in an online shared reading experience provided a unique opportunity to examine different factors that may explain their learning from digital contexts.

The findings from this thesis study support shared reading as an effective literacy learning practice and demonstrate that preschool boys and girls with comparable socio-demographic characteristics learn similarly when digital books are shared online. Among the three factors that were posited to explain children's learning from digital contexts, the results clearly demonstrated that it was executive function that predicted story learning from the online shared reading experience, not sex or emergent literacy skills. The study sample was ethnically diverse yet small in size and homogenous in socio-economic status; therefore, the results may not generalize to the larger population of children who are getting ready for formal schooling. Furthermore, there was still variance that remained unexplained, once sex, emergent literacy skills, and executive function had been taken into consideration. Nevertheless, these findings do support the need for additional research to better understand the unique contribution of executive function to preschool children's literacy outcomes, particularly from digital learning contexts.

Observing preschool children's executive functioning in an everyday learning context represents an untapped area within research. There is a need for more studies using objective measures of observations and for standard tools of observation that can be used consistently across studies. The objective measures that I designed to describe and examine children's executive functioning during online story learning had only been used within the present thesis study. They did not rely on informant reporting or response time, and they represent a structured tool to examine children's executive functioning while they are engaging in an everyday literacy learning activity, thereby warranting further use. Replicating this instrument would contribute to its test-retest reliability and advance the use of objective measures to examine children's executive functioning in (literacy) learning contexts. Finally, given the contribution of executive function to children's learning from shared reading of a digital book online, more research into what strategies scaffold or hinder preschool children's executive functioning during digital learning contexts would be beneficial to clinicians, teachers, and families.

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Appendices

Appendix 1: Study Consent Form

LimeSurvey Online version of study consent form:

https://surveys.mcgill.ca/ls3/864155?lang=en

Microsoft Word version of study consent form:

Study Title: Supporting Behavioural Regulation During Shared Reading With Digital Books

Principal Investigator:	Susan Rvachew, Ph.D., S-LP(C) Professor, Associate Dean and Director	**Student Investigator:**	Dahlia Thompson PhD Candidate
	School of Communication Sciences and Disorders		School of Communication Sciences and Disorders
	Faculty of Medicine and Health Sciences		Faculty of Medicine and Health Sciences
	McGill University		McGill University
	susan.rvachew@mcgill.ca		dahlia.thompson@mail.mcgill.ca

This consent form is one part of the process of informed consent. It provides a complete overview of the reading study describing the purpose, procedures, benefits, risks if any, precautions, and confidentiality associated with this reading study. Both the benefits and the risks have been carefully outlined, to ensure you are making a fully informed decision for you and your child. Please read through the consent information carefully and make a note of any questions you may have. The researcher will meet with you to answer your questions regarding the study.

Study Funding: This project is funded by the Social Sciences and Humanities Research Council of Canada, (G256437, SSHRC 435-2021-0591, Gender Differences in Literacy Learning with Digital Applications)

Introduction: Increasingly children are playing and reading with digital tools such as tablets and phones from an early age. At school, literacy skills are taught with gamified programs on computers. The multimedia and interactive features that are built into digital games and books attract children's attention to important information and help them learn skills such as the relationship between sounds and letters or the characters and plot of a story. However, these features are also distracting to children. When reading digital books to young children, the adult needs to help the child shift their attention between the story, the game features and the adult's talk. In this study we will test different strategies for helping young children regulate their attention and learn from digital books during shared reading.

Study Procedures: This study consists of **four** sessions (3 of which will be with your child). Each session will last for approximately 30 minutes and will be delivered online. We are asking you to be present with your child during the sessions to provide technical and emotional support. This will include checking your child is seated comfortably in front of the computer and fully visible to the researcher, ensuring their basic needs are met (e.g., bathroom break, drink of water), and resolving any technical issues. Prior to the start of the study, we will provide an overview of the McGill University approved web conferencing tool and will give you your log in information. Only you, your child, and the researcher will be present during the online sessions.

- *Session 1.* During the first session we will meet with you to review this consent form and answer your questions regarding the study. If you consent to your child's participation, we will ask you to sign this consent form and complete a brief questionnaire online to provide background information about you and your child. The questionnaire will ask you about (i) your child's health history and speech and language development, and (ii) your typical reading and storytelling activities with your child at home. In addition, we will show you how to use the web conferencing tool and will assist you with any technical questions you may have. We will schedule the remain three sessions based on your schedule and availabilities.
- *Session 2.* Your child will look at some pictures and tell a story about them. Your child will name some letters and provide the sounds for letters.
- *Session 3.* Your child will play three games that are tests of memory, inhibition, and attention. The tests involve naming pictures on the screen, performing or inhibiting an action, and repeating nonsense words.
- *Session 4.* A researcher will read a story in digital format with your child and will engage your child in an interactive discussion about the story. Immediately after completing the book, your child will be asked to retell the story they had just shared. The researcher will ask your child to identify words and letters that match words and letters that occurred frequently in the story.

Benefits and Risks: The potential benefit to you is that you will receive a written report of your child's test performance from the two brief assessment sessions. This report will include information about storytelling ability, letter knowledge, attentional control, and phonological memory. These are important prereading skills. If your child is showing any risk of difficulty with learning to read, we will discuss the level of risk with you and refer you to the appropriate experts if you wish to obtain more assessments, information, or support for your child. We will not provide any therapy to help your child with prereading or school readiness skills. The shared reading session that your child will participate in is not meant to improve your child's literacy skills except that he or she will practice listening to and retelling a story over a brief session. Your child's participation will help us to advise experts who design programs to teach parents to read with their children.

The potential risks to you and your child are that you will be asked to engage in four sessions and complete a questionnaire. This is a significant time requirement for you and your child, and you may find that it is difficult to fit the time into your schedule. We will work with you to find the best times based on your schedule. Your child may not enjoy the reading activity, but your child can ask to stop the research procedures at any time.

When the study is completed, we will send you a letter outlining our findings. Regular updates describing the results of this research program will also be provided on our blog: digitalmediaprojectforchildren.wordpress.com.

Withdrawal From the Study: You may withdraw from the study at any time and for any reason, without penalty. The session will be discontinued if your child appears to be unhappy, if your child asks to stop, or if you ask to withdraw from the study.

Compensation: In appreciation of your time and your child's time, we will provide your child with a $20 Amazon Gift Card and recommendations regarding the purchase of appropriate digital apps or storybooks for preschool aged children.

Subject Rights: You have the right to ask questions at any time. Your participation and the participation of your child in this study is completely voluntary and you can opt not to participate or to withdraw at any time. There is no penalty or repercussion if you choose not to participate in the study or if you choose to withdraw from the study after it has started. Your decision to participate or to withdraw will not affect your ability to access any services or resources your child may need to support his or her speech, language and reading development. Your decision to participate or to withdraw will not affect your ability to access any services or resources to which you and/or your child are otherwise entitled.

Confidentiality: The data that is collected in this study is confidential. The sessions will be conducted online using a web conferencing tool that complies with the privacy laws of Quebec. During the online sessions, only you, your child, and the researcher from the McGill University Child Phonology Lab will be present. The sessions will be recorded and after the study has ended, you can request a personal copy of the recording of the one-on-one reading. All information that is collected about your child during this study will be kept in a file that is identified by number only. The recordings of your child and the questionnaire information will also be identified in this manner. Consent forms, contact information, and questionnaire information will be stored on a secure drive that is managed by McGill University. All recordings and coded data derived from these recordings will be stored on back-up drives in the Child Phonology Laboratory or on McGill University back up drives. The recordings of the sessions will be encrypted and stored long term on McGill University servers. The raw data will be kept for a period up to 7 years after study completion and then it will be destroyed. During this period, the principal researcher, research assistant, and research students in the lab will have access to the data for the purpose of data analysis. In addition, the McGill University

Institutional Review Board may access the study data to ensure the proper management of this study. It is also possible that SSHRC, the funding agency and reviewers from scientific journals where we submit publications about this study may request numerical data from the study. Scientific publications and presentations about this study will not contain any personal or identifying information about you or your child.

Contact

If, at any time during the study, you want more information, have concerns about the study procedures, or decide to withdraw from the study, please contact:

Susan Rvachew, Ph.D., S-LP(C), Professor

School of Communication Sciences and Disorders, McGill University

2001 McGill College Avenue, 8th Floor

Montréal, Quebec, H3A 1G1

Phone : 514-398-4137, E-mail : susan.rvachew@mcgill.ca

If you have any questions about your rights and recourse or your participation in this research study, you can contact Ms. Ilde Lepore, Ethics Officer, at 514-398-8302 or by email at ilde.lepore@mcgill.ca

Consent

The study has been explained to me and my questions have been answered to my satisfaction. I agree to participate in this study. I give my consent for my child to participate in the activities outlined in the *Study Procedures*. I do not waive mine or my child's legal rights by signing this consent. I have received a copy of this consent form for my records.

Signature

Name of Parent/Guardian	E-Signature of Parent/Guardian	Date

Email Address: ____________________

Child's Name	Child's Date of Birth	Child's Sex

Name of Child Phonology Lab personnel obtaining consent	E-Signature of Child Phonology Lab personnel obtaining consent	Date

Child Assent

At the start of the session, the researcher will explain the activities to the child. After explaining, the researcher will pause for the child's response indicating they want to proceed or not. The researcher will also clearly inform the child that at any time during the activities they can say when they want to take a break or if they want to stop. Their ongoing assent will be monitored during sessions.

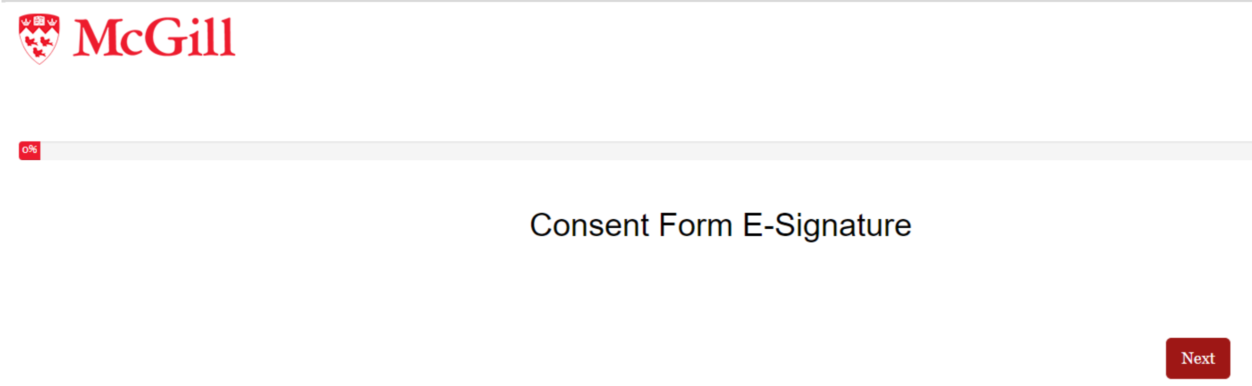
		Y	N
Child's Name	Date	Child Agrees to Participate	

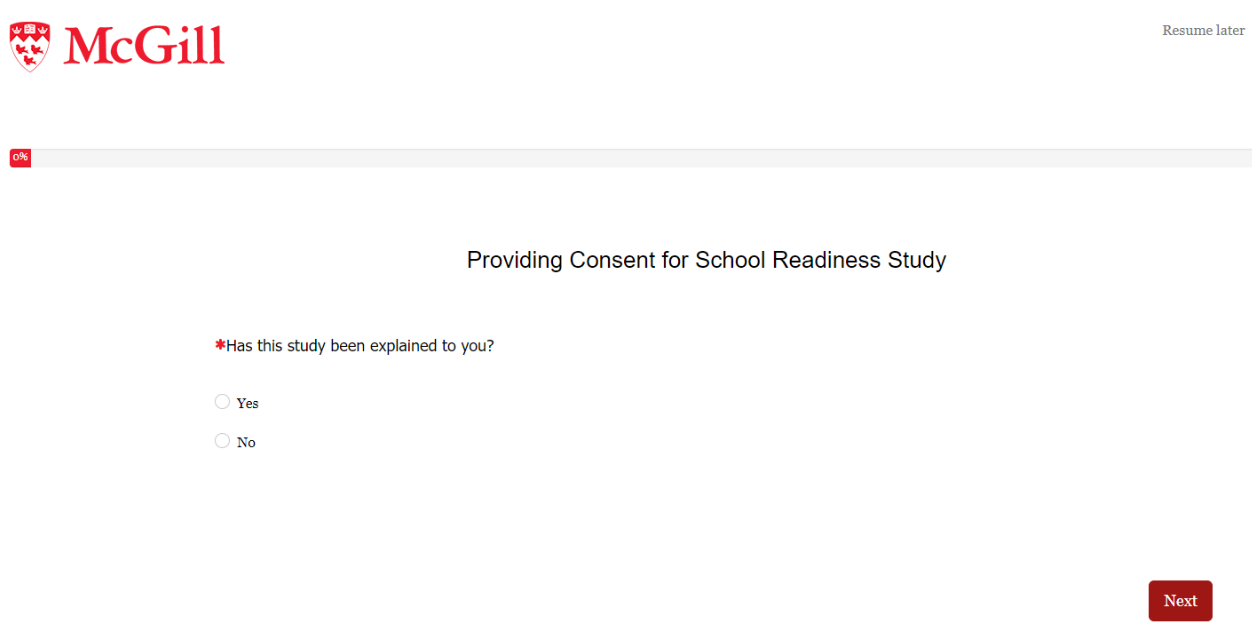
Appendix 2: Study Consent Electronic Signature Page

LimeSurvey Consent Electronic Signature Page:

https://surveys.mcgill.ca/ls3/643329?lang=en

Screenshots of LimeSurvey Electronic Study Consent Signature Page





McGill

Resume later

8%

Providing Consent for School Readiness Study

*Who explained this study to you?

- [x] Name of Researcher: Dahlia Thompson
- [x] Date of Explanation: July 28, 2022

Next

McGill

Resume later

16%

Providing Consent for School Readiness Study

*Were your questions answered to your satisfaction?

( ) Yes ( ) No

Next

McGill

Resume later

33%

Providing Consent for School Readiness Study

The study has been explained to me and my questions have been answered to my satisfaction. I agree to participate in this study. I give my consent for my child to participate in the activities outlined in the *Study Procedures*. I do not waive mine or my child's legal rights by signing this consent. The researcher has explained that I will receive a signed copy of this consent form for my records, shortly after the first session.

Next

McGill

Resume later

41%

Providing Consent for School Readiness Study

*Do you give consent for your child to participate?

○ Yes ○ No

Next

McGill

Resume later

58%

Providing Consent for School Readiness Study

* **Thank you for providing consent for your child to participate in our school readiness study.**

Please complete the section below:

- [ ] Name of Parent/Guardian Giving Consent
- [ ] Please Sign by Printing your Name Again
- [ ] Date Consent Given by Parent/Guardian
- [ ] Name of Child for Whom Consent is Given
- [ ] Date of Birth of Child for Whom Consent is Given
- [ ] Sex of Child for Whom Consent is Given

Appendix 3: Study Background Questionnaire

LimeSurvey Online version of background questionnaire:

https://surveys.mcgill.ca/ls3/742789?lang=en

Microsoft Word version of background questionnaire**:**

Dear Parent/Guardian:

Thank you for allowing your child to participate in our school readiness study.

Please complete this questionnaire to provide background information about your family and your child's development.

This questionnaire has 3 sections and will take approximately <u>10 minutes</u> to complete. You can save and continue at your convenience.

The information you provide will be kept confidential and will only be accessed by the McGill University - Child Phonology Laboratory team.

Yours sincerely,

Principal Investigator: Susan Rvachew, Ph.D., S-LP(C)

Student Investigator: Dahlia Thompson, PhD Candidate

McGill | Faculty of Medicine and Health Sciences | School of Communication Sciences and Disorders

Section 1: Tell us about you and your family

1. What is your name?

2. What is your occupation?

3. What is your highest level of education?

4. Is there another parent in the household?

   ○ Yes ○ No

   If yes

   4Y1: What is their occupation?

   4Y2: What is their highest level of education?

5. What languages are spoken in the home?

6. What percentage of time do you use each of these languages?

7. Are there family members with speech, language, or reading problems?

   ○ Yes ○ No

8. List the family members with speech, language, or reading problems.

Section 2: Tell us about your child

1. What is your child's date of birth?

2. What is the sex of your child?

3. What is the race or ethnic group of your child?

4. What is your child's birth weight?

5. Were there any concerns or complications during or shortly after the birth of your child?

○ Yes ○ No If yes, please describe.

6. Is your child's health generally good?

○ Yes ○ No If no, please describe.

7. Does your child have any medical conditions or diagnoses?

○ Yes ○ No If yes, please describe.

8. Has your child had major accidents or surgeries?

○ Yes ○ No If yes, please describe.

9. Do you have any concerns about your child's motor abilities (e.g., incoordination, clumsiness)?

   ○ Yes ○ No If yes, please describe

10. Do you have any concerns about your child's attention and/or behaviour?

   ○ Yes ○ No If yes, please describe.

11. Do you have any concerns about your child's social interaction with family members and/or other children?

   ○ Yes ○ No If yes, please describe.

12. Has your child ever had trouble feeding (e.g., drooling, difficulty sucking or swallowing?

   ○ Yes ○ No If yes, please describe.

13. Have you ever suspected problems with your child's hearing?

   ○ Yes ○ No If yes, please describe

14. How many ear infections did your child have before age 24 months?

   a. 0-2
   b. 3-5
   c. 6-8
   d. 9 or more

15. At what age (in months) did your child first do the following?

   a. Babble
   b. Say first word
   c. Combine two words together

16. Does your child attend a day care program or preschool?

    ○ Yes ○ No

    If yes, please describe (including the age started attending, number of days, hours per day, and type of program)

17. Has your child received any therapeutic services or medical treatments in the past?

    ○ Yes ○ No If yes, please describe.

18. Is your child currently receiving any therapeutic services or medical treatments?

    ○ Yes ○ No If yes, please describe.

Section 3: Tell us about your home literacy activities.

1. How would you describe your child's reading ability?

   ○ Cannot read at all
   ○ Can read simple sentences
   ○ Can read some words
   ○ Can read simple storybooks
   ○ Can read simple phrases

2. How old was your child when you started reading picture books to them (please estimate age in months)?

3. Please estimate the number of print books your family owns.

4. Please estimate the number of print books you (or another family member) have read to your child, in the past month.

5. Please estimate the number of digital/e-books you (or another family member) have read to your child, in the past month.

6. Please estimate the number of hours your child uses a digital media device (e.g., TV, desktop, laptop, tablet, smartphone) in a typical week.

7. For what activity/activities is your child using the device?

8. When your child uses the device, are they normally using it alone or with adult supervision?

9. Reading together with my child:

Please choose the appropriate response for each item

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Is an important way for the child to learn how to read	○	○	○	○	○
Is an important bonding time for the child and me	○	○	○	○	○
Is an activity I suggest when my child feels bored	○	○	○	○	○
Is a good way to pass time with my child when we travel (Commute, vacation, run errands)	○	○	○	○	○
Calms or distracts my child when they are upset	○	○	○	○	○
Helps my child learn subjects they will face in school like science, social studies or math	○	○	○	○	○

10. In a typical week, how often do you or another family member:

Please choose the appropriate response for each item

	Never	**Rarely**	**Sometimes**	**Often**	**Very Often**
Read to your child	○	○	○	○	○
Engage your child in storytelling	○	○	○	○	○

	Never	**Rarely**	**Sometimes**	**Often**	**Very Often**
Visit the library with your child	○	○	○	○	○
Play rhyming games with your child	○	○	○	○	○
Teach your child letter names	○	○	○	○	○
Teach your child letter sounds	○	○	○	○	○
Teach your child to spell words	○	○	○	○	○
Teach your child to read words	○	○	○	○	○
Encourage your child to engage in letter writing activities	○	○	○	○	○

Thank you!

Child Phonology Laboratory

School of Communication Sciences and Disorders

Faculty of Medicine and Health Sciences

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Montréal, Quebec, H3A 1G1

Telephone: 514 398-3241 | Email: cpl.scsd@mcgill.ca

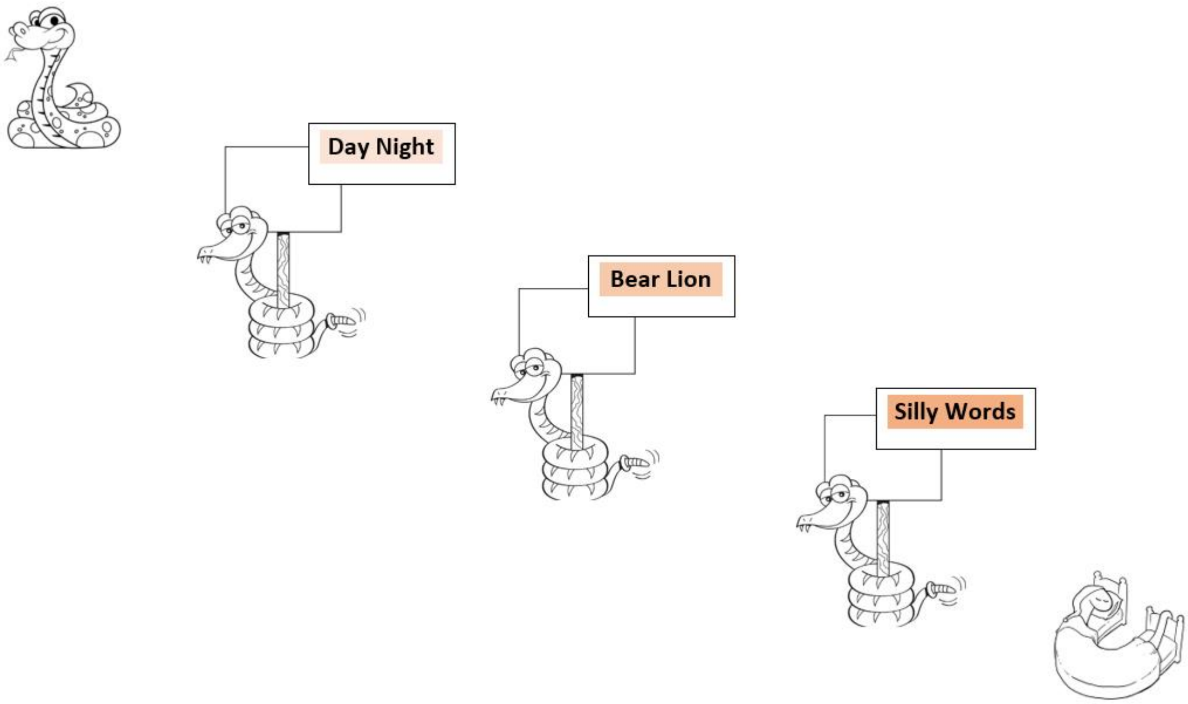
Study Team:

Principal Investigator: Susan Rvachew, Ph.D., S-LP(C)

Student Investigator: Dahlia Thompson, PhD Candidate

Study Coordinator: Tanya Matthews, Ph.D., CCC-SLP

Appendix 4: Session 2 Pathway



Appendix 5: Story Coding Scheme

ITEM	**INSTRUCTIONS**
Participant Number	Enter participant long code
Speaker	C: child; A1: adult reader (researcher); A2: another adult (e.g., caregiver)
(Orthographic) Transcription	Orthographic transcription of story. When child's name mentioned use GDL code number, e.g., [GDLXXX].
Coder's Log	For child's utterance only, enter retell code item. For example, "The froggie wanted to fly" - A1, A3
Unique Word Count	For child's utterances only - for each line of transcript (story related utterances only) - count all unique appearances of nouns, verbs, adjectives, and adverbs. *Exclude character names, pronouns, prepositions, and conjunctions. Compound words count as one word.
Story Grammar Units (A1 To A24)	A1: Character(s) (e.g., boy, girl, frog, froggie, Frank, dog, squirrel) A2: Setting (e.g., in Central Park, at the zoo, by the pond...) A3: Initiating/starting event/problem (e.g., dug a hole/buried a bone, wanted to fly...) A4: Internal response (to starting event/problem) (e.g., felt sad...) A5: Plan to resolve problem A6: Action/Attempt to solve

ITEM	**INSTRUCTIONS**
	A7: Complication A8: Consequence/Outcome A9: Internal Response/Reaction (to outcome) A10: Initiating Event 2 A11: Internal Response/Reaction (feeling) A12: Plan to resolve problem/initiating event A13: Action/attempt to solve A14: Complication A15: Consequence/Outcome A16: Internal Response/Reaction (to outcome) A17: Initiating Event 3 A18: Internal Response/Reaction (feeling) A19: Plan to resolve problem/initiating event A20: Internal Response/Reaction (feeling) A21: Action/attempt to solve A22: Complication A23: Consequence/resolution/ending/outcome A24: Internal Response (to ending/outcome)
A1 To A24 Item Code Count	Participants asked to retell a story they had just heard. The cover of the story provided as visual. MAX Points 30 | Story has 3 episodes.

ITEM	INSTRUCTIONS
	Enter count for story grammar units (A1 to A24) Scoring : 0, 1, 2 (hybrid of the INC and ENNI) - (Petersen et al., 2008 Index of Narrative Complexity; Schneider et al., 2005 Edmonton Narrative Norms Instrument) - 0: if story grammar unit not mentioned - 1: if story grammar unit is mentioned EXCEPT FOR: Initiative Event, Action/Attempt, Ending : score of 2 if mentioned Character: Score of 1 if one main character mentioned (e.g., frog or froggie) | Score of 2 if 2 or more/all main characters mentioned (e.g., the frog or froggie AND baby bird or/and mother bird or bird)
Organization	Organizational Quality of Story (Re)Tell 0 – Completely off topic: All thoughts expressed are unrelated to story 1 – Not Organized: Narrative is hard to follow. Few details provided; events/items not sequenced; frequent topic switches; every event had to be prompted by researcher/examiner. 2 – Slightly Organized: Narrative can be followed but with some difficulty. Some thoughts are unrelated to the story. Some events are provided, some story elements incomplete (e.g., child mentions character or starting event but no action or ending). Some order to events provided.

ITEM	INSTRUCTIONS
	3 – Somewhat Organized: Narrative can be followed with more ease. Very few thoughts are unrelated to the story, and the main character and starting event are mentioned. Events provided are mostly sequenced in correct order, a cause-and-effect relationship begins to emerge, conjunction used to sequence events include ‘and’, ‘then’ etc. 4 – Organized: Narrative is easier to follow. Most thoughts expressed are related to the story. Most events are sequenced, use of ‘higher-level’ conjunction used to sequence events e.g., ‘because’ ‘after that’ etc., Relevant story grammar elements are present (e.g., the main character, starting event, & action/plan to resolve are mentioned), although the listener may have to interpret/infer the ending, includes references to feelings and motivations. 5 – Very organized: Narrative is very easy to follow. All thoughts expressed are related/relevant to story and are connected to each other. Complete episode(s) - Story has a beginning, middle, and end (may use conventional literary forms to signal beginning "once upon a time" and end "the end" of story or other method to clearly indicate story start and story end/conclusion); includes feelings and motivations; correct sequence of events; use of ‘higher-level’ conjunction to sequence events e.g., ‘because’ ‘after that’ etc.,

Appendix 6: Sample Pre-Test Stories

SAMPLE 1 - Age: 4;2 Sex: Female Device used: Desktop

Speaker	**(Orthographic) Transcription for sample 1**
A1	Look at the pictures and tell me your story. Go ahead
C	Once upon a time, there was a dog
C	He found a bone and buried it
C	And out came a bird XXX scared it away
C	And the beaver found the bone hidden
A1	And the beaver found the bone hidden
A1	Tell me more
C	It's done
A1	It's done. Is that the end of your story?
C	Yeah
A1	[GDLXXX] thank you for telling me such a great story

Sample 2 - Age 4;6 Sex: Female Device used: Laptop

Speaker	**(Orthographic) Transcription for sample 2**
A1	Okay [GDLXXX] look at the pictures and tell me your story. Go ahead
C	I don't know
A2	Look at the pictures
A1	Okay. Look at the pictures and tell me what you see. What's going on?
	…
C	I don't know
A1	Okay can you see the first picture here? Look at this picture. Can you see this one?
C	Yeah
A1	Can you see what's going on?
C	He's looking, in the hole
A1	He's looking, in the hole. Tell me more
C	I don't know
A1	Okay. Look at the next picture. Do you see what's going on?
A2	Just want to see what's happening in the picture. Just to tell
A2	We want you to tell us what's going on in the pictures.
C	A doggie
A1	A doggie
A2	Okay what's going on?
C	He's happy

Speaker	**(Orthographic) Transcription for sample 2**
A1	He's happy. That's so right. He's happy
A1	Tell me more
C	I don't know that one
A1	You don't know that one?
A2	You don't know what's which one?
C	That one (child pointing to screen)
A2	Okay. She doesn't know the name of the other character that we see
A1	Okay. I think that's a squirrel
C	It’s a squirrel?
A1	Uh-uh. You see a squirrel
C	The squirrel is looking in the hole
A1	The squirrel is looking in the hole
C	For the bone
A1	For the bone
	…
A1	Anything else?
C	No
A1	That's the end of the story?
C	Yeah
A1	Well, thank you for telling me your story

SAMPLE 3 - Age: 5;5 Sex: Male Device used: Tablet

Speaker	**(Orthographic) Transcription for sample 3**
A1	Okay [GDLXXX] look at the pictures and tell me your story
A1	(PAUSE)
C	There's a dog ...and a mouse
A1	There's a dog and a mouse, mhmm hmm.
A1	Tell me more
C	The dog got the bone and the mouse has a bone
A1	Mhmm hmm
C	The mouse has a bone and a nut
C	The dog has a bone and a nut
C	There's also a pile of dirt. Pile of dirt.
C	There's pile of dirt
A1	Mhmm hmm. Anything else?
C	The squirrel drop the nut …and …XX find the bone
A1	Uh uh, the squirrel dropped the nut and found the bone
C	And then he took the dog's bone
A1	(laughter)
C	He took it
A1	He sure did. He took the dog bone
C	Why?
	PAUSE

Speaker	(Orthographic) Transcription for sample 3
A1	Anything else?
C	N-no
A1	Is that the end of your story
A2	What do you say at the end of the story?
A1	-Yes
A1	Is that the en-? - Thank you. Thank you for telling me an amazing story

Appendix 7: Sample Task-Based Executive Function Responses

Participant	GDLXXX	**Date**	XX-XX	**DAY-NIGHT**
Item Number	**Stimulus**	**Correct Response**	**Participant Response**	**Participant Score**
Practice Trial 1	Sun	Night	Night	1
Practice Trial 2	Moon	Day	Day	1
Practice Trial 3	Sun	Night	Night	1
Practice Trial 4	Moon	Day	Day	1
1	Moon	Day	Night	0
2	Sun	Night	Night	1
3	Sun	Night	Night	1
4	Moon	Day	Day	1
5	Sun	Night	Night	1
6	Moon	Day	Day	1
7	Moon	Day	Day	1
8	Sun	Night	Night	1
9	Sun	Night	Night	1
10	Moon	Day	Day	1
11	Sun	Night	Night	1
12	Moon	Day	Night	0
13	Moon	Day	Night	0
14	Sun	Night	Night	1

Participant	GDLXXX	**Date**	XX-XX	**DAY-NIGHT**
Item Number	**Stimulus**	**Correct Response**	**Participant Response**	**Participant Score**
15	Moon	Day	Day	1
16	Sun	Night	Night	1
			DAY	5
			NIGHT	8
			Raw Score	13
			% Correct	**81%**
			CODING:	1 = Correct Response 0 = Incorrect NR = No Response

Participant NO.	GDLXXX	**Date**	XX-XX		**BEAR-LION**
Item Number	**Gesture**	**Animal**	**Correct Response**	**Participant Response**	**Participant Score**
Practice Trial 1	touch your nose	Bear	Full Move	Full Move	3
Practice Trial 2	touch your ears	Lion	Inhibit Move	Inhibit Move	3
Practice Trial 3	touch your nose	Bear	Full Move	Full Move	3
Practice Trial 4	touch your ears	Lion	Inhibit Move	Inhibit Move	3
1	clap your hands	Bear	Full Move	Full Move	3
2	clap your hands	Lion	Inhibit Move	Inhibit Move	3
3	touch your nose	Bear	Full Move	Full Move	3
4	touch your nose	Lion	Inhibit Move	Inhibit Move	3
5	touch your head	Bear	Full Move	Full Move	3
6	touch your head	Lion	Inhibit Move	Inhibit Move	3
7	touch your ears	Bear	Full Move	Full Move	3
8	touch your ears	Lion	Inhibit Move	Inhibit Move	3
9	clap your hands	Bear	Full Move	Full Move	3
10	touch your ears	Lion	Inhibit Move	Inhibit Move	3
				Bear	15
				Lion	15
				Raw Score	30

Participant NO.	GDLXXX	**Date**	XX-XX		**BEAR-LION**
Item Number	**Gesture**	**Animal**	**Correct Response**	**Participant Response**	**Participant Score**
				% Correct	**100%**
			CODING BEAR TRIAL:	0 = failure to move 1 = wrong movement 2 = partial movement 3 = full, correct movement	
			CODING LION TRIAL:	0 = full movement 1 = wrong movement 2 = partial movement 3 = full inhibition of movement	

SYLLABLE REPETITION TASK

SYLLABLE REPETITION TASK											
					Jatos Worker Link	XXX					
Participant NO.	GDL00		**Date**	XX-XX	**Researcher**	DAHLIA					
Syllables	*Item*	*Target*	*Child's Productic*	*Consonants Corre*	*Memory*	*Subs*	*WC Manner Sub*	*Sound Additio*	*Additions Tota*	*Omissions*	*Comments*
2	**1**	**bada**	bada	2		0	0	0	0	0	
2	**2**	**dama**	dama	2		0	0	0	0	0	
2	**3**	**bama**	bama	2		0	0	0	0	0	
2	**4**	**mada**	mada	2		0	0	0	0	0	
2	**5**	**naba**	naba	2		0	0	0	0	0	
2	**6**	**daba**	naba	1		1	0	0	0	0	
2	**7**	**nada**	nada	2		0	0	0	0	0	
2	**8**	**maba**	maba	2	93.75	0	0	0	0	0	
3	**9**	**bamana**	bamanan	3		0	0	1	0	0	
3	**10**	**dabama**	damadan	1		0	0	1	0	0	
3	**11**	**madaba**	madaba	3		0	0	0	0	0	
3	**12**	**nabada**	nabada	3		0	0	0	0	0	
3	**13**	**banada**	banada	3		0	0	0	0	0	
3	**14**	**manaba**	manaba	3	88.8888889	0	0	0	0	0	
4	**15**	**bamadana**	bamadana	4		0	0	0	0	0	
4	**16**	**danabama**	damabana	2		2	2	0	0	0	
4	**17**	**manabada**	namabama	1		2	2	0	0	0	
4	**18**	**nadamaba**	nadamaba	4	68.75	0	0	0	0	0	
50			**TOTALS**	42		5	4	2	0	0	0

Diagnostic Interpretation

Overall Competency Sco	65% cut-off
Encoding Score	46.9% cut-off
Memory Score	67.5% cut-off
Transcoding Score	80% cut-off

	Competency	**Memory**	**Encoding**	**Transcoding**
		-0.05324451		11.11111111
Score (%)	84	94.6755485	80	88.88888889
Z-score	-0.09009009	0.36309118	0.512027491	-0.394179894

NORMS *See SRT_NORMS sheet (copy appropriate age and paste below)*

Child's Age 5;5

	M	**SD**
Competence	85	11.1
Encoding	65.1	29.1
Memory	90.5	11.5
Transcoding	92.2	8.4

Appendix 8: Sample Story Retells

SAMPLE 1 - Age: 4;2 ; Sex: Female; Device used: Desktop

Speaker	**Orthographic Transcription for retell sample 1**
A1	Go ahead. Tell me the story [GDLXXX] of A Frog Thing
C	Okay. There was a frog named Frank and he wanted to fly
A1	Mhmm hmmm
C	He tried to fly and everyone laughed at him
C	His parents said ...you can do anything you mind
A1	Mhmm hmmm
C	And that night he sat like with his hands down and his feet and his feet on his head
	Mhmm hmmm. He had his feet on his head.
A1	That's so true. What happened next?
C	Then his parents came over and said no when I said no when I meant no when I said you can do in your brain it means frog thing and flying isn't a frog thing
A1	Flying isn't a frog thing, that's what his parents said. Tell me more [GLDXXX]
C	Okay. That - hm I just need to drink something because I haven't had a drink for a little while so -
A1	That's okay. Go ahead and have your drink
	...
C	And next he sat there in the dark.
	He heard a splash ...splash and he went to rescue what?

Speaker	Orthographic Transcription for retell sample 1
	A bird fell in there?
A1	Uh uh
C	Baby bird
A1	Baby bird
C	And he brought back to his -to his mother
A1	Yes
C	And ...then he gave him a kiss and they fly together
A1	That is so true. Is that the end of your story?
C	Uh uh
A1	Well [GDLXXX] thank you for telling me such a great story.

SAMPLE 2 - Age 4;6; Sex: Female; Device used: Laptop

Speaker	**(Orthographic) Transcription for retell sample 2**
A1	Okay [GDLXXX], tell me the story of A Frog Thing. Go ahead
C	I don't rem-anything
A1	You don't remember anything?
C	Yes
A1	You-
C	He wanted to fly and the birds teach him how to fly
A1	He wanted to fly and the birds teach him how to fly. Tell me more
C	And then he flied because the birds teach him
A1	And then he flied because the birds teach him
A1	Did anything else happened in your-in the story?
C	[GDLXXX] shakes head
A1	That's the end of the story?
C	[GDLXXX] nods
A1	Good job. Thank you

SAMPLE 3 - Age: 5;5; Sex: Male; Device used: Tablet

Speaker	**(Orthographic) Transcription for retell sample 3**
A1	[GDLXXX] now it's your turn to tell the story
A1	Tell me the story of A Frog Thing. Go ahead
C	Froggie
A1	Froggie
C	He's looking up at the birdie
A1	He's looking up at the birdie. Mhmm mhmm [A2 in background XX] tell me more about the story
A2	What happens?
C	The froggie want to fly
C	He's sad and everyone laugh at him
A1	Mhmm mhmm
A2	And then what
A1	And everyone laughed at him. What happened next?
C	He XX fly, he was sad
A1	He was sad because he couldn’t fly yes
A2	And then what
A1	Tell me more
C	And then his parents came and then he said, he didn't say everything you wanted to do just everything a frog thing
A1	Yes

Speaker	(Orthographic) Transcription for retell sample 3
C	XX do frog thing
A1	Yes [PAUSE] What happened next?
C	Then he go flying onto the [makes firing/flying noises]
A1	The he goes flying, that's so right
C	Yes
C	And he splash [makes splashing sounds]
A1	And he splashed. Good job
A2	-Anything else happened in the story?
A1	-Anything el…Is that the end of your story?
	The birdie came XX splashing in the water and froggie don't know what the thing
C	the thing that splash
C	And he go in the water to see what happened and there's a little birdie
C	And he go back to the mommy after he get the birdie
A1	Wow, he went back to the mommy after he saved the birdie
C	The baby birdie
A1	The baby birdie...Yes [LONG PAUSE]
A1	Is that the end of your story?
A2	If that's the end, say the end
C	The end
A1	Oh, that's the end? I see a great smile.
A1	So can you tell, is that the end, yes, or no?

Speaker	(Orthographic) Transcription for retell sample 3
C	The end
A1	That's the end . Tadah, thanks for telling me an amazing story
A1	[GDLXXX] you told me so much about that story. Thank you

Appendix 9: Sample Story Comprehension Response

Participant	GDLXXX	**Date**	XX-XX	**Researcher** XX
Item Number	**Item**	**Response Options**	**Participant Response Score**	**Participant Response (transcript)**
1	Q1: What does Frank want to do?	He wants to fly.	2	Fly
2	Q2: Look at Frank. Why does Frank look so discouraged?	Because he wanted/tried to fly and he couldn't/his parents told him flying wasn't a frog thing	1	Because he wants to fly
3	Q3: What made the splash in the water?	The baby bird made the splash.	2	Baby bird
4	Q4: How did the birds make Frank's dream come true?	The two birds/Mother bird and her friend gave Frank a **stick** (to hold onto)	0	They gave him power

Participant	GDLXXX	**Date**	XX-XX	**Researcher** XX
Item Number	**Item**	**Response Options**	**Participant Response Score**	**Participant Response (transcript)**
		so he could fly (with them)		
CODING	Items 1 to 4: 0 = Incorrect Response 1 = Partial Response 2 = Correct Response NR = No Response	**Raw Score** **Percentage Correct**	5 **62.5%**	Max Total 8 points

Appendix 10: Sample Word Recognition Response

Participant NO.	GDLXXX	**Date**	XX-XX	**Researcher**
Item Number	**Item**	**Correct Response**	**Participant Response Score**	**Participant Response (transcript)**
1	Q1: Which word says 'Frank'? - [fly, Frank]	Item #2	2	Number 2
2	Q2: Which word says 'frog'? - [frog, feet]	Item #1	2	Number 1
3	Q3: Which word says 'fly'? - [fly, frog]	Item #1	2	It's number 1
4	Q4: Which word says 'feet'? - [folks, feet]	Item #2	2	Number 2, feet
		Raw Score	8	Max Total
		Percentage Correct	**100%**	8 points
		CODING:	Items 1 to 4: 0 = Incorrect Response 2 = Correct Response NR = No Response	