

READING, WRITING, AND EF DEVELOPMENT

A Longitudinal Examination of Word Reading, Transcription, and Executive Function in Early  
Elementary English and French Immersion Student Populations

by

Amanda N. Field

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF ARTS

in the Department of Educational Psychology and Leadership Studies

© Amanda N. Field, 2025

University of Victoria

All rights reserved, this thesis may not be reproduced in whole or in part, by photocopy or other means, without the permission of the author.

We acknowledge and respect the Lək'wəḡən (Songhees and X<sup>w</sup>sepsəm/Esquimalt) Peoples on whose territory the university stands, and the Lək'wəḡən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

A Longitudinal Examination of Word Reading, Transcription, and Executive Function in Early  
Elementary English and French Immersion Student Populations

by

Amanda N. Field

**Supervisory Committee**

Dr. Gina Harrison, Department of Educational Psychology and Leadership Studies

Supervisor

Dr. Doug Magnuson, Department of Educational Psychology and Leadership Studies

Departmental Member

Dr. Sarah Macoun, Department of Psychology

Outside Member

### **Abstract**

The present study examined word reading, transcription, and executive function (EF) sub-measures longitudinally to identify developmental predictors within English and French Immersion (FI) instructional environment groups. The purpose of this study was to address the mediative role of EF in relation to reading and transcription development both within and cross-linguistically.

67 students, including 31 English and 36 FI students participated in the longitudinal study, completing a battery of standardized literacy and cognitive assessment sub-measures at two timepoints, once in Grade 1 and again in Grade 2. Analysis, including descriptive statistics, correlational and predictive analysis, as well as linear regression-based mediation analysis revealed that EFs, specifically shifting and working memory, directly and indirectly mediated the relation between word reading and transcription within the English group. In contrast, no direct and indirect EF mediative relations were identified within the FI group, though working memory was identified as a direct-only non-mediator. Regarding cross-linguistic transfer, English reading did not significantly predict French transcription and there were no noted EF mediation relations between the two variables. These results indicated that Canadian English and FI instructional environment group students may maintain differentiated literacy and cognitive developmental patterns. Moreover, results indicate that cross-linguistic transfer may be significant only once more comprehensive language proficiency has been acquired.

**Table of Contents**

Supervisory Committee.....	ii
Abstract .....	iii
Table of Contents .....	iv
List of Tables .....	vi
List of Figures.....	vii
Acknowledgements .....	viii
Introduction .....	1
Executive Function .....	3
Reading, Writing, and The Reading-Writing Relation .....	5
Bilingual Linguistic Development .....	17
Executive Summary and the Present Study .....	22
Methodology .....	27
Procedures .....	27
Participants .....	29
Inclusion and Exclusion .....	30
Measures .....	30
Results .....	34
Pre-Analysis.....	34
Attrition.....	35
Descriptive Statistics .....	36
Correlation .....	38
Regression.....	43

Mediation .....50

Discussion .....59

    Research Question 1.....59

    Research Question 2 ..... 64

    Implications .....66

    Limitations .....67

    Executive Summary .....69

References .....70

**List of Tables**

<i>Table 1</i> Overview of Participants .....	30
<i>Table 2</i> Attrition: Y1 Score Differences Between Non-Continuing and Continuing Participants.....	35
<i>Table 3</i> Scores between Language Groups Y1 .....	36
<i>Table 4</i> Scores between Language Groups Y2.....	37
<i>Table 5</i> English Group: Bivariate Pearson Correlation Coefficients .....	40
<i>Table 6</i> French Group: Bivariate Pearson Correlation Coefficients .....	42
<i>Table 7</i> Y1 English Reading as the Predictor .....	45
<i>Table 8</i> Y2 English Transcription as the Outcome.....	46
<i>Table 9</i> Y1 French Reading as the Predictor .....	47
<i>Table 10</i> Y2 French Transcription as the Outcome.....	48
<i>Table 11</i> Y1 English Reading as the Predictor (FI Group) .....	49
<i>Table 12</i> English Group: Mediation.....	55
<i>Table 13</i> FI Group (French Measures): Mediation.....	57

**List of Figures**

*Figure 1* Proposed Analysis Model: Research Questions and Hypotheses .....26

*Figure 2* English Group: Literacy and EF Predictive Relations .....46

*Figure 3* French Group (French Measures): Literacy and EF Predictive Relations.....48

*Figure 4* French Group (English and French Measures): Literacy and EF Predictive Relations.....50

*Figure 5* Significant Direct and Indirect Mediation Across the English Group .....56

*Figure 6* Significant Direct Only Non-Mediation Across the FI Group (French Measures).....58

### **Acknowledgements**

First, I would like to acknowledge the Victoria and Sooke School District principals, teachers, and administrative staff who participated in the facilitation of this study. To the consenting parents, caregivers, and student participants, thank you so much for your contribution. I would also like to thank my research colleagues who supported data collection and scoring. Importantly, I would like to acknowledge my supervisor, Dr. Gina Harrison. I am incredibly grateful to Dr. Harrison for her constant support, guidance, and expertise. I would also like to express my gratitude to my committee for their time and valuable insights. Lastly, I would like to acknowledge my family for their support throughout my graduate studies.

## Introduction

Writing is a complex process that requires “generating, translating, organizing, and transcribing” ideas (Kim et al., 2022, p.2). In early elementary education, transcription, the process of translating thoughts or sounds into written symbols, is a foundational aspect of writing development (Berninger, 1999). Transcription includes two primary components, handwriting fluency (or alphabet fluency) and spelling (Berninger, 1999). Developing proficiency in transcription allows students to engage in more automatic composition and subsequently redistributes resources to support the development of higher-order skills such as planning, revision, and idea generation (Berninger & Winn, 2006). Moreover, researchers have suggested that reading and writing development are interactive processes. For example, in early elementary education, word reading and transcription skills have been shown to contribute to, and predict, the development of orthographic knowledge (Chung et al., 2023; Shahar-Yames & Share, 2008; Stanovich & West, 1989). Defined as the “ability to form, store, and access orthographic representations”, orthographic knowledge supports automatic word identification and encourages the reallocation of available resources to the development of reading and writing skills (Ehri, 2000; Gough & Tunmer, 1986; Shahar-Yames & Share, 2008). Thus, the interplay between word reading and transcription supports broader literary outcomes, including written composition and reading comprehension (Chung et al., 2023; Rocha et al., 2022; Shahar-Yames & Share, 2008).

The acquisition of transcription, and more broadly writing ability, has been suggested to be supported by underlying cognitive skills (Kim, 2019). Among these cognitive skills, executive functions (EFs), commonly characterised as top-down cognitive process that include working memory, shifting or cognitive flexibility, and inhibition, have been increasingly recognized as important drivers of writing development (Hung, 2021; Kim, 2020; Miyake et al., 2000).

Working memory supports the temporary storage and manipulation of information (Miyake et al., 2000). Shifting encourages the ability to switch between cognitive tasks (Miyake et al., 2000). Inhibition supports the management and attention of tasks (Miyake et al., 2000). Each of these processes are theorized to contribute to the automaticity, management, navigation, and attention required to complete the complex and competing demands of reading and writing tasks (Barbu et al., 2019; Cartwright et al., 2020; Hung, 2021; Nouwens et al., 2021; Søndergaard Knudsen et al., 2018; Spencer & Cutting, 2021).

In bilingual contexts, such as Canadian French Immersion (FI) programs, the role of EFs may be particularly important. It has been suggested that bilingual learners maintain increased EF to navigate multiple language systems and integrate cross-linguistic features of language (i.e., phonology, morphology, and syntax) that support both reading (i.e., word reading) and writing (i.e., transcription) skills (Cartwright, 2007; Gottardo et al., 2021). Understanding how EFs contribute to word reading and transcription in both monolingual and bilingual learners could provide further context about the mechanisms that drive writing development in early elementary education.

The present study extends from prior research investigating the predictive relations of EFs, reading, and writing, in early elementary English and FI participants. By exploring the role of EFs in word reading and transcription development, this research seeks to further the general understanding of the associations and interactions between these cognitive and linguistic processes. The following sections will begin by contextualizing EF (i.e., definitions and developmental processes), exploring EF in relation to reading and writing, and finally, investigating these variables in English and FI student populations.

## **Executive Function**

Executive Functions (EFs) are a collection of top-down cognitive processes essential to the regulation of behaviour concerning the attentional allocation, planning, and strategies used to achieve goal-oriented tasks (Miyake et al., 2000; Nouwens et al., 2021). EFs enable individuals to plan, focus attention, manage, and adapt to competing tasks and are used to support varied processes across the lifespan (Colé et al., 2014; Miyake et al., 2000). Though there are competing frameworks regarding the construct of EF, Miyake et al. (2000), and, Miyake and Friedman (2012) have proposed frameworks that operationalize EF in a systematic approach that have been used broadly across reading and writing development studies (Spencer et al., 2020). Miyake et al. (2000) initially presented a three-component model that highlighted working memory, shifting, and inhibition as the core components of EF.

### ***Working Memory***

Working Memory (WM) is the capacity to temporarily store and manipulate information for use in cognitive tasks such as problem-solving, comprehension, and reasoning (Miyake et al., 2000; Miyake & Friedman, 2012). Research has indicated that WM is present and observable in infants as early as five-months of age (Reynolds & Romano, 2016). This basic but apparent WM is observed via retention of information during memory-based tasks, and additionally, neuroimaging studies reveal activity in regions typically associated with WM in adults, including the frontal-parietal network (Reynolds & Romano, 2016). In early childhood to adolescence, research has demonstrated linear growth in WM. For example, Gathercole et al. (2004) observed consistent developmental growth in WM from participants aged 4 to 15 years old. Within early elementary to adolescent age groups, WM is typically assessed by gauging participant's ability to receive oral information, store it, and verbally recall it (i.e., digit and word recall measures) (Gathercole et al., 2004).

### ***Shifting***

Shifting, or cognitive flexibility, refers to the ability to adapt thinking and behaviour to meet the needs of changing tasks, environments, or perceptions (Søndergaard Knudsen et al., 2018). Shifting supports problem-solving and multi-tasking and facilitates the ability to disengage and engage in tasks appropriately (Søndergaard Knudsen et al., 2018). Initial evidence of shifting, like WM, can be observed within the first year of life; however, rapid developments are typically observed in preschool aged children (Buttelmann & Karbach, 2017). Steady increases are then observed throughout childhood and adolescence, mirroring the same growth of neural regions typically associated with EF (i.e., prefrontal cortex) (Buttelmann & Karbach, 2017). Shifting is typically measured by using task switching pattern activities. For example, the Dimensional Change Card Sort task asks participants to organize cards with increasing difficulty in varied orders (i.e., by shape, by colour, etc.) (Zelazo, 2006).

### ***Inhibition***

Inhibition refers to the ability to intentionally suppress dominant, automatic, or irrelevant responses, and instead, focus on task-relevant goals (Miyake et al., 2000). Inhibition is critical for the management of distractions and the regulation of attention (Miyake et al., 2000). Inhibition is present in preschool age children and rapidly develops at this age (Petersen et al., 2016). This development then continues across childhood and adolescence (Petersen et al., 2016). Inhibition is typically measured by assessments that gauge students' ability to intentionally stop a process that is somewhat automatic in nature. For example, the Stroop task asks participants to verbally say the colour of the ink the word is printed in, as opposed to reading the word itself (Stroop, 1935).

Miyake et al.'s (2000) model includes WM, shifting, and inhibition as the core components of EF. These components of EF were initially presented as three separate processes; however, more recently, Miyake and Friedman (2012) expanded on their original model to provide further context about the co-development and interaction between WM, shifting, and inhibition. Miyake and Friedman (2012) proposed that WM and shifting are separate processes, but suggested that inhibition may not be a separate, core component of EF, but instead is a sub-process that supports WM and shifting (Spencer et al., 2020). Both Miyake et al.'s (2000) original three-component model and Miyake & Friedman's (2012) updated two-component model were based on adult populations (Miyake et al., 2000; Miyake & Friedman, 2012). However, both models have been supported in preschool to adolescent populations, leading to uncertainty regarding component separability and integration throughout development at varied ages (Cirino et al., 2018; Lee et al., 2013; Lehto et al., 2003; Wiebe et al., 2008).

In sum, all three components develop within the first few years of life and are associated with neural regions involved in higher-level processing (i.e., prefrontal cortex) (Buttelmann & Karbach, 2017; Gathercole et al., 2004; Petersen et al., 2016). Despite their distinctive functions, these components are interrelated and reflect integrated operation as a part of a cognitive system that facilitates learning across a range of domains (Miyake & Friedman, 2012). Importantly, there is no singular agreed upon model of EF, necessitating further study regarding the interrelation between EF components within different ages and populations.

## **Reading, Writing, and The Reading-Writing Relation**

### ***Reading***

Reading comprehension is a multicomponent cognitive-linguistic process that deciphers meaning from written symbols (D'Angelo et al., 2020). Though varied reading models prioritize the importance of certain variables that drive this process, the widely agreed upon components involved in reading comprehension include word reading, which incorporates both word identification and decoding, as well as linguistic comprehension (i.e., vocabulary knowledge and grammatical understanding) (Cartwright et al., 2020; D'Angelo et al., 2020; Gough & Tunmer, 1986). Word reading, as noted, incorporates word identification, or the automatic recall of memorized information, and decoding skills, or the ability to translate text into meaning. Word reading is an essential skill in early elementary development as it acts as a foundation for broader skill development (Kim, 2017). Developing word reading proficiency necessitates various underlying components including logographic (word recognition based on visual cues), phonological (the process of decoding graphemes, or visuals, into phonemes, or sounds), morphological (the understanding of linguistic structure such as grammar and prefixes), and orthographic skills (rapid and automatic reading) (Kim, 2017). Linguistic comprehension, is defined by Hoover & Gough (1990) as the process of understanding lexical information, connecting and integrating meaning, and the ability to successfully communicate, or translate, that meaning. Vocabulary, listening comprehension, and various other oral language skills have been explored as components of linguistic comprehension (Kim, 2017).

The Direct and Indirect Effects Model of Reading (DIER) is a modern reading comprehension framework that largely builds upon the prominent Simple View of Reading (SVR) model, which originally highlighted reading and linguistic comprehension as the primary

drivers of reading (Hoover & Gough, 1990; Kim, 2017). Though the SVR has been supported across decades, research has indicated that further exploration of the underlying processes supporting word reading and linguistic comprehension is needed (Kim, 2020). The DIER model aligns with the SVR model, but expands beyond the two-factor framework to include underrecognized cognitive and language component skills (Kim, 2020). The DIER model integrates word reading, linguistic comprehension, text-fluency, EF (i.e., working memory, shifting, inhibition), and environmental factors (i.e., socio-emotion, background) into a single, holistic reading comprehension framework (Kim, 2020). The DIER model has been proposed as a modern model for reading comprehension based on its integration of foundational variables and acknowledgement of the hierarchical, dynamic, and interactive relations between them (Kim, 2020). Hierarchically, Kim (2020) clarifies that there are proximal skills, or skills that have direct relation to reading comprehension (i.e., word reading), and distal skills, or skills that have an indirect relation to reading comprehension (i.e., working memory). Dynamically, the DIER model posits that the function of components skills vary based on text characteristics, activity, and development (Kim, 2020). Text characteristics describe the resources allocated to meet comprehension needs (including listening and reading comprehension). Component relations are additionally influenced by activity, such as the type of assessment method being administered (Kim, 2020). Development is a dynamic skill that fluctuates over time. For example, underlying resources (i.e., EFs) are highly activated in early elementary reading skills (i.e., word reading) but may require less activation later over time as foundational processes become more automatic (Kim, 2020). Interactively, Kim (2020) suggests that skills are developed by interacting with other skills and environmental factors, such as socio-emotional factors (i.e., motivation) and background (i.e., content knowledge) (Kim, 2020). The DIER model highlights the role of EF in

reading comprehension via WM, shifting, and inhibition. Moreover, the DIER model emphasizes EFs role in the developmental trajectory of reading, as evidenced by reallocation of resources as skills progress over time. Each EF component maintains its own subset of research in relation to reading development, highlighting the extensive work that has already been accomplished and the gaps that require attention.

**Reading and Working Memory.** WM has been suggested to play a pivotal role in reading comprehension by facilitating the temporary storage and manipulation of language-related information (Kim, 2020). This skill allows readers to keep information (i.e., words, sentences, paragraphs, etc.) in mind and translate it into meaning (Kim, 2020). Kim (2020) notes that WM contributes to reading comprehension by indirectly supporting word reading (through phonological, semantic, and orthographic knowledge) and linguistic comprehension (through vocabulary and grammatical knowledge). Linguistic comprehension, an identified precursor to reading comprehension has been related to WM across several studies. Kim (2015) highlighted WM's role in supporting reading comprehension through vocabulary and syntactic processing. Within this study, 145 early elementary aged, Korean-speaking participants engaged in a battery of language and cognitive measures at one timepoint. The results, acquired from structural equation modeling (SEM) suggested that WM was a foundational cognitive process that indirectly influenced linguistic comprehension (Kim, 2015). In relation to word reading, Hung (2021) explored WM and inhibition in early elementary aged students in Hong Kong ( $n= 165$ ). Findings indicated that WM was a predictor of reading comprehension for beginning readers, and moreover, WM played an indirect role in reading comprehension via syntactic awareness of reading (Hung, 2021). Similarly, a meta-analysis from Peng et al. (2018) suggested that WM was

related to reading comprehension indirectly through decoding and language comprehension, in line with the DIER model (Kim, 2020).

**Reading and Shifting.** Shifting has been suggested to relate to reading in terms of the ability to decode, integrate components of text (i.e., letters, sounds, etc.), and apply strategies of comprehension (Kim, 2020). Shifting in reading comprehension supports readers in developing operations and mental sets (Kim, 2020). This was supported by Søndergaard Knudsen et al. (2018) in their cross-sectional study within third and fourth grade, Dutch-speaking participants. Correlational and regression analysis revealed that shifting was a significant predictor of reading comprehension (Søndergaard Knudsen et al., 2018). Within English-speaking early elementary participants, the role of graphophonological-semantic cognitive flexibility (GSF), or the ability to switch between graphophonological (decoding) and semantic (meaning) components of words, was also explored (Cartwright et al., 2020). The study found that GSF contributed to reading comprehension, both concurrently and longitudinally (Cartwright et al., 2020). Similarly, Altemeier et al. (2008) highlighted the connection between shifting and reading comprehension in fourth grade students, and additionally observed that children with poor reading comprehension often demonstrated decreased flexibility when focusing on word level features of text. This decrease in flexibility was presumed to impair their ability to attend to and integrate meaning (Altemeier et al., 2008). These findings suggest that shifting enables readers to switch between decoding text and interpreting broader contextual or inferential information.

**Reading and Inhibition.** Inhibition has been demonstrated to contribute to reading comprehension by controlling distractions, ignoring unnecessary information, and supporting sustained attention (Kim, 2020). Borella and De Ribaupierre (2014) explored sub-measures of inhibition, including prepotent response inhibition (which blocks dominant responses), resistance

to distractor interference (which supports attention by ignoring irrelevant stimuli), and resistance to proactive interference (which limits the activation of no longer relevant stimuli). These subtypes of inhibition were studied cross-sectionally in participants aged ten to twelve (Grades 4 to Grade 6) (Borella & De Ribaupierre, 2014). Borella and De Ribaupierre (2014) reported that resistance to distractor interference (i.e., actively ignoring unnecessary information) was potentially more important than the other two inhibitory components in relation to reading comprehension. In contrast, Altemeier et al. (2008) found that prepotent response inhibition was correlated with decoding (a key component of reading comprehension) within their dual experiment, longitudinal study within a Grade 1 to Grade 4 participant pool. Overall findings aligned with the DIER model and suggest that there were both direct and indirect relations between EFs and reading comprehension (Altemeier et al., 2008). Moreover, the previously noted Hung (2021) study demonstrated that, in addition to WM measures, prepotent response and cognitive inhibition measures predicted reading comprehension via syntactic awareness within their early elementary education population. Across inhibition and reading comprehension related studies, results suggested that inhibition was an integral process that supported the suppression of irrelevant information to facilitate a coherent mental representation of the text information.

### ***Writing***

Writing, or written composition, is a complex process that requires “generating, translating, organizing, and transcribing” ideas (Kim et al., 2022, p.2). Though varied models prioritize certain variables that drive this process, the widely agreed upon components involved in writing include transcription, which demonstrates the ability to transform phonemes into graphemes, and ideation, which demonstrates the ability to create and organize ideas into text

(Juel et al., 1986). Transcription, as noted, is the physical process of translating sounds into written symbols (Kim & Schatschneider, 2017). Similar to reading comprehension's word reading development, transcription is a foundational skill in early elementary development that acts to facilitate later writing proficiency (Kim & Schatschneider, 2017). This mechanical component of writing is defined by two primary components, including handwriting (or alphabet writing) and spelling (Berninger & Winn, 2006). Handwriting or alphabet writing involves fine motor coordination and demonstrates the ability to match letter sounds to symbols (Berninger & Winn, 2006). Spelling demonstrates the ability to translate spoken language into written form (Berninger & Winn, 2006). Handwriting and spelling are driven by literacy component skills including phonology, semantics, and orthography (Kim, 2019). Ideation (also known as text generation) draws on oral language skills (i.e., vocabulary and grammatical knowledge) to provide the background knowledge needed to create ideas (Kim & Schatschneider, 2017). Oral language skills are then needed to transcribe ideas into word level, sentence level, and paragraph-level text generation (Kim et al., 2018). Practiced writers additionally require high-level planning, self-regulation, and revision skills (Hayes & Flower, 1980).

The conceptualization of writing has evolved significantly over time, shifting from mechanistic views that emphasized transcription (i.e., the simple view of writing model (SVW)) to more integrative models that consider cognitive, linguistic, and EFs (i.e., the not-so-simple view of writing) (Berninger & Winn, 2006; Juel et al., 1986; Kim, 2019; Kim & Park, 2018). The Direct and Indirect Effects Model of Writing (DIEW), similar to its DIER counterpart, acts as a modern, integrative framework that incorporates cognitive, linguistic, and underlying variables that drive the process of writing (Kim, 2019; Kim & Park, 2018; Kim & Schatschneider, 2017). The DIEW model includes additional variables that have been suggested

to influence writing development, both directly and indirectly. These additional variables include topic and discourse knowledge, higher-order cognitive skills (i.e., EFs), reading skills, and socio-emotional components (i.e., motivation) (Kim, 2019). Again, similar to the DIER model, the DIEW model builds off of more simplistic models by exploring the hierarchical, dynamic, and interactive relations between variables (Kim, 2019). Hierarchically, Kim (2019) posits that there are many components of writing that have both direct (i.e., writing and spelling) and indirect (i.e., EFs) effects on writing ability. Dynamically, the DIEW model suggests that component skills change due to developmental shifts. For example, in early elementary stages of development, transcription skills are more effortful tasks and may require increased activation of EFs to support the multi-variable process of writing (Berninger & Winn, 2006). As transcription becomes more automatic, these underlying resources can then be reallocated to support higher-level tasks, such as ideation (Berninger & Winn, 2006). Similar to the DIER model, Kim (2019) suggests that writing development is additionally influenced by the interaction between these variables and environmental factors, such as socio-emotional factors (i.e., interest) (Kim, 2019). The DIEW model acts to extend the theoretical framework beyond the mechanical process of writing and highlights the role of EFs (WM, shifting, and inhibition) (Kim, 2019; Kim & Park, 2018; Kim & Schatschneider, 2017a). Each EF component maintains its own subset of research regarding writing development, highlighting the extensive work that has already been accomplished and the gaps that require attention.

**Writing and Working Memory.** WM has been explored in relation to writing composition and its development, and has been suggested to play an important role in the ability to facilitate and execute multiple processes (i.e., planning, organizing, transcription) at the same time (Kim, 2019). McCutchen (1996) notes that WM is heavily used when transcription is still

effortful (typically in early elementary age-levels). If transcription skills are not developed, WM is not available to support higher-order processes (i.e., ideation) (McCutchen, 1996). Similarly, Abbott and Berninger (1993) explored writing-related development in a cross-sectional study within early elementary and intermediate elementary (Grade 1 to Grade 6) students ( $n= 600$ ). Abbott and Berninger (1993) noted that transcription skills (i.e., alphabet writing and spelling) in early elementary was a strong indicator of writing fluency. Results from this study aligned with theories regarding WM's involvement in early elementary transcription and the eventual reallocation of this underlying skill to other processes (i.e., content organization) in intermediate elementary writing (Abbott & Berninger, 1993). Moreover, Salas and Silvente (2019) conducted a cross-sectional study, across students aged 7.5- 13.6, in beginner (Grade 2), low-intermediate (Grade 4), and upper-intermediate (Grade 8) classrooms ( $n= 1337$ ). Seeking to explore the impact of transcription skills and EFs on text generation ability, Salas and Silvente (2019) reported that WM had both direct and indirect effects on text generation.

**Writing and Shifting.** Shifting plays an integral role in writing development by supporting the ability to shift between tasks, strategies, and frameworks (Berninger, 1999). Empirical evidence suggests that students with higher levels of cognitive flexibility develop more proficient writing ability due to an increased capacity to plan, draft, and revise transcription (Diamond, 2013; Hayes & Berninger, 2014; Kim, 2019). Shifting develops throughout childhood and adolescence allowing increased ability to navigate linguistic components including grammar, content, and varied perspectives (Cartwright et al., 2020; Gathercole et al., 2004). Rocha et al. (2022) demonstrated this within their longitudinal study across Grade 4 and Grade 5 (9.09 to 11.25 years old) Portuguese-speaking students ( $n= 222$ ). Results indicated that transcription and EFs (specifically EF and shifting) in Grade 4 contribute to, and were significant predictors of,

later production of written text in Grade 5. Across this older elementary age group, it was noted additionally that shifting in Grade 5 was a significant, concurrent predictor of writing quality in Grade 5 (Rocha et al., 2022). This finding indicated that shifting supported the management of switching between lower and higher-level processes and was an essential skill in writing development (Rocha et al., 2022).

**Writing and Inhibition.** Inhibition supports writing development by fostering task-relevant attention and suppressing unnecessary information (Borella & De Ribaupierre, 2014). Pazeto et al. (2014) reported that inhibition was significantly related to early writing abilities longitudinally across preschool to kindergarten aged children (four to six years old). This EF component was posited to support students in concentrating on the mechanical aspects of writing (i.e., letter formation) (Pazeto et al., 2014). Moreover, Salas and Silvente (2019), in addition to WM, reported that inhibition had direct and indirect effects on text generation. Salas and Silvente (2019) suggested that inhibition supported writing by suppressing alternative incorrect or unnecessary information (i.e., incorrect letter forms), or by limiting prepotent responses (Borella & De Ribaupierre, 2014). Some research regarding inhibition has suggested that it maintains varied developmental patterns, compared to WM and shifting. Rocha et al. (2022) noted that stable, but less growth in inhibition occurred between Grade 4 and Grade 5 compared to WM and shifting development. However, inhibition, in addition to transcription and shifting, were concurrent predictors of written composition in Grade 5 participants (Rocha et al., 2022). This finding indicated that inhibition, though perhaps somewhat developmentally varied, was an essential skill in task focus and distraction avoidance during composition in later elementary ages.

### ***The Reading-Writing Relation***

The DIER and DIEW models provide dynamic, hierarchical, and interactive pictures of reading comprehension and writing development and highlight the importance of both proximal and distal skills (Kim, 2019, 2020). Importantly, these models highlight the relation between reading and writing processes. Though it is important to understand these processes separately, the shared variance between reading and writing are reported to be as high as 50% (Fitzgerald & Shanahan, 2000; Savage et al., 2017). Reading and writing are both multidimensional processes that interact and influence one another (Berninger, 1999; Puranik & AlOtaiba, 2012). Research suggests that development in one skill subsequently supports development in the other, as they share and are supported by the same cognitive and linguistic processes (Shanahan & Lomax, 1986).

As noted in the previous sections, there are components in both reading and writing that are particularly relevant in early elementary aged development, as this period establishes foundational reading and writing skills. Within reading, word reading (including word reading and decoding), and within writing, transcription (including alphabet writing and spelling) act as building blocks to support future linguistic development. Word reading and transcription components develop in tandem and have high correlation rates (typically above  $r = .70$ ). (Ehri, 2020). Word reading entails logographic (i.e., early recognition of visual cues or graphemes), phonological (i.e., phoneme identification and grapheme-phoneme correspondence), morphological (i.e., understanding of linguistic structure), and orthographic (i.e., automatic identification) knowledge (Ehri, 2005; Shahar-Yames & Share, 2008). Within the early elementary education period, students' progress from relying predominantly on phonological knowledge to orthographic knowledge (Kim, 2017; Perfetti & Stafura, 2014). This demonstrates an increase in automaticity and capacity to further development (Kim, 2017; Perfetti & Stafura,

2014). Word reading is a foundational building block of reading comprehension (Gottardo et al., 2021; Perfetti & Stafura, 2014). Moreover, early elementary education reading components (i.e., pre-reading skills, word reading, vocabulary, etc.) have been demonstrated to support, and predict, later writing development (Dunsmuir & Blatchford, 2004; Hooper et al., 2010).

Transcription, similar to word reading, relies on logographic (i.e., early ability to transcribe recognized visual cues or graphemes), phonological (i.e., grapheme identification and phoneme-grapheme correspondence), morphological (i.e., transcription of linguistic structure), and orthographic (i.e., automatic transcription) knowledge (Ehri, 2000, 2005; Shahar-Yames & Share, 2008). Transcription abilities are highly correlated with later writing quality (Kim, 2020). Moreover, early elementary education transcription has been demonstrated to support reading comprehension by developing phonological decoding skills and reinforcing orthographic representations (Conrad, 2008; Conrad & Deacon, 2016; Ehri, 2020). Word reading and transcription appear to be interdependent skills that draw upon similar cognitive and linguistic processes in different ways. For example, word reading utilizes grapheme-phoneme relations to interpret sounds from text, and conversely, transcription utilizes phoneme-grapheme relations to interpret text from sound (Ehri, 2000). Research suggests that early elementary reading-writing relation acts to support future linguistic development.

Overall, the DIER and DIEW model, as well as current research demonstrate correlations between EFs (WM, shifting, and inhibition), reading comprehension, and writing development (Abbott & Berninger, 1993; Altemeier et al., 2008, 2008; Borella & De Ribaupierre, 2014; Cartwright et al., 2020; Hayes & Berninger, 2014; Hung, 2021; Kim, 2019; McCutchen, 1996; Pazeto et al., 2014; Peng et al., 2018; Salas & Silvente, 2019, 2019; Søndergaard Knudsen et al., 2018). Moreover, the reading-writing relation highlights the importance of understanding these

processes both individually and interactively, and emphasizes the bidirectional development of word reading and transcription in early elementary education as significant indicators of future literacy skills (Ehri, 2000).

Despite insights gleaned from these models as well as the referenced literature, it is apparent that there is far more available research exploring EF and reading comprehension compared to EF and writing development, specifically in early elementary aged participants. Additionally, the importance of the reading-writing relation in early elementary education has been stated; however, there is a gap in research regarding the role of EF in relation to word reading and transcription acquisition. To support increased knowledge within this domain, further study regarding early elementary word reading, transcription, and EF interaction, as opposed to EF and reading or EF and writing is needed. Moreover, though cross-sectional study designs are commonly employed, longitudinal study designs regarding reading, writing, and EF might better illustrate developmental trajectories and more accurately identify temporal, predictive, and developmental relations between variables. Additionally, many studies within elementary aged groups vary in the participant population language base (i.e., Chinese Cantonese, Spanish, Danish) (Hung, 2021; Salas & Silvente, 2019; Søndergaard Knudsen et al., 2018). Further study regarding multilingual studies could provide more accurate insights into understanding cognitive, linguistic, and cultural impacts on reading, writing, and EF development.

### **Bilingual Linguistic Development**

The interplay between reading, writing, and EFs, as noted, have been explored in monolingual populations, and more recently, research has extended this research into in bilingual populations. Bilingual learners, in contrast to monolingual students, are exposed to two

languages throughout their education to develop broader linguistic proficiency (Bérubé et al., 2022). Within the research field, monolingual and bilingual groups are often referred to as first language (L1) and second language (L2) learners (Bérubé et al., 2022). Within the Canadian education system, French Immersion (FI) programs are offered as bilingual education opportunities, aimed at building practical bilingualism in both English and French (Bérubé et al., 2022). First established in the 1960s, publicly available FI programs addressed the linguistic needs of a dual-language country (Bérubé et al., 2022). Though English is the most broadly used language nationally, there are many French-speaking regions, the largest majority of which within the province of Quebec (Genesee & Jared, 2008). All FI programs follow the same curriculum structure. Within early elementary education, across all subjects, students receive 100% of their instruction in French (Savage et al., 2017). This includes verbal instruction, vocabulary, phonics, etc. (Savage et al., 2017). By focusing on French in early development, students are able to develop a strong French language foundation, while informally developing an English foundation external to education settings (i.e., at home, in their community). In Grade 4, English instruction is introduced and gradually increased throughout the remaining elementary education curriculum (Savage et al., 2017). By the end of elementary education, English and French instruction is equally balanced (Savage et al., 2017). The aim of this curriculum structure is to allow students to develop meaningful aptitude in both languages (Bérubé et al., 2022; Genesee & Jared, 2008; Savage et al., 2017).

### ***Cross-Linguistic Transfer***

Throughout historical research regarding monolingual and bilingual populations, empirical evidence indicates that L1 and L2 learners draw upon the same underlying cognitive and linguistic processes to support reading and writing development (Cummins, 1979). The

Linguistic Interdependence Hypothesis, a framework still utilized in modern research, suggests that cognitive and linguistic skills developed in one language (L1) can transfer to another language (L2) via underlying, foundational systems (Cummins, 1979). As noted, these shared underlying skills include phonological, morphological, and orthographic knowledge among others. Reading comprehension-based studies including Deacon et al. (2007) and D'Angelo et al. (2020) validated this framework across early elementary education, FI population-based studies. Deacon et al. (2007) demonstrated that morphological awareness contributed to both English and French reading development in bilingual participants. Notably, the degree of morphological impact on L1 (English) and L2 (French) reading skill development occurred at different times, suggesting that morphological awareness shifts as reading skills mature (Deacon et al., 2007). Similarly, D'Angelo et al. (2020) noted that poor comprehension in L1 (English) could contribute to poor comprehension in L2 (French). In contrast to the number of reading comprehension related studies in bilingual learning environments, there is less research available regarding writing in bilingual environments. Savage et al. (2017) spoke to this gap and provided evidence to support the reading-writing relation via their longitudinal, elementary education (kindergarten and Grade 1 to Grade 6), FI population-based study. Savage et al. (2017) noted that early reading sub-measures (i.e., decoding) predicted later writing accuracy. Moreover, early sentence formulating (the ability to orally create sentences using prompts) predicted later writing accuracy both within and cross-linguistically (Savage et al., 2017). Moreover, Chung et al. (2023) additionally explored the reading-writing relation in their FI population-based study. Chung et al. (2023) explored orthographic development across L1 (English) and L2 (French) reading (word reading and decoding) and transcription (spelling) in early elementary education. Chung et al. (2023) noted that English word reading and spelling contributed to later

orthographic development in both L1 (English) and L2 (French). The researchers noted that this interaction occurred temporally; word reading in Grade 1 and spelling in Grade 2 contributed to orthographic knowledge in Grade 3, within and across languages (Chung et al., 2023). These studies emphasise the impact of cross-linguistic transfer of skills. Moreover, they demonstrate the importance of shared reading and writing resources as well as their contribution to the development of future linguistic achievement.

### ***Bilingual Development and EFs***

Bilingual students utilize phonological, morphological, and orthographic skills to support the development of multiple languages. EFs (including WM, shifting, and inhibition) have been explored as underlying processes to support the acquisition of multiple language learning (Barbu et al., 2019; Deacon et al., 2007; Nicolay & Poncelet, 2013, 2015). Bilingual learners have been suggested to demonstrate increased EF skill capacity compared to their monolingual peers (Nicolay & Poncelet, 2013, 2015). These finding suggests that bilingual learners may require increased EF support in order to manage and navigate multiple linguistic systems. Research explores bilingual development in terms of WM, shifting, and inhibition, across age groups, to determine developmental trajectories. WM, a skill that supports the holding and manipulation of information, has been suggested to support the facilitation of cross-linguistic transfer by integrating L1 and L2 linguistic structures (Kim & Schatschneider, 2017). Shifting has been theorized to enable students to switch between, and adapt to, varied linguistic structures. Though some studies report higher shifting (or cognitive flexibility) proficiency in bilingual students versus their monolingual peers in early elementary age students, other studies have demonstrated non-significant group differences (Barbu et al., 2019; Nicolay & Poncelet, 2013). Though Nicolay & Poncelet (2013) and Barbu et al. (2019) report findings on studies similar in

population (i.e., early elementary, French-speaking monolinguals and English immersion program bilinguals) differences in results were attributed to reduced exposure to immersion programs at the early elementary age, and thus, minimal time to develop or engage in consistent use of both languages (Barbu et al., 2019; Bialystok & Barac, 2013). Moreover, differences could be indicative of the evaluation tools used, and their potential limitations in detecting cognitive differences (Barbu et al., 2019). Inhibition is a skill that is theorized to support bilingual students in managing interference and suppressing unnecessary information from the linguistic system not currently being used. Bialystok and Martin (2004) explored inhibition in a three-part experimental study design. The first study examined monolingual (English) and bilingual (Cantonese-English) early elementary aged students ( $n= 67$ ). The second study examined monolingual (English) and bilingual (French-English) early elementary aged students ( $n= 30$ ). The third study examined monolingual (English) and bilingual (Mandarin or Cantonese-English) early elementary aged students ( $n= 53$ ). Results from all three studies identified that bilingual students exhibited better inhibitory control in ignoring non-essential information (Bialystok & Martin, 2004). In sum, extensive research has been conducted to explore the relations between bilingual development and underlying EF contribution in linguistic development.

Despite advancements in understanding the interplay between EF, reading, and writing in bilingual learners, several notable gaps remain. First, while reading comprehension in monolingual and bilingual populations has been widely examined (i.e., D'Angelo et al., 2020; Deacon et al., 2007) there is less research regarding the writing development of these populations. Savage et al. (2017) and Chung et al. (2023) communicated important findings regarding the reading-writing relation and highlighted the need for further comparative,

longitudinal study to explore cross-linguistic aspects of writing development. Second, though EFs have been suggested to be increased in bilingual populations, results of such findings vary (Barbu et al., 2019; Nicolay & Poncelet, 2015). Additionally, the temporal development of EF in bilingual versus monolingual students is uncertain. Employing comparative, longitudinal studies could be used to explore EF development, including predictive patterns and proficiency levels, in monolingual and bilingual populations. Third, research regarding EFs within the Canadian FI populations is limited. Though results from other studies can be generalized, varied immersion programs follow different curricular protocol. Whereas Canadian FI programs are facilitated using French as the sole instructional language until Grade 4, Nicolay & Poncelet (2013) describe their participants receiving English and French consistently throughout their education, switching weekly (i.e., English one week, French the next, etc.). Further study could explore comparative, longitudinal studies that include FI specific bilingual participants to obtain more accurate results regarding the developmental trajectories of students withing Canadian education programs. Lastly, there is a gap in research regarding the integration of cross-linguistic reading and writing-based studies and EF-based studies. Combining these two research focuses, in a comparative, longitudinal study could provide a more comprehensive understanding regarding EFs role in predicting and mediating the reading and writing development of early elementary education.

## **Executive Summary and the Present Study**

### ***Problem Statement***

Despite available research regarding the reading, writing, the reading-writing relation, EFs, and second-language learners, gaps in understanding remain. First, it is evident that research disproportionately focuses on EF and reading comprehension as opposed to EF and

writing development, specifically within early elementary populations. Though research regarding reading, EF, and reading comprehension is essential, more information is needed regarding EF and writing development, in varied instructional environments (i.e., English and FI). This gap is further exemplified by increasing research that highlights the reading-writing relation (Chung et al., 2023; Savage et al., 2017). It is apparent that many studies that seek to address the role of EF in relation to reading, and EF in relation to writing often occur separately in isolation. More research is needed to address the interaction between early elementary EF, reading, and writing development. The second notable gap in literature is the high use of cross-sectional design. While cross-sectional study design provides a singular image of cognitive and linguistic relations, they cannot capture the developmental trajectories of EFs, reading, and writing development over time. Future study could employ longitudinal study design to identify temporal, predictive, and developmental relations between variables. Moreover, this study design could contribute to general understanding regarding the extent to which EF develops within students of differing instructional environments, such as English and FI, over time. The third notable gap in the literature lies in the diversity of linguistic context across studies. Many studies that address early elementary EF and literacy development maintain varied language bases, including Chinese Cantonese, Spanish, and Danish speakers (Hung, 2021; Salas & Silvente, 2019; Søndergaard Knudsen et al., 2018). While diversity can be beneficial in providing generalizability of results, research also highlights that results can vary based on language of study. Similarly, research regarding monolingual and bilingual EF development differ in language context (Barbu et al., 2019; Nicolay & Poncelet, 2013). To provide the most accurate understanding of early elementary EF, reading, and writing development in the Canadian FI context, future research could explore the trajectory of these variables by employing

comparative, longitudinal study of Canadian English program and Canadian FI program participant pools. Finally, there is a significant gap in research integrating EF-based studies with cross-linguistic reading and writing research. By combining these two areas in a comparative, longitudinal study, results could provide a comprehensive understanding of how EF mediate and predict reading and writing development in learners across varied instructional environment groups. An integrated approach could additionally clarify the dynamic interdependencies between cognitive and linguistic systems.

In sum, there is a great deal of available research regarding reading, writing, and EF in monolingual and bilingual participant pools; however, to our knowledge, there are no available studies that seek to explore the development of EFs (including WM, shifting, and inhibition) role in the reading-writing relation, in the early elementary, Canadian English and FI instructional environment populations. By conducting a study that addresses these variables, gaps in literature could be addressed, and could contribute to further evidence-based practices to support the literacy development of student in varied educational contexts.

### ***Purpose of the Current Study***

Based on the findings of historical and recent research, as well as the identified gaps in the literature, impactful results could be acquired from a study seeking to further understand the developmental associations between EFs, reading, and writing ability, both within and cross-linguistically. The present study aims to address these gaps in understanding by reporting on a two-year longitudinal study within both English and FI instructional environment groups. The purpose of this study is to explore word reading, transcription, and EF sub-measures longitudinally (from Grade 1 to Grade 2) to address developmental predictors within English and FI student populations. The research questions were developed to explore these developmental

building blocks both within, and cross-linguistically, to determine whether these variables predict development in the same way. This research aims to advance our understanding of the cognitive and linguistic mechanisms that underpin writing development in early elementary education.

### ***Research Questions***

The research questions include (a) does EF (WM, shifting, and inhibition) mediate the relation between Year 1 (Y1) Reading (word reading and pseudoword decoding) and Year 2 (Y2) Transcription (spelling and alphabet writing) within English and FI participant groups, and (b), does Y1 English Reading (word reading and pseudoword decoding) predict Y2 French Transcription (spelling, alphabet writing), and moreover, is this relation mediated by EFs (WM, shifting, and inhibition).

### ***Hypotheses***

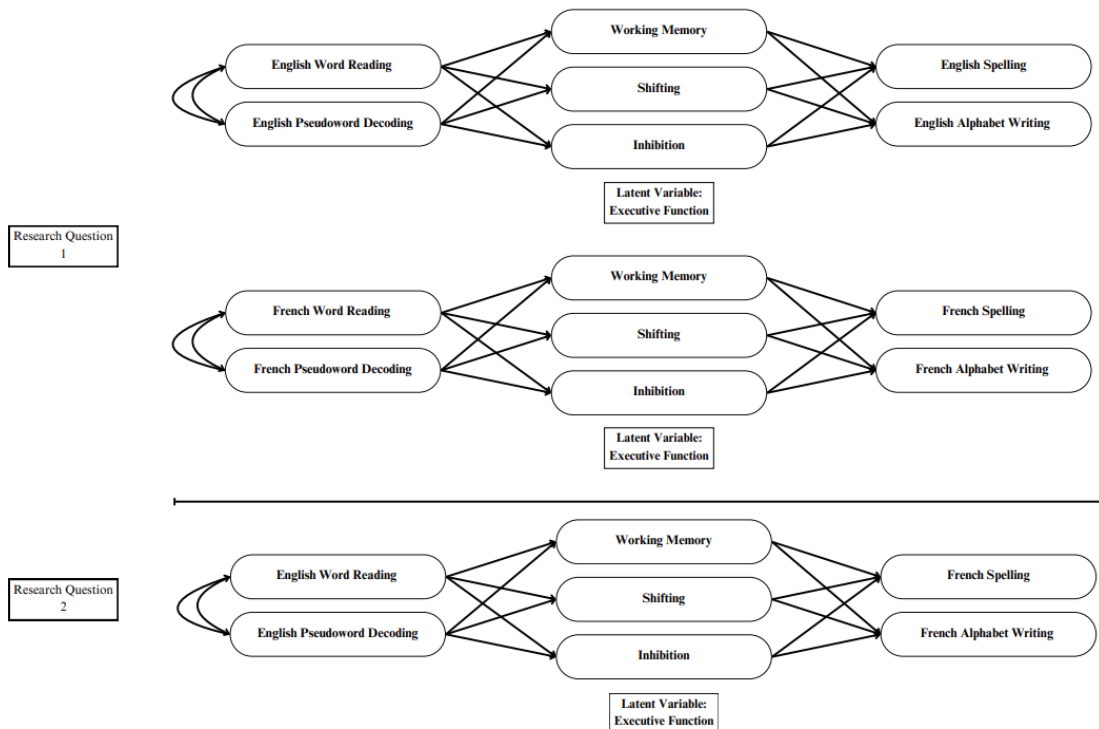
For the first research question, I predict that EF will significantly mediate the relation between Y1 Reading (word reading and decoding) and Y2 Transcription (spelling and alphabet writing) in both FI and English participant groups. For the second research question, I predict that Y1 English Reading will significantly predict French Y2 Transcription and moreover, EF will mediate this relation.

- H1a: WM mediates the predictive relation between Y1 Reading and Y2 Transcription within both English and FI groups.
- H1b: Shifting mediates the predictive relation between Y1 Reading and Y2 Transcription within both English and FI groups.
- H1c: Inhibition mediates the predictive relation between Y1 Reading and Y2 Transcription within both English and FI groups.

- H1d: EF mediates the predictive relation between Y1 Reading and Y2 Transcription within both English and FI groups.
- H2a: Y1 English Reading predicts Y2 French Transcription within the FI group.
- H2b: WM mediates the predictive relation between Y1 English Reading and Y2 French Transcription within the FI group.
- H2c: Shifting mediates the predictive relation between Y1 English Reading and Y2 French Transcription within the FI group.
- H2d: Inhibition mediates the predictive relation between Y1 English Reading and Y2 French Transcription within the FI group.
- H2e: EF mediates the predictive relation between Y1 English Reading and Y2 French Transcription within the FI group.

**Figure 1**

*Proposed Analysis Model: Research Questions and Hypotheses*



### **Methodology**

This study utilized a longitudinal, between-group research design that worked to observe and track changes to the dependent variables over time. This study was a subset of Dr. Gina Harrison's SSHRC supported, five-year longitudinal study. Dr. Harrison's study seeks to examine FI and English group EF as well as reading (at year one, three, and five) and writing (at year two and four), using a variety of norm-referenced measures. The present study only included two timepoints (Y1 and Y2) and was specific to the word reading, transcription, and EF measurements.

### **Procedures**

This research study was approved by the University of Victoria's (UVic) Research Ethics Board (#22-0593), Sooke School District's Ethics Department, and Victoria School District's Ethics Department. Sooke and Victoria were selected due to their proximity to the research team, and the varied locations of their schools, ranging from urban to rural/ remote. All participant's parents or guardians were provided with written informed consents, and students were provided with oral assent prior to any participation in the study, per British Columbia's Freedom of Information and Protection of Privacy Act (FOIPPA). Participation was voluntary and all participants were provided with the option to stop at any time.

Y1 recruitment and consent processes included (a) the Principal Investigator (PI) contacted individual school principals, (b) the PI contacted the Grade 1 classroom teachers at the participating schools to ask if they are able to involve their students in this study, (c) the PI followed-up with interested teachers with an information letter and arranged a time to drop off the Parent Consent Forms to distribute to the students, (d) the classroom teachers distributed the Parent Consent Forms to their students to take home to their parents, (e) the returned and signed

Parent Consent Forms were collected and participant lists were created, and (f) prior to conducting any assessment, a research team member reviewed and obtained oral assent to participate from each student. Y2 recruitment and consent procedure included (a) the PI contacted the Grade 2 teachers of the students who participated in the study at Y1, in Grade 1 with an introductory email, (b) the PI followed-up with interested teachers with an information letter and arranged a time to distribute Parent Consent Forms to all students, including any new students who did not participate previously, (c) the classroom teachers distributed the Parent Consent Forms to their students to take home to their parents, (d) the returned and signed Parent Consent Forms were collected and participant lists were created, and (e) prior to conducting any assessment, a research team member reviewed and obtained oral assent to participate. Across Y1 and Y2, after parental consent was obtained, participants were divided into either the FI group or the English group, based on their classroom's primary form of curriculum instruction. English literacy measures were administered to the English group participants and both English and French measures were administered to the FI students only.

Data was collected between February and June 2023 (Y1) and February and June 2024 (Y2). Data was collected by trained research assistants (RAs). Bilingual (English and French speaking) RAs administered both English and French measures. English speaking RAs administered only English assessments. The assessments were conducted individually, in quiet rooms within each school. Order effects were addressed by creating six differently ordered versions of the assessment measures (FI and English booklets A through F). The RAs selected each booklet at random directly before administration. Each administration of the measures included in this study took 25 minutes total.

## Participants

Y1 participants included 112 Grade 1 students, recruited from 6 schools. The sample included 61 students (42 female, 19 male) in the FI group, and 51 students (25 female, 26 male) in the English group. There was no significant difference in age between the FI (mean = 81.89 months,  $SD = 3.73$ ) and English (mean = 82.18 months,  $SD = 3.61$ ) students. As the present study is based on developmental growth, only participants who completed Y1 and Y2 measures were included in the longitudinal analysis. Continuing Y1 to Y2 participants included 67 consenting Grade 2 students recruited from 7 schools. The sample included 36 students (22 female, 14 male) in the FI group, and 31 students (15 female, 16 male) in the English group. There was no significant difference in age between the FI (mean = 93.39,  $SD = 3.73$ ) and English (mean = 93.64,  $SD = 4.2$ ) students. See Table 1 for an overview of participant information.

Within the Sooke School District catchment area, based on 2021 census data, the total population was 15,086 (Government of British Columbia, (n.d.)). Median after-tax income for families (average family size of 2.9) in 2020, was \$93,000 (Government of British Columbia, (n.d.)). Regarding primary languages, there were 13,635 reported English only households, five French only households, 1,350 English and French, and ten neither English nor French households (Government of British Columbia, (n.d.)). Within the Victoria School District catchment area, based on 2021 census data, the total population was 91,867 (Government of British Columbia, (n.d.)). Median after-tax income for families (average family size of 2.5) in 2020, was \$88,000 (Government of British Columbia, (n.d.)). Regarding primary languages, there were 76,660 reported English only households, 35 French only households, 11,735 English and French households, and 685 neither English nor French households (Government of British Columbia, (n.d.)). Demographics were reported using publicly available census data from British

Columbia (Government of British Columbia, (n.d.). Census data, conducted every five years, provides general demographic information about small geographical areas. These variables provided a broad contextual understanding of the participants' communities without requiring direct personal data collection.

### **Inclusion and Exclusion**

At Y1 (Grade 1) and Y2 (Grade 2), students in FI and English academic instructional programs were recruited. Due to the diversity of learners in today's classrooms, no children were excluded from participation.

**Table 1**

*Overview of Participants*

<i>Year</i>	<i>Gender</i>	<i>English Program</i>	<i>French Program</i>	<i>Total</i>
<b><i>Y1 Total</i></b>	Female	26	42	68
	Male	25	19	44
	<b>Total</b>	<b>51</b>	<b>61</b>	<b>112</b>
<b><i>Y2 Total</i></b>	Female	36	49	85
	Male	58	47	105
	<b>Total</b>	<b>94</b>	<b>96</b>	<b>189</b>
<b><i>Y2 Returning</i></b>	Female	10	15	25
	Male	21	21	42
	<b>Total</b>	<b>31</b>	<b>36</b>	<b>67</b>

*Note.* Y1 total participants = 112, Y2 total returning participants = 67

### **Measures**

The instrumentation selected for this study were sub-measures of norm-referenced, standardized assessments. The internal consistency of these measures is high, with coefficients reported in the upper .80's and .90's. Across all measures starting and stopping rules as well as the basals and ceilings were determined as described in the test manuals (Delis et al., 2001; Korkman et al., 2012; Wechsler, 2003, 2005, 2009). All EF, word reading, and transcription

measures were scored using the scoring rules described by each respective sub-measure, apart from Alphabet Writing (see below for further detail). Standardization of scores was accomplished by using the respective sub-measure conversion manuals or via z-score calculations, followed by conversion into standardized scores using a psychometric conversion table (in cases where the manuals norm-referenced standards scores did not have the correct age of comparison (Delis-Kaplan Executive Function System Color-Word Interference Test) or where scoring rules were slightly altered to encourage more precise between group comparison (Wechsler Individual Achievement Test Alphabet Writing sub-measure). Statistical Package for Social Sciences (SPSS) was used to process the collected data and address the study research questions.

In Y1, Grade 1 participants completed word reading (word reading and pseudoword reading) and EF (WM, shifting, and inhibition) sub-measures. In Y2, Grade 2 participants complete transcription (spelling and alphabet writing) and EF (WM, shifting, inhibition) sub-measures. FI participants complete both English and French measures. In contrast, English participants only completed English measures. All EF measures were administered in English.

*EFs.* Working Memory was assessed using sub-measures of the Wechsler Intelligence Scale for Children- Fourth Edition (WISC-IV) including the Digit Span Backward and the Letter-Number Sequence measure (Wechsler, 2003). The Digit Span Backward measure asked students to repeat numbers in the reverse order to that which was verbally presented by the examiner. The Letter-Number Sequence measure asked participants to report back a series of letters numbers (again, provided verbally by the examiner) first by reporting the numbers in ascending order followed by the letters in alphabetical order. Note that in Y1, only the Digit Span Backwards measure was administered. The Letter-Number Sequence measure was included

in Y2. Shifting was assessed using the Neuropsychological Assessment, Second Edition (NEPSY-II) Shapes sub-measure and the Delis-Kaplan Executive Function System (D-KEFS-II) Category Switching sub-measure (Delis et al., 2001; Korkman et al., 2012). The Shapes sub-measure contained three tasks including naming, inhibition, and shifting. Shifting was assessed using the naming and shifting tasks, as well as the total errors name across the Shapes sub-measure. The naming task asked participants to verbally identify the name of the shape of an object (either circle or square) on a list as quickly as possible. The shifting task used the same object list but asked participants to verbally report on the name of the shape, depending on its colour. For example, if the circle was black, they were to name the opposite shape. If it was white, they were to name the shape that it actually was. The D-KEFS-II Category Switching sub-measure asked participants to name as many items that belong within two groups (i.e., furniture and fruit), switching back and forth (i.e., desk, grape, chair, etc.) as they could in 60-seconds. Inhibition was assessed using the D-KEFS-II Color-Word Interference Test and the NEPSY-II Inhibition sub-measure (Delis et al., 2001; Korkman et al., 2012). The D-KEFS-II Color-Word Interference Test asked participants to review a list of words and verbally report the colour of the ink that each word was printed in, as opposed to reading the word itself (Delis et al., 2001). The NEPSY-II Inhibition sub-measure used the same object list as the shifting measures but asked participants to verbally report on the opposite name of each object (Korkman et al., 2012). In sum, the EF measures took approximately ten minutes total to administer.

***Word Reading.*** To address French word reading, the Wechsler Individual Achievement Test- Second Edition- French Version (WIAT-II FR) Word Reading and Pseudoword Decoding sub-measures were administered (Wechsler, 2005). For the Word Reading measure, participants were asked to pronounce letter names and real words from a graded word list. To address

pseudoword reading, the WIAT-II FR Pseudoword Decoding sub-measure was administered (Wechsler, 2005). Participants were asked to phonetically read non-words from a graded list. English word reading was assessed using the Wechsler Individual Achievement Test- Third Edition (WIAT-III) Word Reading sub-measure (Wechsler, 2009). Participants were asked to pronounce letter names and real words from a graded word list. To address pseudoword reading, the WIAT-III Pseudoword Decoding sub-measure was administered. Again, participants were asked to phonetically read non-words from a graded list. English and French word reading measures (word reading and pseudoword reading) took approximately five minutes respectively to complete.

***Transcription.*** The WIAT-II FR French Spelling sub-measure was used to assess spelling (Wechsler, 2005). This measure asked students to write letters and word spellings from dictation (Wechsler, 2005). The WIAT-II FR Alphabet Writing sub-measure was used to assess French alphabet writing (Wechsler, 2005). The Alphabet Writing sub-measure asked participants to write as many letters, in alphabetical order, that they could in 15-seconds. The WIAT-III English Spelling sub-measure was administered for English spelling (Wechsler, 2009). Similar to the French sub-measure, the WIAT-III Spelling sub-measure asked participants to write letter and word spellings from dictation (Wechsler, 2009). The WIAT-III Alphabet Writing sub-measure was used to assess English alphabet writing dictation (Wechsler, 2009). In contrast to the French Alphabet Writing sub-measure, the WIAT-III asked participants to write as many lowercase letters, in alphabetical order, as possible that they could in 30-seconds (Wechsler, 2009). To create more opportunities for comparison across English and French groups, this measure was administered using the WIAT-III 30-second time limit. English and French transcription tasks took approximately ten minutes, respectively.

## Results

Within the results section, pre-analysis and attrition will be included first to identify outlying scores and to explore performance between continuing and non-continuing participants. Descriptive statistics will then be presented to summarize students' performance across all of the measures, followed by correlational analysis across all measures, run separately for the English and FI instructional environment groups. Linear regression analysis, using composite scores, will then be presented to determine the predictive strength between variables in both the English and the FI groups and will act as the foundation for subsequent mediation analysis.

To directly address the study's primary research questions regarding the role of EF in mediating early reading and transcription, mediation analysis will be presented. Though initially structural equation modeling (SEM) was attempted, after completing exploratory factor analysis, it was clear that the data set was not suitable for SEM or pathway analysis (further details are included in the limitations section). The presented mediation analysis, referred to as the linear regression-based approach, is an alternative to SEM or pathway analysis and will act as a theoretical exploration of predictive and mediative relations between variables (Baron & Kenny, 1986; Tibbe & Montoya, 2022; Zhao et al., 2010). This will be used to determine EFs role in mediating early reading and transcription skills across the English and FI instructional environment groups.

### Pre-Analysis

Prior to analyzing the longitudinal data, preparation of the data and pre-analysis was required. First all Y1 and Y2 data ( $n= 112$ ) was standardized and cleaned to identify incomplete and missing data. All missing scores were attributed to English participants not completing French measures or noted behavioural or academic barriers that impacted the successful

completion of the sub-measure. Outliers were then identified via boxplots and were explored. Each outlier demonstrated natural academic performance variation that occur in early elementary inclusive education settings (i.e., “not yet meeting” to “exceeding” grade level expected performance) (*A Parent’s Guide to Effective Reading: Grades 1 to 3.*, n.d.). This was not unexpected as the inclusion criteria of the study was open to all students. All scores were double-checked to ensure scoring accuracy and were included in the data set and act to represent current inclusive classroom settings (*A Parent’s Guide to Effective Reading: Grades 1 to 3.*, n.d.). Lastly, Skewness and Kurtosis analyses were conducted. Across all variables, acceptable levels of normality were observed. Skewness values ranged from -0.94 to 1.23 (*SE* = 0.23 to 0.40), and kurtosis values ranged from -2.0 to 2.3 (*SE* = 0.45 to 0.78), which fall within the acceptable range for normality ( $\pm 2$ ). The only value slightly above the range of normality was the kurtosis score for Y2 French Alphabet Writing (2.3); however, this was only a marginal difference and therefore, no variables required transformation.

**Attrition**

Y1 and Y2 participant data has been outlined above within the methods section. Table 2 displays the means and standard deviations of Y1 sub-measures within English non-continuing (NC), English Continuing (C), FI NC, and FI C participant groups. An Analysis of Variance (ANOVA) revealed that none of the differences in Y1 scores, between NC and C groups, were significant.

**Table 2**

*Attrition: Y1 Score Differences Between Non-Continuing and Continuing Participants*

Y1 Measures	English NC <sup>a</sup>		English C <sup>b</sup>		FI NC <sup>c</sup>		FI C <sup>d</sup>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
EF: WM- DSB	96.50	12.04	100.32	7.63	98.75	8.63	96.94	7.68

EF: Shifting- NA	99.5	14.95	103.71	11.90	101.67	14.19	106.11	12.37
EF: Shifting- SW	91.37	19.59	93.14 <sup>2</sup>	17.39	92.92	17.13	95.97	16.03
EF: Shifting- TE	109.17 <sup>1</sup>	24.15	116.21	18.35	114.79	23.84	118.19	19.13
EF: Inhibition- CW	100.55	13.98	95.39	13.83	97.25	19.23	101.11	14.10
EF: Inhibition- IN	108.5	17.25	110.16	16.10	107.92	18.82	114.31	16.39
Reading: English WR	88.1	15.74	96.94	16.75	83.32 <sup>3</sup>	14.37	85.86	17.66
Reading: French WR					77.47 <sup>3</sup>	19.50	81.28	12.51
Reading: English PD	93.50	19.25	100.32	16.83	89.44 <sup>3</sup>	17.33	88.83	16.23
Reading: French PD					85.40 <sup>3</sup>	11.50	84.55	10.06

*Note.* EF: WM-DSB= WISC-IV Digit Span Backwards sub-measure, EF: Shifting- NA= NEPSY-II Shapes sub-measure- naming task, EF: Shifting- SW= NEPSY-II Shapes sub-measure- switching task, EF: Shifting- TE= NEPSY-II Shapes sub-measure- total errors across tasks, EF: Inhibition- CW= D-KEFS-II Color-Word Interference sub-measure, EF: Inhibition- IN= NEPSY-II Shapes sub-measure- inhibition task, Reading: English WR= WIAT-III Word Reading sub-measure, Reading: French WR= WIAT-II FR French Word Reading sub-measure, Reading: English PD= WIAT-III Pseudoword Decoding sub-measure, Reading: French PD= WIAT-II FR French Pseudoword Decoding sub-measure. <sup>a</sup>*n* = 20, <sup>b</sup>*n* = 31, <sup>c</sup>*n* = 24, <sup>d</sup>*n* = 36. <sup>1</sup>*n* = 18, <sup>2</sup>*n* = 29, <sup>3</sup>*n* = 25.

**Descriptive Statistics**

Table 3 displays the mean, sample size, and standard deviation between the continuing English and FI group Y1 measures. It was noted that the differences in scores were not significant, apart from one sub-measure. Y1 English Pseudoword Decoding demonstrated a significant difference between the English and FI group ( $t = 2.84, df = 65, p = .006$ ).

**Table 3**

*Scores between Language Groups Y1*

Y1 Measures	English			FI		
	<i>M</i>	<i>N</i>	<i>SD</i>	<i>M</i>	<i>N</i>	<i>SD</i>
EF: WM- DSB	100.32	31	7.63	96.94	36	7.68
EF: Shifting- NA	103.71	31	11.90	106.11	36	12.37
EF: Shifting- SW	93.14	31	17.39	95.97	36	16.03
EF: Shifting- TE	116.21	29	18.35	118.19	36	19.13
EF: Inhibition- CW	95.39	31	13.83	101.11	36	14.10
EF: Inhibition- IN	110.16	31	16.10	114.31	36	16.40
Reading: English WR	96.94	31	16.75	85.86	36	17.66

Reading: French WR				81.28	36	12.51
Reading: English PD	100.32	31	16.83	88.83	36	16.23
Reading: French PD				84.55	36	10.06

*Note.* EF: WM-DSB= WISC-IV Digit Span Backwards sub-measure, EF: Shifting- NA= NEPSY-II Shapes sub-measure- naming task, EF: Shifting- SW= NEPSY-II Shapes sub-measure- switching task, EF: Shifting- TE= NEPSY-II Shapes sub-measure- total errors across tasks, EF: Inhibition- CW= D-KEFS-II Color-Word Interference sub-measure, EF: Inhibition- IN= NEPSY-II Shapes sub-measure- inhibition task, Reading: English WR= WIAT-III Word Reading sub-measure, Reading: French WR= WIAT-II FR French Word Reading sub-measure, Reading: English PD= WIAT-III Pseudoword Decoding sub-measure, Reading: French PD= WIAT-II FR French Pseudoword Decoding sub-measure.

Table 4 displays the mean, sample size, and standard deviation between the continuing English and FI group Y2 measures. Regarding literacy measures, the English group achieved a comparatively higher score on the English Spelling Transcription sub-measure and this difference was statistically significant ( $t = 3.40, df = 65, p < .001$ ). Conversely, the FI group achieved a comparatively higher score than the English group on the English Alphabet Writing sub-measure. This difference was also statistically significant ( $t = -2.86, df = 64, p = .006$ ). This result could be due to the fact that the FI group completed the French Alphabet Writing sub-measure first and the English version second, at a later point in the procedures. Given that French and English share the same alphabet, this increased performance may be due to practice effects.

**Table 4**

*Scores between Language Groups Y2*

Y2 Measures	English			FI		
	<i>M</i>	<i>N</i>	<i>SD</i>	<i>M</i>	<i>N</i>	<i>SD</i>
EF: WM- DSB	90.97	31	9.79	94.58	36	11.17
EF: WM- LNS	91.45	31	18.94	99.17	36	14.17
EF: Shifting- NA	101.94	31	11.52	104.72	36	11.77
EF: Shifting- SW	96.80	30	18.14	108.44	36	18.51
EF: Shifting- TE	110.17	30	20.23	118.89	36	13.58
EF: Inhibition- CW	95.16	31	15.39	101.97	36	13.42
EF: Inhibition- IN	110.16	31	12.75	114.72	36	16.12

Transcription: English SP	94.58	31	13.17	82.80	36	14.87
Transcription: French SP				81.97	36	12.73
Transcription: English AW	85.97	30	13.60	95.44	36	13.21
Transcription: French AW				87.91	35	12.67

*Note.* EF: WM-DSB= WISC-IV Digit Span Backwards sub-measure, EF: WM- LNS= WISC-IV Letter-Number Sequence measure, EF: Shifting- NA= NEPSY-II Shapes sub-measure- naming task, EF: Shifting- SW= NEPSY-II Shapes sub-measure- switching task, EF: Shifting- TE= NEPSY-II Shapes sub-measure- total errors across tasks, EF: Inhibition- CW= D-KEFS-II Color-Word Interference sub-measure, EF: Inhibition- IN= NEPSY-II Shapes sub-measure- inhibition task, Transcription: English SP= WIAT-III Spelling sub-measure, Transcription: French SP= WIAT-II FR French Spelling sub-measure, Transcription: English AW= WIAT-III Alphabet Writing sub-measure, Transcription: French AW= WIAT-II FR Alphabet Writing sub-measure.

**Correlation**

Correlational analyses was conducted across the English and FI instructional environment groups to determine variable associations and to support the later creation of composite scores for regression analyses. Correlational analyses (using Pearson correlation coefficients) between all measures across the English Group are represented in Table 5. The results indicate that there were significant positive correlations between all Y1 English reading and Y2 English transcription measures. Both Y1 English reading variables were significantly correlated with the Y1 and Y2 Shifting NEPSY-II Shapes naming task variable, both Y2 WM variables, and the Y2 Inhibition D-KEFS-II Color-Word Interference sub-measure. The Y1 English WIAT-III Pseudoword Decoding sub-measure additionally demonstrated significant correlations with the Y2 Inhibition NEPSY-II Shapes inhibition task. Both Y2 English transcription variables were significantly correlated with the Y2 WM WISC-IV Digit Span Backwards sub-measures and the Y2 Shifting NEPSY-II Shapes total errors across tasks variable. Y2 English Spelling was significantly associated with the Y1 and Y2 Shifting NEPSY II Shapes naming task variable, the Y2 WM WISC-IV Letter-Number Sequence sub-measure and demonstrated a significant negative correlation with the Y1 Inhibition D-KEFS-II Color-Word Interference sub-measure.

The Y2 WIAT-III English Alphabet Writing sub-measure was significantly associated with the Y1 Shifting NEPSY-II Shapes total errors across tasks variable, the Y2 NEPSY-II Shapes switching task, and the Y2 Inhibition NEPSY-II Shapes inhibition task. In determining the suitability of variable matching for composite combination, the English WIAT-III Pseudoword Decoding and Word Reading sub-measures demonstrated significant correlation ( $r = .89, p < .01$ ); however, this correlation suggests that high multicollinearity may be present. To prepare for linear regression, a variance inflation factor (VIF) check was conducted within SPSS and multicollinearity diagnostics demonstrated no concern, with VIF values of 1.0, suggesting no redundancy between the variables (Gaskin, 2020).

**Table 5**  
*English Group: Bivariate Pearson Correlation Coefficients*

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Y1 English- WR	1																
2. Y1 English- PD	.89**	1															
3. Y1 WM- DSB	.30	.30	1														
4. Y1 Shifting- NA	.47**	.45*	.08	1													
5. Y1 Shifting- SW	.07	.06	-.07	.25	1												
6. Y1 Shifting- TE	.22	.17	-.07	.28	-.12	1											
7. Y1 Inhibition- CW	-.29	-.30	-.13	-.01	.42*	-.03	1										
8. Y1 Inhibition- IN	.30	.20	.16	.59**	.18	.42*	.13	1									
9. Y2 WM- DSB	.43*	.41*	.34	.25	.04	.35	-.06	.01	1								
10. Y2 WM- LNS	.50**	.37*	.14	.27	-.22	.40*	-.18	.24	.46*	1							
11. Y2 Shifting- NA	.39*	.38*	-.04	.43*	.04	-.01	-.17	.21	.29	.32	1						
12. Y2 Shifting- SW	.35	.34	.26	.45*	.17	.12	.09	.20	.51**	.20	.31	1					
13. Y2 Shifting- TE	.24	.23	.04	.31	-.22	.41*	-.23	.36	.40*	.37*	.19	.52**	1				
14. Y2 Inhibition- CW	.44*	.39*	.07	.07	.09	.07	.21	.33	.21	.26	.37*	.21	.18	1			
15. Y2 Inhibition- IN	.35	.36*	.11	.32	-.16	.15	-.01	.37*	.26	.10	.34	.55**	.52**	.50**	1		
16. Y2 English- SP	.74**	.62**	.09	.41*	.02	.28	-.45*	.22	.55**	.62**	.44*	.19	.42*	.29	.20	1	
17. Y2 English- AW	.43*	.39*	.19	.28	.17	.45*	.21	.35	.49**	.36	.16	.48**	.39*	.44*	.41*	.43*	1

*Note.* Y1 English- WR= WIAT-III Word Reading sub-measure, Y1 English PD= WIAT-III Pseudoword Decoding sub-measure, Y1 WM-DSB= WISC-IV Digit Span Backwards sub-measure, Y1 Shifting- NA= NEPSY-II Shapes sub-measure- naming task, Y1 Shifting- SW= NEPSY-II Shapes sub-measure- switching task, Y1 Shifting- TE= NEPSY-II Shapes sub-measure- total errors across tasks, Y1 Inhibition- CW= D-KEFS-II Color-Word Interference sub-measure, Y1 Inhibition- IN= NEPSY-II Shapes sub-measure- inhibition task, Y2 WM-DSB= WISC-IV Digit Span Backwards sub-measure, Y2 WM- LNS= WISC-IV Letter-Number Sequence measure, Y2 Shifting- NA= NEPSY-II Shapes sub-measure- naming task, Y2 Shifting- SW= NEPSY-II Shapes sub-measure- switching task, Y2 Shifting- TE= NEPSY-II Shapes sub-measure- total errors across tasks, Y2 Inhibition- CW= D-KEFS-II Color-Word Interference sub-measure, Y2 Inhibition- IN= NEPSY-II Shapes sub-measure- inhibition task, Y2 English SP= WIAT-III Spelling sub-measure, Y2 English AW= WIAT-III Alphabet Writing sub-measure.  
\* p < .05. \*\* p < .01 (two-tailed).

Correlational analyses (using Pearson Correlation Coefficients) between all measures across the FI Group are represented in Table 6. There were significant positive correlations between all Y1 French reading and Y2 French transcription measures, apart from the Y1 WIAT-II FR French Pseudoword Decoding sub-measure and Y2 WIAT-II FR French Spelling sub-measure. Both Y1 French reading variables were positively correlated with the Y1 and Y2 WM WISC-IV Digit Span Backwards sub-measure and the Y1 Shifting NEPSY-II Shapes total errors across tasks variable. The Y1 WIAT-II FR French Word Reading sub-measure demonstrated additional significant positive correlations with the Y2 WM WISC-IV Letter-Number Sequence sub-measure and the Y2 Shifting NEPSY-II Shapes total errors across tasks variable. The Y1 English reading measures were not significantly correlated with the Y2 French transcription measures; however, Y1 English reading measures were both significantly correlated with the concurrent Y1 French reading measures. The Y1 English reading measures demonstrated significant negative correlations with the Y1 Inhibition D-KEFS-II Color-Word Interference sub-measure and no significant positive correlations with any EF variables were noted. The Y2 WIAT-II FR French Alphabet Writing sub-measure was significantly correlated with the Y1 and Y2 WM WISC-IV Digit Span Backwards sub-measure, as well as the Y2 Shifting NEPSY-II Shapes total errors across tasks variable. In determining the suitability of variables matching for composite combination, the English WIAT-III Pseudoword Decoding and Word Reading sub-measures ( $r = .79, p < .01$ ) and the French WIAT-II FR Pseudoword Decoding and Word Reading sub-measures ( $r = .77, p < .01$ ) demonstrated significant correlation; however, these correlations can indicate that high multicollinearity may be present. Again, a variance inflation factor (VIF) check was conducted within SPSS and multicollinearity diagnostics demonstrated no concerns, with VIF values of 1.0, suggesting no redundancy between the variables (Gaskin, 2020).

**Table 6**  
*French Group: Bivariate Pearson Correlation Coefficients*

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1. Y1 English-WR	1																			
2. Y1 English-PD	.79**	1																		
3. Y1 French-WR	.44**	.27	1																	
4. Y1 French-PD	.49**	.33*	.77**	1																
5. Y1 WM-DSB	.20	.14	.67**	.51**	1															
6. Y1 Shifting-NA	-.05	.03	.32	.28	.53**	1														
7. Y1 Shifting-SW	.16	.24	.33	.23	.30	.41*	1													
8. Y1 Shifting-TE	.155	.19	.34*	.44**	.38*	.21	.26	1												
9. Y1 Inhibition-CW	-.43**	-.42*	.06	.05	.19	.20	.08	.01	1											
10. Y1 Inhibition-IN	.09	.22	.20	.15	.18	.65**	.54**	.20	.13	1										
11. Y2 WM-DSB	.23	.32	.34*	.43**	.38*	.12	.17	.53**	.04	.03	1									
12. Y2 WM-LNS	.09	.18	.38*	.23	.36*	.56**	.37*	-.12	.17	.39*	.27	1								
13. Y2 Shifting-NA	-.01	.18	.31	.17	.09	.39*	.31	.08	.21	.35*	.26	.64**	1							
14. Y2 Shifting-SW	.06	.12	.20	-.011	.10	.31	.36*	.23	.04	.49**	.09	.45**	.49**	1						
15. Y2 Shifting-TE	-.04	.03	.42**	.26	.28	.39*	.35*	.39*	-.02	.29	.43**	.44**	.44**	.55**	1					
16. Y2 Inhibition-CW	-.00	-.01	-.01	.07	.19	.41*	.24	-.12	.30	.24	.06	.42*	.25	.37*	.01	1				
17. Y2 Inhibition-IN	-.01	.04	.21	.19	-.01	.42**	.43**	.07	.07	.45**	.21	.52**	.52**	.53**	.56**	.36*	1			
18. Y2 French-SP	.27	.21	.47**	.26	.23	-.00	.07	-.04	-.27	-.08	.18	.29	.19	.00	0.14	-.11	.15	1		
19. Y2 French-AW	.17	.08	.44**	.38*	.34*	.12	.12	.17	-.08	.15	.47**	.02	.07	.06	.34*	-.04	.23	.52**	1	

*Note.* Table 6 variables are the same as the variables included in Table 5, apart from the addition of French-WR= WIAT-II FR French Word Reading sub-measure and Y1 French PD= WIAT-II FR French Pseudoword Decoding sub-measure. Additionally, the English transcription measures (spelling and alphabet writing) were replaced with the French transcription measures including Y2 French SP= WIAT-II FR French Spelling sub-measure and Y2 French AW= WIAT-II FR French Alphabet Writing sub-measure.  
 \*  $p < .05$ . \*\*  $p < .01$  (two-tailed).

## Regression Analysis

The presented regression analyses support the identification of significant concurrent and longitudinal patterns of development between early reading, EF, and transcription and will act as the initial step in the subsequent mediation analysis. This section establishes the foundational direct effects that inform the mediation analysis models presented below and thus support the overall exploration of the primary research questions. Within the present regression analyses, predictive relations between literacy and EF variables will be explored via two primary sets of linear regression analyses for each instructional environment group. The first sets of models across English and FI groups utilize Y1 Reading measures as the predictors, to evaluate their impact on concurrent (Y1) and future (Y2) EFs, as well as Y2 Transcription scores. The second sets of models conversely uses Y2 Transcription as the dependent variable outcome to examine past (Y1) and concurrent (Y2) EFs as predictors. Note that for each figure, unstandardized coefficients (*B*) are reported in order to maintain consistency across all following mediation analysis and to allow for direct interpretability of effects. Moreover, instructional environment groups throughout the remaining results sections will include the English group, the FI group (French measures), and the FI groups (English and French measures) in order to explore relations within and cross-linguistic relations.

To examine these predictive relations across all measures, composite scores were created to allow for more conservative comparisons. These composite scores were created in SPSS for each literacy and EF concept (i.e., reading, transcription, WM, etc.) by calculating the mean of the relevant sub-measures to create a combined average score. English literacy composite scores included the Y1 English Reading Composite (including the WIAT-III Word Reading and Pseudoword Decoding sub-measures) and the Y2 English Transcription Composite (including

the WIAT-III Spelling and Alphabet Writing sub-measures). French literacy measures included the Y1 French Reading Composite (including the WIAT-II FR Word Reading and Pseudoword Decoding sub-measures) and the Y2 French Transcription Composite (including the WIAT-II FR Spelling and Alphabet Writing sub-measures). Y1 EF composites included the Y1 Shifting Composite (including the NEPSY-II Shapes sub-measure naming, switching, and total errors tasks), and the Y1 Inhibition Composite (including the D-KEFS-II Colour-Word Interference Test and the NEPSY-II Shapes sub-measure inhibition task). The Y1 WM WISC-IV Digit Span-Backwards measure was the only WM variable within Y1 of the study. Y2 EF composites included the Y2 Shifting Composite (including the NEPSY-II Shapes sub-measure naming, switching, and total errors tasks), the Y2 Inhibition Composite (including the D-KEFS-II Colour-Word Interference Test and the NEPSY-II Shapes sub-measure inhibition task), and the Y2 WM Composite (including the WISC-IV Digit Span Backward sub-measure and the WISC-IV Letter-Number Sequence measure), as this sub-measures was added in Y2 of the study. In addition, overall Y1 and Y2 EF Composites were included. The overall Y1 EF Composite was comprised of all Y1 EF sub-measures. The overall Y2 EF Composite included all of the Y2 EF sub-measures.

### ***English Group***

Figure 2 provides a visual representation of the significant, predictive relations, based on the following linear regression analysis findings. Within the first model, as noted in Table 7, linear regression analyses demonstrated that Y1 English Reading predicted Y2 English Transcription, Y1 and Y2 Shifting, Y2 Inhibition, and Y2 WM. Additionally, the overall Y2 EF composite was predicted by Y1 English Reading. Within the second model, as noted in Table 8, linear regression analyses demonstrated that Y2 English Transcription was predicted by Y1 and

Y2 Shifting, Y2 Inhibition, and Y2 WM. Moreover, Y1 and Y2 overall EF composites were significant predictors of Y2 English Transcription.

Though longitudinal EF predictive relations were not essential in later mediation analysis, they were included within the present regression section to explore developmental growth over time. The predictive relations between Y1 and Y2 EFs is as follows: Y1 Shifting predicted Y2 Shifting [ $F(1, 29) = 5.13, p = .031$ ]. Y1 Inhibition predicted Y2 Inhibition [ $F(1, 29) = 4.34, p = .046$ ]. Y1 WM did not significantly predict Y2 WM [ $F(1, 29) = 1.72, p = .200$ ]. Overall, the Y1 EF Composite significantly predicted the Y2 EF Composite [ $F(1, 29) = 5.09, p = .032$ ].

The study’s first research question hypothesis posited that EF would significantly mediate the relation between Y1 English Reading and Y2 English Transcription. Based on the present linear regression analyses, there was evidence to support this, though further exploration within the mediation section below will be addressed. The present evidence specifically suggested that Y1 and Y2 Shifting (H1b), Y2 WM (H1a), Y2 Inhibition (H1c), and Y2 EF (H1d) were both predicted by Y1 English Reading and predicted Y2 English Transcription.

**Table 7**

*Y1 English Reading as the Predictor*

<b>Outcome Variable</b>	<b>B</b>	<b>SE</b>	<b>β</b>	<b>t(30)</b>	<b>p</b>	<b>R<sup>2</sup></b>	<b>F(1, 29)</b>	<b>p (model)</b>
Y2 English Transcription	.47	.096	.67	4.91	<.001	.450	24.13	<.001
Y1 WM- DSB	.14	.083	.31	1.73	.094	.094	3.01	.094
Y1 Shifting Composite	.24	.107	.39	2.29	.029	.153	5.26	.029
Y1 Inhibition Composite	.00	.128	.00	.000	.997	.00	.00	.997
Y1 EF Composite	.14	.084	.29	1.64	.111	.085	2.70	.111
Y2 WM Composite	.39	.122	.51	3.19	.003	.259	10.16	.003
Y2 Shifting Composite	.37	.133	.46	2.77	.010	.209	7.66	.010
Y2 Inhibition Composite	.34	.123	.46	2.79	.009	.211	1.76	.009
Y2 EF Composite	.34	.100	.54	3.44	.002	.290	11.84	.002

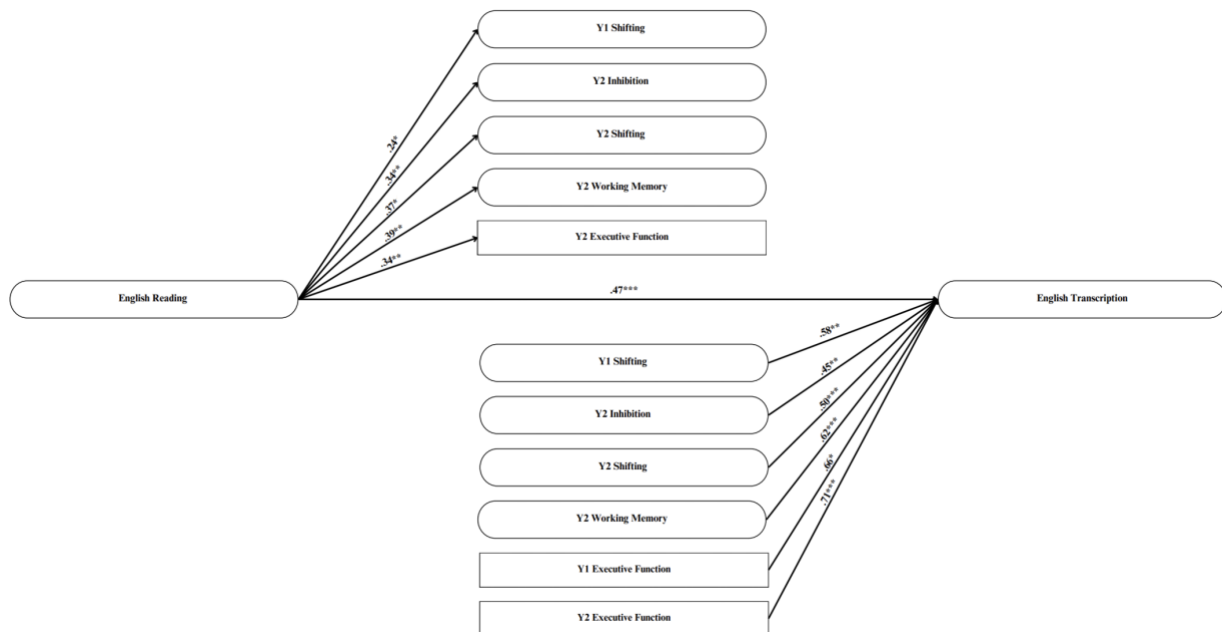
**Table 8**

*Y2 English Transcription as the Outcome*

Predictor Variable	B	SE	$\beta$	t(30)	p	R <sup>2</sup>	F(1, 29)	p (model)
Y1 WM- DSB	.28	.274	.19	1.03	.310	.036	1.07	.310
Y1 Shifting Composite	.58	.179	.52	3.26	.003	.268	10.60	.003
Y1 Inhibition Composite	.15	.186	.15	.809	.425	.022	.655	.425
Y1 EF Composite	.66	.248	.44	2.65	.013	.194	6.98	.013
Y2 WM Composite	.62	.126	.68	4.95	<.001	.458	24.49	<.001
Y2 Shifting Composite	.50	.132	.58	3.81	<.001	.335	14.58	<.001
Y2 Inhibition Composite	.45	.153	.48	2.94	.006	.230	8.66	.006
Y2 EF Composite	.71	.155	.65	4.61	<.001	.423	21.25	<.001

**Figure 2**

*English Group: Literacy and EF Predictive Relations*



Note. Unstandardized coefficients (B) included. \*\*\* p < .001, \*\* p < .01, \* p < .05.

**FI Group (French Measures)**

Figure 3 provides a visual representation the significant, predictive relations, based on the following linear regression analysis findings. Within the first model, as noted in Table 9, linear regression analyses demonstrated that Y1 French Reading predicted Y2 French Transcription, Y1 Shifting, and Y1 and Y2 WM. Additionally, the overall Y1 EF composite was predicted by Y1 French Reading. Within the second model, as noted in Table 10, linear regression analyses demonstrated that Y2 WM predicted Y2 French Transcription.

Though longitudinal EF predictive relations were not essential in later mediation analysis, they were included within the present regression section to explore developmental growth over time. The predictive relations between Y1 and Y2 EFs is as follows, Y1 Shifting predicted Y2 Shifting [ $F(1, 34) = 11.74, p = .002$ ]. Y1 Inhibition predicted Y2 Inhibition [ $F(1, 34) = 7.96, p = .008$ ]. Y1 WM predicted Y2 WM [ $F(1, 34) = 9.15, p = .005$ ]. Overall, the Y1 EF Composite significantly predicted the Y2 EF Composite [ $F(1, 34) = 16.70, p < .001$ ].

The study's first research question hypothesis posited that EF would significantly mediate the relation between Y1 French Reading and Y2 French Transcription. Based on the present linear regression analyses, there was evidence to support this, though further exploration within the mediation section below will be addressed. The present evidence specifically suggested that Y2 WM (H1a) was both predicted by Y1 French Reading and predicted Y2 French Transcription.

**Table 9**

*Y1 French Reading as the Predictor*

<b>Outcome Variable</b>	<b>B</b>	<b>SE</b>	<b><math>\beta</math></b>	<b>t(35)</b>	<b>p</b>	<b>R<sup>2</sup></b>	<b>F(1, 34)</b>	<b>p (model)</b>
Y2 French Transcription	.49	.156	.48	3.16	.003	.227	9.98	.003
Y1 WM- DSB	.46	.096	.63	4.77	<.001	.401	22.78	<.001
Y1 Shifting Composite	.52	.163	.48	3.18	.003	.229	10.09	.003
Y1 Inhibition Composite	.18	.18	.17	.992	.328	.028	.984	.328

Outcome Variable	B	SE	$\beta$	t(35)	p	R <sup>2</sup>	F(1, 34)	p (model)
Y1 EF Composite	.33	.124	.41	2.62	.013	.168	6.87	.013
Y2 WM Composite	.43	.146	.45	2.96	.006	.205	8.76	.006
Y2 Shifting Composite	.32	.186	.28	1.72	.094	.080	2.97	.094
Y2 Inhibition Composite	.18	.195	.16	.917	.365	.024	.841	.365
Y2 EF Composite	.29	.148	.32	1.96	.058	.102	3.84	.058

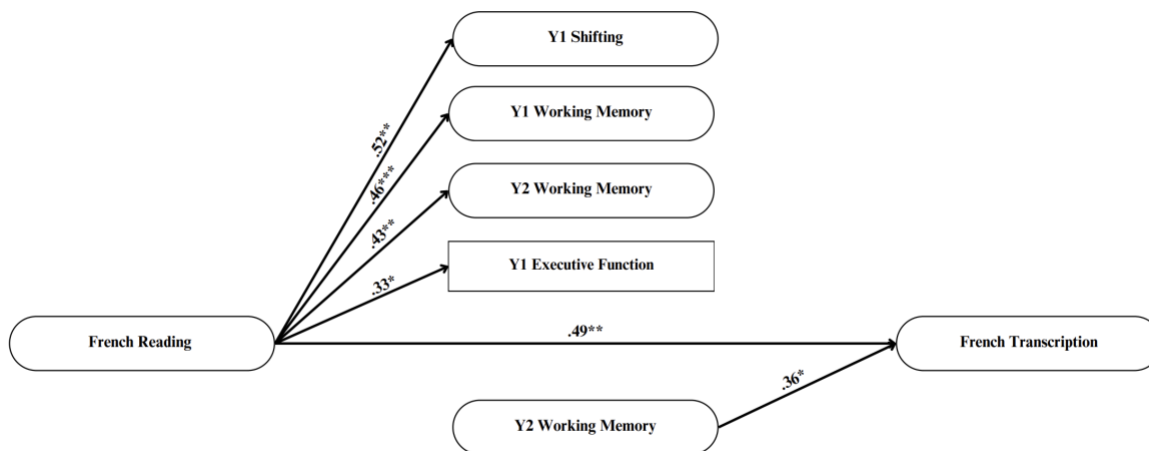
**Table 10**

*Y2 French Transcription as the Outcome*

Predictive Variable	B	SE	$\beta$	t(35)	p	R <sup>2</sup>	F(1, 34)	p (model)
Y1 WM- DSB	.47	.231	.33	2.03	.051	.107	4.09	.051
Y1 Shifting Composite	.11	.162	.12	6.78	.502	.013	.459	.502
Y1 Inhibition Composite	-.09	.163	-.09	-.567	.574	.009	.321	.574
Y1 EF Composite	.05	.223	.04	.232	.818	.002	.054	.818
Y2 WM Composite	.36	.175	.33	2.05	.049	.110	4.19	.049
Y2 Shifting Composite	.15	.155	.17	.996	.326	.028	.992	.326
Y2 Inhibition Composite	.09	.153	.11	.624	.537	.011	.389	.537
Y2 EF Composite	.25	.190	.22	1.32	.195	.049	1.75	.195

**Figure 3**

*French Group (French Measures): Literacy and EF Predictive Relations*



*Note.* Unstandardized coefficients (B) included. \*\*\* p < .001, \*\* p < .01, \* p < .05.

***FI Group (English and French Measures)***

Figure 4 provides a visual representation the significant, predictive relations, based on the following linear regression analysis findings. Within the first model, as noted in Table 11, linear regression analyses demonstrated that Y1 English Reading did not predict Y2 French Transcription. Y1 English Reading did not predict any EFs within the FI group, including Y1 and Y2 WM, Y1 and Y2 Shifting, and Y1 and Y2 Inhibition. Additionally, the overall Y1 and Y2 EF composites were not predicted by Y1 English Reading. As the second model FI group Y2 Transcription outcome relations are the same as noted in the previous FI (French Measures) section, those were not included here. Moreover, the Y1 EF to Y2 EF results were similarly reported in the previous FI (French Measures) section and were not included again here.

The study's second research question hypothesis posited that English reading would significantly predict French transcription and moreover, EF would mediate this relation. Based on the present linear regression analyses, the evidence did not support this hypothesis. Though further exploration within the mediation section below will be addressed, the present regression evidence specifically suggested that Y1 English Reading did not predict Y2 French Transcription (H2a). Moreover, no EFs (including WM, shifting, inhibition or overall EF) were both predicted by Y1 English Reading and predictors of Y2 French Transcription.

**Table 11**

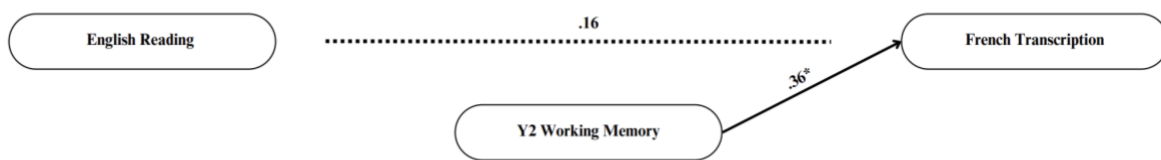
Y1 English Reading as the Predictor (FI Group)

<b>Outcome Variable</b>	<b>B</b>	<b>SE</b>	<b><math>\beta</math></b>	<b>t(35)</b>	<b>p</b>	<b>R<sup>2</sup></b>	<b>F(1, 34)</b>	<b>p (model)</b>
Y2 French Transcription	.16	.144	.23	1.36	.184	.050	1.84	.184
Y1 WM- DSB	.09	.081	.18	1.05	.299	.032	1.11	.299
Y1 Shifting Composite	.14	.121	.20	1.15	.255	.038	1.34	.255
Y1 Inhibition Composite	-.12	.122	-.16	-.948	.350	.026	.899	.350
Y1 EF Composite	.03	.090	.06	.357	.724	.004	.127	.724
Y2 WM Composite	.16	.105	.26	1.54	.131	.066	2.40	.131

Outcome Variable	B	SE	$\beta$	t(35)	p	R <sup>2</sup>	F(1, 34)	p (model)
Y2 Shifting Composite	.05	.128	.07	.424	.674	.005	.180	.674
Y2 Inhibition Composite	-.00	.131	-.00	-.046	.963	.000	.002	.963
Y2 EF Composite	.06	.103	.10	.569	.573	.009	.324	.573

**Figure 4**

*French Group (English and French Measures): Literacy and EF Predictive Relations*



*Note.* Dotted line = non-significant. Unstandardized coefficients (*B*) included. \*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$ .

**Mediation**

As noted, a linear regression-based approach was used to facilitate mediation analysis, and thus, addressed the primary research questions regarding EFs mediation role between reading and transcription, both within and cross linguistically. This approach acted as a theoretical exploration of predictive and mediative relations between variables (Baron & Kenny, 1986; Tibbe & Montoya, 2022; Zhao et al., 2010). This mediation analysis process, initially outlined by Baron and Kenny (1986) identifies direct and indirect variable effects. Direct effect analysis utilizes linear regression to identify relations between an independent variable (*X*), a mediator (*M*), and a dependent variable (*Y*). Between these variables, direct paths of effect are analyzed and include (a) the effects of *X* to *M*, (b) the effects of *M* to *Y*, (c), the effects of *X* to *Y*, and the effects of *X* on *Y* while controlling for *M* (*c'*). The indirect effects analysis is

typically calculated using the product of coefficients equation ( $a \times b$ ) and bootstrapping to identify significance via computed confidence intervals (Baron & Kenny, 1986; Tibbe & Montoya, 2022; Zhao et al., 2010).

Direct mediation analyses were initiated within the previous regression analysis section. Two sets of models were explored per language group. The first models explored Y1 reading as the predictor and demonstrated (a) the effects of X to M (Y1 Reading to EFs) as well as (c) the effects of X to Y (Y1 Reading to Y2 Transcription). The second language models explored Y2 transcription as the outcome and demonstrated (b) the effects of M to Y (Y1 EFs to Y2 Transcription). Within this section, the previous linear regression results will be used to explore (c') the effects of X on Y while controlling for M, or the effects of Y1 Reading on Y2 Transcription while controlling for individual EF variables. Indirect mediation analysis was determined per the coefficient calculation ( $a \times b$ ) and statistical significance was determined using percentile bootstrapped confidence intervals (using 5,000 resamples) (Tibbe & Montoya, 2022). Mediation and non-mediation effects were categorized using Zhao et al.'s (2010) five patterns of mediation and non-mediation including (a) complementary mediation, a mediated (indirect) effect and direct effect (same direction), (b) competitive mediation, a mediated (indirect) effect and direct effect (opposite directions), (c) indirect-only mediation, a mediated effect exists, but no direct effect, (d) direct-only non-mediation, a direct effect exists, but no indirect effect, and (e) no-effect non-mediation, neither direct effect nor indirect effect exists. Please note, composite scores were again used to facilitate mediation analysis. For more information about the composite scores, refer to the regression analysis section.

### ***English Group***

Figure 5 acts a visual representation of the significant direct and indirect mediative relations between Y1 English Reading, EF, and Y2 English Transcription measures. As noted in the previous linear regression analysis section, Y1 English Reading significantly predicted Y2 English Transcription. Moreover, Y1 and Y2 Shifting, Y2 WM, Y2 Inhibition, and Y2 EF were both predicted by Y1 English Reading and predicted Y2 English Transcription. Direct and indirect mediation relations between Y1 English Reading and Y2 English Transcription were explored below and noted in Table 12.

**Y1 Shifting.** Y1 English Reading predicted Y1 Shifting, Y1 Shifting predicted Y2 English Transcription, and Y1 Shifting indicated partial, direct mediation of Y1 English Reading and Y2 English Transcription. This partial, direct mediation was indicated by a, still significant, but decreased coefficient score ( $B = .47$  to  $B = .39$ ) when controlling for Y1 Shifting. The indirect effect of Y1 English Reading on Y2 English Transcription through Y1 Shifting was statistically significant, ( $B (axb) = .14, 95\% CI [.02, .69]$ ), indicating that Y1 Shifting maintained significant, complimentary mediation between Y1 English Reading and Y2 English Transcription.

**Y2 Shifting.** Y1 English Reading predicted Y2 Shifting, Y2 Shifting predicted Y2 English Transcription, and Y2 Shifting indicated partial, direct mediation of Y1 English Reading and Y2 English Transcription. This partial, direct mediation was indicated by a, still significant, but decreased coefficient score ( $B = .47$  to  $B = .36$ ) when controlling for Y2 Shifting. The indirect effect of Y1 English Reading on Y2 English Transcription through Y2 Shifting was statistically significant, ( $B (axb) = .19, 95\% CI [.06, .51]$ ), indicating that Y2 Shifting maintained significant, complimentary mediation between Y1 English Reading and Y2 English Transcription.

**Y2 WM.** Y1 English Reading predicted Y2 WM, Y2 WM predicted Y2 English Transcription, and Y2 WM indicated partial, direct mediation of Y1 English Reading and Y2 English Transcription. This partial mediation is indicated by a, still significant, but decreased coefficient score ( $B = .47$  to  $B = .31$ ) when controlling for Y2 WM. The indirect effect of Y1 English Reading on Y2 English Transcription through Y2 WM was statistically significant, ( $B (axb) = .24, 95\% CI [.13, .64]$ ), indicating that Y2 WM maintained significant, complimentary mediation between Y1 English Reading and Y2 English Transcription.

**Y2 Inhibition.** Y1 English Reading predicted Y2 Inhibition, Y2 Inhibition predicted Y2 English Transcription, and Y2 Inhibition indicated partial, direct mediation of Y1 English Reading and Y2 English Transcription. This partial, direct mediation was indicated by a, still significant, but decreased score ( $B = .47$  to  $B = .40$ ) when controlling for Y2 Inhibition. The indirect effect of Y1 English Reading on Y2 English Transcription through Y2 Inhibition was not statistically significant, ( $B (axb) = .15, 95\% CI [-.04, .41]$ ), indicating that Y2 Inhibition was a direct-only non-mediator.

**Y2 EF.** Y1 English Reading predicted Y2 EF, Y2 EF predicted Y2 English Transcription, and Y2 EF indicated partial, direct mediation of Y1 English Reading and Y2 English Transcription. This partial mediation was indicated by a, still significant, but decreased coefficient score ( $B = .47$  to  $B = .32$ ) when controlling for the Y2 EF Composite. The indirect effect of Y1 English Reading on Y2 English Transcription through Y2 EF was statistically significant ( $B (axb) = .24, 95\% CI [.19, .69]$ ), indicating that Y2 EF maintained significant, complimentary mediation between Y1 English Reading and Y2 English Transcription.

**Indirect-Only Mediation.** There is always the potential that variables can exhibit indirect-only mediation, where variables can have indirect but no direct mediation effects. This

was explored across the non-direct variables, including Y1 WM, Y1 Inhibition, and the Y1 EF Composite. No significant indirect mediation was present and thus no indirect-only mediation relations were observed.

The study's first research question hypothesis posited that EF would significantly mediate the relation between Y1 French Reading and Y2 French Transcription. Based on the present mediation analyses, there was evidence to support this. The present evidence specifically suggested that Y1 Inhibition (H1c) maintained direct-only non-mediation between Y1 English Reading and Y2 English Transcription. Y1 and Y2 Shifting (H1b), Y2 WM (H1a), and Y2 EF (H1d) were all significant, direct and indirect complementary mediators of Y1 English Reading and Y2 English Transcription.

**Table 12**

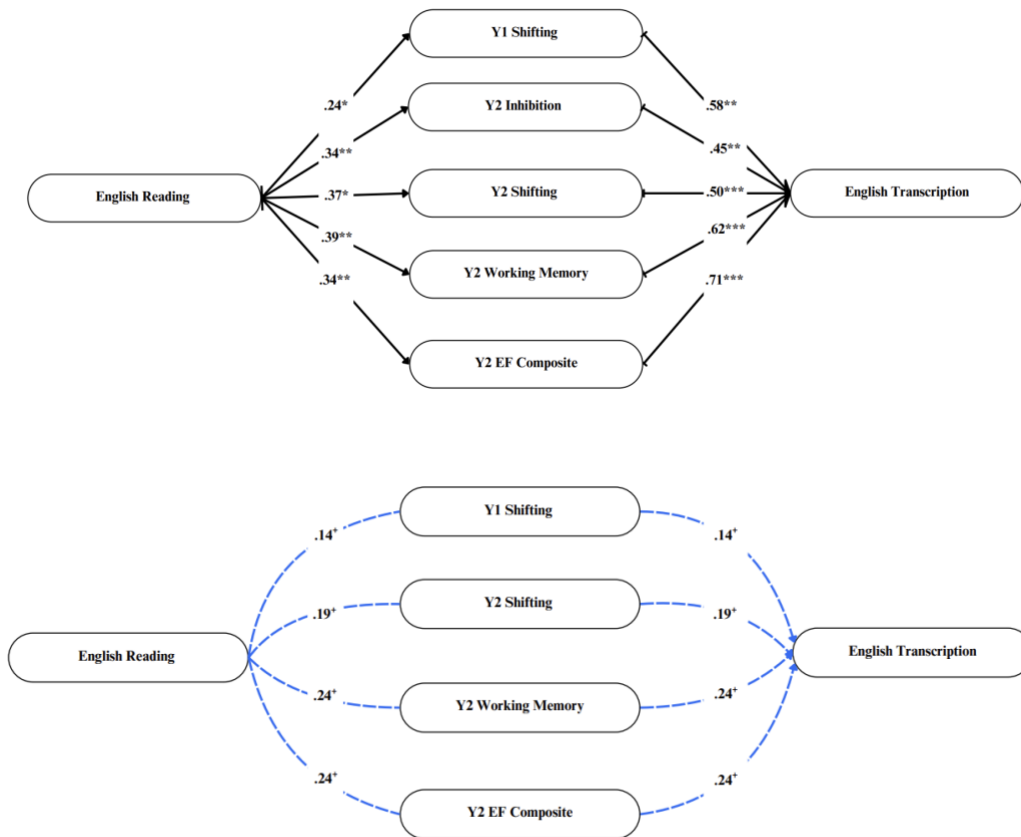
*English Group: Mediation*

<b>Predictor</b>	<b>Outcome</b>	<b>B</b>	<b>SE</b>	<b>β</b>	<b>t(30)</b>	<b>p</b>	<b>95% CI</b>
Y1 English Reading	Y2 English Transcription	.47	.096	.67	4.91	<.001	[.28, .67]
Y1 English Reading	Y1 Shifting	.24	.107	.39	2.29	.029	[.02, .46]
Y1 Shifting	Y2 English Transcription	.58	.179	.52	3.26	.003	[.22, .95]
Y1 English Reading	Y2 English Transcription (controlling for Y1 Shifting)	.39	.099	.56	3.95	<.001	[.19, .59]
Y1 English Reading	Y2 English Transcription (controlling for Y1 Shifting)	.14 <sup>1</sup>					[.02, .69]
Y1 English Reading	Y2 English Transcription	.47	.096	.67	4.91	<.001	[.28, .67]
Y1 English Reading	Y2 Shifting	.37	.133	.46	2.77	.010	[.09, .64]
Y2 Shifting	Y2 English Transcription	.50	.132	.58	3.81	<.001	[.23, .77]
Y1 English Reading	Y2 English Transcription (controlling for Y2 Shifting)	.36	.100	.52	3.62	<.001	[.16, .57]
Y1 English Reading	Y2 English Transcription (controlling for Y2 Shifting)	.19 <sup>1</sup>					[.06, .51]
Y1 English Reading	Y2 English Transcription	.47	.096	.67	4.91	<.001	[.28, .67]
Y1 English Reading	Y2 WM	.39	.122	.51	3.19	.003	[.14, .64]
Y2 WM	Y2 English Transcription	.62	.126	.68	4.95	<.001	[.36, .88]
Y1 English Reading	Y2 English Transcription (controlling for Y2 WM)	.31	.097	.45	3.21	.003	[.11, .51]
Y1 English Reading	Y2 English Transcription (controlling for Y2 WM)	.24 <sup>1</sup>					[.13, .64]
Y1 English Reading	Y2 English Transcription	.47	.096	.67	4.91	<.001	[.28, .67]
Y1 English Reading	Y2 Inhibition	.34	.123	.46	2.79	.009	[.09, .59]
Y2 Inhibition	Y2 English Transcription	.45	.153	.48	2.94	.006	[.14, .76]
Y1 English Reading	Y2 English Transcription (controlling for Y2 Inhibition)	.40	.107	.58	3.79	<.001	[.19, .62]
Y1 English Reading	Y2 English Transcription (controlling for Y2 Inhibition)	.15 <sup>1</sup>					[-.04, .41]
Y1 English Reading	Y2 English Transcription	.47	.096	.67	4.91	<.001	[.28, .67]
Y1 English Reading	Y2 EF	.34	.100	.54	3.44	.002	[-.01, .59]
Y2 EF	Y2 English Transcription	.71	.155	.65	4.61	<.001	[-.14, .64]
Y1 English Reading	Y2 English Transcription (controlling for Y2 EF)	.32	.103	.46	3.10	.004	[.11, .53]
Y1 English Reading	Y2 English Transcription (controlling for Y2 EF)	.24 <sup>1</sup>					[.19, .69]

*Note.* <sup>1</sup>Indirect Effects ( $B = (axb)$ )

**Figure 5**

*Significant Direct and Indirect Mediation Across the English Group*



*Note.* Solid line = direct relation, large dash line = indirect relation. Unstandardized coefficients (*B*) included. \*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$ . += significant (as per confidence interval).

***FI Group (French Measures)***

Figure 6 acts a visual representation of the significant direct relations between Y1 French Reading, EF, and Y2 French Transcription measures. As noted in the previous linear regression analysis section, Y1 French Reading predicted Y2 French Transcription. Moreover, Y2 WM was both predicted by Y1 French Reading and predicted Y2 French Transcription. Direct and indirect mediation relations between Y1 French Reading and Y2 French Transcription were explored below and noted in Table 13.

**Y2 WM.** Y1 French Reading predicted Y2 WM, Y2 WM predicted Y2 French Transcription, and Y2 WM indicated partial, direct mediation of Y1 French Reading and Y2 French Transcription. This partial, direct mediation was indicated by  $a$ , still significant, but decreased coefficient score ( $B = .49$  to  $B = .42$ ) when controlling for Y2 WM. The indirect effect of Y1 English Reading on Y2 English Transcription through Y2 WM was not statistically significant, ( $B (axb) = .15$ , 95% CI [-.25, .53]), indicating that Y2 WM was a direct-only non-mediator.

**Indirect-Only Mediation.** Indirect-only mediation, where variables can have indirect but no direct mediation effects, was explored across the non-direct variables, including Y1 WM, Y1 Shifting, Y1 Inhibition, Y2 Shifting, Y2 Inhibition, and both Y1 and Y2 EF Composites. No significant indirect mediation was present.

The study’s first research question hypothesis posited that EF would significantly mediate the relation between Y1 French Reading and Y2 French Transcription. Based on the present mediation analyses, there was not sufficient evidence to support this hypothesis. The present evidence specifically suggested that Y2 WM (H1a) maintained direct-only non-mediation between Y1 French Reading and Y2 French Transcription.

**Table 13**

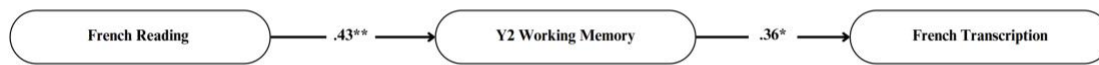
*FI Group (French Measures): Mediation*

<b>Predictor</b>	<b>Outcome</b>	<b>B</b>	<b>SE</b>	<b><math>\beta</math></b>	<b>t(35)</b>	<b>p</b>	<b>95% CI</b>
Y1 French Reading	Y2 French Transcription	.49	.156	.48	3.16	.003	[.18, .81]
Y1 French Reading	Y2 WM	.43	.146	.45	2.96	.006	[.14, .73]
Y2 WM	Y2 French Transcription	.36	.175	.33	2.05	.049	[.00, .71]
Y1 French Reading	Y2 French Transcription (controlling for Y2 WM)	.42	.175	.41	2.42	.021	[.06, .78]
Y1 French Reading	Y2 French Transcription (controlling for Y2 WM)	.15 <sup>1</sup>					[-.25, .53]

*Note.* <sup>1</sup>Indirect Effects ( $B = (axb)$ )

**Figure 6**

*Significant Direct Only Non-Mediation Across the FI Group (French Measures)*



*Note.* Solid line = direct relation. Unstandardized coefficients (*B*) included. \*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$

***FI Group (English and French Measures)***

As noted, Y1 English Reading did not predict Y2 French Transcription, and no direct mediation was observed. Indirect-only mediation, where variables can have indirect but no direct mediation effects, was explored across the non-direct variables, including Y1 WM, Y1 Shifting, Y1 Inhibition, Y2 WM, Y2 Shifting, Y2 Inhibition and both Y1 and Y2 EF Composites. No significant indirect mediation was present.

## Discussion

This study addressed gaps in current research regarding EF development in relation to early reading and writing development across early elementary English and FI instructional environment groups. The purpose of this longitudinal study was to explore word reading, EF, and transcription sub-measures longitudinally (from Grade 1 to Grade 2), to address developmental predictors within English and FI student populations. The following discussion will review the results and respond to the initial research questions and hypotheses.

### **Does EF mediate the relation between Y1 Reading and Y2 Transcription within English and FI participant groups?**

The first research question addressed what mediative role EF played in relation to early reading and transcription development across early education English and bilingual (FI) learning students. Again, this research question was addressed using a regression-based mediation analysis approach that explored direct and indirect effects. Literature suggests that both direct and indirect effects need to be explored to determinate the presence of mediation (Zhao et al., 2010). The predicted outcome, that EFs (specifically, WM (H1a), shifting (H1b), inhibition (H1c), and overall EF (H1d)) would significantly mediate the relation between reading and transcription in both FI and English participant groups was, in part, supported by the results of the study.

Within the English group, Y1 Shifting, Y2 Shifting, Y2 WM, and the Y2 EF composite all demonstrated statistically significant direct and indirect effects. These EF variables both directly predicted transcription outcomes and partly explained the process of development, indicating that each of these EF variables played a role in explaining how early education English student's reading skills contributed to their later transcription skills. Additionally, Y2

Inhibition was identified as a direct-only non-mediator. This was demonstrated by statistically significant direct effects, but insignificant indirect effects, indicating that Y2 Inhibition was directly associated with the outcome but was not associated with the pathway between reading and transcription.

**Executive Function.** In the present study results, it was noted that the overall Y2 EF Composite directly predicted transcription outcomes and partially facilitated the process of development between reading and transcription. This result aligns with current research that suggests all three EF components (WM, shifting, and inhibition), despite their distinctive functions, are interrelated (Miyake & Friedman, 2012). Though many studies have contextualized EFs role in relation to reading and EF's role in relation to writing, the present results illustrate longitudinal interaction between early elementary EF, reading, and writing development within the English instructional environment group.

**Working Memory.** Results described within the present study suggested that Y2 WM directly predicted transcription outcomes and partially facilitated the process of development between reading and transcription. These results align with current research that highlight WM's role in reading and transcription skill development. Regarding reading development, Hung (2021) found that WM directly and indirectly predicted reading comprehension via syntactic awareness in early elementary aged students. Similarly, Kim (2015) and Peng et al. (2018) noted that WM indirectly contributed to reading comprehension through language comprehension, decoding, and syntactic processing. In terms of transcription skill development, WM has been identified as a crucial cognitive process during developmental periods where transcription is still effortful, and moreover, evidence has demonstrated that WM maintains both direct and indirect effects on text generation (McCutchen, 1996; Salas & Silvente, 2019). Collectively, research

addressing reading and transcription suggests that WM may be an integral cognitive skill during effortful literacy skill development, particularly within early elementary education. The results outlined within the present study additionally align with the Direct and Indirect Effects Model of Reading (DIER) and Writing (DIEW), which suggest that EFs (i.e., WM) are distal skills that indirectly support literacy development by facilitating more effortful processes. These processes include word reading (through phonological, semantic, and orthographic knowledge), linguistic comprehension (through vocabulary and grammatical knowledge), and transcription (via temporarily storage and manipulation of information) (Kim, 2019, 2020).

**Shifting.** Results described within the present study suggested that both Y1 and Y2 Shifting directly predicted transcription outcomes and partially facilitated the process of development between reading and transcription. These finding align with current research that emphasize the role of shifting in reading and transcription skill development. In the context of reading, Søndergaard Knudsen et al. (2018) demonstrated that shifting was a significant predictor of reading comprehension within Dutch-speaking participants in Grade 3 and Grade 4. Cartwright et al. (2020) similarly demonstrated that graphophonological-semantic cognitive flexibility (GSF), or the ability to switch between graphophonological (decoding) and semantic (meaning) components of words, was a concurrent and longitudinal, predictor of reading comprehension in English-speaking early elementary participants. Regarding transcription skill development, Rocha et al. (2022) noted that, within their Grade 4 and Grade 5 participant population, transcription and shifting contributed to and were significant predictors of, later production of written text. Both current research and the results outlined within the present study are consistent with the DIER and DIEW models, which note that EF, or self-regulatory processes, indirectly support literacy development. Taken together, present results, available

research, and theoretical frameworks suggest that shifting may be an integral cognitive skill that contributes to the concurrent and longitudinal development of reading and transcription by supporting the ability to shift between tasks, strategies, and frameworks (Berninger, 1999; Kim, 2019, 2020; Rocha et al., 2022).

**Inhibition.** Results described within the present study suggested that Y2 Inhibition directly predicted transcription outcomes, but it did not mediate the relation between reading and transcription. This finding, in part, aligns with current research regarding the role of inhibition in relation to reading and transcription skill development. Hung (2021) found that proponent response and cognitive inhibition measures directly and indirectly predicted reading comprehension via syntactic awareness in early elementary aged students. Moreover, Altemeier et al. (2008) reported that prepotent response inhibition was correlated with decoding (a key component of reading comprehension) within their Grade 1 to Grade 4 participant pool. In contrast, evidence suggests inhibition may maintain differentiated patterns of development in relation to reading and transcription in comparison to WM and shifting (Miyake & Friedman, 2012). Miyake and Friedman (2012) highlighted that WM and shifting are separate processes, but suggested that inhibition may not be a separate, core component of EF. Instead, Miyake and Friedman (2012) suggested that inhibition may be a sub-process that supports WM and shifting (Spencer et al., 2020). Moreover, Rocha et al. (2022) noted that stable, but less growth in inhibition occurred between Grade 4 and Grade 5 compared to WM and shifting development. Overall, these findings, in addition to related research and noted theoretical frameworks, suggest that inhibition, though directly related to transcription outcomes, may be developmentally varied compared to WM and shifting and this may have impacted its role as a significant mediator of reading and transcription development.

Within the FI group, results noted that there were no EF variables that both directly predicted transcription outcomes and partially facilitated the process of development between reading and transcription. Notably, Y2 WM was identified as a direct-only non-mediator. This was demonstrated by statistically significant direct effects, but insignificant indirect effects and indicated that Y2 WM was directly associated with the outcome but was not associated with the pathway between reading and transcription.

**Executive Function (WM, Shifting, and Inhibition).** Results described within the present study suggested that EF (including overall EF, WM, shifting, and inhibition) did not directly predict transcription outcomes, nor did they facilitate the process of development between reading and transcription. These findings align with current research regarding EF in relation to reading and transcription skill development in bilingual learning environments. Research has suggested that bilingual learners who consistently attended immersion programs (i.e., three years) demonstrated increased EF skill capacity compared to their monolingual peers in order to navigate multiple language frameworks (Nicolay & Poncelet, 2013, 2015). In contrast, evidence suggests that in early elementary immersion education, language framework development occurs at varied temporal rates (compared to non-immersion programs), and because of this, EF developmental patterns may be impacted (Au-Yeung et al., 2015; D'Angelo et al., 2020). This evidence regarding language proficiency aligns with the current study results, demonstrating that only Y2 WM was directly related to transcription outcomes but not involved in facilitating the relation between reading and transcription. Moreover, both the DIER and DIEW frameworks note that patterns of underlying cognitive skill development are dependent on language proficiency (Kim, 2019, 2020). Taken together, present results, available research, and theoretical frameworks suggest that EF (including overall EF, WM, shifting, and inhibition) may

be constrained during period of emerging language proficiency development in FI instructional environment groups.

**Does Y1 English Reading predict Y2 French Transcription, and moreover, is this relation mediated by EFs?**

The second research question addressed cross-linguistic transfer relations within the early elementary education FI instructional environment group; moreover, the second research question addressed what mediative role EF played in relation to early reading and transcription development, cross-linguistically. Again, this research question was addressed using a regression-based mediation analysis approach that explored direct and indirect effects. The predicted outcomes noted that, English reading (word reading and decoding) would predict Y2 French transcription (spelling and alphabet writing) (H2a), and moreover, this relation would be mediated by WM (H2b), shifting (H2c), inhibition (H2d), and overall EF (H2e). The results of this study did not support the hypothesis. Specifically, Y1 English reading did not predict Y2 French transcription, nor did it significantly predict any EF components in the FI group, including both Y1 and Y2 measures of WM, shifting, and inhibition. Only Y2 WM was directly associated with the outcome but was not associated with the pathway between reading and transcription. As such, no significant cross-linguistic transfer and no direct or indirect mediation was observed within the FI group.

Historical and current research regarding bilingual populations suggests that that cognitive and linguistic skills developed in one language (L1) can transfer to another language (L2) via underlying, foundational systems, though this transfer has been suggested to be dependent on sufficient language proficiency (Cummins, 1979; Kim et al., 2022). As the present study's early elementary population did not maintain proficiency in either English or French,

cross-linguistic transfer would not necessarily be expected; however, the second research question's hypothesis was posited as recent research has demonstrated cross-linguistic transfer in early elementary English and FI student populations. Chung et al. (2023) demonstrated early elementary cross linguistic transfer of English word reading in Grade 1 to later French orthographic development in Grade 3. Additionally, Deacon et al. (2007) demonstrated that English morphology in Grade 1 predicted both English and French word reading in Grade 2. Though these findings may have been influenced by the specific sub-measures included during these early elementary developmental stages, the present study's second research question hypothesis was designed to further investigate the potential cross-linguistic transfer of reading and writing during relevant periods of skill acquisition. As research suggests that transfer first originates from the stronger language, and students are more likely to be proficient in English oral language in Grade 1 (as it is the primary language used across British Columbia where the present study took place), the second research questions' hypothesis predicted that Y1 English Reading would predict later Y2 French Transcription (Chung et al., 2023).

The lack of transfer between Y1 English Reading and Y2 English Transcription aligns with frameworks that suggest that cross-linguistic transfer may depend on the development of foundational literacy frameworks to support the transfer of linguistic information (Cummins, 1979; Kim et al., 2022). As noted, in Canadian FI programs, students receive 100% of their instruction (i.e., verbal, vocabulary, phonics, etc.) in French, (Savage et al., 2017). By focusing on French in early development, students are able to develop a strong French language foundation, while informally developing an English foundation external to education settings (i.e., at home, in their community). English instruction is not instructed until Grade 4. As the FI student participants within this study had not formally received any English reading instruction

in school, the absence of cross-linguistic transfer aligns with current research and relevant theoretical frameworks and suggests that cross-linguistic transfer of early English reading skills to later French transcription outcomes may be impacted by language exposure and instructional context.

Overall, the results described within the present study generally align with current research and relevant theoretical frameworks, and demonstrate the direct and indirect relations between reading, EFs (WM, shifting, and inhibition), and transcription both within and across English and FI instructional environment groups. These results support our understanding regarding EFs role in the facilitation of foundational literacy skills and highlights the developmental similarities and differences between English and FI instructional environment groups during early elementary education, a critical developmental period.

### ***Implications***

The implications of this study are anticipated to contribute to and inform theory, practice, future research, and educational instruction. The results of this longitudinal study suggest that literacy development is influenced both by foundational skills and underlying cognitive processes over time. The results also highlight the developmental similarities and differences that may occur between English and FI instructional environment groups. Within the results of the first research question, the English group demonstrated clear predictive and mediative pathways between early English reading, EF, and transcription, whereas the FI group demonstrated less significant predictive and no mediative pathways between early French reading, EF, and transcription. These results suggest that early FI learners may maintain differentiated literacy developmental patterns. The second research question addressed cross-linguistic transfer between English and French development, and results indicated that orthographic development,

cognitive systems, or the integration of the two may not be as well unified as L1 learners at this point within early education FI programs. Though some modern research suggests that cross-linguistic transfer can occur in early elementary, the present study results align with frameworks that indicate that cross-linguistic transfer may be significant only once higher proficiency or development has been acquired (Cummins, 1979; Kim et al., 2022).

Further study regarding the developmental trends between English and FI program participants is needed. Extending this longitudinal study to address multiple timepoints and subsequent elementary development could provide further context about the potential emergence of predictive and mediative relations between EFs, L1, and L2 literacy development. Moreover, expanding this research to address language spoken at home could support a more comprehensive understanding of linguistic development in English and FI instructional programs.

Educational implications based on this study point to the need for explicit orthographic instructional support (i.e., orthographic pattern instruction, spelling, and transcription) within bilingual learning FI programs. Providing educational support that addresses EF development directly, to encourage scaffolded information retention, flexibility and inhibition may also facilitate early education bilingual literacy growth.

### ***Limitations***

The results and discussion should also be informed by the limitations of the study, including the study sample and lack of fit with the initial mediation analysis method. Each limitation should be considered. First, because convenience sampling strategy was employed, there is the potential that bias could have occurred, and generalizability be called into question. However, due to various constraints, this sampling method was the most suitable option and still

produced a large and varied enough sample to analyze and interpret. Additional mitigative strategies, such as careful consideration and choice of measures as well as the longitudinal design promoted increased validity and reliability. It should be noted that the FI group results may have been impacted by the overall exposure to the language. The participants included in this study were Grade 1 and Grade 2 students. These are the second and third years of formal education and for some, the second and third years of direct exposure to the French language. Moreover, the noted attrition between Y1 and Y2 could have impacted the results. Though, it was noted that the differences in Y1 scores between continuing and non-continuing participants were not significant. Second, the census data collected provide general demographic information about small geographical areas (i.e., school catchment zones); however, individualized collection of this information, notably, the education level of parents (particularly the mother education) could have provided more accurate information regarding measure performance and developmental growth (Pazeto et al., 2020).

Lastly, regarding analysis, our initial analysis plan utilized structural equation modeling (SEM) or pathway analysis. After completing pre-analysis, correlational, and regression analysis, exploratory factor analysis was completed. This step identifies underlying structures within a dataset and additionally illustrates the fitness of the data to be used in subsequent pathway or SEM analysis. Within exploratory factor analysis, model fit, factor structure, communalities, sample size, and variables per factor determine feasibility for SEM or pathway analysis (Gaskin, 2020). After conducting exploratory factor analysis using the three proposed models (including the English Group, the FI Group (French literacy), and the FI Group (English and French literacy)), it was clear that the data set was not suitable for SEM or pathway analysis. This was demonstrated first by a below average sample size. Typically, a sample of at least 100 to 150 is

suggested, and this study's sample set was  $n=67$ . Second, it is recommended that at least three indicators per variable be available, and we had one to two indicators, with one occurrence of three indicators per variable. Third, the data indicated poor factor structure, weak loadings, and low communalities. Lastly, all three models demonstrated risk of poor model fit (using Kaiser-Meyer-Olkin Measure of Sampling Adequacy) (Gaskin, 2020). The resulting analysis was thus a theoretical exploration of predictive and mediative relations between literacy and EF variables, using a regression-based approach.

### *Executive Summary*

In sum, the present study examined word reading, EF, and transcription-measures longitudinally to identify developmental predictors within English and French Immersion (FI) instructional environment groups. The results of this study suggest that literacy development is influenced both by foundational skills and underlying cognitive processes over time. Results revealed that EFs, specifically shifting and working memory, directly and indirectly mediated the relation between word reading and transcription within the English group. In contrast, no direct and indirect EF mediative relations were identified within the FI group, though working memory was identified as a direct-only non-mediator. Regarding cross-linguistic transfer, English reading did not significantly predict French transcription and there were no noted EF mediation relations between the two variables. These results indicated that Canadian English and FI instructional environment group students may maintain differentiated literacy and cognitive developmental patterns. Moreover, results indicate that cross-linguistic transfer may be significant only once more comprehensive language proficiency has been acquired.

### References

- A parent's guide to effective reading: Grades 1 to 3.* ((n.d.)). BC Confederation of Parent Advisory Councils. <https://bccpac.bc.ca/upload/2016/05/parentguidetoreadingps.pdf>
- Abbott, R. D., & Berninger, V. W. (1993). Structural equation modeling of relationships among developmental skills and writing skills in primary- and intermediate-grade writers. *Journal of Educational Psychology, 85*(3), 478–508. <https://doi.org/10.1037/0022-0663.85.3.478>
- Altemeier, L. E., Abbott, R. D., & Berninger, V. W. (2008). Executive functions for reading and writing in typical literacy development and dyslexia. *Journal of Clinical and Experimental Neuropsychology, 30*(5), 588–606. <https://doi.org/10.1080/13803390701562818>
- Au-Yeung, K., Hipfner-Boucher, K., Chen, X., Pasquarella, A., D'Angelo, N., & Hélène Deacon, S. (2015). Development of English and French Language and Literacy Skills in EL1 and EL French Immersion Students in the Early Grades. *Reading Research Quarterly, 50*(2), 233–254. <https://doi.org/10.1002/rrq.95>
- Barbu, C., Gonzalez, A., Gillet, S., & Poncelet, M. (2019). Cognitive Advantage in Children Enrolled in a Second-Language Immersion Elementary School Program for One Year. *Psychologica Belgica, 59*(1), 416–435. <https://doi.org/10.5334/pb.469>
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182. <https://doi.org/10.1037/0022-3514.51.6.1173>

- Berninger, V. W. (1999). Coordinating Transcription and Text Generation in Working Memory during Composing: Automatic and Constructive Processes. *Learning Disability Quarterly*, 22(2), 99–112. <https://doi.org/10.2307/1511269>
- Berninger, V., & Winn, W. (2006). Implications of advancements in brain research and technology for writing development, writing instruction, and educational evolution. In *Handbook of writing research* (In MacArthur CA, Graham S, Fitzgerald J (Eds.), pp. 96–114). Guilford Press.  
[https://scholar.google.com/scholar\\_lookup?title=Handbook%20of%20writing%20research&author=VW%20Berninger&author=WD%20Winn&author=CA%20MacArthur&author=S%20Graham&author=J%20Fitzgerald&publication\\_year=2006&](https://scholar.google.com/scholar_lookup?title=Handbook%20of%20writing%20research&author=VW%20Berninger&author=WD%20Winn&author=CA%20MacArthur&author=S%20Graham&author=J%20Fitzgerald&publication_year=2006&)
- Bérubé, D., Uchikoshi, Y., & Marinova-Todd, S. H. (2022). A longitudinal examination of French and English reading comprehension in French immersion programs in Canada. *Applied Psycholinguistics*, 43(3), 607–640. <https://doi.org/10.1017/S0142716422000030>
- Bialystok, E., & Barac, R. (2013). Emerging bilingualism: Dissociating advantages for metalinguistic awareness and executive control. *Cognition*, 122(1), 67–73.  
<https://doi.org/10.1016/j.cognition.2011.08.003>
- Bialystok, E., & Martin, M. M. (2004). Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science*, 7(3), 325–339.  
<https://doi.org/10.1111/j.1467-7687.2004.00351.x>
- Borella, E., & De Ribaupierre, A. (2014). The role of working memory, inhibition, and processing speed in text comprehension in children. *Learning and Individual Differences*, 34, 86–92. <https://doi.org/10.1016/j.lindif.2014.05.001>

- Buttelmann, F., & Karbach, J. (2017). Development and Plasticity of Cognitive Flexibility in Early and Middle Childhood. *Frontiers in Psychology, 8*, 1040.  
<https://doi.org/10.3389/fpsyg.2017.01040>
- Cartwright, Marshall, T. R., & Hatfield, N. A. (2020). Concurrent and Longitudinal Contributions of a Brief Assessment of Reading-Specific Executive Function to Reading Comprehension in First and Second Grade Students. *Mind, Brain and Education, 14*(2), 114–123. <https://doi.org/10.1111/mbe.12236>
- Chung, S. C., Koh, P., Chen, X., & Deacon, S. H. (2023). Orthographic knowledge: A predictor or an outcome of word reading and spelling in bilingual children? *Reading and Writing, 36*(3), 517–539. <https://doi.org/10.1007/s11145-022-10302-5>
- Cirino, P. T., Ahmed, Y., Miciak, J., Taylor, W. P., Gerst, E. H., & Barnes, M. A. (2018). A framework for executive function in the late elementary years. *Neuropsychology, 32*(2), 176–189. <https://doi.org/10.1037/neu0000427>
- Colé, P., Duncan, L. G., & Blaye, A. (2014). Cognitive flexibility predicts early reading skills. *Frontiers in Psychology, 5*. <https://doi.org/10.3389/fpsyg.2014.00565>
- Conrad, N. J. (2008). From reading to spelling and spelling to reading: Transfer goes both ways. *Journal of Educational Psychology, 100*(4), 869–878. <https://doi.org/10.1037/a0012544>
- Conrad, N. J., & Deacon, S. H. (2016). Children's Orthographic Knowledge and Their Word Reading Skill: Testing Bidirectional Relations. *Scientific Studies of Reading, 20*(4), 339–347. <https://doi.org/10.1080/10888438.2016.1183128>
- Cummins, J. (1979). Linguistic Interdependence and the Educational Development of Bilingual Children. *Review of Educational Research, 49*(2), 222–251.  
<https://doi.org/10.3102/00346543049002222>

- D'Angelo, N., Krenca, K., & Chen, X. (2020). The Overlap of Poor Reading Comprehension in English and French. *Frontiers in Psychology, 11*, 120.  
<https://doi.org/10.3389/fpsyg.2020.00120>
- Deacon, S. H., Wade-Woolley, L., & Kirby, J. (2007). Crossover: The role of morphological awareness in French immersion children's reading. *Developmental Psychology, 43*(3), 732–746. <https://doi.org/10.1037/0012-1649.43.3.732>
- Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System* [Dataset]. <https://doi.org/10.1037/t15082-000>
- Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64*(1), 135–168.  
<https://doi.org/10.1146/annurev-psych-113011-143750>
- Dunsmuir, S., & Blatchford, P. (2004). Predictors of writing competence in 4- to 7-year-old children. *British Journal of Educational Psychology, 74*(3), 461–483.  
<https://doi.org/10.1348/0007099041552323>
- Ehri, L. C. (2000). Learning To Read and Learning To Spell: Two Sides of a Coin. *Topics in Language Disorders, 20*(3), 19–36. <https://doi.org/10.1097/00011363-200020030-00005>
- Ehri, L. C. (2005). Learning to Read Words: Theory, Findings, and Issues. *Scientific Studies of Reading, 9*(2), 167–188. [https://doi.org/10.1207/s1532799xssr0902\\_4](https://doi.org/10.1207/s1532799xssr0902_4)
- Ehri, L. C. (2020). The Science of Learning to Read Words: A Case for Systematic Phonics Instruction. *Reading Research Quarterly, 55*(S1). <https://doi.org/10.1002/rrq.334>
- Fitzgerald, J., & Shanahan, T. (2000). Reading and Writing Relations and Their Development. *Educational Psychologist, 35*(1), 39–50. [https://doi.org/10.1207/S15326985EP3501\\_5](https://doi.org/10.1207/S15326985EP3501_5)
- Gaskin, J. E. (2020). *Structural Equation Modeling*. MyEducator.

- Gathercole, S. E., Pickering, S. J., Ambridge, B., & Wearing, H. (2004). The Structure of Working Memory From 4 to 15 Years of Age. *Developmental Psychology, 40*(2), 177–190. <https://doi.org/10.1037/0012-1649.40.2.177>
- Genesee, F., & Jared, D. (2008). Literacy development in early French immersion programs. *Canadian Psychology / Psychologie Canadienne, 49*(2), 140–147. <https://doi.org/10.1037/0708-5591.49.2.140>
- Gottardo, A., Chen, X., & Huo, M. R. Y. (2021). Understanding Within- and Cross-Language Relations Among Language, Preliteracy Skills, and Word Reading in Bilingual Learners: Evidence From the Science of Reading. *Reading Research Quarterly, 56*(S1). <https://doi.org/10.1002/rrq.410>
- Gough, P. B., & Tunmer, W. E. (1986). Decoding, Reading, and Reading Disability. *Remedial and Special Education, 7*(1), 6–10. <https://doi.org/10.1177/074193258600700104>
- Government of British Columbia. ((n.d.)). *Census income data*. <https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/income/census-income-data>
- Hayes, J. R., & Berninger, V. W. (2014). Cognitive processes in writing: A framework. In *Writing development in children with hearing loss, dyslexia, or oral language problems: Implications for assessment and instruction* (B. Arfé, J. Dockrell, V. Berninger, pp. 3–15). Oxford University Press.
- Hayes, J. R., & Flower, L. S. (1980). Identifying the Organization of Writing Processes. In *Landmark Essays on Rhetorical Invention in Writing* (1st ed., pp. 153–180). Routledge. <https://doi.org/10.4324/9781003580126-15>

- Hooper, S. R., Roberts, J. E., Nelson, L., Zeisel, S., & Kasambira Fannin, D. (2010). Preschool predictors of narrative writing skills in elementary school children. *School Psychology Quarterly*, 25(1), 1–12. <https://doi.org/10.1037/a0018329>
- Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, 2(2), 127–160. <https://doi.org/10.1007/BF00401799>
- Hung, C. O.-Y. (2021). The role of executive function in reading comprehension among beginning readers. *British Journal of Educational Psychology*, 91(2), 600–616. <https://doi.org/10.1111/bjep.12382>
- Juel, C., Griffith, P. L., & Gough, P. B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade. *Journal of Educational Psychology*, 78(4), 243–255. <https://doi.org/10.1037/0022-0663.78.4.243>
- Kim, Y. G. (2020). Structural relations of language and cognitive skills, and topic knowledge to written composition: A test of the direct and indirect effects model of writing. *British Journal of Educational Psychology*, 90(4), 910–932. <https://doi.org/10.1111/bjep.12330>
- Kim, Y.-S. G. (2015). Language and Cognitive Predictors of Text Comprehension: Evidence From Multivariate Analysis. *Child Development*, 86(1), 128–144. <https://doi.org/10.1111/cdev.12293>
- Kim, Y.-S. G. (2017). Why the Simple View of Reading Is Not Simplistic: Unpacking Component Skills of Reading Using a Direct and Indirect Effect Model of Reading (DIER). *Scientific Studies of Reading*, 21(4), 310–333. <https://doi.org/10.1080/10888438.2017.1291643>

- Kim, Y.-S. G. (2019). Structural relations of language and cognitive skills, and topic knowledge to written composition: A test of the direct and indirect effects model of writing. *British Journal of Educational Psychology, 90*(4), 910–932. <https://doi.org/10.1111/bjep.12330>
- Kim, Y.-S. G. (2020). Toward Integrative Reading Science: The Direct and Indirect Effects Model of Reading. *Journal of Learning Disabilities, 53*(6), 469–491. <https://doi.org/10.1177/0022219420908239>
- Kim, Y.-S. G., Gatlin, B., Al Otaiba, S., & Wanzek, J. (2018). Theorization and an Empirical Investigation of the Component-Based and Developmental Text Writing Fluency Construct. *Journal of Learning Disabilities, 51*(4), 320–335. <https://doi.org/10.1177/0022219417712016>
- Kim, Y.-S. G., & Park, S.-H. (2018). Unpacking pathways using the direct and indirect effects model of writing (DIEW) and the contributions of higher order cognitive skills to writing. *Reading and Writing, 32*(5), 1319–1343. <https://doi.org/10.1007/s11145-018-9913-y>
- Kim, Y.-S. G., & Schatschneider, C. (2017). Expanding the developmental models of writing: A direct and indirect effects model of developmental writing (DIEW). *Journal of Educational Psychology, 109*(1), 35–50. <https://doi.org/10.1037/edu0000129>
- Kim, Y.-S. G., Wolters, A., Mercado, J., & Quinn, J. (2022). Crosslinguistic transfer of higher order cognitive skills and their roles in writing for English-Spanish dual language learners. *Journal of Educational Psychology, 114*(1), 1–15. <https://doi.org/10.1037/edu0000516>
- Korkman, M., Kirk, U., & Kemp, S. (2012). *NEPSY - Second Edition* [Dataset]. <https://doi.org/10.1037/t15125-000>

- Lee, K., Bull, R., & Ho, R. M. H. (2013). Developmental Changes in Executive Functioning. *Child Development, 84*(6), 1933–1953. <https://doi.org/10.1111/cdev.12096>
- Lehto, J. E., Juujärvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology, 21*(1), 59–80. <https://doi.org/10.1348/026151003321164627>
- McCutchen, D. (1996). A capacity theory of writing: Working memory in composition. *Educational Psychology Review, 8*(3), 299–325. <https://doi.org/10.1007/BF01464076>
- Miyake, A., & Friedman, N. P. (2012). The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions. *Current Directions in Psychological Science, 21*(1), 8–14. <https://doi.org/10.1177/0963721411429458>
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex “Frontal Lobe” Tasks: A Latent Variable Analysis. *Cognitive Psychology, 41*(1), 49–100. <https://doi.org/10.1006/cogp.1999.0734>
- Nicolay, A.-C., & Poncelet, M. (2013). Cognitive advantage in children enrolled in a second-language immersion elementary school program for three years. *Bilingualism: Language and Cognition, 16*(3), 597–607. <https://doi.org/10.1017/S1366728912000375>
- Nicolay, A.-C., & Poncelet, M. (2015). Cognitive benefits in children enrolled in an early bilingual immersion school: A follow up study. *Bilingualism: Language and Cognition, 18*(4), 789–795. <https://doi.org/10.1017/S1366728914000868>
- Nouwens, S., Groen, M. A., Kleemans, T., & Verhoeven, L. (2021). How executive functions contribute to reading comprehension. *British Journal of Educational Psychology, 91*(1), 169–192. <https://doi.org/10.1111/bjep.12355>

- Pazeto, T. D. C. B., Dias, N. M., Gomes, C. M. A., & Seabra, A. G. (2020). Prediction of Reading and Writing in Elementary Education through Early Childhood Education. *Psicologia: Ciência e Profissão*, *40*, e205497. <https://doi.org/10.1590/1982-3703003205497>
- Pazeto, T. D. C. B., Seabra, A. G., & Dias, N. M. (2014). Executive Functions, Oral Language and Writing in Preschool Children: Development and Correlations. *Paidéia (Ribeirão Preto)*, *24*(58), 213–222. <https://doi.org/10.1590/1982-43272458201409>
- Peng, P., Barnes, M., Wang, C., Wang, W., Li, S., Swanson, H. L., Dardick, W., & Tao, S. (2018). A meta-analysis on the relation between reading and working memory. *Psychological Bulletin*, *144*(1), 48–76. <https://doi.org/10.1037/bul0000124>
- Perfetti, C., & Stafura, J. (2014). Word Knowledge in a Theory of Reading Comprehension. *Scientific Studies of Reading*, *18*(1), 22–37. <https://doi.org/10.1080/10888438.2013.827687>
- Petersen, I. T., Hoyniak, C. P., McQuillan, M. E., Bates, J. E., & Staples, A. D. (2016). Measuring the development of inhibitory control: The challenge of heterotypic continuity. *Developmental Review*, *40*, 25–71. <https://doi.org/10.1016/j.dr.2016.02.001>
- Puranik, C. S., & AlOtaiba, S. (2012). Examining the contribution of handwriting and spelling to written expression in kindergarten children. *Reading and Writing*, *25*(7), 1523–1546. <https://doi.org/10.1007/s11145-011-9331-x>
- Reynolds, G. D., & Romano, A. C. (2016). The Development of Attention Systems and Working Memory in Infancy. *Frontiers in Systems Neuroscience*, *10*. <https://doi.org/10.3389/fnsys.2016.00015>

- Rocha, R. S., Castro, S. L., & Limpo, T. (2022). The role of transcription and executive functions in writing: A longitudinal study in the transition from primary to intermediate Grades. *Reading and Writing, 35*(8), 1911–1932. <https://doi.org/10.1007/s11145-022-10256-8>
- Salas, N., & Silvente, S. (2019). The role of executive functions and transcription skills in writing: A cross-sectional study across 7 years of schooling. *Reading and Writing, 33*(4), 877–905. <https://doi.org/10.1007/s11145-019-09979-y>
- Savage, R., Kozakewich, M., Genesee, F., Erdos, C., & Haigh, C. (2017). Predicting writing development in dual language instructional contexts: Exploring cross-linguistic relationships. *Developmental Science, 20*(1), e12406. <https://doi.org/10.1111/desc.12406>
- Shahar-Yames, D., & Share, D. L. (2008). Spelling as a self-teaching mechanism in orthographic learning. *Journal of Research in Reading, 31*(1), 22–39. <https://doi.org/10.1111/j.1467-9817.2007.00359.x>
- Shanahan, T., & Lomax, R. G. (1986). An analysis and comparison of theoretical models of the reading–writing relationship. *Journal of Educational Psychology, 78*(2), 116–123. <https://doi.org/10.1037/0022-0663.78.2.116>
- Søndergaard Knudsen, H. B., Jensen De López, K., & Archibald, L. M. D. (2018). The contribution of cognitive flexibility to children’s reading comprehension – the case for Danish. *Journal of Research in Reading, 41*(S1). <https://doi.org/10.1111/1467-9817.12251>
- Spencer, M., & Cutting, L. E. (2021). Relations among Executive Function, Decoding, and Reading Comprehension: An Investigation of Sex Differences. *Discourse Processes, 58*(1), 42–59. <https://doi.org/10.1080/0163853X.2020.1734416>

- Spencer, M., Richmond, M. C., & Cutting, L. E. (2020). Considering the Role of Executive Function in Reading Comprehension: A Structural Equation Modeling Approach. *Scientific Studies of Reading, 24*(3), 179–199.  
<https://doi.org/10.1080/10888438.2019.1643868>
- Stanovich, K. E., & West, R. F. (1989). Exposure to Print and Orthographic Processing. *Reading Research Quarterly, 24*(4), 402. <https://doi.org/10.2307/747605>
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643–662. <https://doi.org/10.1037/h0054651>
- Tibbe, T. D., & Montoya, A. K. (2022). Correcting the Bias Correction for the Bootstrap Confidence Interval in Mediation Analysis. *Frontiers in Psychology, 13*, 810258.  
<https://doi.org/10.3389/fpsyg.2022.810258>
- Wechsler, D. (2003). *Wechsler Intelligence Scale for Children, Fourth Edition* [Dataset].  
<https://doi.org/10.1037/t15174-000>
- Wechsler, D. (2005). *WIAT-II: Test de Rendement Individuel de Wechsler*. Harcourt assessment, Harcourt Canada. <https://books.google.ca/books?id=xDorQwAACAAJ>
- Wechsler, D. (2009). *Wechsler Individual Achievement Test (3rd ed.)*. San Antonio, TX: Psychological Corporation.
- Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology, 44*(2), 575–587. <https://doi.org/10.1037/0012-1649.44.2.575>
- Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature Protocols, 1*(1), 297–301.  
<https://doi.org/10.1038/nprot.2006.46>

Zhao, X., Lynch, J. G., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and Truths about Mediation Analysis. *Journal of Consumer Research*, 37(2), 197–206.

<https://doi.org/10.1086/651257>