The Impact of Dual-Language Representation on Reading Development in Bilingual Children

by

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Abstract

When reading, words are broken down into morphological components that involve meaning and letter-order information; These are activated in two languages in bilinguals. These dual representations facilitate reading in bilinguals proficient in both languages, with efficient cross-language activation and morphological processing. This dual activation may be detrimental in bilinguals with low-to-intermediate second-language (L2) proficiency, as overlap and interactions between strong- and weak-language representations of morphological components may inhibit lexical access. This study investigated how dual-language representation impacts access to morphological information during reading, and whether bilingual proficiency can mediate effects. Grade 6 monolingual (N = 26), high-proficient (HP; N = 11) and low-proficient (LP; N = 9) bilingual children participated. Standardized reading and L2 vocabulary measures were followed by a primed lexical decision task in English. Prime-target pairs were semantically related (e.g., walker-WALK), orthographically related (e.g., corner-CORN), or unrelated. Event related potential (ERP) and response time (RT) data were analyzed, focusing on how strength of dual language proficiency can impact reading in bilinguals. Comparisons between bilinguals and monolinguals were also examined. RTs and ERP N400 waveforms involving semantic processing were facilitated by semantically related primes for monolinguals. LP bilinguals performed like HP bilinguals, but with ERP N250 orthographic-prime facilitation. HP bilinguals relied more on orthographic information, with reduced primacy of semantic information in word identification. Results support interactive activation accounts of bilingualism, demonstrating that morpho-syntactic and -orthographic activation presents differently in bilinguals of varying L2 proficiency and in monolinguals; possibly driven by the quality of dual language representations.

Keywords: morphological awareness, dual-language representation, ERP, bilingual, reading

The Impact of Dual-Language Representation on Reading Development in Bilingual Children

Reading is essential for academic and occupational success. For skilled readers, reading can be facilitated by morphological representations, which contain meaning (known as morpho-semantic), and visual information (known as morpho-orthographic; Rosenburg & Kruk, 2022). Although the various components of reading have been studied extensively in monolinguals, questions remain regarding how these components influence reading in bilinguals (Sauval et al., 2016; Vernice & Pagliarini, 2018). In particular, the potential effects on reading of having morphological representations in more than one language constitutes an influence on reading that is unique to bilinguals (Comesaña et al., 2018; Vernice & Pagliarini, 2018). Research with bilinguals indicates a complex relationship between language and reading-related cognitive processes. While some research shows bilinguals have better executive functioning and attentional control than monolinguals (Bialystock et al., 2014), other research shows a bilingual disadvantage on lexical tasks, particularly those involving semantic fluency (Marsh et al., 2019). In fact, bilingual children appear to be outperformed by monolingual children on measures of morphological awareness, and they show different relationships in how morphological skills predict reading achievement (Vernice & Pagliarini, 2018). This finding indicates that morphological awareness might play a different role in reading acquisition in bilingual compared to monolingual children that might reflect a disadvantage resulting from cross-language activation, involving interference by shared linguistic information in the two languages; this may also impact reading development.

This study explores dual language representations in bilinguals, particularly using event related potentials (ERPs) to investigate its impact on word recognition in bilingual children. I examined how French-English bilingual children access morpho-semantic versus morpho-orthographic information during reading in English. I then evaluated how these processes are impacted by proficiency in French as well as reading ability.

Components of Reading Development

Early stages of reading acquisition involve translating print into sound. This process involves phonological recoding, where grapheme and phoneme representations are combined (Sauval et al., 2016). Phonological awareness, which involves manipulating and representing sound units of words (phonemes), is essential to reading and reading development (Tobia & Marzocchi, 2014). Over time, readers become proficient at recognizing words rapidly with a high degree of automaticity (Sauval et al., 2016). For skilled readers, the process of recognizing and understanding printed words becomes automatic. Similar to phonological awareness, orthographic awareness involves understanding letter patterns and combinations that make up written words (Velluntino et al., 2004). Sauval and colleagues (2016) describe that phonological activation of letters develops rather quickly, whereas the automatic activation processes used for word recognition develops more slowly. This indicates that when visual words become familiar, the reliance on explicit phonological decoding is replaced by rapid and fluent word recognition (Sauval et al., 2016).

Readers rely on metalinguistic processes to guide their reading in word decoding, fluency, and reading comprehension (Velluntino et al., 2004). Metalinguistic processes include the uses of phonological, orthographic, and morphological awareness for easier word recognition. Morphological awareness involves understanding that words consist of individual units of meaning (morphemes), and the ability to decode word representations containing meaning (morpho-semantic) and visual information (morpho-orthographic). In beginning stages of visual word recognition, the morpho-orthographic system allows words to be broken down into their base and suffix components (for example, *package* is separated into *pack* and *age*; Comesaña et al., 2018). These processes all work in unison to successfully develop reading ability. It has been suggested that once word decoding is automatized, morphological awareness and orthographic knowledge work in tandem to decode complex word structures, allowing readers to make inferences regarding the lexical information of complex words (Vernice & Pagliarini, 2018). In fact, morphological awareness might be considered an important predictor not only of reading fluency, but of reading comprehension as well (Vernice & Pagliarini, 2018). While these processes have been extensively studied in monolinguals, many questions remain to be explored involving bilinguals and the implications of having morphological representations in multiple languages (Comesaña et al., 2018).

Dual Language Representations and Cross-Language Activation

Bilingual individuals have lexical representations that contain information from both of their languages. Although several different accounts have been proposed to explain the nature of these representations and the way that bilingual language is organized in the brain (e.g., BIA+, Dijkstra & van Heuven, 2002; BLINCS, Shook & Marian, 2013; Revised Hierarchical Model, Kroll & Stewart, 1994), these theories all converge on the understanding that connections exist between language representations for bilinguals. Cross-language activation is a phenomenon in which bilinguals activate both of their languages while speaking, listening, or reading in one language alone (Bobb et al., 2020; Marian & Spivey, 2003; Desroches et al., 2022). Indeed, Bobb and colleagues go so far as to state that there is no longer a question of whether cross-language activation occurs, but under what conditions we see this activation, and what linguistic processes may be involved.

The Bilingual Interactive Activation (BIA+) model, a current theory of word recognition in bilinguals, posits that phonological and orthographic information are automatically activated in both languages when a word is visually presented (Dijkstra & Van Heuven, 2002; Kaushanskaya & Marian, 2007). This model characterizes the information processing and lexical access to the lexicon as being fast-acting and non-selective in language activation. Therefore, when a word is presented, it is separated into its base and suffix and all form representations for these parts are activated. Simultaneously, the word is translated into the other language and is activated along with its respective base and suffix forms, and with additional representations (Comesaña et al., 2018). Thus, lexical processing is highly interactive, wherein words sharing semantic, morphological, orthographic or phonological characteristics are co-activated along with the originally presented word (Mulder et al., 2015). For example, when presented with the English word *house*, words such as *housekeeper* or *wheelhouse* may be co-activated due to their morphological relatedness (Schreuder & Baayen, 1997). This web of co-activated words is known as the morphological family (Mulder et al., 2015). Further, this effect extends for bilinguals into a cross-language morphological family, as an individual fluent in Dutch may also automatically activate the words *bejaardenhuis* (elderly home) or *huizenmarkt* (house market; Mulder et al., 2013). In monolinguals, high levels of lexical co-activation speed up word recognition within morphological families, and is beneficial to reading fluency (Mulder et al., 2015). These authors specify that words in larger morphological families are processed more efficiently than those in smaller morphological families, as evidenced by shorter response latencies on a lexical decision task for the former (Mulder et al., 2015; Shreuder & Baayen, 1997). These authors interpreted this to be due to larger amounts of activation being spread back and forth across semantic, phonological, orthographic, and morphological representations of a target word and other words of the morphological family. On the other hand, cross-language activation and dual-language representation causes different effects in morphological processing for bilinguals, as is explored below.

Cognitive Advantages and Disadvantages in Bilinguals as Related to Language

Research on bilinguals' reading-related and spoken word processing shows a complex relationship between language and cognition (Beyersmann et al., 2015; Bialystok et al., 2009; Bialystock, 2021; Carrasco-Ortiz et al., 2012; Comesaña et al., 2018; Diependaele et al., 2011; Kuo et al., 2017; Liang & Chen, 2014; Mulder et al., 2013; Saiegh-Haddad & Geva, 2008; Titone et al., 2011; Vernice & Pagliarini, 2018). Some research suggests that bilinguals outperform monolinguals on tasks involving executive functioning, particularly attentional control, inhibition, and switching (Marsh et al., 2019; Poarch & van Hell, 2012). This is referred to as the *bilingual advantage*. Specifically, these advantages are attributed to superior performance in clustering and switching of language forms and units in the context of phonemic fluency in bilinguals, as compared to monolinguals (Marsh et al., 2019; Poarch & van Hell, 2012). Clustering refers to successively producing words that rhyme, are homonyms, or are phonologically related, while switching refers to the change in subcategories, thus producing words that do not belong to the cluster (Marsh et al., 2019). For example, these authors describe that a sequence such as "farce, farm, fast, fog, frog, and flog" is composed of one switch and two clusters. The bilingual advantage is also seen in the context of phonemic fluency, as this develops in conjunction with executive control (Bialystok et al., 2009). Further, it is believed that this advantage is more often seen in the context of phonemic fluency due to word translations being more easily suppressed when there is little orthographic overlap (e.g., "dog" in English and "hund" in Swedish; Marsh et al., 2019).

On the other hand, executive control, which is stronger in bilinguals, is not as heavily involved in tasks involving semantic fluency and lexical access (Bialystock et al., 2009; Marsh et al., 2019). In fact, bilingualism can impair lexical access, as seen in prolonged reaction times and poor accuracy on lexical access tasks, such as picture naming. This is known as the *bilingual disadvantage*, and it is suggested to be a result of cross-language interference by shared linguistic information in bilinguals' two languages (Marsh et al., 2019). This cross-language interference is more strongly observed in semantic fluency tasks, as opposed to phonemic fluency (Marsh et al., 2019). Interestingly, a study by Bobb et al. (2020) presented ERP evidence showing that in highly proficient (HP) bilinguals, the L2 translation of an L1 auditory target was co-activated in the absence of phonological overlap during a spoken word recognition task. This finding suggests that bilingual lexical access is non-selective in language selection, and that the co-activation in one language when the other is in use is automatic (Bialystock et al., 2009; Bialystock, 2021; Bobb et al., 2020). This finding also indicates that the effects of language co-activation are not due solely to phonological overlap, and extend to the lexical level (Bobb et al., 2020; Freeman & Marian, 2022). This explanation is consistent with the Bilingual Language Interaction Network for Comprehension of Speech (BLINCS; Shook & Marian, 2013). While the localist, connectionist BIA+ model integrates two languages at the lexical level, it is specific to set-state occurrences of bilingual processing, and as such must be carefully examined to account for any variability in its processing (Shook & Marian, 2013). On the other hand, the BLINCS model includes these localist aspects of the BIA+ model, while integrating dynamic bilingual language processing (Shook & Marian, 2013). This is encompassed through this connectionist model four self-organizing maps (cluster of words within a language) consisting of phonological, phono-lexical, ortho-lexical, and semantic processing levels. These levels are interactive, clustering words within a language together, and co-activating words and rhymes within- and between-languages (Desroches et al., 2022, Shook & Marian, 2013). Thus, the BLINCS model strives to account for the dynamic, natural changes of bilingualism, and importantly includes the evolution of cross-language lexical activation (Shook & Marian, 2013).

Cognitive Advantages and Disadvantages in Bilinguals as Related to Written Word Processing

It has also been suggested that bilinguals demonstrate an advantage in metalinguistic knowledge, specifically being able to focus and direct attention to particular language aspects (Bialystok et al., 2014). In fact, Kuo and colleagues (2017) state that for both first and second-language learners, metalinguistic knowledge is a primary indicator of literacy and language development. Importantly, morphological awareness is highly intertwined with reading ability. Vernice and Pagliarini (2018) demonstrated that reading related inflectional morphology develops early, while derivational morphology develops progressively over time. Further, derivational morphology, particularly those aspects involving the development of metalinguistic skills, is enhanced by cross-language activation of cognate words and through increased sensitivity of the words' structural language features in bilingual children (Vernice & Pagliarini, 2018). In other words, bilingual children often develop increased sensitivity to the structural features of their two languages, thus leading to increased cognitive flexibility in processing metalinguistic knowledge and linguistic input (Kuo et al., 2017).

Cross-language activation and dual-language representations may allow bilingual children to access structural and morphological features of words more effortlessly, particularly due to cognate awareness (Kuo et al., 2017). Identical cognates are words that have identical orthographic overlap across languages, nearly identical semantic overlap, as well as phonological overlap, depending on the languages involved (e.g., *excellent* in both French and English; Titone et al., 2011). Therefore, words having high semantic and orthographic overlap are more easily translated across languages, as facilitated through dual-language representations, thus contributing to the strong metalinguistic abilities involved in bilingual reading. A recent study provided further evidence that HP bilinguals showed increased benefit from semantic co-activation of cognate words compared to low-intermediate (LP) proficient bilinguals, as marked by lexical decision priming effects for cognate and non-cognate words in the HP group only (Comesaña et al., 2018). These results have been taken as support of the Bilingual Interactive Activation (BIA+) model, evidenced by non-selective cross-language activation through phonological, orthographic, semantic, and morphological co-activation (Comesaña et al., 2018). Thus, morphological processing in the L2 and semantic cross-language activation appear to become more efficient as L2 proficiency increases.

Contrary to these findings, other research has found that cross-language activation causes poorer performance for bilinguals on reading tasks involving phonological overlap between the first language (L1) and the L2 (e.g., plaid-*plage*; Carrasco-Ortiz et al., 2012). Further, cross-language activation may lead to poor morphological awareness, as well as less-efficient lexical and semantic access, due to activating two competing lexical entries for a single word (Vernice & Pagliarini, 2018). As previously stated, semantic fluency tasks are more often affected by cross-language interference, as translational equivalents are not as easily suppressed as words with little overlap, as well as executive control being less heavily involved in semantic and lexical access tasks (Marsh et al., 2019). Overall, the effects of cross-language activation and dual-language representation remain mixed.

Event Related Potentials in Language Research

A brain's electrical activity can be measured by placing electrodes on the scalp, amplifying the signal, and tracking voltage fluctuations over time using electroencephalogram (EEG; Luck, 2005). ERPs refer to small segments of the EEG signal that are time-locked to the presentation of an event, such as a stimulus item. Experiments assessing behavioural data typically only assess reaction times. Alternatively, ERPs give a detailed look at the brain's activity and the timing of cognitive processes during language tasks (Bosch & Leminen, 2018). The ERP waveforms are then averaged into positive and negative voltage changes, known as peaks, waves, or components (Luck, 2005). Thus, P and N denote positive and negative going waveforms, respectively, with the associated numerical labels indicating their position within the waveform (e.g., N250 depicts a negative component at approximately 250 ms). ERPs are beneficial in studying cognitive processing as they provide a continuous record of brain activity from the moment a stimulus is presented to its response, which helps identify which stages of processing are influenced by different experimental changes and manipulations (Luck, 2005).

In fact, ERP data are measured on a millisecond scale, which allows us to observe the various cognitive processes that are implicated in word recognition prior to any physical response occurring, as is the case in recording reaction times (Bosch & Leminen, 2018). Further, the degree of negativity in components, such as the N250 and N400, are believed to reflect the amount of effort necessary to process a visually presented word, which may vary with the presence of a related prime word (Jared et al., 2017). A priming effect is a memory effect which occurs when the exposure to a particular stimulus impacts the reaction to a secondary stimulus. Specifically, research in language has demonstrated that showing related prime words makes it easier to identify the target word (e.g., *teacher-TEACH*) compared to unrelated prime words (e.g., *ringing-TEACH*), because the pertinent word is being pre-emptively automatically activated (Bosch & Leminen, 2018).

The N400 is a negative wave, and a well-studied language-related component (Luck, 2005). The N400 typically shows larger voltage activity when the brain receives unexpected semantic information (e.g., a small N400 peak would be elicited upon seeing the words “flour-SUGAR”, whereas a larger N400 peak would be elicited if shown the words “tire-SUGAR”; Luck, 2005). In other words, the N400 was a component of interest in the current study due to its sensitivity to semantic and lexical information across morphological primes. The N250 is another well-studied component of interest, as it is sensitive to pre-lexical orthographic and phonological information (Jared et al., 2017). As mentioned, these ERP components are well-researched, particularly in studies of morphological processing. For example, Liang and Chen (2014) investigated the ways in which morphologically complex words are processed differently by L2 learners as their proficiency changes. Their ERP results demonstrated that HP bilinguals experienced priming effects in their morphological condition in the 350-550 ms range, as evidenced by N400 voltage reductions, while the LP group showed no such priming effects. On the other hand, both bilingual groups in this study were found to have priming effects in the N400 component range associated with their orthographic condition, meaning that highly proficient and less proficient bilinguals were sensitive to word form (Liang & Chen, 2014).

Another study by Jared and colleagues (2017) evaluated the ways in which readers process complex English words and whether semantic transparency has an influence on these processes, using masked priming lexical-decision tasks. Their results revealed priming effects at the N250 and the N400 when target words were preceded by semantically related primes, while no such priming effects were found for targets preceded by orthographically-related primes, meaning that there was an influence of semantic transparency on priming. On the other hand, nonword trials led to more priming effects for orthographic primes. Ultimately, this research provides evidence that the strength of semantic-orthographic relationships has an impact on the early processing of morphologically complex words in English speaking adults (Jared et al., 2017). Overall, ERP research, particularly the N250 and N400 components, provides key information surrounding morphological processing that is instrumental to the investigations in the current study.

The Current Study

While there is evidence of dual-language representation and cross-language activation in bilinguals, questions remain regarding the conditions under which language co-activation may occur (Bobb et al., 2020). Specifically, how dual-language representation presents differently in the context of high and low proficient bilinguals is not well understood (Carrasco-Ortiz et al., 2012; Comesaña et al., 2018, Marsh et al., 2019). Further, it is unclear at which point dual-language representation in cross-language activation transitions from being inhibitory in tasks involving lexical access (Carrasco-Ortiz et al., 2012; Vernice & Pagliarini, 2018), to being beneficial in this context (Comesaña et al., 2018). Recent literature shows that low-proficient bilinguals demonstrate increased L1 activation when auditory linguistic input is presented in one language (Blumenfeld & Marian, 2007). Moreover, similar studies of auditory and visual word processing reveal that bilinguals having high L2 proficiency are more easily able to inhibit linguistic input in the non-target language, compared to bilinguals with lower L2 proficiency (Blumenfeld & Marian, 2013; Freeman & Marian, 2022). Together, this literature provides evidence that HP bilinguals may resolve competition from dual-language representation more efficiently and quickly than LP bilinguals in the context of L2 auditory and visual word recognition (Blumenfeld & Marian, 2013; Freeman & Marian, 2022).

The current study aimed to contribute to this literature by investigating dual-language representation in LP and HP bilinguals compared to monolinguals, using response times and ERP voltages while performing a primed lexical decision task. Participants were administered standardized behavioural measures, followed by a lexical decision task performed while recording ERP data. The lexical decision task consisted of four conditions. The first involved morpho-semantic related prime-target pairs (e.g., *teacher-TEACH*). The second involved morpho-semantic unrelated prime target pairs (e.g., *ringing-TEACH*). The third condition included morpho-orthographic related prime-target pairs (e.g., *corner-CORN*) and the fourth included morpho-orthographic unrelated prime-target pairs (e.g., *lonely-CORN*). It was predicted that the prime-type and suffix-type conditions of the lexical decision task (morpho-semantic, morpho-orthographic, related, unrelated) would allow us to examine L2 proficiency-group differences on these measures, particularly in ERP modulations (Madziak et al., 2021).

First, I hypothesized that monolingual children would show larger priming effects for morpho-semantic targets than morpho-orthographic targets, as marked by larger reaction time differences and larger reductions in voltages between related and unrelated conditions in the N400 range for semantic compared to orthographic primes, effectively replicating results found by Madziak and colleagues (2021).

Second, I hypothesized that both bilingual groups would show larger priming effects for morpho-orthographic targets than morpho-semantic targets, as evidenced by larger reaction time differences and larger reductions in voltages between related and unrelated conditions in the N400 range for orthographic compared to semantic primes. As is posited by the BIA+ model, phonological and orthographic information is automatically activated in both languages when a visual word is presented (Dijkstra & Van Heuven, 2002; Kaushanskaya & Marian, 2007), thus facilitating this fast-acting, non-selective language activation. This is also supported by Liang and Chen (2014), who found that both HP and LP bilinguals experience priming effects in the N400 range for orthographic pairs. Further, as many studies have demonstrated increased facilitation in lexical access involving cognate words (Comesaña et al., 2018; Titone et al., 2011), I expected to see similar facilitation effects for prime-target pairs involving orthographic overlap. While lexical access involving cognate words typically demonstrates facilitation effects for bilinguals on a semantic level (Comesaña et al., 2018; Liang & Chen, 2014; Titone et al., 2011), cognate words were not included in the current study, and words sharing orthographic similarities were rather non-cognates. Therefore, I predicted smaller priming effects for morpho-semantic targets, as dual-language representation is expected to cause additional interference in situations of semantic overlap (Carrasco-Ortiz et al., 2012; Marsh et al., 2019; Vernice & Pagliarini, 2018). Given that the lexical decision task was presented in their L1, I predicted that LP bilinguals would perform similarly to the monolingual group, except that they would show smaller priming effects due to increased dual-language representation interference (Comesaña et al., 2018; Titone et al., 2011).

Lastly, as morphological awareness is strongly related to reading ability, I hypothesized reading ability differences would impact performance on the lexical decision task. In other words, bilingual participants with poor reading abilities were predicted to show decreased performance due to increased inhibitory effects in both languages, while strong readers would experience facilitated dual-language representation effects (Vernice & Pagliarini, 2018; Mulder et al., 2013; Saiegh-Haddad & Geya, 2008).

Methods

Participants

Participants included grade 6 monolingual (N = 33) and bilingual students, consisting of low-intermediate proficient (LP; N = 10) and high proficient (HP; N = 13) bilingual groups. Some participants were excluded from the final analysis for various reasons. Two monolingual participants were excluded for having PPVT-4 scores below the cut-off criteria and five were excluded for speaking an additional language other than English at home (final monolingual group N = 26). One LP participant was excluded for having scores below the cut-off criteria in both the English and French PPVT tests; another was excluded for having a number of incorrect trials on the lexical decision task surpassing the cut-off criteria (final LP bilingual group N = 8). Two HP participants were excluded due to technical difficulties involving elevated voltage noise during ERP recordings (final HP bilingual group N = 11). A power analysis was conducted to assess the minimum sample size required for a medium effect size, based on Cohen's criteria. A significance criterion of $\alpha = .05$, and a power of 0.80 were used, indicating that a total sample size of 30 was required for this analysis. Therefore, the final total sample size of 45 participants was satisfactory for the analyses conducted. However, assuming that each group should include a minimum of 10 participants each, the LP group may have not been large enough to reveal their full potential statistical significance.

Monolingual participants were native English speakers with no knowledge of an additional language. Bilingual participants consisted of L1-French, L2-English learners, recruited from French (L1) schools in Winnipeg. High and low bilingual proficiency levels were assessed using the Peabody Picture Vocabulary Test in both English and French equivalents. As poor morphological awareness could be due to uneven vocabulary sizes, this effect was mitigated by studying balanced bilinguals, such as HP French L1 speakers living in an English dominant population, with balanced proficiency status confirmed by relative equivalent performance on English and French vocabulary measures, and whose performance on a primed lexical decision task may more closely resemble that of the monolingual population (Vernice & Pagliarini, 2018). French-English bilinguals in Manitoba experience a unique exposure to both languages. For example, children with a French L1 often attend fully French schools, however they are primarily exposed to English outside of the classroom, in the community, on television/social media, and in social contexts. Further, many families speak a mixture of French and English at home, often depending on the language proficiency of each parent. Thus, the ways in which bilingualism and French proficiency is represented in Manitoba is inherently different than how it may be represented in other bilingual milieus, such as in Québec, for example. It is essential to consider these unique circumstances when defining high- and low-proficiency language standards in this sample. Therefore, language proficiency group membership was determined by several factors.

First, all participants were required to have a standard score within 1 standard deviation of the mean on the English PPVT-4, to ensure English proficiency. English monolingual participants were excluded if they indicated proficiency in any another language (e.g., attend English school but speak Tagalog at home), or had English PPVT-4 scores lower than 1 SD below the mean. Second, as the French PPVT-5-CDN-FR was normed using Québec residents, this may not be an accurate representation of the Manitoba sample's French vocabulary. However, this test remains an important proxy measure of French proficiency. As such, bilinguals in this sample were required to have a standard score within 2 standard deviations of the mean on the French PPVT-5 to be considered as highly proficient. Lastly, as bilingual children tend to have more limited exposure to French outside of school, it is important to consider the amount of French exposure that they receive at home. Thus, in order to be considered highly proficient, participants were required to speak French at least 50% of the time at home, as determined by the parent's language history questionnaire. Participants meeting this criteria of home language exposure and minimum PPVT scores were considered HP bilinguals, while those who did not (i.e., French PPVT scores < 2 SD below the mean, and/or speaking French at home less than 50% of the time) were considered LP bilinguals. Participant demographic and language proficiency measures can be found in Tables 1 and 2, respectively.

Data of the monolingual English-speaking participants are from an archive of children recruited for a previous study in the University of Manitoba Early Years Reading Laboratory; therefore, secondary data was used for this part of the analysis. The final sample consisted of 26 monolingual, 9 LP, and 11 HP grade 6 children (N = 45). Data were collected from students with a wide range of reading abilities, as identified through teacher nominations, and verified using standardized test scores, including the Test of Word Reading Efficiency, Second Edition (TOWRE-2). Participants with TOWRE-2 standard scores below 90 were considered poor readers, and those with scores of 100 or higher (the average of the normative population) were considered good readers.

Materials and Measures

Parents of child participants were given a consent form to permit the participation of their child, along with a short questionnaire to collect demographic information, as well as reading-related information. This information included questions such as how often their child reads on a daily basis, how often do the parents read with the child, and so on (see Appendix A). These forms also asked permission to be included in a follow-up study at the University of Winnipeg involving ERP measurements. All forms were translated to French for distribution to French-speaking parents and teachers. A language history questionnaire was also given to bilingual participants, in order to assess French proficiency along with the French version of the PPVT-5 (see Appendix A).

Standardized tests

Prior to the experimental trials, participants were assessed using the Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2), Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4), Weschler Abbreviated Scale of Intelligence, Second Edition (WASI-II), Test of Word Reading Efficiency, Second Edition (TOWRE-2), Edinburgh handedness test, as well as sight word vocabulary in English and French. These measures were administered in a quiet space without distractions, at the participant's school, or in laboratory spaces at the University of Manitoba or University of Winnipeg. The collection of ERP data took place at the University of Winnipeg laboratory during the administration of the lexical decision task. All standardized test mean scores can be found for each group in Table 3.

CTOPP-2. The Comprehensive Test of Phonological Processing, Second Edition (Wagner et al., 2013), was administered to measure phonological processing. The Elision, nonword repetition, rapid letter naming and rapid digit naming subtests were administered. In the Elision subtest, participants were asked to say a word, and repeat it after removing a sound from the word (e.g., Say "toothpaste". Now say "toothpaste" without saying "tooth"). Nonword repetition involved participants repeating a non-word exactly as they heard it from the researcher. In rapid letter and digit naming, participants named letters and digits orally from respective lists as quickly and accurately as possible. These tasks took around 10 minutes to complete in total. The subtests for this test have coefficients > .80 for reliability (Wagner et al., 2013). These four subtests were included in the inferential analyses to control for phonological processing.

PPVT-4. The Peabody Picture Vocabulary Test, Fourth Edition (Dunn & Dunn, 2007), assessed participants' receptive English vocabulary knowledge by asking them to point towards one of four pictures that matches the word spoken by the researcher. This test was used as an exclusionary criterion to ensure that poor reader results were not due to a weak vocabulary, and as a proxy for language proficiency to verify balanced and unbalanced bilingualism. This test took 10 minutes to administer. Participants required a score within 1 standard deviation of the mean (i.e., SS > 85) to be included. The French translation equivalent, *Échelle de vocabulaire en images Peabody, Cinquième Édition*, was administered to all bilingual participants as a measure of French proficiency. Participants scoring more than 2 standard deviations below the mean (i.e., SS < 70) were considered low-proficient bilinguals, and scores of 70 or higher were considered high-proficient, along with the according language proficiency questionnaire data. This test has a reliability coefficient of > .90 (Dunn & Dunn, 2007).

WASI-II. The Weschler Abbreviated Scale of Intelligence, Second Edition (Weschler, 2011), was administered using the Matrix reasoning subtest. This subtest assessed nonverbal intelligence by showing participants an incomplete visual pattern and asking them to choose one out of five options that best fits the missing piece. This test was included as an exclusionary criterion, wherein participants must have a T-score of at least 30 (2 SD below the mean), in order to establish their capacity for understanding instructions in the lexical decision task. This test took about 10 minutes. This test has a reliability coefficient of r = .87 (Weschler, 2011).

TOWRE-2. The Test of Word Reading Efficiency, Second Edition (Torgesen et al., 2015) was administered using the phonemic decoding and sight word efficiency subtests. These measured how accurately and quickly participants recognize words by asking participants to read pronounceable non-words, and real words respectively. Participants were asked to read as many items as possible from each list in 45 seconds. This test was included in order to establish reader groups across participants. These tasks took around 5 minutes to administer. This test has reliability coefficients from .87 to > .90 (Torgesen et al., 2015). A standard score below 90 indicated poor readers, while scores of 100 or higher indicated good readers.

Edinburgh Handedness Test. This test was used to determine whether participants were exclusively left-handed. The researcher asks the participant a series of questions, to which the participant responded with which hand they would perform this action (e.g., “Show me with which hand you brush your teeth”). Participants who were exclusively left-handed were excluded from the data analysis of the ERP phase of the study, due to potential language laterization differences in the hemispheres of left-handed brains. This task took around 2 minutes to administer.

Lexical Decision Task

Participants were tested on the lexical decision task in an ERP lab at the University of Winnipeg in a sound-attenuated booth (WhisperChamber Inc.), following testing of standardized measures. This task was conceptualized and used as part of a previous study (Madziak et al., 2021). ERP was used to record electrophysiological responses throughout the lexical decision task starting at the onset of the prime in each trial, providing information on brain activity during morphological segmenting using the task.

The task consisted of prime and target pairs in four conditions, using two independent variables: suffix type (morpho-semantic, morpho-orthographic), and relatedness (related, unrelated), to measure morphological processes in bilingual and monolingual participants. This task included 40 trials of each condition, as well as 160 non-word trials presented throughout the task. Therefore, participants completed 320 trials for this lexical decision task (see Appendix B for stimuli list). The first condition involved morpho-semantically related prime-target pairs, which were semantically transparent (morpho-semantic suffix type condition; e.g., *worker, WORK*). The second condition consisted of morpho-semantically unrelated prime-target pairs. This involved the same set of targets as the first condition but used unrelated prime words. The third condition involved morpho-orthographically related prime-target pairs, which were semantically opaque for the morpho-orthographic condition (the primes contained related orthographic information in their root morphemes but were unrelated in meaning to the target; e.g., *corner-CORN*). The last condition involved morpho-orthographically unrelated prime-target pairs. These consisted of the same morpho-orthographic targets as the third condition but used unrelated prime words. Target items were counterbalanced across two blocks and randomized in order. A target paired with an unrelated prime in Block One would have been paired with a related prime in Block Two. This task took approximately 20 minutes to administer.

The Essex Children's Word Database (http://www.essex.ac.uk/psychology/cpwd; Masterson et al., 2010) was used to ensure that prime and target words were matched on word frequency and orthographic neighborhood. The items used between conditions were also matched on these conditions. All items used were included in this database. There were no significant differences between target lists or prime lists on frequency and orthographic neighborhood (frequency: related primes, $t(39) = -0.99$, $p = .33$; targets, $t(40) = -0.32$, $p = .75$; unrelated primes, $t(40) = 0.76$, $p = .45$ and orthographic neighborhood: related primes, $t(38) = -0.07$, $p = .94$; targets, $t(39) = 1.28$, $p = .21$; unrelated primes, $t(39) = -0.54$, $p = .59$). There was a significant difference in word length for target lists (targets, $t(39) = -3.67$ $p < .05$). The mean length of pseudo-suffixed words was 4.15, and the mean length for the morpho-semantic targets was 3.63 letters, resulting in a difference of 0.52 letters. There were no significant differences in word length for the prime lists (related primes, $t(38) = -0.83$, $p = .41$; unrelated primes, $t(39) = 0.14$, $p = .90$). To account for children's potential familiarity with certain target words, frequency of words (log word frequency; Brysbaert & New, 2009) was used to control the assumption that children would be exposed to higher-frequency words from younger ages. Frequency of words was used as a proxy for the Kuperman Age of Acquisition database, as this database did not include all target words (Madziak et al., 2021). Nonword stimuli were also reviewed to ensure that no stimuli consisted of legal French words.

Sight word vocabulary. This task was presented using a computer to evaluate which prime words are in the participant's sight vocabulary, meaning they could recognize them effortlessly. Participants were presented each prime word individually and asked to read them out loud. The researcher then inputted correct and incorrect answers into the computer; this allowed us to know which words each participant could decode and understand. This is essential for ERP analysis. Trials containing unknown primes were excluded from that participant's ERP data. Participants who did not know 25% or more of the prime words were excluded from the ERP analysis. This task took approximately 5 minutes to administer.

Event Related Potentials (ERP)

Differential modulations of ERPs, specifically the N250 and N400 wave form voltages measured in specific time windows following the onset of the primes, were used along with behavioural measures (response times in making lexical decisions after the onset of the target) during the lexical decision task to examine how bilingual children access morpho-semantic and morpho-orthographic information during reading, and how these processes are impacted by L2 proficiency. N400 wave forms were used due to its sensitivity to lexical and semantic information across morphological primes, while the N250 is sensitive to pre-lexical phonological and orthographic information (Madziak et al., 2021). Electroencephalographic (EEG) caps were fitted to each participant, containing 32 electrodes which are placed around the scalp for appropriate ERP data recordings. ERP analyses focused on the four conditions of the lexical decision task; morpho-semantically related, morpho-semantically unrelated, morpho-orthographically related, morpho-orthographically unrelated.

ERP data were recorded at 500 Hz from 32 Ag/AgCI ActiChamp active electrodes. Impedance levels, which are a measure of resistance to the flow of current in the EEG signal, were kept below 20 kΩ, as is recommended for this type of system. ERP waveform data were processed using BrainVision Analyzer 2.0 (Brain Products GmbH, 2006). Data were filtered from .1-30 Hz with a 24 dB/Oct phase shift. A 60 Hz notch filter was applied to remove any potential electrical noise that could have affected the data. Data were referenced online to Fz, and re-referenced offline to the approximate mastoids (TP9/TP10). Data was segmented for each condition and trials were corrected to the 100 ms pre-stimulus interval. Artifact rejection was performed to remove trials having voltages greater than 85µV or lower than -85µV.

Procedure

The current study used data obtained from a previous master’s thesis project (Madziak et al., 2021) for English speaking monolingual participants, as well as new data which were collected from 2022 to 2024. For the bilingual groups, behavioural measures were administered at their schools a minimum of one week prior to ERP data collection. Participants whose parents agreed to involve their children in the ERP testing were tested at the ERP laboratory at the University of Winnipeg. Parents/guardians were compensated for travel costs to the University of Winnipeg's ERP laboratory. Parental consent was first collected, followed by the participant's assent to begin the ERP study. In the lab, participants were fitted with an EEG cap, and sat 100 cm away from a computer screen in the dimly lit, sound-attenuated booth. After connecting the EEG cap to the amplifier and recording devices, the researcher remained in the booth with the participant to inject electrostatic gel into the 32 electrodes of the net, in order to achieve proper impedance levels for ERP analysis. The task was presented on a high-resolution computer monitor (Dell Precision M4800).

The researcher informed the participant of instructions for the lexical decision task. Participants were instructed to remain as still as possible, and to alert the researcher if they felt they needed a break. Participants were instructed to respond as quickly and accurately as possible by clicking a mouse button depending on whether they recognized the target as a word or not. Participants clicked a blue labelled mouse button if they recognized the target as a word in English, and an orange button if they did not recognize the target as a word in English. The lexical decision task involved 10 practice trials, followed by 320 experimental trials. A trial consisted of a fixation cross displayed in the middle of the screen for 500 ms, followed by a forward mask of eight hashmarks displayed for 500 ms. The prime stimulus was then shown for 67 ms in lowercase letters, with an interstimulus interval of 50 ms, for an SOA total of 117 ms. This SOA length was selected based on previous research reporting that this time is sufficient for poor readers to process the primes (Law et al., 2018; Quémart & Calsalis, 2015; Quémart et al., 2018). Finally, the target stimulus was presented in uppercase letters and remained on the screen until the participant had responded with either the blue or orange buttons. Accuracy and response times for lexical decision were recorded for the behavioural data, and EEG voltages were recorded throughout, with triggers indicating onset of primes recorded, which were used to determine ERP voltages for each word-target trial. The total participation time for all measures, including standardized measures and the lexical decision task was approximately 72 minutes per participant.

Statistical Analysis

For this analysis, ERP voltages were determined using Brain Analyser, while overall ERP data were analysed in SPSS. Behavioural data (response times for correct word trials) was analysed in R for monolingual and bilingual participants. Participant response times were examined to evaluate language-group differences in morphological awareness and dual-language representation, reflected by the strength of priming effects. Raw reaction times underwent an inverse transformation, in order to correct for possible violations of assumptions for parametric statistical analysis. Trials were excluded if they were incorrect, involved response times longer than 3000 ms or shorter than 300 ms. Linear mixed effects modelling was used for response time data (LMER in R; Baayen, 2008; Baayen et al., 2008), using transformed response times as the dependent variable. Relatedness, suffix type, and language group were used as fixed independent variables, and participant and item as random effects independent variables. Reader group was included as a covariate in a secondary analysis.

Results

Group Demographics

Demographic information for the three language groups is provided in Table 1. The number of male and female participants were comparable overall, and mean ages across groups were not significantly different. In the final sample, the monolingual group consisted of 17 typical readers and 9 poor readers; the LP group consisted of 4 children in each reader group; the HP group consisted of 9 typical readers and 2 poor readers.

Behavioural Analysis

An inverse transformation was conducted on the raw reaction time (RT) data for the inferential analyses, to correct for any violations of assumptions for parametric analyses (formula: InverseRT= -1000/RT; inverse RTs and estimated marginal means are found in Table 3). R lme4 (Baayen, 2008; Baayen et al., 2008; Bates et al., 2014; R Core Team, 2016) was used to conduct linear mixed-effects modelling for the inverse-transformed response times. Fixed effects consisted of prime type (related/unrelated), suffix type (morpho-semantic/morpho-orthographic) and language group (monolingual, LP, HP), with reading ability (TOWRE-index score) as a covariate. The model included random intercepts for subject and item, as well as interactions involving the fixed-effects factors. These were included in the final model for best fit, confirmed by a backward stepwise model selection (Beyersmann et al., 2016) and a chi-square log-likelihood ratio tests with regular maximum likelihood parameter estimation. Degrees of freedom were calculated using Satterthwaite approximations. The final best-fitting model was: lmer(inverse ~ prime type + suffix type + TI + logFreq + (1|subject) + (1|item) + prime type:suffixtype). Inverse reaction times and estimated marginal means can be found in Table 4.

There was a significant main effect of reading ability ($\beta = -0.008$, $SE = 0.002$, $F(1,43) = 20.85$, $p < .001$), indicating that stronger readers responded faster than poorer readers. There was also a significant main effect of log word frequency ($\beta = -0.048$, $SE = 0.013$, $F(1,77.1) = 13.87$, $p < .001$). This suggests that participants had faster reaction times for target items of higher frequencies. The interaction between suffix type and prime type was also significant, $F(1,6389.3) = 4.14$, $p = .042$. Post-hoc analyses determined that there was a significant priming effect for morpho-semantic targets ($p < .001$), meaning that participants demonstrated faster reaction times for semantically related primes ($M_{inverse} = -1.37$, $SE = .03$; $M_{ms} = 839$, $SE = 26.80$) compared to semantically unrelated primes ($M_{inverse}$ = -1.31, *SE* = .03; M_{ms} = 865, *SE* = 26.80). No significant priming effect was found for morpho-orthographic primes.

Electrophysiological Analysis

A 2x2x3 mixed model ANOVA was conducted for both the N250 and N400 time intervals. The within-subjects independent variables were prime type (relatedness: related, unrelated), and suffix type (morpho-semantic, morpho-orthographic), while language group (monolingual, low-proficient bilingual, high-proficient bilingual) served as the between-subjects variable. The dependent variable consisted of the mean voltage at each of the two waveforms of interest, the N400 and N250. A repeated measures ANCOVA was also conducted as a follow-up analysis to examine any influences of reading ability, using reader group (poor reader vs typical reader) as a covariate. Mean voltages and standard errors for all conditions can be found in Table 5. It should be noted that standard errors are reported (rather than standard deviations), as standard errors allow to robustly measure the variability between groups and within groups and are not influenced by group sizes. The mean voltages for the N250 and N400 time intervals reflect the degree of effort required for processing the presented information. Therefore, as these waveforms are negative-going, voltages referred to as “reduced” or “less negative” would reflect more facilitation, meaning that the stimuli are being processed more quickly, efficiently, and easily (i.e., more positive). On the other hand, “more negative” voltages reflect more effort being required for processing. It should also be noted that a priming effect refers to a memory effect, in which exposure to one stimulus (i.e., a prime word) would influence the reaction to another stimulus (i.e., the target word). More specifically, priming effects are defined by the difference between the unrelated and related conditions. In other words, if the subtraction of voltages between the related and unrelated conditions equal zero, then there is no priming effect.

Conversely, if the subtraction is equal to a negative number, then a priming effect is present for that condition.

N250 Time interval

Repeated measures ANOVAs were conducted on averaged voltages in the time window of 140 ms to 250 ms at the Fz electrode to examine the N250 component across participants. While the N250 is typically examined at the Fz electrode site to evaluate pre-lexical phonological and orthographic expectation, I also investigated the N250 at the Pz electrode site for exploratory purposes, as this site is typically sensitive to lexical and semantic expectation.

Fz electrode. A significant main effect of relatedness was found ($F(1,42) = 13.82$, $p < .001$, $\eta_p^2 = .248$). Participants produced reduced voltages (i.e., less negative voltages) for targets primed by related items ($M = -1.47$, $SE = .94$) compared to unrelated items ($M = -3.81$, $SE = .75$). All other main effects were not significant. A significant two-way interaction was found between suffix type and language proficiency ($F(2,42) = 6.53$, $p = .003$, $\eta_p^2 = .237$). Bonferroni-adjusted pairwise comparisons revealed that the LP group produced less negative N250s in the morpho-orthographic condition ($M = .250$, $SE = 1.72$) compared to the morpho-semantic condition ($M = -2.66$, $SE = 1.75$), $p = .009$. This same trend is also approaching significance for the monolingual group ($p = .067$) and the HP group ($p = .078$).

No other significant two-way interactions were found. No three-way interactions were found to be significant.

Pz electrode. Here, a main effect of relatedness was also found ($F(1,42) = 7.19$, $p = .010$, $\eta_p^2 = .146$), with participants demonstrating less negative voltages for targets primed by related items ($M = .079$, $SE = 1.02$) compared to unrelated items ($M = -1.34$, $SE = 1.06$). No other main or interactions effects were found to be significant, although a marginally significant three-way interaction was found between suffix type, relatedness, and language group (p = .063). Bonferroni-adjusted pairwise comparisons specified that the monolingual group had reduced voltages for targets primed by related items in the morpho-semantic condition (M = -1.24, SE = 1.24) compared to the morpho-orthographic condition (M = -2.76, SE = 1.24), p = .037. Within the morpho-semantic condition, the monolingual group also produced reduced voltages for targets primed by related items (M = -1.24, SE = 1.24) compared to those primed by unrelated items (M = -3.46, SE = 1.32), p = .004. Interestingly, this same effect also appeared for the HP group, but in the morpho-orthographic condition (related: M = 1.96, SE = 1.90; unrelated: M = -1.82, SE = 2.00), p = .016.

A follow-up ANCOVA was conducted to investigate any potential influences of reading ability. In this analysis, suffix type (morpho-semantic, morpho-orthographic) and relatedness (related, unrelated) served as within-subjects variables, while language group (monolingual, LP, and HP) served as between-subjects variables, and reader score (based on the TI measure) served as a covariate. At the Fz electrode site, no significant main effects were found, although a two-way interaction between suffix type and language proficiency remained significant, F (2,41) = 6.91, p = .003, η_p^2 = .252. At the Pz electrode site, no significant main or interaction effects were found. However, an interaction between relatedness and reading score appears to be approaching significance (p = .086), and the interaction between suffix type, relatedness, and language proficiency remains marginally significant (p = .093).

N400 Time interval

Repeated measures ANOVAs were conducted on averaged voltages in the time window of 300 ms to 550 ms at the Pz electrode to examine the N400 component across participants. While the N400 is typically examined at the Pz electrode site to evaluate lexical and semantic expectation, I also investigated the N400 at the Fz electrode site for exploratory purposes, as this site is typically sensitive to pre-lexical phonological and orthographic expectation.

Pz electrode. This analysis revealed a main effect of suffix type ($F(1,42) = 4.65$, $p = .037$, $\eta_p^2 = .100$), wherein participants showed reduced negativity for targets primed by morpho-semantic items ($M = 6.63$, $SE = .94$) compared to those primed by morpho-orthographic items ($M = 5.65$, $SE = .97$), $p = .037$. A main effect of relatedness was also found ($F(1,42) = 19.12$, $p < .001$, $\eta_p^2 = .313$), wherein participants had reduced negativity for targets primed by related items ($M = 7.37$, $SE = .97$) compared to those primed by unrelated items ($M = 4.90$, $SE = .99$), $p < .001$. A significant between-subjects effect was found for language proficiency ($F(2,42) = 4.62$, $p = .015$, $\eta_p^2 = .180$). No significant two-way interactions were found.

A significant three-way interaction was found between suffix type, relatedness, and language proficiency ($F(2,42) = 3.95$, $p = .027$, $\eta_p^2 = .158$). A Bonferroni-adjusted pairwise comparison indicated that for targets primed by morpho-semantically unrelated items, the HP group had significantly reduced N400s ($M = 8.08$, $SE = 1.87$) compared to the monolingual group ($M = 1.45$, $SE = 1.22$), $p = .015$. For targets primed by morpho-orthographically related items, the HP group once again showed significantly reduced negativity ($M = 9.86$, $SE = 1.86$) compared to the monolingual group ($M = 2.45$, $SE = 1.21$), $p = .005$. The monolingual group also demonstrated significantly reduced voltages for targets primed by the morpho-semantically related items ($M = 5.49$, $SE = 1.14$) compared to those primed by morpho-orthographically related items ($M = 2.45$, $SE = 1.21$), $p < .001$. Of those morpho-semantic targets, the monolingual group produced significantly reduced N400s for those primed by related items ($M = 5.49$, $SE = 1.14$) compared to those primed by unrelated items ($M = 1.45$, $SE = 1.22$), $p < .001$. Interestingly, the HP group appeared to inversely experience these effects. Specifically, the HP group produced reduced voltages for targets primed by morpho-semantically unrelated items (*M* = 8.09, *SE* = 1.87) compared to morpho-orthographically unrelated items (*M* = 4.98, *SE* = 1.92), *p* = .027. This group also showed reduced N400s for targets primed by morpho-orthographically related items (*M* = 9.86, *SE* = 1.86) compared to those primed by unrelated items (*M* = 4.98, *SE* = 1.92), *p* = .002.

Fz electrode. Here, a main effect of relatedness was also found ($F(1,42) = 7.32$, $p = .010$, $\eta_p^2 = .148$), wherein participants demonstrated reduced negativity for targets preceded by related primes (*M* = -2.13, *SE* = 1.11) compared to unrelated primes (*M* = -3.73, *SE* = 1.05). No other significant main effects were found. No significant two- or three-way interactions were found.

A separate ANCOVA was conducted for the N400 time interval to investigate any potential effects of reading ability, using the same variables as in the N250 ANCOVA. At the Pz electrode, the between-subjects effect of language proficiency remained significant ($F(2,41) = 4.40$, $p = .019$, $\eta_p^2 = .177$). A significant two-way interaction of relatedness and reading score was found ($F(1,41) = 6.21$, $p = .017$, $\eta_p^2 = .131$). The three-way interaction between suffix type, relatedness, and language proficiency remained significant ($F(2,42) = 3.36$, $p = .045$, $\eta_p^2 = .141$). Bonferroni-adjusted pairwise comparisons confirmed that all significant patterns of group differences found at the Pz electrode for the N400 ANOVA remained consistent. At the Fz electrode, a significant two-way interaction of relatedness and reading score was replicated ($F(1,41) = 4.16$, $p = .048$, $\eta_p^2 = .092$). No other effects were found to be significant.

Discussion

The current study evaluated morphological priming in monolinguals, as well as low-proficient and high-proficient bilinguals. Behavioural data analyses demonstrated that morphological priming occurred across groups, and that reaction times were modulated by word frequency as well as participant reading ability. ERP analyses indicated that morphological priming took place across language groups, although effects differed. It should be noted that, specifically, priming effects refer to the difference between the related and unrelated conditions; this also includes interactions involving Relatedness. All three groups demonstrated N250 voltages that were modulated by suffix type, with more facilitation for morpho-semantic primes compared to morpho-orthographic primes (however, these effects were only marginally significant for the monolingual and HP groups). For monolinguals, both the N400 and N250 voltages were modulated by related primes, although greater priming effects were seen for morpho-semantic compared to morpho-orthographic primes. This has been previously observed in adults (e.g., Jared et al., 2017). This group also demonstrated greater priming effects for related targets across suffix-type conditions, compared to unrelated targets.

On the contrary, the HP group showed more facilitation than the monolingual group in both suffix conditions at the N400, although these were strictly seen for unrelated prime-target pairs. The HP group also showed more facilitation for unrelated morpho-semantic primes as opposed to morpho-orthographic primes. Greater priming effects were also demonstrated for morpho-orthographic related pairs compared to unrelated pairs. The N250 component was also evaluated across language groups. While this component did not reveal any differences between suffix type conditions, or interaction effects between suffix and prime types, a significant main effect of relatedness was found with reduced voltages for related primes compared to unrelated primes. Further an interaction between suffix type and language group revealed that the LP group demonstrated significantly reduced voltages for morpho-orthographic primes, compared to morpho-semantic primes. This suggests that, congruently with other studies (e.g., Beyersmann et al., 2015), bilinguals are sensitive to orthographic overlap in time window preceding lexical expectation.

Morphological Access in Monolingual Readers

ERP analysis results demonstrate that morpho-semantically related primes significantly facilitate visual word recognition compared to morpho-orthographically related primes for monolingual children. This was evidenced by a significant three-way interaction between suffix type, prime type, and language group at the N400, with larger voltage reductions for targets that were preceded by morpho-semantic related primes, rather than morpho-orthographic related primes. These results reveal that for monolingual children, the added element of semantic information is beneficial to visual word processing, to a larger degree than the opaque visual information provided by morpho-orthographic primes. These results are supported by studies of lexical access and morphological priming in adults and children (Jared et al., 2017; Madziak et al., 2021; Quémart et al., 2018), which demonstrate that individuals show more rapid word recognition when prime-target pairs have close semantic overlap. Therefore, the currently observed reduced N400 voltages for morpho-semantically related prime-target pairs further support this evidence of facilitated lexical access in monolingual children. These results also support the hypothesis that priming effect differences would be observed between prime-type conditions.

Morphological Access in Bilingual Readers

ERP analyses revealed significant priming effects for HP bilinguals modulated by relatedness of prime-target pairs. Interestingly, contrary to the monolingual group, the reduced voltages primarily involved unrelated prime-target pairs. Specifically, the HP group showed more facilitation than the monolingual group for unrelated pairs in both the morpho-semantic and morpho-orthographic conditions. Further, this group demonstrated increased facilitation for unrelated items in the morpho-semantic condition, compared to the morpho-orthographic condition. However, for morpho-orthographic targets, larger voltage reductions were seen for those preceded by related primes, compared to unrelated primes. Therefore, it generally appears as though highly proficient bilingual children experience facilitated visual word recognition when target words are preceded by a related prime sharing some orthographic overlap. This may suggest that highly proficient bilingual children more strongly rely on shared orthography features for visual word detection, rather than the semantic information that appears to benefit word recognition in monolinguals.

The N250 was also analyzed across bilinguals. While the LP group did not show any significant effects at the N400 component, results demonstrate that LP bilingual children have increased facilitation for morpho-orthographic targets rather than morpho-semantic ones. This effect was marginally significant for HP bilinguals as well. Thus, LP bilinguals appear to be sensitive to orthographic expectations at the N250 component and may rely on this orthographic information for visual-word recognition more heavily than semantic information, as monolinguals do. Overall, these results may be partially supported by findings by Liang and Chen (2014), who found that HP bilinguals experience facilitated processing of morphologically related pairs by engaging in “rule-based decomposition”, in which the decomposition of primes leave a trace in the episodic memory, thus leading to facilitated target access and reduced N400 voltages. These authors hypothesize that LP bilinguals rely more heavily on lexical storage and memorization, thus not engaging in prime decomposition, and no priming effects in the N400 range. On the other hand, these authors also found that both bilingual groups experienced priming effects in the N400 range for orthographic pairs, as well as inhibited effects for semantic pairs. Of note, the Liang and Chen (2014) study's semantic pairs were not morphologically related (e.g. *laughing-SMILE*), which could have had effects differing from the current study, which combined morphological and semantic pairs (e.g., *smiling-SMILE*).

Taken together, the various results observed in the current study offer support for the BIA+ model. As previously described, according to the BIA+ model, bilinguals automatically activate many representations of a word in both of their languages when one is visually presented (Dijkstra & van Heuven, 2002). Congruently with this model, the current results indicate that in an effort to more efficiently process these large quantities of linguistic information, highly proficient bilingual children may inhibit access to the semantic information that benefits monolingual children's morphological processing, and that they instead tend to rely on the orthographic information for more effective linguistic processing. While similar processing was also observed for the LP group, this facilitation for morpho-orthographic items was only seen at the N250 level for that group, rather than the N400 level. This implies that morphological processing in LP bilingual children may be inherently different than the way in which HP bilingual children process this same information, with LP bilinguals showing morpho-orthographic facilitation at the pre-lexical orthographic level, while HP bilinguals show this facilitation at the lexical-semantic level. Overall, these results offer partial support for the bilingual-group hypotheses that were tested in this study, in that the findings are consistent with the perspective that cross-language morphological access is modulated by bilingual proficiency, and that bilinguals may experience an added benefit from strategically relying on orthographic information rather than semantic information during visual word processing (Carrasco-Ortiz et al., 2012; Marsh et al., 2019; Vernice & Pagliarini, 2018).

Strengths, Limitations and Future Directions

This research provides insight into how bilingual children learn to read, and how dual-language representation impacts how bilingual children access morphological, orthographic, and semantic information as they read. This research helps us to understand the relationship between language proficiency across multiple languages and reading development. The current study intended to investigate the potential effects of reading ability on dual-language representation and morphological access in bilingual children. However, small sample sizes of both bilingual groups limited these findings. Future studies with larger samples may have increased potential in evaluating the possible modulations of reading ability and language proficiency on morphological access. These effects should aim to be further examined through ERP as well as behavioural analyses. A limitation of this study is that in recruiting bilingual students, we encountered participants who were in fact fluently multilingual in other languages. Winnipeg is known to be a very diverse multicultural city, and schools often have many recent-immigrant families who speak additional languages than English and/or French at home. Future research should aim to study potential lexical differences in multilingual individuals, in comparison to bilingual and monolingual groups. Future research should also explore dual-language representation in younger participants, in order to evaluate at what point this dual representation becomes faciliatory in reading fluency. Moreover, the current study exclusively assessed bilingual performance on an English lexical decision task. In order to more profoundly investigate dual-language representation and cross-language activation, as well as their potential facilitation or interference effects on reading across various levels of bilingual proficiency, it would be beneficial to implement a bilingual lexical decision task, utilizing cognates and interlingual homographs as targets. This may allow for a more well-rounded assessment of dual-language representation and cross-language activation, as bilingual participants would have to evaluate stimuli in both their L1 and L2 simultaneously, rather than exclusively performing a task in their L2.

The current study also had several strengths. First, a study of this magnitude and technicality was a considerable challenge for a master's thesis project. ERP analysis is very meticulous, time consuming, and arduous to execute. It also provides incredibly specific and precise data, which in the current study allowed a deeper understanding of the linguistic processes occurring in the brains of bilingual children than would have been possible with behavioural data alone, and allowed for a substantial contribution to be made to an important field of study. While time constraints effectively reduced the number of participants that were included, both low- and high-proficient bilingual groups were successfully selected and utilized from various communities across Winnipeg and southern Manitoba. To this point, bilingualism is a large and important topic of consideration in Manitoba. More specifically, the Manitoban francophone community, being the largest in Western Canada, make up a vast portion of the population in both urban and rural settings. However, this unique population with rich historical and modern-day issues, is often under-represented in language-based research. Thus, while a major strength of the current study is its focus on dual-language representation as modulated by language proficiency in children, a more important aspect is its consideration and contribution to the Franco-Manitoban community.

Conclusion

The current study demonstrated that morphological priming occurred across monolingual, LP, and HP groups. Monolinguals demonstrated larger priming effects for morpho-semantically related pairs, while HP bilinguals demonstrated larger priming effects for morpho-orthographically related pairs. The LP group also experienced priming effects for the morpho-orthographic targets, but with some differences compared to the HP group. Overall, these findings offer partial evidence that bilingual children experience facilitated visual word recognition when trials involve morpho-orthographic overlap. This would imply that bilinguals also rely more heavily on morpho-orthographic information while reading, and that they may not experience the added boost from semantic information while decoding, as would monolingual readers. This being said, more research is needed to understand the complex relationship between bilingual language proficiency, dual-language representation, and reading ability.

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Table 1.

Demographics for Language Groups

Variable	Language groups: Monolingual	Low-proficient Bilingual	High-proficient Bilingual
Total (Female)	26 (12)	8 (3)	11 (9)
Child Age (Months)	134.1*	140.5	140.5*
Household Income[a]	19	7	11
Missing	0	1	0
Wears Glasses	5	1	5

Note. Values represent the number of individuals included in each group for demographics.

[a] Number of household incomes over 50,000.

*Groups differ significantly at the $p < .05$ level.

Table 2.

Language Proficiency Measures for Language Groups

	Language groups		
Variable	Monolingual	Low-proficient Bilingual	High-proficient Bilingual
Fluent in English	25	7	11
Missing	0	1	0
Frequency of English Spoken at Home			
Never	-	0	0
Seldom	-	0	5
50%	-	0	5
Usually	-	1	1
Almost Always	-	7	0
Fluent in French	0	7	11
Missing	0	1	0
Frequency of French Spoken at Home		1	5
Never	-	0	0
Seldom	-	8	0
50%	-	0	4
Usually	-	0	4
Almost Always	-	0	3
Typical Readers (Poor readers)	17 (9)	4(4)	9(2)

Note. Frequency of languages spoken at home was collected via the *Language History Questionnaire* provided to bilingual participants (this information was not collected from monolingual participants who indicated speaking no other languages at home).

Table 3.

Language Group Differences in Pre-testing Measures

Pretesting Measures	Monolinguals	Low-proficient Bilinguals	High-proficiency Bilinguals
TOWRE-2			
TI	99.88	93.50	107.45
WES	100.81	95.13	105.09
WASI-IV			
MRS	51.19	46.00	55.18
CTOPP-2			
ELS	9.42	9.50	10.82
RLS	8.54	9.38	8.82
RDS	9.08	10.75	8.91
PPVT-4			
VOS (ENG)	109.04	105.38	106.09
PPVT-5			
VOS (FR)[a]	-	72.38**	86.55**

Language Groups: Monolinguals, Low-proficient Bilinguals, High-proficiency Bilinguals.

Note. TI = Standardized TOWRE Index; WES= Word reading efficiency standard score; MRS = Matrix reasoning standardized score ELS = Elision standardized score; RLS = Rapid letter naming standardized score; RDS = Rapid digit naming standardized score; VOS (ENG) = Vocabulary standardized score on English PPVT-4; VOS (FR) = Vocabulary standardized score on French PPVT-5.

[a]French PPVT-5 measures were not collected with the monolingual group.

**Groups differed significantly at the $p < .001$ level.

Table 4.

Inverse Reaction Times and Estimated Marginal Means for Participant Groups

Condition	Reader Group					
	Monolingual		LP		HP	
Inverse RT (-1000/ms)						
Semantic - *related*	-1.43 [a]	(0.04) [b]	-1.31	(0.08)	-1.28	(0.06)
Orthographic - *related*	-1.31	(0.04)	-1.19	(0.08)	-1.18	(0.07)
Semantic - *unrelated*	-1.37	(0.04)	-1.25	(0.08)	-1.22	(0.06)
Orthographic - *unrelated*	-1.30	(0.04)	-1.17	(0.08)	-1.13	(0.07)
Estimated RT (ms)						
Semantic - *related*	804.0[c]	(33.1)[b]	899.0	(58.3)	879.0	(49.8)
Orthographic - *related*	888.0	(33.4)	1017.0	(58.7)	975.0	(50.1)
Semantic - *unrelated*	826.0	(33.1)	925.0	(58.2)	912.0	(49.8)
Orthographic - *unrelated*	888.0	(33.3)	1037.0	(58.8)	1011.0	(50.1)

Note. LP: low-proficient bilingual children; HP: high-proficient bilingual children.

[a] Means of inverse reaction times

[b] Standard errors

[c] Estimated marginal means of raw reaction times based on the best fitting model.

Table 5.

*Mean Voltages (*μV*) at the N250*

	Language-Group					
	Monolingual		**LP**		**HP**	
Main Effect Conditions						
Morpho-semantic	-3.21	(0.97)	-2.66[a]	(1.75)[a]	-2.16	(1.49)
Morpho-orthographic	-4.31	(0.96)	0.25[a]	(1.72)[a]	-3.78	(1.47)
Related	-3.01[b]	(1.09)[b]	-0.02	(1.97)	-1.39[c]	(1.68)[c]
Unrelated	-4.51[b]	(0.87)[b]	-2.39	(1.58)	-4.55[c]	(1.34)[c]
Interaction Conditions						
Morpho-semantic Related	-2.32	(1.15)	-1.13	(2.07)	-0.96	(1.77)
Morpho-semantic Unrelated	-4.09	(1.06)	-4.19	(1.91)	-3.35	(1.63)
Morpho-orthographic Related	-3.70	(1.17)	1.09	(2.12)	-1.82	(1.81)
Morpho-orthographic Unrelated	-4.91	(0.95)	-0.59	(1.72)	-5.72	(1.46)

Note. LP: low-proficient bilingual children; HP: high-proficient bilingual children. Main Effect Conditions reflect estimated marginal mean voltages (and standard errors) for Suffix type and Prime type conditions, respectively. Interaction Conditions reflect estimated marginal mean voltages (and standard errors) for Suffix type x Prime type interaction conditions. Main voltages and standard errors for each language-group at the Fz electrode in the 140-250 ms Time Window.

[a] Mean voltages differed significantly between Suffix type conditions within the LP group at the $p < .05$ level.

[b] Mean voltages differed significantly between Prime type conditions within the Monolingual group at the $p < .05$ level.

[c] Mean voltages differed significantly between Prime type conditions within the HP group at the $p < .05$ level.

Table 6.

Mean Voltages (µV) at the N400

	Language-Group					
	Monolingual		**LP**		**HP**	
Main Effect Conditions						
Morpho-semantic	3.48[a b]	(1.09)[a b]	7.40	(1.97)	9.01[b]	(1.68)[b]
Morpho-orthographic	2.21[a b]	(1.13)[a b]	7.31	(2.03)	7.42[b]	(1.73)[b]
Related	3.98[c d]	(1.10)[c d]	8.25	(1.99)	9.89[c e]	(1.69)[c e]
Unrelated	1.71[d]	(1.15)[d]	6.46	(2.08)	6.53[e]	(1.77)[e]
Interaction Conditions						
Morpho-semantic Related	2.32[h j]	(5.91)[h j]	1.13	(4.31)	-0.96	(6.62)
Morpho-semantic Unrelated	4.09[f j]	(5.24)[f j]	4.19	(6.37)	3.35[f i]	(5.02)[f i]
Morpho-orthographic Related	3.70[g h]	(5.43)[g h]	1.09	(5.03)	1.82[g k]	(7.69)[g k]
Morpho-orthographic Unrelated	4.91	(5.30)	-0.59	(2.55)	5.72[i k]	(4.89)[i k]

Notes. LP: low-proficient bilingual children; HP: high-proficient bilingual children. Main Effect Conditions reflect estimated marginal mean voltages (and standard errors) for Suffix type and Prime type conditions, respectively. Interaction Conditions reflect estimated marginal mean voltages (and standard errors) for Suffix type x Prime type interaction conditions. Mean voltages and standard errors for each language-group at the Pz electrode in the 300-550 ms Time Window.

[a] Mean voltages differed significantly between Suffix type conditions within the Monolingual group at the $p < .05$ level.

[b] Mean voltages differed significantly for both Suffix Type conditions between the Monolingual and HP groups at the $p < .05$ level.

[c] Mean voltages differed significantly for the Related condition between the Monolingual and HP groups at the $p < .05$ level.

[d] Mean voltages differed significantly for both Related conditions within the Monolingual group at the $p = .001$ level.

[e] Mean voltages differed significantly for both Related conditions within the HP group at the $p = .001$ level.

[f] Mean voltages differed significantly for the Morpho-semantic Unrelated condition between the Monolingual and HP groups at the $p < .05$ level.

[g] Mean voltages differed significantly for the Morpho-orthographic Related condition between the Monolingual and HP groups at the $p < .05$ level.

[h] Mean voltages differed significantly between Related Suffix type conditions within the Monolingual group at the $p < .001$ level.

[i] Mean voltages differed significantly between Unrelated Suffix type conditions within the HP group at the $p < .05$ level.

[j] Mean voltages differed significantly between the Morpho-semantic Prime type conditions within the monolingual group at the $p < .001$ level.

[k] Mean voltages differed significantly between the Morpho-orthographic Prime type conditions within the HP group at the $p < .05$ level.

Appendix A

Cross-language Reading Study
Parent/Guardian Consent Form
Richard Kruk, Dept. of Psychology
University of Manitoba

Dear Parents or Guardians:

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

An important part of every child's early educational experience is learning to read. As a researcher in the Department of Psychology at the University of Manitoba, I am conducting a study to help us understand more about how children become mature readers. In particular, I am studying how children's developing skills in morphological awareness has an impact on learning to recognize printed letters and words. This is an important dimension of learning to read.

Children develop their reading abilities by using morphological information in words. For bilingual children, this information is activated in both languages, simultaneously. We believe that for fluently bilingual children, this activation allows for an advantage in recognizing morphological information, and in reading. In children who are not balanced bilinguals, we believe that this activation may create a disadvantage in these same areas. Although the reasons for these differences are not clearly understood, with a better understanding of how underlying skills develop in the first school years, and how they are related to learning to read, more effective methods of instruction can be developed for children, particularly bilinguals.

The participation of your child is requested for a two-part study that will examine the relationship between morphological awareness and reading skills. The **first part** of the study will take place at your child's school in autumn of 2023 and spring of 2024, and will involve one 60-minute session in a quiet room at the school. Your child's teacher will be asked to indicate the best days and times for your child to be involved in the sessions. During those sessions, each child will participate in several brief paper-and-pencil school-like tasks that involve language, memory and reading. In addition, each child will participate in several computer-based visual games and reading-like tasks. The computer presentation will be both motivating and fun, as it is designed to be game-like. Our past experience with these tasks indicates that children very much enjoy playing with these computer "games" and experiencing the paper-and-pencil tasks. A researcher and a psychology student from the University who are carefully trained in working with children will conduct the study at the school. The **second part** of the study will be conducted at the University of Winnipeg, and will involve brief computerized reading tasks, using electroencephalogram (EEG) technology. Please read and complete the consent form on this part in the attached "**EEG Phase**" document.

All results will be kept in strict confidence to protect your child's anonymity; only researchers involved in the study will have access to results, organized using code numbers rather than children's names, and stored in a locked room at the University. Involvement in this research will not affect your child's work or progress at school. At the end of the study, children will be given a short explanation of the study, and offered stickers, a pencil and eraser, and a certificate as tokens of our appreciation. As is expected in all research involving vulnerable individuals like children, should the researcher learn of information indicating child abuse, according to the law she will share this with a legal authority.

With your support, I hope that this research will bring us closer to a better understanding of reading in children. This is critical to a literate society like ours. When the study is complete, anticipated at approximately Summer 2024, a report of the overall findings will be available at the school to interested teachers and parents, and on a website dedicated to this project (www.earlyreadingproject.ca). Reading researchers will learn about the results in professional journals and conferences. A copy of the report of overall findings will be sent to you; please include your mail or email address on the attached form.

If you will allow your child to be included in this study, please detach and complete the form and return it to your child's teacher in the envelope provided within the next several days.

Participation in this study is completely voluntary, and you and your child have the right to withdraw from the research at any time. I sincerely appreciate your cooperation. If you would like more information about the study please contact me at the Department of Psychology, University of Manitoba at 474-7349, or via email at Richard.Kruk@umanitoba.ca. Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject.

In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. The University of Manitoba may look at the research records to see that the research is being done in a safe and proper way.

This research has been approved by the Psychology/Sociology Research Ethics Board, and by the school division. If you have any concerns or complaints about this project you may contact me, or the Human Ethics Coordinator (HEC) at (204) 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Sincerely,

Dominique Ruest, B.A. (hons), Étudiante à la maitrise (Psychologie scolaire)	Richard Kruk, Ph.D., Professeur	Amy Desroches, Ph.D., Professeur

Parent/Guardian Consent Form

Name of Child (please print): ______________________________________

Child's Date of Birth: Month _____ Day _____ Year _____

CHECK HERE

____ I give permission for my child to participate in the study conducted by Richard Kruk.

____ I do NOT give permission for my child to participate in the study conducted by Richard Kruk.

If you are giving permission, please provide us with additional information in the attached questionnaire.

Signature of Parent/Guardian: _______________________ Date: _________________

Researcher's Signature: ____________________________ Date: _________________

If you are interested in receiving a copy of a report of the final results, please write your mailing or email address below:

____

We are planning to conduct a **follow-up study** involving a small number of children at the University of Winnipeg. If you are willing to have your child considered for this follow-up study, please indicate:

_____ YES, I am willing to have my child considered for a follow-up study

_____ NO, I am NOT willing to have my child considered for a follow-up study

If you indicated YES, please provide the best way to contact you for the follow-up:

Telephone: ____________________ Email: _____________________________

Cross-language Reading Study
Parent Questionnaire

Please complete this questionnaire, as we would like to learn about your child and his/her reading and other experiences.

Name of child (please print): ____

Child's gender (circle): Male Female

Child's Age: _______________________________

Child's School: _____________________________

Child's Teacher: ____________________________

Please circle the approximate number of days per week your child spends reading at home:
Weekdays: 0 1 2 3 4 5
Weekends: 0 1 2

On these days, please circle the approximate number of minutes per day spent reading:
Weekdays: None About 30 About 60 About 90 More than 90; please estimate _____
Weekends: None About 30 About 60 About 90 More than 90; please estimate _____

Please circle the approximate number of days per week your child spends playing *interactive* video games (games with rapidly moving objects/scenes):
Weekdays: 0 1 2 3 4 5
Weekends: 0 1 2

On these days, please circle the approximate number of minutes per day spent playing *interactive* video games (games with rapidly moving objects/scenes):

Weekdays: None About 30 About 60 About 90 More than 90; please estimate _____
Weekends: None About 30 About 60 About 90 More than 90; please estimate _____

Please see over …

Please indicate <u>your highest level of education</u>:	<u>Other parent/guardian (if applicable)</u>:
___ Some High School	___ Some High School
___ High School	___ High School
___ Some post-secondary	___ Some post-secondary
___ Post-secondary diploma/degree	___ Post-secondary diploma/degree

Annual household income:
___ Less than $50,000
___ $50,000 or more

Home postal code: ________________________________

Is your child fluent in English?: Yes____ No_____

Language(s) spoken at home: ________________________________

Does your child require corrective lenses (eye glasses) for reading?: Yes____ No ____

Does your child have special needs that could have an impact on his/her school experience?:
Yes ____ No ____

If yes, please specify the nature of the special need(s):
____ ADHD (attention deficit hyperactivity disorder that was diagnosed)
____ Speech Impediment (e.g. lisp)
____ Learning disability (e.g. reading disability, writing disability)
____ Other. Please specify the nature of the special need(s): ____________________

Number of brothers and/or sisters your child has: _____________________

Has your child received any formal additional reading help from school?:
Yes_____ No_____

Other than help from family members, has your child received any formal additional reading help outside of school (for example, a private tutor)?:
Yes_____ No_____

Cross-language Reading Study
Language History Questionnaire

My child's name: ____________________

My child's date of birth: (MM/DD/YYYY) ______________________________

Your relationship to the child ______________ (*Who is filling out this questionnaire? Ex. Mother, father, etc.*)

Place of Birth	**Mother (Guardian)**	**Father (Guardian)**	**Child**
Born in Canada	YES NO	YES NO	YES NO
Born outside of Canada	Specify country: _______________ Age of arrival in Canada __________	Specify country: _______________ Age of arrival in Canada __________	Specify country: _______________ Age of arrival in Canada __________

1. What is your child's first language? ______________________
2. At what age did your child first speak English? ______________________
3. At what age did your child first speak French? ______________________
4. Has your child attended a DSFM school since kindergarten? Yes _________ No __________
5. If you answered "No" above, what type of school did your child previously attend? (i.e., English only, French Immersion, etc.) ____
6. Did you child attend preschool within the DSFM? Yes _________ No ___________
7. What languages do you and your partner speak with your child? Please check the appropriate boxes, and write in any other languages spoken in the blank.

	Never	Seldom	50%	Usually	Almost always
English					
French:					
Other language(s): _________________					

8. What languages does your child speak? Please check the appropriate boxes, and write in any other languages your child speaks in the blank.

	Never	Seldom	50%	Usually	Almost always
English					
French:					
Other language(s): ________________					

9. What language is spoken by you and your partner *most often* in your home?

____

10. How often does your child do the activities below, either in English or in other languages? Please check the appropriate boxes below, and please specify the language in which the child does the activity.

Activity	**English**			**French**			**Other Language(s): ________________**		
	Every day	**Once a week**	**Almost never/ never**	**Every day**	**Once a week**	**Almost never/ never**	**Every day**	**Once a week**	**Almost never/ never**
Reads books/ magazines									
Uses a computer									
Watches TV/movies									
Writes									

Appendix B

Word Stimuli

Morpho-Orthographic Items			Morpho-Semantic Items		
Related	**Unrelated**	**Target**	**Related**	**Unrelated**	**Target**
archer	bushy	ARCH	acting	nearer	ACT
army	cats	ARM	aimed	rainy	AIM
belly	eaten	BELL	badly	liked	BAD
bonkers	likely	BONK	boxer	toasty	BOX
bother	player	BOTH	buying	louder	BUY
brother	charming	BROTH	cooking	postal	COOK
butter	fished	BUTT	creamy	darker	CREAM
coaster	others	COAST	crying	posted	CRY
copy	taller	COP	deeper	grassy	DEEP
corner	lonely	CORN	dirty	loved	DIRT

country	filling	COUNT	drinking	talking	DRINK
early	soaked	EARL	drying	weaker	DRY
every	lower	EVER	eating	slower	EAT
factory	cheaper	FACT	farmer	stormy	FARM
fairy	beans	FAIR	filled	lovely	FILL
flicker	nearly	FLICK	fixing	boiler	FIX
flower	warming	FLOW	flying	throwing	FLY
forest	prayer	FOR	golden	frosty	GOLD
hungry	warmer	HUNG	harder	filthy	HARD
husky	personal	HUSK	hunter	roasted	HUNT
layer	fluffy	LAY	later	quickly	LATE
listen	creepy	LIST	lucky	named	LUCK
many	used	MAN	mainly	mainly	MAIN
metal	sandy	MET	mixer	doing	MIX
million	clearly	MILL	moody	waved	MOOD
mother	raining	MOTH	opened	boards	OPEN
party	tower	PART	owner	bumpy	OWN
petal	messy	PET	playing	tighter	PLAY

poster	bricks	POST	reader	painting	READ
potion	coldly	POT	robber	sleepy	ROB
question	treated	QUEST	sadly	hairy	SAD
sandal	wooden	SAND	shyly	mower	SHY
scary	older	SCAR	singer	greedy	SING
shoulder	fighting	SHOULD	slowly	leader	SLOW
shower	boldly	SHOW	teacher	ringing	TEACH
slimy	eater	SLIM	tester	quietly	TEST
streamer	cleaner	STREAM	trying	sneaky	TRY
sweater	swinging	SWEAT	walked	smelly	WALK
vanish	sticky	VAN	warning	milky	WARN
wander	jumped	WAND	winner	lately	WIN

Note. All participants saw 40 morpho-semantic related prime-target pairs, 40 morpho-semantic unrelated prime-target pairs, 40 morpho-orthographic related prime- target pairs, and 40 morpho-orthographic unrelated prime-target pairs.

Non-Word Stimuli

Non-word Items					
Unrelated	**Related**	**Nonword**	**Unrelated**	**Related**	**Nonword**
army	cats	BEWK	bushy	archer	PIRD
fished	butter	BLOM	sticky	vanish	PULE
crying	posted	BOK	listen	creepy	QUEK
forest	prayer	CALN	sleepy	robber	RER
named	lucky	CELD	boxer	toasty	RESK
fighting	shoulder	CHARSC	milky	warning	RIBE
country	filling	CIBE	eater	slimy	RINT
doing	mixer	COV	flying	throwing	ROMF
walked	smelly	CRA	older	scary	SANT
golden	frosty	DAL	quietly	tester	SARC
acting	nearer	DAR	bricks	poster	SELK
potion	coldly	DRARM	jumped	wander	SHYC
treated	question	DROGG	leader	slowly	SOV
drawing	mainly	EEF	creamy	darker	STARC
quickly	later	ELV	bonkers	likely	SUSK
flower	warming	FLUN	sandy	metal	TASE
cleaner	streamer	FOM	belly	eaten	TASH
hunter	roasted	GAV	coaster	others	TEWK
deeper	grassy	GED	fairy	beans	TIND
tower	party	GIGN	clearly	million	TUFE

nearly	flicker	GLON	bumpy	owner	UXT
ringing	teacher	GLONE	fixing	boiler	VAB
aimed	rainy	HOZ	boards	opened	VAR
buying	louder	JUN	bother	player	VEET
factory	cheaper	LOLK	every	lower	VISC
badly	liked	LORV	filled	lovely	VOS
boldly	shower	LUEL	petal	messy	VRAB
copy	taller	MEMK	wooden	sandal	WARR
painting	reader	MIGN	harder	filthy	WEEF
raining	mother	MOME	brother	charming	WEIM
farmer	stormy	NADE	greedy	singer	WOL
lately	winner	NAV	dirty	loved	YAD
corner	lonely	NOLC	many	used	YASC
talking	drinking	NOMB	hairy	sadly	YIL
fluffy	layer	NORT	mower	shyly	YIT
waved	moody	OLT	eating	slower	YOL
soaked	early	ORM	tighter	playing	YOW
sneaky	trying	OWD	personal	husky	ZEAN
hungry	warmer	PEIM	drying	weaker	ZIL
sweater	swinging	PEWN	cooking	postal	ZOP

Note. Each prime was paired with a non-word target to ensure the task involved a lexical decision regarding whether the target stimuli constituted a legal English word or not.