The Impacts of Language Proficiency on Cross-Language Activation in Bilingual Children

by

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Abstract

The bilingual lexicon contains words from more than one language. Representations from both languages are automatically activated when bilinguals encounter words. However, the degree of cross-language activation varies between individuals, depending on language proficiency. This study investigated the effects of language proficiency and reading ability on bilingual written word recognition. Participants included Grade 6 balanced bilinguals (*n* = 20) and Grade 5 and 6 unbalanced bilinguals (*n* = 19). This two-phase study included standardized reading measures and vocabulary tests, followed by a primed lexical decision task. Target words for the lexical decision task consisted of 40 English-French interlingual homographs (i.e., words that are spelled the same between languages but have different meanings). Prime-target pairs consisted of cross-language semantically related (e.g., bedding-LIT, where bed is the meaning of the interlingual homograph LIT in French), or unrelated (e.g., bedding-PAIN). Event related potentials (ERP) and response time (RT) data were analyzed to examine how balanced and unbalanced bilinguals access and integrate lexical information from more than one language. RT and ERP N400 amplitudes revealed that balanced bilinguals experienced facilitation in the related condition, indicating that they were able to integrate representations across languages (e.g., seeing “bedding” in English primed “LIT”, which is related only if cross-language connections are made). In contrast, unbalanced bilinguals showed no differences between related and unrelated primes. Results lend support to the view that bilingual’s languages are automatically activated, while highlighting the important role of language proficiency in bilinguals’ two languages.

Keywords: bilingual, cross-language activation, language proficiency, semantic networks, reading ability

The Impacts of Language Proficiency on Cross-Language Activation in Bilingual Children

The 2021 Canadian census revealed that 18% of Canadians (6.86 million) identified as English-French bilinguals (Statistics Canada, 2022). Of this group, 47.6% of English-French bilinguals reported having French as their mother tongue, and 9% reported having English as their mother tongue. Additionally, 1.3% of Canadians reported having both English and French as their first official spoken language (Statistics Canada, 2022). The rates of bilingualism have important implications in the Canadian school system, seeing that children are learning and reading in both their first and second languages. Yet, questions remain about how bilinguals store and represent language, and how they process the linguistic information they take in through spoken and written word recognition. In part, this lack of clarity relates to the complexities of bilinguals. Bilingualism occurs on a continuum, with varying degrees of language proficiency. Some bilinguals have equal proficiency in both of their languages; these individuals are considered balanced bilinguals. In contrast, others have asymmetrical proficiency, meaning that they have greater proficiency in one language; these individuals are considered unbalanced bilinguals. Furthermore, there is a lack of understanding about how language proficiency affects word recognition when bilingual children learn to read.

Reading is instrumental to children's academic success, and language knowledge is critical to reading acquisition. Research in bilingualism suggests that bilinguals activate word representations in both of their languages simultaneously and automatically, but relatively little is known about how this affects reading. Reading is a complex process that involves both lower-level skills, such as phonological awareness (i.e., decoding) and orthographic awareness (i.e., word recognition), as well as higher level skills, such as vocabulary and reading comprehension (Chung et al., 2019). Simply put, reading involves looking at print and deriving sound and meaning. For a reader to understand and derive meaning from words, they must develop comprehension abilities. However, past research has indicated that despite having adequate phonological decoding skills, readers with poor comprehension abilities may struggle with reading words that are of lower frequency or have irregular spelling, without the support of semantic information (Nation & Snowling, 1998). Morphological awareness (knowledge of and ability to manipulate the smallest meaningful units of spoken or written words; Carlisle, 1995) is another aspect of language that facilitates reading by providing a means to derive spoken and written word meaning through morpheme segmentation (e.g., unbreakable = un+break+able). While good readers make use of morpheme segmentation, poor readers struggle with morphological segmentation and parsing complex words, and this contributes to reading impairment (Tong et al., 2011).

For bilinguals, there is substantial evidence that knowledge of more than one language affects reading and language development (Chung et al., 2019). However, whether the knowledge of more than one language creates advantages or disadvantages remains unclear. For example, some studies have shown that bilinguals outperform monolinguals on phonemic fluency tasks (e.g., Marsh et al., 2019), while others have shown that monolinguals outperform bilinguals in tasks requiring lexical access and morphological awareness (e.g., Lehtonen et al., 2012; Schröter & Schroeder, 2018). Moreover, some cross-language studies have found cross-language interference effects (e.g., Durlik et al., 2016; Friesen et al., 2014; Libben & Titone, 2009; Titone et al., 2011), while others have found cross-language facilitation effects (e.g., de Bruijn et al., 2001; Kerkhofs et al., 2006). Thus, whether bilinguals experience cross-language facilitation or interference in reading may depend on language proficiency in the two languages (see a discussion by van Heuven & Dijkstra, 2010) and the task at hand (Dijkstra, 2007).

Language proficiency across languages can impact a bilingual's lexical (word-related) processing, particularly in word recognition (Schröter & Schroeder, 2018). Extensive research has been conducted with bilinguals using interlingual homographs (i.e., words that are spelt the same in two languages but have different meanings) to explore the effects of bilingualism on word recognition (e.g., de Bruijn et al., 2001; Durlik et al., 2016; Kerkhofs et al., 2006; Kousaie & Phillips, 2011; Libben & Titone, 2009; Lijewska & Olko, 2018; Titone et al., 2011). Interlingual homographs share orthography between languages, but not semantic meaning (e.g., chat and chat; cat in French), thus, these word forms provide an effective measure of observing the effects of bilingualism. More specifically, interlingual homographs provide an effective measure of cross language activation, as there is a competition for the meaning of a word in a bilingual's two languages (Durlik et al., 2016; Friesen et al., 2014; Friesen & Haigh, 2018; Jared et al., 2011; Kerkhofs et al., 2006; Lehtonen et al., 2012).

The purpose of this study was to understand the impact of bilingual language proficiency and reading ability on word recognition using event related potentials (ERPs). More specifically, I investigated the effects of language ability and reading ability by examining how balanced and unbalanced bilinguals processed interlingual homographs during a primed lexical decision task.

Models of Bilingual Language Processing

Nearly half of the world's population is bilingual (43%; Rogers, 2023); thus, bilingualism represents a significant portion of the population and warrants unique attention in research. This is particularly pertinent in a country like Canada, which has two official languages (French and English). While there has been debate on whether a bilingual's mental lexicon separates languages at the lexical level such as in the bilingual interactive activation model of lexical access (BIMOLA; Grosjean, 1988), recent research has converged on the idea that language is non-selective in the bilingual lexicon. That is, language non-selectivity is indicative of cross-language activation, where representations from both languages are automatically activated when words are encountered by bilinguals. While the BIMOLA posits that the mental lexicon separates languages at the lexical level, it acknowledges that bilinguals' languages are still interactive to some extent, and that this cross-language interaction varies depending on L2 (second language) proficiency (Grosjean, 1988). There are several theories of bilingualism that bolster this idea of cross-language activation, such as the self-organizing model of bilingual processing (SOMBIP; Li & Farkas, 2002), the Inhibitory Control model (ICM; Green, 1998), and a prominent account, the updated bilingual interactive activation plus model (BIA+; Dijkstra & van Heuven, 2002).

The BIA+ is a language processing model which posits that the lexicon (word knowledge) integrates knowledge from multiple languages in a non-selective way (Dijkstra & van Heuven, 2002). Several factors contribute to the extent of which cross-language activation occurs, such as language proficiency, age of acquisition of L2, and whether the reader is reading in their L1 (first language) or L2 (Dijkstra & van Heuven, 2002). Similarly, the ICM (Green, 1998) is a language production model which maintains an integrated lexicon, where a bilingual's languages are subsets of a larger language system as a whole. This model states that bilinguals require executive control over inhibiting languages that are not currently in use. Thus, a bilingual's two or more languages are constantly relatively active, but the language in use prevails over the one that is not.

Evidence for cross-language activation has been demonstrated through lexical decision tasks when primes in one language facilitate or hinder lexical decisions on target words in a second language. It is well understood that for unbalanced bilinguals, there is a strong priming direction from L1 to L2, but not for the inverse of L2 to L1 (c.f., the BIA+ model proposed by

Dijkstra & van Heuven, 2002). This can be equally attributed to the combination of the higher resting activation levels of the L1 primes and the lower resting activation levels of the L2 targets (Smith et al., 2019). That is, words of higher frequency in the reader's L1 have high resting levels while words of lower frequency of occurrence in the readers L2 have lower resting levels (Dijkstra & Van Heuven, 2002). Due to the lower resting activation levels of L2 words (i.e. words that are of lower frequency of usage) there is a longer latency in the process of lexical access to L2 words, which in turn reduces the priming efficacy of L2 words when L1 words act as targets (c.f., the BIA+ model proposed by Dijkstra & van Heuven, 2002). In contrast, balanced bilinguals show symmetrical priming effects from L1 primes to L2 targets and L2 to L1 (For a review, see van Hell & Tanner, 2012). This can be attributed to the high resting activation levels of both languages. To summarize, for unbalanced bilinguals, word recognition in L2 is comprehensively influenced by knowledge of L1; however, there is little evidence for the inverse of reading in L1 being influenced by knowledge of L2.

While research on bilingualism has provided insightful findings on how the bilingual lexicon operates, careful consideration must be made when generalizing results to all bilinguals when language proficiency is not assessed (see a discussion by Dijkstra & van Heuven, 2012). Language proficiency is an important factor to consider in bilingual research, because bilingualism occurs on a continuum (Grosjean, 2024). High proficiency in a language suggests a greater exposure and usage of words in said language, leading to faster activation of word recognition (van Heuven & Dijkstra, 2010). For unbalanced bilinguals, the relatively lower use of their L2 leads to a greater processing cost in reading compared to their L1 (Dijkstra & van Heuven, 2012). The implications that this has on readers according to the BIA+ model (Dijkstra & van Heuven, 2002) is that both balanced and unbalanced bilinguals activate representations from words in both languages; however, there is a delayed activation of L2 representations, also referred to as a temporal delay (Dijkstra & van Heuven, 2012). The temporal delay effect refers to the delayed activation of L2 lexical representations, compared to those in L1. In the case of interlingual homographs (words that, despite looking the same, have distinct meanings in each language) the temporal delay effect is significantly reduced in balanced bilinguals, who are equally proficient in their L2 and L1, as both languages have similar resting activation levels (Dijkstra & van Heuven, 2002). In contrast, unbalanced bilinguals have disproportionately higher L1 activation levels, compared to L2, essentially delaying the L2 activation.

Further evidence of cross language activation has been demonstrated through the use of semantic priming tasks. Semantic priming is used in lexical decision tasks on the premise that when readers are presented with a target word, lexical decisions are facilitated when there is a prime-target semantic relationship (e.g., spoon and fork; both cutlery/utensils; Hutchison et al., 2013). While the semantic priming effect is well understood for monolingual lexical decision tasks (e.g., Hutchinson et al., 2013), cross-language semantic priming in bilingual lexical decision tasks is an area that is less understood. A cross language semantic priming effect occurs when a target word in a particular language (e.g., L2) is preceded by a prime word in a different language (e.g., L1) that is semantically related to the target word (e.g., the English word spoon is semantically related to the French word fourchette; *fork* in French).

Several studies have investigated the semantic priming effect using lexical decision tasks (e.g., de Bruijn et al., 2001; Kousaie & Phillips, 2011; Kerkhofs et al., 2006; Smith et al., 2019) An important question that arises in bilingual priming tasks is the extent to which within-language and between-language primes work to prime readers. Smith and colleagues (2019) investigated within- and between-language priming with unbalanced Hebrew-English bilingual participants by having them completed a within-language lexical decision task in their L1 Hebrew (experiment 3) as well as a cross-language lexical decision task (experiment 4). As predicted, the within language lexical decision task showed significant priming effects for semantically related prime and target pairings; this served as a control condition. Interestingly, Smith et al. (2019) found significant between-language priming effect, indicating that Hebrew (L1) targets were equally primed by related within and cross-languages sematic primes. Likewise, English (L2) targets were also equally primed by within and cross-language primes. This study demonstrates cross-language activation during primed lexical decision task using single language targets; however, the outcomes might differ if interlingual homographs were used as targets.

In a lexical decision task that includes interlingual homograph target words (e.g., CHAT: means a *casual conversation* in English, while it means *cat* in French), competition arises between the reader's L1 and L2 meanings of the word. According to the BIA+ model, bilinguals activate the L1 and L2 meanings of an interlingual homograph in parallel; however, the L1 meaning would prevail over the L2 meaning (Kerkhofs et al., 2006). Put otherwise, the temporal delay assumption posits that the L2 meaning of a interlingual homograph is activated slower than the L1 meaning (Dijkstra & van Heuven, 2002). However, Kerkhofs and colleagues (2006) demonstrated that recognition of an L2 interlingual homograph target word can be strengthened by a semantically related prime (e.g., a French-English example could be French prime "souris" (mouse) and interlingual homograph target "chat" (conversation in English, cat in French). Taken together results from Smith et al. (2019) and Kerkhofs et al. (2006) provide evidence that cross-language semantic activation has the potential to prime readers equivalently to within-language semantic relationships.

Although many studies have identified cross-language activation, the precise nature of this is unclear since some studies find interference while others find facilitation effects. For instance, results from most studies involving word naming, semantic judgement, and sentence constraint tasks have yielded interference effects for interlingual homograph stimuli (i.e., slower responses times and more errors; e.g., Durlik et al., 2016; Friesen et al., 2014; Libben & Titone, 2009; Titone et al., 2011). Upon recognition of an interlingual homograph, bilinguals activate two separate semantic representations (Friesen et al., 2014). Consequently, the co-activation of orthography and semantic meaning from the non-target language can lead to competition, thus slowing the response to lexical decisions on interlingual homographs compared to single language control words (Friesen et al., 2014). Interlingual homograph recognition in the bilingual lexicon will suffer even more conflict when they are semantically ambiguous; that is, when they are presented without language cues (Van Heuven et al., 2008)

In contrast, priming tasks have typically produced facilitation effects for interlingual homographs (see Friesen & Haigh, 2018). In these tasks, the co-activation of the interlingual homograph activates meanings across languages, leading to facilitation in identifying a target word. In a primed lexical decision task, interlingual homographs can yield faciliatory or interference effects, depending on whether they are used as primes or targets. Single language primes paired with interlingual homographs have the benefit of facilitating word recognition to prime the reader to recognize the interlingual homograph in the same language as the prime (e.g., de Bruijn et al., 2001; Kousaie & Phillips, 2011; Kerkhofs et al., 2006). In contrast, interlingual homograph primes may lead to slower response times on single language targets by co-activating competing meanings out of language context, leading to more difficult subsequent word recognition (Friesen & Haigh, 2018).

Interlingual homograph interference or faciliatory effects depend on several factors, such as task demands, stimulus composition, and instructions (Dijkstra, 2007). Dijkstra and colleagues (1998) presented one of the first studies to isolate the effects of explicit instruction and task-language expectancy. In their three-part study, Dijkstra and colleagues (1998) demonstrated that the level of language selectivity in word recognition depended on the characteristics of the task. In Experiment 1, Dutch-English bilinguals performed an English only lexical decision task that included interlingual homographs. Results from Experiment 1 revealed that the English only task resulted in similar response times for interlingual homograph and single language control words; thus, no interference effects were obtained. In Experiment 2, Dutch-English bilinguals performed an English-Dutch lexical decision task that included interlingual homographs, English only controls, and Dutch only controls, where participants were asked to respond “yes” to English words only (i.e., Dutch controls required a “no” response; Experiment 2). In Experiment 3, Dutch-English bilinguals completed a task with the same stimuli as Experiment 2, but this time participants were told to respond “yes” if the stimulus was a real word in either language (Experiment 3). Interestingly, interlingual homograph interference effects were observed in Experiment 2, whereas faciliatory effects were observed in Experiment 3. This finding highlights the importance of task expectation and instruction.

Dijkstra and colleagues (2000) further extend these findings in a replication study to explore the effects of task instruction and stimulus list composition. In their study, the same stimulus list was used from Experiment 2 and 3 in Dijkstra et al., (1998). In their study, Dijkstra et al., (2000) had participants complete an English lexical decision task, but were told that there would be mixed-in Dutch words, to which they were required to select “no” to Dutch control words. However, participants were unaware that Dutch control words were only present in the second part of the task. In the first part of the task, which contained only English words, there were no significant differences in response times between interlingual homographs and English only controls. However, strong interference effects were present in the second part of the task when Dutch controls were intermixed with English controls and interlingual homographs. The authors concluded that participants' general expectations about the task, and language stimuli intermixing, have greater effects on participants language mode than explicit instruction alone. Taken together, results from Dijkstra et al., (1998) and Dijkstra et al., (2000) provide compelling evidence that task instruction and stimulus materials can significantly affect the degree of language selectivity.

Task instruction, stimulus material, and expectation all have effects on a bilingual's language mode (Grosjean, 2024). According to Grosjean (2024), the level of activation in a bilingual's two languages occur on a continuum, from monolingual to bilingual. That is, bilingual's language processing and communication changes when they are communicating with monolinguals versus when they are with other bilinguals. In the monolingual speech mode, bilingual speakers implicitly deactivate their other language (though not completely), because there are no expectations of the other language being used. In contrast, when in bilingual mode, both languages may be active. At the cognitive level, this implies that the state of activation level in both a bilingual's languages are active. That is, both L1 and L2 are highly active. In contrast, when in monolingual mode L1 is highly active and L2 is activated at a lesser extent. Balanced bilinguals operate at a level where both of their languages are active to a greater extent that unbalanced bilinguals do. Similar to the BIA+ model, language activation levels depend on a number of factors, such as language proficiency and the relative use of the L2 (Grosjean, 2024). Taken together, explicit instruction, task stimuli, and participant expectations have significant effects on whether bilinguals approach a task in bilingual mode.

Impacts of Language Proficiency on Cross-Language Effects

Cross-language activation in bilinguals can lead to both facilitation and inference in word recognition, and these effects are strongly influenced by language proficiency. For example, participants in Lijewska and Olko (2018) demonstrated facilitation effects during a primed lexical decision task. In their study, Lijewska and Olko (2018) recruited unbalanced bilinguals who demonstrated proficiency in L2 and lived in an L1 dominant environment. Participants completed a primed lexical decision task (Experiment 1) including Polish target words and English primes that were translation equivalents of the targets. Results from Experiment 1 revealed that Polish target words were recognized significantly faster when they were preceded by their English equivalent translation, compared to unrelated control primes (Lijewska & Olko, 2018). These results demonstrate that unbalanced bilinguals who are proficient in their L2 can demonstrate significant L2-L1 priming effects during a lexical decision task. However, this priming effect is modulated by language proficiency in the learners L2 (Chaouch-Orozco et al., 2021). To further explore the effects of cross-language activation, Lijewska and Olko (2018) conducted a second experiment which consisted of a semantic categorisation task with the same bilingual participants. In this task, a category name was given at the beginning of each trial, followed by an English prime (translation equivalent or non-equivalent), followed by a Polish target, which participants were asked to decide as quickly and accurately as possible whether the Polish words belonged to the category. Like their first experiment, results indicated faster response times when Polish targets were preceded by English equivalent translations compared to control non-equivalents. Overall, results from Lijewska & Olko, 2018 provide evidence for significant L1-L2 translation and priming effects, and that L2-L1 priming effects are modulated by language proficiency in the readers L2.

Other studies investigating cross-language activation have found interference effects. For instance, Friesen and colleagues (2014) investigated how different groups of bilinguals process interlingual homographs during a word naming task. In their first experiment, English-French bilinguals experienced more difficulty (indicated by longer response times) when naming interlingual homographs compared to single language control words, suggesting that the non-target language's semantic and phonological representations were active when reading interlingual homographs. In a second experiment, French-English bilinguals completed the same task and showed less interference when reading interlingual homographs in their L1 French, but more interference when reading interlingual homographs in their L2 English. Overall, the interlingual homograph interference effect was most pronounced when participants named words in their L2 (Experiments 1 and 2; Friesen et al., 2014). When naming words in L1, the interlingual homograph effect was much less present.

Contextual constraints and task demands also affect the degree of language non-selectivity during bilingual reading. Libben and Titone (2009) examined the effects of semantic constraint using eye-movement recordings to investigate how French-English bilinguals process interlingual homographs and cognates (i.e., words that are spelled the same in two languages and carry the same meaning, e.g., piano and piano) in sentences with high and low semantic constraint. In their study, they found that interlingual homographs were generally read more slowly in both conditions, whereas cognates produced facilitation. A similar study by Titone and colleagues (2011) also used contextual sentence constraint to investigate the effects of interlingual homograph and cognate cross-language activation during L1 reading as a function of L2 age acquisition and task demands. Participants were English L1 and French L2 bilinguals who were proficient in both languages. Titone and colleagues (2011) had participants read high and low- constraint sentences during two experiments. In Experiment 1, participants read high- and low- constraint sentences in their L1 English. Similarly to Libben and Titone (2009), Titone and colleagues (2011) observed that when bilingual readers read in their L1, knowledge of their L2 led to facilitation with cognates and interference with interlingual homographs. In Experiment 2, participants read similar English sentences as in Experiment 1; however, there was intermixed French filler sentences in order to get the reader to approach the task in more of a bilingual mode rather than monolingual mode (Titone et al., 2011). In comparison between Experiments 1 and 2, Titone and colleagues (2011) found that there was significantly more interlingual homograph interference with the presence of L2 filler sentences (Experiment 2). The authors concluded that their results were in line with the BIA+ model (Dijkstra & Van Heuven, 2002), and that the extent to which language access was non-selective was modulated by the age of acquisition of their L2. Thus, L1 language processing can be significantly influenced by L2 knowledge to the extent that bilinguals are proficient in both languages.

Inhibitory control mechanisms may also contribute to how bilinguals experience cross-language activation, though proficiency may not always reduce interference effects. Durlik and colleagues (2016) explored whether bilinguals with higher L2 proficiency would inhibit irrelevant meanings during interlingual homograph recognition. Using a semantic relatedness judgement task, Durlik and colleagues (2016) paired Polish-English interlingual homographs targets (e.g. pies means pastry in English and means dog in Polish) with words that were either related or unrelated to the Polish meaning of the word, to which participants responded yes or no if the pair of words were semantically related. They predicted that bilinguals with higher L2 proficiency (balanced bilinguals) would experience less interference when encountering interlingual homographs, by being more efficient in inhibiting the irrelevant language, consistent with the IC model by Green (1998). Moreover, they predicted that bilinguals with lower L2 proficiency (unbalanced bilinguals) would experience more interference. However, results from Durlik and colleagues (2016) revealed that both balanced and unbalanced bilinguals showed similar interference conflict with activating both meanings of the interlingual homograph, demonstrated by slower response times. These results align with the BIA+ model, demonstrating that interlingual homograph recognition suffers from interference from two competing meanings in both bilingual groups. The authors noted however that these results may have been because the two bilingual groups weren't heterogeneous enough in terms of their L2 proficiency.

Electrophysiological Evidence of Cross Language Activation Using N400 Amplitudes

Event related potentials (ERPs) are brain responses that are related to specific stimuli, thus providing an effective way of measuring semantic language processing (Kutas & Van Petten, 1994). Using an electroencephalogram (EEG), ERPs are observed during lexical tasks to gain a better understanding of the stages in word processing (Lehtonen et al., 2012). ERPs provide continuous data measured in milliseconds through high temporal resolution during reading tasks (see a discussion by van Heuven & Dijkstra, 2010; Madziak, 2020). The N400 amplitude (negative voltage peak 400 milliseconds after stimulus onset) is sensitive to semantic processing. More specifically, the N400 produces greater negativity in response to an unrelated target, whereas the N400 is less negative going in response to semantically related words (Kutas & Van Petten, 1994). This difference in amplitude reflects the N400 semantic priming effect (de Bruijn et al., 2001).

The effects of cross-language activation on N400 amplitudes have been studied during semantic primed lexical decision tasks involving bilinguals (de Bruijn et al., 2001; Kerkhofs et al., 2006; Kousaie & Phillips, 2011;), thus, a thorough examination of N400 amplitude demonstrates how bilinguals access cross-language semantic information during a lexical decision task. Past research exploring the effects of language with bilinguals using electrophysiological measures has been conducted with right-handed participants, due to potential language laterization differences in the brain hemispheres of left-handed individuals (Szaflarski et al., 2012). de Bruijn and colleagues (2001) investigated response times and N400 ERPs while Dutch-English bilinguals completed a semantic priming task involving interlingual homographs. Participants saw each interlingual homograph twice; once with a related word and once with an unrelated word. Of the interlingual homographs, half were preceded by English primes, and half were preceded by Dutch primes. Results from this study revealed two important findings. First, target words that were semantically related to interlingual homographs produced faster response times and elicited less negative going N400s compared to unrelated words. Second, target words were responded to faster and elicited less negative going N400s when they were paired with interlingual homographs, regardless of the language of the prime (English or Dutch). The authors interpreted these results as indicating that target words that are presented with an interlingual homograph allow for the target word to be more easily integrated than unrelated words, indicative of language non-selectivity and lending support to the BIA+ model (de Bruin et al., 2001). Kousaie and Phillips (2011) extended these results in a group of English-French balanced bilinguals. Similar to results by de Bruin and colleagues (2001), bilinguals in Kousaie and Phillips (2011) demonstrated language non-selectivity indicated by faster response times and less negative going N400s in response cross-language interlingual homograph prime-target pairings.

In a similar study investigating N400 amplitudes during a lexical decision task, Kerkhofs and colleagues (2006) extended findings for interlingual homograph facilitation effects in a lexical decision task involving Dutch-English bilinguals. An important distinction between de Bruijn et al., (2001) and Kerkhofs et al., (2006) is that the former used triplets in their lexical decision task, whereas the latter used pairs. However, the results support the same findings, despite task differences. Kerkhofs and colleagues (2006) demonstrated that the recognition of Dutch-English interlingual homograph targets was influenced by semantically related English primes, demonstrated by faster response times and less negative going N400s. Kerkhofs and colleagues (2006) found that interlingual homograph targets that were preceded by primes that were semantically related to the L2 meaning of the interlingual homograph were faster recognized than words that were unrelated. Moreover, higher frequency homographs produced faster response latencies in comparison to lower frequency interlingual homographs. These effects were also observed at the N400 amplitude; related primes elicited less-negative going N400s compared to unrelated primes, and higher frequency interlingual homograph targets elicited less-negative going N400s. Interlingual homograph targets of lower frequency elicited more-negative going N400s. Therefore, the authors concluded that although the L1 meaning of a interlingual homograph can interfere with the L2 meaning, this interference can be reduced by strengthening the access (i.e., increasing recognition) to L2 meaning with a semantically related prime (Kerkhofs et al., 2006). Thus, the reader's L2 meaning of an interlingual homograph can be activated by an L1 word that is semantically related to that meaning.

Results from Kerkhofs et al. (2006) reveal an important implication for the current study. In their analysis, words of lower frequency led to slower response times and more-negative going N400s. Although Kerkhofs and colleagues (2006) did not include a combination of balanced and unbalanced bilinguals, frequency effects suggests that greater exposure to a language leads to encountering words at a higher frequency, compared to less exposure. Thus, in theory, balanced bilinguals encounter both L1 and L2 meanings of an interlingual homograph at a similar frequency (i.e., split exposure) compared to unbalanced bilinguals, who may encounter the L1 meaning of the interlingual homograph at a higher frequency than the L2 meaning. This discrepancy in language exposure contributes to asymmetrical priming effects between L1-L2 and L2-L1 semantic primes.

The Present Study

While there is evidence of cross-language activation in bilinguals during lexical decision tasks, the degree of facilitation or interference that interlingual homographs produce remains unclear. Moreover, previous research on word identification in bilingual reading has not accounted for differences in balanced and unbalanced bilinguals, thus generalizing without controlling for language proficiency (see Dijkstra & van Heuven, 2012 for a discussion). The current study sought to examine cross-language activation in English/French interlingual homograph word identification in balanced and unbalanced English-French bilingual children. More specifically, the current study aimed to explain how the combined effects of language proficiency and reading ability influence interlingual homograph word recognition. Balanced and unbalanced bilingual participants were recruited and administered several standardized measures. N400 ERP amplitudes and response times were collected during a lexical decision task consisting of two different prime-target pairings: cross-language semantic related (e.g. bedding – LIT), and unrelated (e.g. army - LIT), where LIT is the French translation of the word “bed”.

First, I hypothesized that balanced bilinguals would show significant priming effects for cross-language semantically related primes compared to unrelated primes, indicated by quicker response times and less negative going N400 amplitudes, like Dijkstra et al. 1998 (Experiment 3), Kerkhofs et al. (2006), Kousaie and Phillips (2011), and de Bruijn et al. (2001). Participants in the current study were instructed to respond “yes” to words that were legal words in French or English, to put them in “bilingual mode” (Grosjean, 2024; Grosjean & Wei, 2007), and to maximize the cross-language priming effect (de Bruijn et al., 2001; Dijkstra et al., 1998). Therefore, I predicted that balanced bilinguals, who have relatively equal exposure to each language and strong cross-language semantic networks, would efficiently integrate cross-language primes.

Second, I hypothesized that unbalanced bilinguals would not show significant differences in N400 amplitudes or response times between the related and unrelated condition. Unbalanced bilinguals are disproportionately exposed to their L1; thus, these bilinguals have less exposure to “bilingual mode” (Grosjean, 2024; Grosjean & Wei, 2007). With unequal exposure to each language, the cross-language semantic networks for unbalanced bilinguals would be less efficient. The BIA+ model posits that upon being presented an interlingual homograph, bilinguals activate meanings from both of their languages; however, the L1 meaning of the word will prevail over the L2. The related primes in the current study were strategically chosen to prime bilingual participants for reading the interlingual homographs in French (the unbalanced bilingual’s L2). Therefore, if the BIA+ model posits that the L1 meaning of the interlingual homograph will prevail (Dijkstra & Van Heuven, 2002), and in combination with less efficient cross-language networks, unbalanced bilinguals would not benefit from the cross-language priming, essentially treating interlingual homographs as unrelated to target words.

Finally, I hypothesized that reading ability would impact participants’ performance on the lexical decision task. Reading ability is strongly related to word recognition, where strong readers have quicker lexical processing and decoding skills than poor readers (Deacon & Kirby, 2004; Madziak, 2020; Pasquarella et al., 2014). Thus, I predicted that stronger readers would be quicker at making lexical decisions than poorer readers, indicated by faster response times for both balanced and unbalanced bilingual participants with better reading ability.

Method

Participants

Participants included Grade 5 and 6 English-French bilingual students (*N*=43), consisting of balanced-bilinguals (BB; $n = 23$) and unbalanced-bilinguals (UB; $n = 20$). The BB group consisted of 23 grade 6 students, while the UB group consisted of 11 grade 6 students and 9 grade 5 students. The UB group consisted of grade 5 and 6 students because, in their school division, grade 5 and 6 students were in combined classes. The BB group participants were in grade-6-only classes. Two BB participants were excluded from the final analysis due to noisy ERP recordings during the lexical decision task, and one more BB participant was excluded for having scores below the cut-off criteria on both the French and English PPVT tests (final BB group $n = 20$). One UB participant was excluded due to an elevated number of incorrect trials on the lexical decision task, not meeting the minimum set cut-off criteria of 13 correct trials per condition (final UB group $n = 19$). Thus, the final total sample size included 39 participants.

Participant group demographic information is provided in Table 1. A chi-square test determined that the number of males and females in each of the groups did not differ significantly ($X^2(1,N=39) = 0.22$, $p = .643$). Despite the BB group consisting of Grade 6 students only, whereas the UB group consisted of Grade 5 and 6 students, students in the BB group did not differ significantly in months (M=140.5, SD = 3.74) compared to the UB group (M = 137.2, SD = 6.64, $t(37) = 1.92$, $p = .06$). BB participants were recruited in the spring of 2023 in a French-language school division in Winnipeg, where participants consisted of L1-French and L2 English learners. In order to attend this French school division, students had to have at least one

French speaking parent. UB participants were recruited in the spring of 2024 through a French immersion school division in Winnipeg, where the participants consisted of L1-English and L2-French learners. To attend this school division, parents do not have to be French speaking.

To assess for language proficiency, all participants were administered both the English PPVT-4 and French PPVT-5-CDN-FR. To ensure English proficiency, all participants were required to have a standard score within 1 standard deviation of the mean on the PPVT-4 to be included in the final analysis. To ensure French proficiency, all participants were required to have a standard score within 3 standard deviations of the mean on the PPVT-5-CDN-FR to be included in the final analysis. The PPVT-5-CDN-FR required a less stringent cut-off criteria because the test was normed in Québec with monolingual French speakers, the only Canadian province with French as the sole official language. Thus, the French norms on the PPVT-5-CDN-FR may not be representative of Manitoba's French vocabulary. However, this test remains as a proxy measure for French proficiency. As Canada is a country with French and English as official languages, French-English bilinguals have a distinct experience of language exposure, and this varies among Canadian provinces.

Considering the complex nature of bilingualism in Manitoba, vocabulary scores alone were not sufficient in determining language proficiency. Therefore, additional criteria involved exposure to both languages. Parents of participants in the current study completed language history questionnaires to consider the extent to which participants were exposed to French and English outside of school (see Appendix A). Parents were asked about the frequency of English and French spoken at home. Results from the language history questionnaire can be found in Table 2. Results from the language history questionnaire further corroborated that participants in each school division differed in their exposure to French and English. BBs attended fully French speaking schools and had French speaking parents. Outside of school, they were exposed to more of a balance of French and English, making them balanced bilinguals. UBs have a different experience in language exposure, as they attended school in French but rarely spoke French outside of school. Hence, these students were not equally exposed to each language, making them unbalanced bilinguals. This distinction illustrates the convoluted differences in bilingualism in Manitoba and highlights the importance of distinguishing between language proficiencies. Otherwise, the term “bilingual” can encompass a heterogeneous group. Although these questionnaires may not provide an exact measure of language proficiency, it was the most effective way to gain a better picture considering the complex nature of bilingualism.

Frequencies of English and French spoken at home are provided in Table 2. A Chi-square test determined that the BB and UB groups differed significantly on the frequency of English spoken at home ($X^2(3, N=39) = 12.82$, $p < .005$). Similarly, the BB and UB groups also differed significantly on frequency of French spoken at home ($X^2(4, N=39) = 20.46$, $p < .001$). This indicates that outside of school, the BB group was exposed to a combination of French and English, whereas the UB group almost exclusively communicated in English. Results from the language history questionnaire corroborated the justification for establishing language proficiency differences between the BB and UB groups. Based on the language history questionnaire, some BB participants may have had language profiles more closely resembling the UB group; however, these participants remained in the BB group based on the French speaking school division they attend. Moreover, some multilingual participants spoke languages other than French and English at home; thus, these participants were grouped based on the school divisions they attend.

Materials and Measures

The study was approved by ethics boards at the University of Manitoba and the University of Winnipeg. Parents of participating students received either online or paper-copy consent forms giving permission for their children to participate in both phases of the study. The first phase of the study took place in participants' schools, while the second phase took place at the University of Winnipeg. Along with the consent form, parents were asked to answer a series of questions regarding demographics and their child's reading, such as how often they read (see Appendix A). All forms were translated in French for distribution to French-speaking parents and teachers in the French school division, while English forms were distributed for parents and teachers in the French immersion school division, as this population is more fluent in English.

Standardized tests

In the first phase of the study, participants underwent several reading measures which were administered at the participant's school by trained University of Manitoba graduate students, several weeks before the second phase of study. Participants we're 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), and the Edinburgh handedness test. In the second phase of the study, which took place in the EEG laboratory at the University of Winnipeg, participants were administered the French equivalent of the PPVT-4, l'Échelle de Vocabulaire en Images Peabody, Cinquième Édition,, a computer-presented French cross-language vocabulary translation task, and a lexical decision task while ERP data were being collected. All standardized test mean scores can be found for each group in Table 3. A detailed description of each task is described below.

CTOPP-2. The Comprehensive Test of Phonological Processing, Second Edition (Wagner et al., 2013), was administered to assess phonological processing. From this measure, the following four subtests were administered: The Elision subtest, Rapid Digit Naming, Rapid Letter Naming, and Nonword Repetition. The Elision subtest contains 20 items that measured the ability to remove phonological segments from words to create new words (e.g., Say “cup”. Now say “cup”, without saying /k/). The Rapid Digit Naming (RDN) subtest measured the ability to rapidly name numbers as quickly and accurately as possible. Likewise, the Rapid Letter Naming (RLN) subtest measured the ability to rapidly name letters as quickly and accurately as possible. Both the RDN and RLN tests contained 36 items. Finally, the Nonword Repetition subtest involved the researcher saying up to 30 non-words (e.g. SART), and the participant repeating the word back to the researcher. Composite scores from the phonological awareness (Ellison and Nonword Repetition) and Rapid Naming (RDN and RLN) subtests were averaged for an overall phonological processing score. Reliability of the subtests have average internal consistency coefficients of >.80 (Wagner et al., 2013).

PPVT-4. The Peabody Picture Vocabulary Test, Fourth Edition (Dunn & Dunn, 2007) was administered to assess participants’ receptive vocabulary knowledge. This test has a reliability coefficient of >.90 (Dunn & Dunn, 2007). In this test, participants were asked to point to one of four pictures that matches the meaning of the word verbally presented by the researcher. This test was used as an exclusionary criterion to ensure that poor reading ability is not due to a weak vocabulary, as well as serving as a proxy to ensure that participants had adequate English vocabularies. Participants included in the final analysis were required to obtain a score no more than 1 standard deviation below the mean. Participants were also administered the French equivalent of the PPVT-4, l’Échelle de Vocabulaire en Images Peabody, Cinquième

Édition (PPVT-5-CDN-FR), to assess French proficiency. In order to be included in the final analysis, participants were required to obtain a PPVT-5-CDN-FR standard score no more than 3 standard deviations below the mean, to ensure an adequate French vocabulary. These tests, along with the data obtained from the language history questionnaires, provided more information on language proficiency and exposure to distinguish between BB and UB participants.

WASI-II. The Weschler Abbreviated Scale of Intelligence, Second Edition (Weschler, 2011), was administered to assess non-verbal intelligence. This test has a reliability coefficient of .87 (Weschler, 2011). The Matrix Reasoning subtest test was used, where participants were presented with a series of incomplete visual patterns and subsequently asked to choose one of five options that best completes the picture. This test was used as an exclusionary criterion to assess participants' intellectual capacity, where they required a T-score of 30 (2 SD below to mean) or higher to be included in the final analysis. No participants were excluded on this basis.

TOWRE-2. The Test of Word Reading Efficiency, Second Edition (Torgeson et al., 2012), was administered to assess the ability to read both real words and pronounceable non-words fluently. This test has a reliability coefficient of .90 (Torgeson et al., 2012). Participants were administered the Sight Word Efficiency subtest, where they were asked to read as many real words as quickly and accurately in 45 seconds, followed by the Phonemic Decoding Efficiency subtest, where they were asked to read as many non-words in 45 seconds (Torgeson et al., 2012). Composite standard scores from this test (here labelled TI for TOWRE-2 Index) were used to control for reading ability and was used as a co-variate in the final analysis.

Edinburgh Handedness Test. This test was administered to assess whether participants are exclusively left-handed. Participants were asked a series of questions regarding several tasks (e.g. show me which hand you drink a cup with). This test served as an exclusionary criterion.

Due to potential language lateralization differences in left-handed brains, exclusively left-handed participants (who endorsed "left" on all questions) were excluded from the ERP data analysis. No participants were excluded on this basis.

Group differences on standardized measures are provided in Table. 3. Independent samples t-test revealed that the UB group had significantly higher scores on the TOWRE-2 Index (TI; M = 114.95, SD = 18.50) compared to the BB group (M = 102.30, SD = 18.66, t(37) = -2.13, p <.05). The TOWRE-2 was an English task; thus, the discrepancy between group scores is likely due to the UB group completing the task in their L1, whereas the BB group completed the task in their L2. This timed task most closely resembled the lexical decision task, which requires quick and efficient word decoding; thus, the TI score was used as a co-variate in the final analysis to control for reading ability. Independent samples t-tests revealed that the UB group had significantly higher scores on the English PPVT-4 (M = 114.42, SD = 10.24) compared to the BB group (M = 105.50, SD = 12.89, $t(37) = -2.39$, $p < .05$). This score discrepancy indicates that the UB group is more proficient in English. In contrast, the BB group had significantly higher scores on the French PPVT-5 (M = 79.85, SD =10.56) compared to the UB group (M = 69.37, SD = 8.45, $t(37) = 3.41$, $p < .01$). This score discrepancy indicates that the BB group is more proficient in French than the UB group. The PPVT scores were used to ensure that participants had sufficient proficiency in both languages to participate in the study. There were no other significant differences on standardized measures between groups.

Lexical Decision Task

In the second phase of the study, participants were administered a lexical decision task in the Development of Reading and Language Laboratory at the University of Winnipeg. This phase of the study took place during the summer of the year that the standardized tests were administered. Thus, the BB group data were collected in the summer of 2023, and the UB group data were collected during the summer of 2024. Upon arrival at the University of Winnipeg EEG lab, parents/guardians signed a consent form for their child's participation, and the child's assent was obtained throughout the study. Parents/guardians were compensated for their travel and time. Participants were encouraged to alert the researchers anytime they needed to take a break to avoid fatigue and maximize the quality of data collection.

The lexical decision task used in this study was a novel task strategically designed for the purpose of this thesis. The task consisted of cross-language prime-target pairings that were semantically related or unrelated (e.g. bedding-LIT; see Appendix B for the material list). This experiment was designed to distinguish the effects of bilingual language proficiency and reading ability on word recognition in BB and UB participants. Primes consisted of English multi-morphemic words that were paired with target French/English interlingual homographs where the English primes were semantically related to the French meaning of the interlingual homograph. Important to note here is that the cross-language primes were not direct translation equivalents; rather, the primes are multi-morphemic words where the root word is the translation equivalent. These words were chosen based on a previous study in the lab that investigated morphological segmentation. Thus, the only relation between primes and targets were due to cross-language meanings. For example, the pairing of breading-PAIN is cross-language semantically related because pain is the French translation of the root word "bread". The lexical decision task took approximately 10 minutes to administer.

We carefully examined all prime and target words to make sure that the stimuli had similar properties in both languages. Specifically, we used WordGen, a database containing frequency and orthographic data on English and French words (Duyck et al., 2004) to provide values relating to these variables. A paired samples-t-test was conducted to determine if there were any significant differences between French and English readings of the interlingual homographs. There were no significant differences between French and English interlingual homographs on frequency [$t(37) = -1.91$, $p = .064$]. The average log frequency for the English meanings of the interlingual homographs was 1.59 and the average log frequency for the French meanings was 1.89. There was a significant difference between French and English interlingual homographs on orthographic neighborhood size [$t(39) = 2.39$, $p = .022$]. The significant difference in orthographic neighborhood size between French and English interlingual homographs is consistent with what is reported in the literature (Marian et al., 2012). The mean number of letters in the interlingual homographs was 4.3 (M = 4.3; SD = .912), and the average difference in orthographic neighborhood size for French and English words of 4.3 letters is 7 and 12, respectively (Marian et al., 2012). This difference is due to the natural difference in languages. Hence, English words tend to have larger orthographic neighborhood sizes. Nonword stimuli were also examined to ensure that the pseudowords were not only nonwords in English, but also nonwords in French.

Participants were told that they were going to see a series of letter stings, which could be real French and English words, or non-words. Letter strings were presented one at a time on the screen, and participants were instructed to respond as quickly and accurately as possible by clicking a blue mouse button if the letters formed a real word in French or English, or an orange mouse button if the letters did not form a real word in either language. To ensure that participants were in “bilingual mode” rather than “monolingual mode”, participants were told that they would see French and English words, but no further details about the words were provided. This served two important purposes. First, we wanted to maximize cross-language activation effects. Second, because we did not want participants to recognize interlingual homographs in one language only and select the orange button for “not a word” in English because they recognized it in French. The lexical decision task consisted of 10 practice trials for which ERPs were not recorded, followed by 160 trials (80-word trials, 80 non-word trials) for the cross-language lexical decision task. Of the 80-word trials, 40 were in the related condition and 40 were unrelated. The trials were presented in a randomized order in two counterbalanced blocks; targets paired with a related prime in block one were paired with an unrelated prime in block two.

The delineation of each trial was as follows: the screen displayed a fixation cross in the center for 500 ms; this was to direct the participant’s attention to the centre of the screen where stimuli were displayed, followed by a forward mask of eight hashmarks (#) displayed for an additional 500 ms. The prime stimulus then appeared in lowercase letters for 67 ms with an inter-stimulus interval duration of 50 ms, after which the target was presented until the participant gave a response; hence, the stimulus onset asynchrony (SOA) was 117 ms. Previous research has demonstrated that SOAs in this range are sufficient for automatic prime processing (Quémart & Calsalis, 2015), whereas longer SOAs may evoke more intentional processing strategies (Hutchison et al., 2013). The target stimulus then appeared in the center of the screen in uppercase letters until the participant made a lexical decision; blue button for yes, orange button for no. The next trial followed after a 1000 ms interval.

Interlingual Homograph Vocabulary Task

After the lexical decision task, participants were administered a French vocabulary task, which included the 40 interlingual homographs used in the lexical decision task. This task took approximately 5 minutes to administer. Participants were presented one interlingual homograph at a time and asked to verbally pronounce the interlingual homograph in French, and afterwards translate the French meaning of the interlingual homograph to English (e.g., tire in French means pull in English). Correct responses were scored with a 1, and incorrect responses were scored with a 0. This task allowed the researchers to know which interlingual homographs the participants were able to decode in both languages (i.e., French and English). The cross-language lexical decision task was comprised of primes which were related to the French meaning of the interlingual homograph targets, thus; understanding the French meaning of the interlingual homographs was paramount for the semantic priming to have its intended effects. Interlingual homographs which the participants were unable to translate the French meaning to English were excluded from the final ERP analysis to gain the most accurate understanding of the cross language semantic priming effects.

Electrophysiological Recording & Preprocessing

Prior to beginning the lexical decision task, participants were fitted with a 32-electrode electroencephalographic (EEG) cap that was carefully placed and measured around the scalp. ERPs were recorded in a sound-attenuated booth (WhisperChamber Inc.) and participants were seated 100 cm away from the computer screen (Dell Precision M4800 monitor). BrainVision Recorder was used to measure impedance values for the EEG data collection. Impedance values are a measure of resistance to the flow of electrical current in the EEG signal; thus, all 32 electrodes and the ground electrode were injected with electrostatic gel to achieve impedance levels below 20 kΩ, as is recommended for this type of system. Once optimal impedance values were achieved, participants were instructed to remain as still as possible and refrain from moving around as this could cause noise in the ERP amplitude readings. EEG data were collected at 500 Hz throughout the task from 32 Ag/AgCI ActiChamp active electrodes, and ERPs were time locked to the onset of the presentation of the target words. Data were filtered from .1-30 Hz with a 24 dB/Oct phase shift. To remove any potential electrical noise that could affect the data, a 60 Hz notch filter was applied. Data were referenced online to Fz, and re-referenced offline to the TP9/TP10 mastoids. Data for each condition was segmented and trials were corrected to the 100 ms pre-stimulus interval. Trials having voltages greater than 85µV or lower than -85µV were removed through artifact rejection.

The criteria to be included in the final analysis required participants to a) obtain an English PPVT-4 score above 1 SD below the population mean, b) obtain a French PPVT-5 score above 3 SDs below the population mean, c) obtain a Matrix Reasoning score above 2 SDs below the population mean, and d) correctly translate 75% of the interlingual homograph targets. Thus, all participants in the final analysis met these criteria. The final sample included 20 BB participants and 19 UB participants.

Data Analysis

Behavioural Data Analysis

Only the trials containing real word targets were included for the behavioural data analysis (80 trials). For the final analysis, incorrect trials on the lexical decision task were removed as well as all trials where the participant responded quicker than 300 ms or slower than 3500 ms. Moreover, participants who lost more than 50% of their trials due to electrode channel or movement noise were excluded from the final analysis of behavioural and ERP data. Raw response times were inversely transformed to correct for possible violations of assumptions (described in further detail below; Brysbaert & Stevens, 2018), and were analyzed using a linear mixed effects model (LMER in R; Baayen, 2008; Baayen et al., 2008) with the inversed response times as the dependent variable. Inferential statistics included the independent fixed variables language group and prime type, while random effects independent variables included participant and item. Reading ability was included as a co-variate fixed-effects independent variable.

ERP Data Analysis

ERP data were analyzed using a 2 x 2 factorial ANOVA in SPSS to examine the N400 amplitude across participant groups and prime type conditions. To examine the N400, I investigated the average voltages in the time window of 350 ms to 450 ms acquired at the Pz electrode. More specifically, I compared mean N400 amplitudes on cross-language semantic related vs unrelated primes across BB and UB participants. Similarly, both between and within-subjects ANOVA was used, with the within-subjects variable being prime relatedness and the between-subjects variable language group.

Results

Reaction Time Analysis

To ensure possible violations of assumptions for parametric analyses were controlled, an inverse transformation on the raw reaction times (RT) for correct trials was conducted using the formula InverseRT = -1000/RT for the inferential analysis. Inverse reaction times are more powerful because they result in less noise and higher estimates of both fixed and random effects (Brysbaert & Stevens, 2018). Inverse transformation times and raw reaction times can be found in Table 4 for ease of interpretation. Response time data were analyzed using a linear mixed effects model (LMER in R; Baayen, 2008; Baayen et al., 2008) with the inverse response times as the dependent variable. The fixed effects variables included in the inferential statistics were prime type (related, unrelated) and language group (BB, UB), with reading ability (TOWRE-2 index score) as a covariate. Reading ability was included as a covariate to control for the group difference on this measure. Random effects variables included participant and item, with item referring to the target. The model also included interaction effects involving the fixed-effects variables. These variables were included in the best fitting model, corroborated by a backwards reduced stepwise model selection. The Satterthwaite method was used to calculate degrees of freedom. The final best fitting model was: inverse ~ Lang_Group + PrimeType + TI + (1 | Subject) + (1 | item) + Lang_Group:PrimeType.

There was a significant main effect of reading ability ($\beta = -0.009$, $SE = 0.002$, $t(36.25) = -4.46$, $p < .001$), indicating that participants with higher TI scores (i.e., stronger readers) responded faster than participants with lower TI scores (i.e., poorer readers). The effect of log word frequency was also marginally significant ($\beta = -0.04$, $SE = 0.02$, $t(36.79) = -1.91$, $p < 0.1$), suggesting a trend showing that participants had faster response times to target words of higher English frequency of use. There was also a significant main effect of prime type ($\beta = 0.05$, $SE = 0.02$, $t(2058) = 2.45$, $p < .01$), indicating that participants had faster RTs for English primes that were semantically related to the French meaning of target interlingual homographs, compared to unrelated primes. There was no significant main effect of language group ($\beta = 0.02$, $SE = 0.08$, $t(38.48) = 0.25$, $p = .80$), indicating that there was no significant difference on RTs between language groups when averaging across both related and unrelated conditions. The interaction between language group and prime type was significant ($\beta = -0.08$, $SE = 0.03$, $t(2057) = -2.66$, $p < .001$). Post-hoc analysis revealed a significant priming effect in the BB group for semantically related primes ($\beta = 0.05$, $SE = 0.02$, $t(991) = 2.39$, $p < .01$), but not for the UB group ($\beta = 0.03$, $SE = 0.02$, $t(1033) = 1.28$, $p = .20$). This indicates that semantically related English primes produced a significant facilitation effect on response times for interlingual homograph recognition for BB participants, while UB participants did not show significant priming effects.

Put otherwise, the absence of significant difference between related and unrelated conditions in the UB group indicates that primes were perceived as unrelated to the targets in both conditions.

Electrophysiological Analysis

A 2 (prime type: cross-language related, unrelated) X 2 (language group: balanced, unbalanced bilinguals) ANOVA was conducted on mean amplitude measured during the N400 time interval (350 ms to 450 ms) post target onset at the Pz electrode (which has a central/parietal location). Past research has indicated that the N400 peaks to lexical and semantic processing over this location (Toffolo et al., 2022). The within-subjects independent variable was prime type (cross-language semantic related, unrelated), while language group (BB, UB) was the between-subjects variable. Mean voltages and standard deviations are presented in Table 5. The mean voltage for the N400 amplitude time interval reflects the extent of observed priming effects between the primes and targets. Thus, differences in N400 means reflect differences on word identification processes. Because the N400 is a negative amplitude, facilitation effects are observed when voltages are less negative going. This indicates that information is processed more efficiently, requiring less mental exertion. In contrast, voltages that are more negative going indicate that information is being processed less efficiently and thus requires more mental exertion. Moreover, a priming effect occurs when exposure to one stimulus (the prime) influences the response to a subsequent stimulus (the target). Thus, in the case of a lexical decision task, a priming effect occurs when a target word is recognized quicker and more efficiently when it is paired with a related prime word. Priming is reflected in the ERP waveform by reduced N400s to primed vs unprimed targets.

The distribution of scores was approximately normal with a skewness of 0.51 (SE = .378) and kurtosis of 0.54 (SE = .741). Results of the ANOVA revealed no main effect of prime type

(F(1,37 = 1.17, p = .287, $\eta_p{}^2$ = .031), indicating that related and unrelated primes alone did not have a significant effect on mean N400 voltages. Moreover, there was no main effect of group (F(1,37) = .23, p = .631, $\eta_p{}^2$ = .006), indicating that group membership did not significantly impact N400 voltages. However, a significant interaction was found between prime type and language group (F(1,37 = 5.96, p = .020, $\eta_p{}^2$ = .139). Pairwise comparisons were conducted using Bonferroni-adjusted correction to control for multiple comparisons with a corrected alpha level of .0083. SPSS adjusted the p-values accordingly. The results of the Bonferroni-adjusted pairwise comparison revealed that BB participants showed significantly reduced negativity for targets paired with related primes (M = 4.49, SE = 1.46) compared to unrelated primes (M = 1.78, SE = 1.36), p = .016, $\eta_p{}^{2\cdot}$ = .147 (see Figure 1). In contrast, no significant differences were found in the UB group between related primes (M = 1.71, SE = 1.49) and unrelated primes (M = 2.75, SE = 1.39), p = .348, $\eta_p{}^2$ = .024 (see Figure 1). This indicates that the prime types affected the N400 amplitudes differently, depending on participants' language proficiency. More specifically, the BB participants showed a significant cross-language semantic priming effect, whereas the UB participants did not show a significant cross-language semantic priming effect.

Discussion

The current study investigated cross-language semantic priming in balanced and unbalanced bilinguals. The findings provide insight into the underlying processes of bilingual lexical access while highlighting individual differences in language proficiency and reading ability. Most studies investigating cross-language priming have been conducted with either balanced or unbalanced bilinguals (e.g., Chaouch-Orozco & Rothman, 2021; de Bruijn et al., 2001; Dijkstra et al., 1998; Dijkstra et al., 2000; Durlik et al., 2016; Friesen et al., 2014; Kousaie & Phillips. 2011; Kerkhofs et al., 2006; Libben & Titone, 2009; Smith & Prior, 2019; Titone et al., 2011), but these studies had not explored how language proficiency may affect cross-language activation by having both balanced and unbalanced bilinguals complete the same task. Thus, this study adds to the existing literature by directly exploring the effects of language proficiency on cross-language semantic priming. Behavioural and ERP results support my hypotheses that cross-language activation during a lexical decision task would be modulated by language proficiency. In the following sections, I will discuss the behavioural and ERP patterns in each group separately. Subsequently, I will discuss the theoretical implications of the results as they relate to the BIA+ model, followed by a brief discussion on the effects of reading ability on word recognition.

Reaction Time Results

Balanced Bilinguals

The significant interaction of prime type and language group in the current study revealed that English primes that were semantically related to the French meaning of target homographs elicited faster response times compared to unrelated primes in the BB group. This is consistent with research showing that bilingual lexical processing is influenced by cross-language semantic relationships (de Bruijn et al., 2001; Dijkstra et al., 1998; Kerkhofs et al., 2006; Smith et al., 2019. Importantly, this finding aligns with the bilingual interactive activation plus model (BIA+; Dijkstra & van Heuven, 2002), which posits an integrated bilingual lexicon where both of a bilingual's languages are co-activated during primed lexical access and retrieval. According to the model, it is not the word's language membership that determines the activation of lexical representation; rather, it is the similarity of the word input (Dijkstra & van Heuven, 2002). Therefore, upon homograph recognition, multiple lexical representations are activated in parallel.

Unbalanced Bilinguals

In contrast, the UB group showed no significant differences in response times between related and unrelated primes. Put otherwise, these results indicate that UBs treated cross-language semantically related primes as though they were unrelated. This discrepancy of behavioural patterns between BBs and UBs demonstrates the modulatory role that L2 language proficiency has on cross-language activation (Dijkstra & van Heuven, 2002). These results obtained in the UB group are somewhat contradictory to those obtained in Smith et al. (2019), because the UBs in their study demonstrated significant cross-language semantic priming effects, indicated by faster response times in the semantic related condition compared to unrelated. One plausible explanation for this discrepancy could be that Smith et al. (2019) did not include homographs in their stimuli list, only single language primes and targets were used. Thus, there may not have been competing meanings for single language targets in the UB mental lexicon. In the current study, the use of homograph targets allowed for a direct investigation of competing meanings. Therefore, the absence of difference in response times in the UB group indicate that the English primes did not significantly facilitate the recognition of French homograph meanings, likely because the competing L1 English meaning prevailed over the L2 French meaning.

ERP Results

Balanced Bilinguals

ERP results revealed that, as hypothesized, the BB participants demonstrated clear facilitation effects in cross-language semantic priming. More specifically, related primes elicited significantly less negative going N400 amplitudes compared to unrelated primes, suggesting that BB participants were able to integrate semantic primes with target homographs. The presence of less-negative going N400 amplitudes indicates that less cognitive effort was required to access lexical representations, due to cross-language priming. These results align with previous findings by Dijkstra et al. (1998, 2000), who examined bilingual word recognition in tasks involving language inter-mixing instructions to set task expectations; that is, tasks involving instructions and stimuli from more than one language. The current findings also lend further support to the integrated lexicon hypothesis proposed by the BIA+ model (Dijkstra & van Heuven, 2002), which posits that the bilingual lexicon is integrated and highly interactive. The findings indicate that the BB group, with similar L1 and L2 proficiency, had similar resting activation levels in their two languages (Grosjean, 2024; Smith et al., 2019; van Heuven & Dijkstra, 2010), which allowed for efficient semantic integration across languages. Put otherwise, the BBs in the current study benefited from cross-language semantic primes due to similar L1 and L2 proficiency.

Another complimentary explanation for the cross-language priming effect finding involves frequency of exposure to the two languages. BB participants' somewhat equal exposure to French and English across various environments likely resulted in comparable frequencies of encountering both meanings of the homograph targets in their day to day lives. UB participants, on the other hand, have likely disproportionately encountered the L1 meanings compared to the L2 meanings of the homograph targets. This has important implications on the current study, given that word frequency has been shown to modulate semantic priming effects, with higher frequency items eliciting less negative going N400 amplitudes (i.e., more efficient word processing). This was also controlled for in the stimulus list composition, as there was no significant difference in frequency between French and English homograph meanings. For the BB participants, similar L1 and L2 exposure may have resulted in both homograph meanings being active during target presentation, thus increasing the likelihood of cross-language priming in comparison to UB participants. The discrepancy of priming effects between the BB and UB groups indicate that cross-language priming may occur on a continuum that is likely related to L2 proficiency, broadly speaking. That is, cross-language representations may be more readily activated as L2 proficiency increases.

Results from the BB participants are consistent with findings from de Bruijn et al. (2001) who found that immediate (in-trial stimuli) local language context did not influence activation of homograph meaning in the bilingual lexicon, notwithstanding the methodological differences of using item triplets and the participants being UB adults (albeit, with minimum 8 years of L2 use). That is, despite the provision of an English language prime context in the current study, the BB group was still able to activate the French homograph meaning in the related condition. Taken together, these findings suggest that the BB group possessed a highly interactive cross-language semantic network, due to proficiency in both languages. This allowed for a more automatic activation of homograph representations in the lexicon, even when presented in an immediate English local language context.

Unbalanced Bilinguals

An ERP analysis revealed that, as hypothesized, UB participants did not exhibit faciliatory effects in word recognition, evidenced by the absence of significant differences in mean N400 voltages between related and unrelated prime conditions. This suggests that the UB group's cross language semantic networks did not integrate information across their languages to facilitate access to L2 semantic representations of homograph targets. Despite demonstrating the ability to translate French-English homographs in the translation task, the cross-language semantic priming had no significant effect on reading French homographs in this group. According to the BIA+ model (Dijkstra & van Heuven, 2002), this may be due to the semantic interference of the L1 dominant English meaning of the homograph, which hindered the activation of the L2 French meaning. Due to unequal language proficiency and exposure, the UB group may have experienced stronger activation of the English meanings of the target homographs because their relative higher L1 frequency. With this interpretation, the L1 meaning would have likely interfered with access to the L2 meaning. That is, UB participants' disproportionate exposures to the L1 English meanings of homographs compared to the L2 French meanings likely produced stronger L1 lexical representations in the UB mental lexicons, thus leading to stronger L1 activation when exposed to the target homograph during the lexical decision task.

This interpretation supports the idea that cross-language activation may have been less efficient in the UB group. The results suggest that the English primes, which were meant to prime the reader to the French meanings of target homographs, may have inadvertently activated the English meaning of the homograph, potentially eliminating the priming effect for the target word. This is what is known as a local language context (Dijkstra & van Heuven, 2002). That is, the immediate English language context in the task, created as a consequence of the English prime language, may have been more efficient in priming the English meaning of the homograph in the UB group than the cross-language semantic relationship between primes and targets. Interestingly, these findings contrast with those of de Bruijn et al. (2001), who reported cross-language semantic priming effects in their UBs despite the presence of local language context cues. The BIA+ model suggests that the local language context does not influence activation in the bilingual lexicon (For a discussion, see van Heuven & Dijkstra, 2010). However, results from the current study suggest that local language context may have influenced word recognition for the UB group, potentially biasing them to their L1 English dominant language. This discrepancy indicates that language proficiency plays a critical role in modulating the effects of local language context during homograph recognition. Overall, the current results suggest that language proficiency emerges as an important factor influencing cross-language activation, particularly the activation of L2 homograph lexical semantic representations. Moreover, the current study provides new evidence suggesting that immediate local language context may modulate cross-language activation, depending on bilinguals' language proficiency.

Language Proficiency

The significant interaction effect between language group and prime type suggests that BB participants, who have more symmetrical language proficiency due to equal exposure to their two languages, experience stronger cross-language activation than the UB participants. Despite the BB and UB groups both attending school in French, language history questionnaires determined that the groups differed significantly with their use of French and English outside of school. That is, outside of school, the UB group interacted primarily in English, whereas the BB group interacted in a combination of French and English. Language proficiency and exposure plays a crucial role in a bilingual's language mode (Grosjean, 2024). At the cognitive level, this implies that BB participants' more-equal activation levels during language processing leads to stronger cross-language connections, increasing their ability to access lexical representations in each language (Grosjean & Wei, 2007; Grosjean, 2024). In contrast, the UB participants may have weaker cross-language connections that lead them to rely more on their dominant language during word identification. This has implications for the current study, because UB participants may have been activating their L1 lexical representations when identifying homographs, which would in turn reduce the cross-language priming effects.

The BIA+ model states that a bilingual's L1 and L2 have differing resting activation levels at any given time, depending on language proficiency and task expectations. A bilingual's language mode is defined as the state of activation level of the bilingual's languages (Grosjean, 2024); thus, task expectation can have a significant effect on the resting activation levels in each of a bilingual's languages. In the present study, participants received instructions in English to complete a lexical decision task and were told to respond "yes" to real words in French or English. With explicit instructions, this set the experiment in a global language context (van Heuven & Dijkstra, 2010). That is, bilingual participants' activation levels and processing mechanisms in French and English were readily activated as a result of being told that they would see French and English target words, essentially maximizing the potential effects of cross-language language priming (de Bruin et al., 2001). The BIA+ model posits that when orthographic representations are activated (e.g., upon word recognition), linked semantic representations become active as well (see van Heuven & Dijkstra 2010 for a discussion). This process is not language specific. However, when a bilingual is less proficient in their L2 (i.e., the UB group), activation of their L2 representations will be delayed due to higher resting activation levels in their L1. This is consistent with the temporal delay assumption, which maintains that L1 representations are activated first upon homograph recognition (Dijkstra & van Heuven, 2002). Moreover, the resting activation level for words is associated with the frequency of usage in bilinguals (van Heuven & Dijkstra, 2010). That is, higher proficiency in a language suggests words are activated faster in that language, compared to words in the lower proficiency language.

Reading Ability

Analysis of behavioral data revealed a significant main effect of reading ability, indicating that stronger readers demonstrated quicker responses in the lexical decision task compared to poorer readers. This finding aligns with prior research indicating that more proficient readers have better developed and more efficient word recognition abilities (e.g., Deacon & Kirby, 2004; Pasquarella et al., 2014). In the current study, word retrieval and lexical access for target word identification was facilitated by strong reading abilities in participants. Participants with weaker reading abilities demonstrated slower lexical access.

Overall, the findings of the current study provide support for the idea that bilingual lexical processing is modulated by language proficiency in the two languages. Moreover, the presence of significant cross-language priming effects, as indicated by differences in response times and in N400 amplitudes for related primes in the BB participants but not the UB participants, further supports the view that balanced bilinguals experience quicker (automatic) activation of lexical/semantic information across their two languages.

Strengths, Limitations, and Future Direction

The present study has several notable strengths in its contributions to what is known about bilingual lexical access. First, to my knowledge this is one of the first studies to directly investigate the effects of language proficiency on bilingual lexical access by comparing balanced and unbalanced bilinguals in the same task. Therefore, these findings further extend our knowledge of the role of individual differences in language proficiency. Second, the behavioral and electrophysiological ERP results combined add a level of specificity and accuracy in the data (for example in data measured to the level of milliseconds, and two methods of examining bilingual lexical access). Cross-language activation occurs without conscious awareness; thus, electrophysiological evidence allows for a deeper and broader understanding of the underlying processes involved in lexical access in bilinguals. Third, this study required a considerable amount of time to collect and analyze data due to the number of standardized tests and language questionnaires administered, ERP analysis, and the two-phase study. Therefore, I attempted to address plausible confounding variables which could affect word recognition, by including reading ability and language proficiency as independent variables in the final analysis to ensure that the results were validly interpreted. Moreover, participants in both groups received the same task instruction to be as consistent as possible to measure the effects of the independent variables. Finally, bilingual participants in the current study represent the breadth of the Franco-Manitoban community, including participants from both urban and rural schools. This is an important consideration, keeping in mind that French-Canadians are emerging from a time where they had to fight for their right to speak their language because it was not valued. Thus, it is paramount that future research continues to explore the effects of bilingualism in a country that proudly has two official languages.

With this being said, there are several limitations that must be considered in understanding the full impact of the findings of the current study. First, while the findings present compelling evidence of cross-language lexical access during a cross-language semantic priming task, we could not make a comparison between within-language priming and cross-language priming, as the participants did not complete a single-language task as a baseline for comparison. Future research should investigate the extent to which within-language and cross-language priming effects differ in balanced and unbalanced bilinguals by having participants complete both a single language and cross-language task. Second, participants in the current study were instructed during the lexical decision task that they would see words in both French and English. With this information, participants were able to approach the task in “bilingual mode”; therefore, it is unclear whether cross-language lexical access was an automatic process or strategic in nature. Regardless, clear differences emerged between the two bilingual groups despite receiving the same instructions. Future research should employ a task in which participants are not given explicit instructions about the language of the task to investigate different response patterns. Third, it is unclear whether the local (immediate, within trial) language context affected the UB group's homograph recognition, as the task did not include French primes as a comparison. Future research should consider using French primes as well as English primes, to examine local language context effects. Finally, in recruiting bilingual participants for the current study, we encountered several participants who were multilingual in other languages. Winnipeg is home to a highly multiculturally diverse population; therefore, many of its inhabitants speak languages in addition to French and English. Future research should consider the potential impacts of multilingualism compared to bilingualism on cross-language lexical access.

Conclusion

Findings from the present study demonstrated that the extent of cross-language activation during visual word recognition varied as a function of language proficiency. Balanced bilinguals demonstrated significant priming effects between English primes that were semantically related to the French meaning of French-English interlingual homographs compared to unrelated primes, indicated by faster response times and less negative going N400 amplitudes. In contrast, unbalanced bilinguals did not experience this benefit of cross-language semantic priming, demonstrated by no significant differences in response times and N400 amplitudes between related and unrelated conditions. These findings suggest that children who have more equal first and second language proficiency show more automatic activation of L1 and L2 semantic information when reading. Taken together, these results align with the BIA+ model, which posits an integrated bilingual lexicon (Dijkstra & van Heuven, 2002). However, the extent to which bilinguals accessed cross-language lexical representations was modulated by language proficiency.

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Table 1.

Demographics for Language Groups

Variable		Language groups. BB	UB
Total (Female)		20 (12)	19 (10)
Child Age in Months	(SD)	140.5 (3.74)	137.21 (6.64)
Grade 6 (Grade 5)		20 (0)	11(8)
Household Income[a]		19	17
Wears Glasses		7	3

Note. BB: balanced bilingual children; UB: unbalanced bilingual children. All variables except Child Age represent the number of individuals included in each group for demographics.

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

Table 2.

Language Proficiency Measures for Language Groups

	Language groups	
Variable	BB	UB
Fluent in English	20	19
Frequency of English Spoken at Home		
Never	0	0
Seldom	5	0
50%	5	1
Usually	3	1
Almost Always	7	17
Fluent in French	20	19
Frequency of French Spoken at Home		
Never	0	8
Seldom	8	11
50%	4	0
Usually	4	0
Almost Always	4	0

Note. BB: balanced bilingual children; UB: unbalanced bilingual children. Frequency of home-based children's experiences reported by parents via the *Language History Questionnaire.*

Table 3.

Language Group Differences on Standardized Measures

	Language Groups	
Pretesting Measures	BB	UB
TOWRE-2		
TI	102.30 (18.66)	114.95* (18.49
WES	101.25 (18.56)	116.37* (16.89)
WASI-IV		
MRS	51.10 (10.49)	51.84 (6.52)
CTOPP-2		
ELS	10.35 (2.76)	10.89 (1.56)
RLS	9.05 (2.82)	10.11(3.37)
RDS	9.60 (2.34)	11.37 (3.19)
PPVT-4		
VOS (ENG)	105.50 (12.89)	114.42* (10.24)
PPVT-5		
VOS (FR)	79.85 (10.56)	69.37** (8.48)

Note. BB: balanced bilingual children; UB: unbalanced bilingual children. Standard deviations in parentheses. TI = TOWRE-2 Index standard score (norm population mean 100, SD 15); WES= Word reading efficiency standard score; MRS = Matrix reasoning T score (norm population mean 50, SD 10); ELS = Elision scaled score (norm population mean 10, SD 3); RLS = Rapid letter naming scaled score; RDS = Rapid digit naming scaled score; VOS (ENG) = Vocabulary standardize score on English PPVT-4; VOS (FR) = Vocabulary standard score on French PPVT-5.

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

**Groups differed significantly at the $p < .01$ level.

Table 4.

Inverse Reaction Times and Raw Reaction Times, Estimated Marginal Means, for Participant Groups

Condition	Language Group			
	BB		UB	
Inverse RT (-1000/ms)				
Semantic Related	-1.16 [a] *	(0.07) [b]	-1.27	(0.05)
Semantic Unrelated	-1.11	(0.07)	-1.29	(0.05)
Estimated RT (ms)				
Semantic Related	1050 [c]**	(66.5) [b]	920	(49.5)
Semantic Unrelated	1107	(66.6)	894	(49.5)

Note. BB: balanced bilingual children; UB: unbalanced bilingual children. There were no significant between-group differences.

[a] Means of inverse reaction times. [b] Standard errors. [c] Estimated marginal means of raw reaction times based on the best fitting model.

*The BB group differed significantly between related and unrelated conditions at the p <.01 level.

** The BB group differed significantly between related and unrelated conditions at the p < .05 level.

Table 5.

Mean Voltages (μV) for the N400

	Language-Group			
	BB		UB	
Prime Conditions				
Semantic Related	4.49 [a] *	(1.46) [b]	1.71	(1.49)
Semantic Unrelated	1.78*	(1.36)	2.76	(1.39)

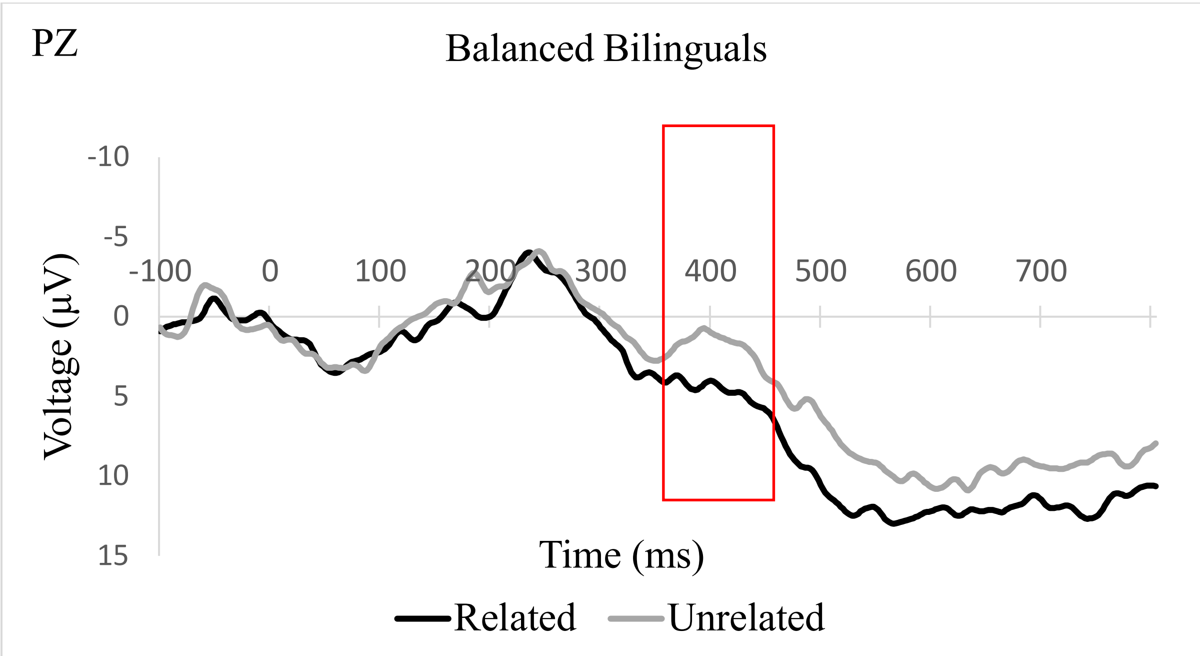
Note. BB: balanced bilingual children; UB: unbalanced bilingual children. Prime conditions reflect cross-language semantically related prime-target parings, and unrelated prime-target pairings, respectively. Mean voltages and standard errors for each language-group at the Pz electrode measured during the 350-450 ms time window. Higher voltage numbers indicate less negativity in the N400 amplitude. Therefore, higher voltage numbers indicate a faciliatory priming effect. Lower voltage numbers indicate more negativity in the N400 amplitude, demonstrating no priming effect. A significant two-way interaction effect was found between prime type and language group, indicating that the effect of prime type depended on language proficiency. There was a significant difference between semantically related and unrelated primes in the BB group only.

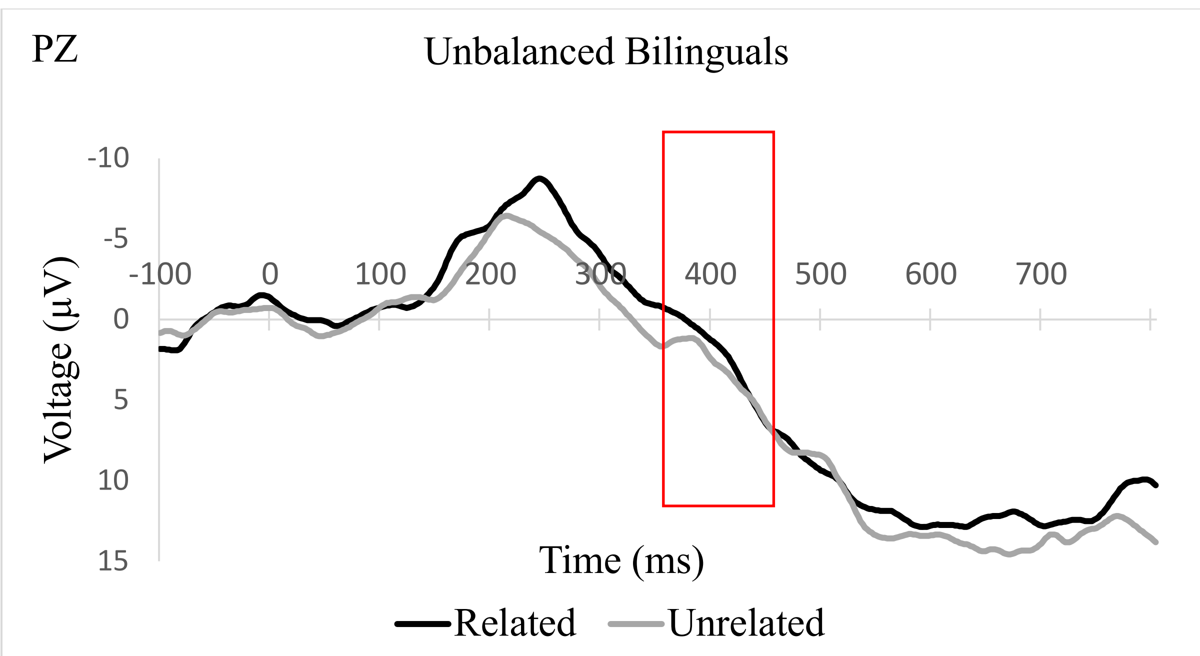
[a] Mean of N400 voltages. [b] Standard errors.

* $p < .05$.

Figure 1.

Group Differences in N400 Averages Between Related and Unrelated Conditions





Note. Average waveforms for cross-language related and unrelated conditions within each language group. The N400 amplitude was analyzed at the Pz electrode from 350-450ms post stimulus onset.

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 2025, 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. 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,

Deric Marcoux, B.A. (hons),	Richard Kruk, Ph.D.,	Amy Desroches, Ph.D.,
School Psychology MA Student	Professor	Professor

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 <u>days per week</u> 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 <u>minutes per day</u> 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 <u>days per week</u> 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 <u>minutes per day</u> 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 your highest level of education:	Other parent/guardian (if applicable):
___ 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

Prime-Target pairs in the lexical decision task

Unrelated	Related	Target	Condition
skulls	bedding	LIT	Cross-language semantic
uglier	breading	PAIN	Cross-language semantic
leaving	cornered	COIN	Cross-language semantic
orderly	fleshy	CHAIR	Cross-language semantic
thingy	clothing	HABIT	Cross-language semantic
saying	handy	MAIN	Cross-language semantic
hitting	dirty	SALE	Cross-language semantic
holding	noisy	SON	Cross-language semantic
shows	ending	FIN	Cross-language semantic
bloody	ovens	FOUR	Cross-language semantic
blades	toothy	DENT	Cross-language semantic
bears	rounded	TOUR	Cross-language semantic
wavy	pulling	TIRE	Cross-language semantic
tooted	emotional	SENSIBLE	Cross-language semantic
nicely	shorter	COURT	Cross-language semantic
hundreds	kittens	CHAT	Cross-language semantic
melting	waited	ATTEND	Cross-language semantic
windy	cleaning	RANGER	Cross-language semantic
wiring	strongly	FORT	Cross-language semantic

Unrelated	Related	Target	Condition
jumper	training	STAGE	Cross-language semantic
cornered	jumper	BOND	Cross-language semantic
breading	wiring	FILE	Cross-language semantic
fleshy	windy	VENT	Cross-language semantic
bedding	melting	FOND	Cross-language semantic
handy	hundreds	CENT	Cross-language semantic
clothing	bears	OURS	Cross-language semantic
dirty	nicely	FINE	Cross-language semantic
ending	tooted	PET	Cross-language semantic
noisy	wavy	VAGUE	Cross-language semantic
ovens	blades	LAME	Cross-language semantic
rounded	bloody	SANG	Cross-language semantic
toothy	hitter	TAPE	Cross-language semantic
pulling	holding	TENANT	Cross-language semantic
emotional	shows	PIECE	Cross-language semantic
shorter	saying	DIRE	Cross-language semantic
kittens	thingy	CHOSE	Cross-language semantic
waited	orderly	RANG	Cross-language semantic
cleaning	leaving	SORT	Cross-language semantic
strongly	uglier	LAID	Cross-language semantic
training	skulls	CRANE	Cross-language semantic
jumped	treated	BLOM	Non-word

Unrelated	Related	Target	Condition
tower	flying	SOV	Non-word
creamy	boards	CALN	Non-word
hunter	mower	SUSK	Non-word
sandy	fished	HARSC	Non-word
ringing	cleaner	TASH	Non-word
fighting	boldly	COV	Non-word
painting	fluffy	TIND	Non-word
flower	leader	DAR	Non-word
forest	clearly	UXT	Non-word
fixing	harder	DROGG	Non-word
hairy	tighter	VAR	Non-word
walking	factory	ELV	Non-word
fairy	drawing	VISC	Non-word
closed	walked	FOM	Non-word
typing	doing	VRAB	Non-word
acting	crying	GLONE	Non-word
earlier	lately	WEEF	Non-word
brother	petal	JUN	Non-word
sitting	listen	WOL	Non-word
dirty	filled	LORV	Non-word
copy	greedy	YASC	Non-word
calmly	wooden	MEMK	Non-word

Unrelated	**Related**	**Target**	**Condition**
nails	farmer	SOV	Non-word
hungry	aimed	MOME	Non-word
older	buying	SUSK	Non-word
sleepy	golden	NAV	Non-word
drinking	country	TASH	Non-word
potion	sneaky	NOMB	Non-word
nearly	milky	TIND	Non-word
drying	named	OLT	Non-word
bonkers	deeper	UXT	Non-word
every	boxer	OWD	Non-word
bricks	sticky	VAR	Non-word
quietly	sweater	PEWN	Non-word
bushy	eater	VISC	Non-word
talking	bother	PULE	Non-word
personal	soaked	VRAB	Non-word
badly	coaster	RER	Non-word
cooking	army	WEEF	Non-word

Note. Each interlingual homograph target was paired with a related and an unrelated prime. Each prime was also paired with a non-word target to ensure the task involved a lexical decision on whether the target was a real French or English word.