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Phonological Priming in Japanese-English Bilinguals: Evidence from Lexical Decision and ERP

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

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PHONOLOGICAL PRIMING IN JAPANESE-ENGLISH BILINGUALS: EVIDENCE FROM LEXICAL DECISION AND ERP

(Spine title: Phonological Priming in Japanese-English Bilinguals)

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by Eriko Ando

Graduate Program in Psychology

A thesis submitted in partial fulfilment
of the requirements for the degree of
Master of Science

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entitled:

Phonological Priming in Japanese-English Bilinguals: Evidence from Lexical Decision and ERP

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Abstract

One of the main questions in bilingualism is whether the representations activated from one language influence processing of the other language. The current study investigated this issue by examining masked phonological priming effects in Japanese-English bilinguals when English words (e.g., guy) were primed by phonologically related logographic (Kanji) words (e.g., 害, /gai/, “harm”) and also when English words (e.g., guide) were primed by phonologically similar phonogram (Katakana) words (e.g.,サイド, /saido/,”side”) . In Experiment 1, lexical decisions to English words were facilitated when they were preceded by phonologically similar versus dissimilar primes, particularly when the primes were one-Kanji and when they were Katakana words. Experiment 2 generally replicated Experiment 1, and showed priming effects in event-related potentials, although the effects were somewhat different from the behavioral data. The results are discussed with regard to the role of phonological activation in bilingual word recognition.

Keywords: bilingualism, visual word recognition, masked priming paradigm, event-related potentials

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It is becoming common for people in many societies to use more than one language. As a result, following extensive psycholinguistic research in the monolingual population, research in bilingualism has been receiving increasing attention in recent years. There are several interesting questions to be considered from a psycholinguistic perspective. For example, does possessing knowledge of multiple languages change the way people process linguistic information compared to monolinguals? When bilingual people are using one of their languages, they appear to be like monolinguals (i.e., there is no intrusion from the other language). However, inside of their mind, what is happening to the other language that is not in use?

The current research investigated phonological processing in visual word recognition in bilinguals. While a number of studies, some of which will be reviewed in the following sections, have already investigated the architecture of bilinguals' lexical knowledge with a focus on their phonological representations, most of these studies have been conducted with bilinguals whose languages use the same alphabet (such as English and Dutch). The research presented here examined whether theoretical conclusions drawn from studies on this specific type of bilingual can be generalized to bilinguals whose languages use different scripts, for example, Japanese-English bilinguals. More specifically, the goal of the research was to determine whether Japanese-English bilinguals activate a common phonological store from Japanese and English printed words.

Bilingual Lexical Representation: Shared or Separate?

One of the main questions being asked in bilingualism research is whether the information from the two languages is stored in a single shared system or in independent separate systems. This question is particularly important because these two views provide contrasting predictions regarding how information from one language could influence the processing of the other language in bilinguals. In monolingual word recognition studies, it has been shown that the processing of a given word simultaneously activates its neighbors, i.e., non-target words that share some characteristics with the target word. For example, Van Orden (1987) conducted an experiment where monolingual participants were first shown a category name (e.g., food), and were then asked to respond "yes" if the subsequent target word belong to the category (e.g., meat) and to respond "no" if the word does not belong to the category (e.g., melt). Interestingly, the participants were more likely to respond ‘yes’ incorrectly when a non-category member target was a homophone (e.g., meet) of a category member (e.g., meat) than when it was not a homophone (e.g., melt). Such a finding suggests that phonological activation based on a given target word simultaneously activates other words that share sound information. In bilinguals, if information from the two languages is stored in a single shared system, such non-target activation seen in monolingual studies should occur not only within a language but also across languages. That is, when activating a word in one language, not only similar words in the same language become active, but also similar words in the other language should also become active in bilinguals’ minds. In other words, lexical processing in bilinguals should occur in a language-nonselective manner. However, it is also possible that the lexical properties of two languages are represented independently from each other, given that bilinguals typically do not show confusion or intrusion from the other language when actively using one. In this view, bilingual lexical processing should be language-selective.

In early bilingual research, empirical evidence on this question was conflicting. For example, Glanzer and Duarte (1971) showed evidence in support of the shared system view. In their study, English-Spanish bilinguals were given a list of words to recall. The researchers found that the bilinguals' recall performance was enhanced not only when the exact same words in the same language were repeated in the list, but also when the words with the same meaning in the other language were repeated in the list. From this finding, they argued that information from one language influences the processing of another language, which is consistent with the prediction of the shared system view. On the other hand, Goggin and Wickens (1971) showed evidence in support of the alternative, the separate systems view, using a paradigm known as *proactive interference* (PI). In a typical experiment using the paradigm, participants study several lists of words, and after each list, they are tested on free recall. An interesting finding is that when lists consist of words in the same category (e.g., fruits: apple, orange, and banana), recall performance progressively declines, because older items from earlier list(s) interfere with the learning of new items. However, when one of the later lists contains words from a different category, recall performance improves substantially, a phenomenon known as *release from PI*. Goggin and Wickens investigated the phenomena with Spanish-English bilinguals, and showed that not only a category change produced a release from PI but so did a language change. Such findings suggest that the representations of a bilingual's two languages are independent from each other, which is consistent with the prediction of the separate systems view.

In order to account for these conflicting findings, and more importantly and generally in order to explain the architecture of bilinguals' lexical representations, several models of bilingual word processing have been proposed. Of those, the two most influential models are the Revised Hierarchical Model (RHM) proposed by Kroll and Stewart (1994) and The Bilingual Interactive Activation (BIA) Model proposed by Dijkstra, Van Heuven, and Grainger (1998) (and its successor BIA+ model proposed by Dijkstra & Van Heuven, 2002). The following two sections briefly describe the two models, with a particular focus on predictions of the shared vs. separate system views.

The Revised Hierarchical Model. The RHM consists of two types of representations that are architecturally different: lexical (word forms) and conceptual (meanings). On one hand, there are two separate lexical representations, one for the native language and the other for the second language. On the other hand, the conceptual representations are assumed to be shared by the two languages. Given these distinctions, the model is consistent with predictions of both the shared and the separate systems views depending on the task. In other words, the RHM supports the shared view if the task is related to the meaning of words, while it supports the separate view if the task is related to the forms of words. Thus, Glanzer and Duarte (1971) found that repeated words were memorized better even if the language was different because the meaning of the words was stored in a shared system. On the other hand, Goggin and Wickens (1971) found a proactive interference effect when the language was changed because the word forms of Spanish and English were stored separately.

Although the RHM is a general model of bilingual lexical representations, its assumptions particularly fit well with those who acquired their second language (L2) after their first language (L1). The model assumes that unbalanced bilinguals, whose L1 is more proficient, have richer L1 lexical representations than L2 representations. The important issue to note is that L2 words are not necessarily recognized the same way as L1 words because the connections among lexical and conceptual systems differ in strength. When recognizing L1 words, activation proceeds from the L1 lexicon directly to the conceptual system. In contrast, L2 words are recognized either by accessing the translation equivalents in the L1 lexicon, or by directly accessing the conceptual system. These assumptions come from the fact that L2 words are often acquired by associating them with their L1 translation equivalents.

With regard to the architecture of bilingual lexical representations and in particular phonological information, the RHM is consistent with the idea of separate systems because it assumes a distinct lexical system for each language. The assumption of independent storage of the lexical properties for each language implies that processing can be language selective. That is, lexical properties in one language could be inhibited while activating the other language. As such, this account can provide an explanation as to why bilinguals typically do not show intrusions from the other language when speaking.

Although the RHM has played a role in providing an important foundation for discussing bilingual language representation, findings from recent studies provide little support for the model. For example, Dijkstra, Van Heuven, and Grainger (1998) found that Dutch-English bilinguals’ responses to English words progressively slowed down as the number of Dutch orthographic neighbors increased. Orthographic neighbors of a word are the set of same-length words that can be produced by changing one letter of the target word (e.g., the neighbors of *land* are *band, sand, hand, lank,* and *lane*; Coltheart, Davelaar, Jonasson, & Besner, 1977). If the lexical forms of two languages are organized independently from each other, the number of Dutch neighbors would not influence the recognition of English words. The results of this study show otherwise, implying that the orthographic overlap between two languages led the bilinguals to activate the lexical representations of both languages.

Furthermore, Dijkstra, Timmermans and Schriefers (2000) also demonstrated that Dutch-English bilinguals activated lexical information from Dutch while reading English words. In their experiment, the participants were told to press a button whenever they saw English words. Some of the stimuli were English words that only occur in English (e.g., home), while others were interlexical homographs of Dutch words (e.g., room). An interlexical homograph is a word that has the same spelling but different meaning word in another language (e.g., *room* means “a portion of space” in English while it means “cream” in Dutch). The researchers found interlexical homograph effects, where the participants were significantly slower to respond when the English words were homographs of Dutch words than when they were English-only words. Such evidence suggests that the lexical properties of both languages were activated even though the task required only one of the languages.

Given that the RHM dissociates the representations for L1 and L2 lexicons, it is challenging for the model to explain why orthographic forms of words from both languages are activated simultaneously while the participants were explicitly told to use only one of their languages (Brysbaert & Duyck, 2010). Hence, the RHM does not seem to be the best model to account for the processing of word recognition in bilinguals. Another bilingual model, which will be described next, took a different approach to deal with the issue of bilingual lexical representation.

The Bilingual Interactive Activation Model. The BIA model was originally developed based on an existing computational model of monolingual word processing, the Interactive Activation (IA) model (McClelland & Rumelhart, 1981). In the IA model, three levels of nodes were assumed: visual features, letters, and the orthographic form of words. The activation in each level inhibits or facilitates the activity in adjacent levels. For example, when presented with a word “work,” corresponding feature nodes get activated (e.g., features such as "\" "/", "|", "O"), which then activate corresponding letter nodes and then word nodes. The important characteristic of this model is that not only the target word “work” but also the words share some information with the target (e.g., fork, word) also get some activation because of the activation from feature and letter levels.

The BIA model consists of four levels of nodes: visual features, letters, the orthographic forms of words, and language information. As in the IA model, the activation in each level inhibits or facilitates the activity in adjacent levels. A bilingual’s two languages are assumed to share the feature and letter nodes. Word nodes are organized in interconnected language subsets in a single lexicon, and each word node is connected to one of two language nodes. When a language node is activated, it sends inhibitory signals to the word nodes in the other language subset, so that bilinguals respond only to a target language. Thus, unlike the RHM, the BIA model assumes a single interconnected system for the two languages, where the visual input non-selectively activates word candidates when orthographic properties of words are shared between languages.

There were a few critical problems with the BIA model as a general model of bilingual word processing. First, the BIA model is incomplete in that it does not have phonological and semantic representations. Without such representations, the model is incapable of explaining any phenomena related to semantics and phonology. A second problem concerns the language nodes, which played a role in selecting which language to activate in the model. A problem with the language nodes is that they confound the issue of the representational (what words belong to which language) and functional (filtering non-target language out) aspects of word processing.

To account for these problems, the successor of the BIA model, the Bilingual Interactive Activation Plus (BIA+) model (Dijkstra & Van Heuven, 2002) was proposed with a few critical changes. First, the BIA+ model added more features including phonological and semantic representations in order to account for cross language effects in those domains. It is important to note, however, that these effects may not be observable in all circumstances. More specifically, the model assumes that cross language effects are larger from L1 to L2 rather than L2 to L1. This is referred as the "temporal delay assumption." The logic behind this assumption is that semantic and phonological representations are activated more slowly in L2 than in L1, because the subjective frequencies of L2 words are lower (so they need more stimulation) than L1 words. Second, the language nodes in the BIA+ model no longer serve the original role in selecting which language to activate. In the BIA+ model, this issue is assumed to be dealt with in a task/control system that is independent from the word identification system. This architecture of the model allows simultaneous activation of lexical properties from both languages in the word identification system, while the control system limits the responses to the appropriate language. Thus, BIA+ model predicts bilingual lexical processing to be non-selective in general. However, depending on the task demand, it may appear to be selective under certain circumstances.

As will be described in the following section, a number of existing studies have provided results consistent with the predictions of the BIA+ model. That is, lexical information is activated in a language non-selective manner. These findings suggest that the separate systems view is inadequate to explain bilingual lexical representations, since the view assumes distinct systems for the lexical properties of each language. Given that this thesis concerns phonological processing, the following section focuses on the bilingual word recognition studies that have investigated phonological activation in particular. To begin, several studies with bilinguals whose two languages use similar or the same orthographic scripts (e.g, English and French; hereafter *same-script bilinguals*) are reviewed. The same-script bilingual studies comprise the majority of evidence available today. Then, a few studies that employed bilinguals whose two languages use different scripts (e.g, English and Japanese; hereafter *different-script bilinguals*) are reviewed. If bilinguals were to have separate representations for each language, it is plausible that they would be most likely to do so when the writing systems of their two languages were very different.

Evidence for Non-selective Phonological Activation

Evidence from Same-Script Bilinguals. Evidence for language non-selective activation of phonological representations has been found in the majority of same-script bilingual studies (Dijkstra, Jaarsveld, & Brinke, 1998; Jared & Kroll, 2001; Jared & Szucs, 2002, Haigh & Jared, 2007). For example, Jared and Szucs (2002) conducted a study using interlexical homographs with French-English and English-French bilinguals. There were three blocks of trials that all participants completed. In the first and third blocks, participants were asked to name English words that were either English-only words or interlexical homographs. In the second block, they were asked to name French words. In both of the English naming blocks, French-English bilinguals responded more slowly to the homographs than to English only words. Such findings straightforwardly support the notion of non-selective access. Interestingly, however, English-French bilinguals responded slower to English homographs only when they were preceded by the French naming block. Thus, the findings from the study also suggest that selective access can occur under some circumstances, particularly when the task is in the dominant language and the influence is expected from a relatively weak L2.

Another study by Jared and Kroll (2001) investigated whether bilinguals use spelling-sound correspondence from both of their languages in parallel. In their experiment, French-English and English-French bilinguals were asked to name three types of English words, which differed in their phonological neighborhood characteristics. In the first type of words, the medial vowel and the final consonants (word body) are always pronounced in the same consistent way (e.g., “-ip” in drip). These words only have phonological neighbors in English (e.g. trip, slip, and clip). The second type of words had word bodies that have more than one pronunciation. For example, “steak, /stéik/” and “bead, /bíːd/” share a word body “ea” but it is pronounced differently in the two words. In a monolingual study by Jared, McRae, and Seidenberg (1990), naming latencies for the second type of words were slower than for the first type, a finding known as the consistency effect. This effect occurs because that the input of the spelling “ea” leads to two possible candidates of pronunciations “éi” or “íː,” which compete for activation and slow naming. The third, and most critical, type of words had word bodies that have different pronunciations across languages. For example, “-ait” in the English word “bait” and in the French word “fait” have different pronunciations. If phonological activation in bilinguals is language non-selective, the presence of a competing pronunciation in the non-target language should also interfere with the naming, compared to the condition where there is no competitor. The results revealed an interference effect in the error data during both English naming blocks. However, the interference effect in naming latencies was observed only during the English block that occurred after, but not before, the French naming block. Such findings indicate that prior French activation plays an important role, making the cross-language interference effect more pronounced and observable. Moreover, this interference effect was particularly strong in French-English bilinguals (who were doing the task in their L2). Thus, these findings suggest that spelling-sound correspondences can be activated by bilinguals in a non-selective manner, but in limited circumstances, as predicted by the temporal delay assumption from the BIA+ model.

The two studies reviewed so far confirm that phonological information is activated in a language non-selective manner. However, one limitation with the studies is that both used naming tasks, which require participants to explicitly activate phonological information. Thus, it is possible that the effects shown are somewhat exaggerated due to the task demand. Evidence that phonological activation is typically not selevtive for language would be stronger if similar effects were observed in a task that does not require explicit activation of phonological information, such as a lexical decision task. Indeed, Haigh and Jared (2007) did exactly that with English-French and French-English bilinguals. Participants were presented with a string of letters one at a time and were asked to press buttons to indicate whether each was an English word or a nonword. In the experiment, critical words were English words (e.g., sank) that were either homophones of French words (e.g., cinq) or were not homophones (e.g., sand). The researchers found that decision latencies to the homophone words were significantly faster compared to non-homophone words in French-English bilinguals but not in English-French bilinguals. This finding suggests that cross-language phonological activation still occurs even when participants do not have to actively pronounce the words to complete the task, but again shows that the influence is particularly strong from L1 to L2.

Further evidence for the language non-selective access view comes from masked priming studies. In a typical masked priming paradigm, a target stimulus is preceded by a brief presentation of another stimulus (prime) and a visual mask (e.g., #####) in a way that participants barely notice the prime. Brysbaert, Van Dyck, and Van de Poel (1999) asked Dutch-French bilinguals to identify (by typing in) briefly presented French target words (e.g., oui) which were either primed by a phonologically similar Dutch word (e.g., wie) or by a phonologically unrelated Dutch word (e.g., jij). Note that the phonological similarity is present only if Dutch spelling-sound correspondences are used to activate a phonological representation of the prime word; neither types of primes sound similar to the French targets if pronounced using French spelling-sound correspondences. The researchers found that perceptual identification performance was superior when targets were primed by phonologically similar words (30%) than when they were primed by unrelated words (23%), suggesting that phonological activation from one language prior to the target presentation facilitated the processing of target words in the other language.

Duyck, Diependaele, Drieghe, and Brysbaert (2004) conducted a similar study using Dutch-French bilinguals. In their study, they had two groups of bilinguals who differed in French proficiency: high and low. The participants were asked to identify French target words that were preceded by one of the three types of Dutch primes: homophonic words, grapheme control (similar spelling but different pronunciation), unrelated words. In spite of the difference in their levels of L2 proficiency, both high and low proficiency groups showed phonological priming of equivalent magnitude (6.9% and

7.4%, respectively), suggesting that the cross-language phonological effect is likely to exist in broad population of bilinguals.

Although the findings from Brysbaert et al. (1999) and Duyck et al. (2004) strongly support the non-selective access view in bilinguals, both studies only examined the influence of L1 on L2 but not vice versa. One of the studies that explored the influence of phonological activation by L2 words on the recognition of L1 words was conducted by Van Wijnendaele and Brysbaert (2002) in French-Dutch bilinguals. In their study, the researchers found that the recognition of French targets (e.g., faim) was facilitated by homophonic Dutch primes (e.g., fain). Thus, although the numbers are few, there are some cases where the cross-language phonological effect is observed in L2 to L1 direction.

As reviewed above, the majority of studies show evidence in support of the idea that bilingual lexical access is language non-selective, based on the findings showing that bilinguals activate phonological representations of both languages even when using only one of them. However, it is important to note that such simultaneous activation of phonological representations does not occur in all circumstances. One of the circumstances is that the influence of phonological activation from L2 is usually weaker compared to activation from L1 (Haigh & Jared, 2007; Jared & Kroll, 2001; Jared & Szucs, 2002). Nevertheless, the fact that phonological representations from the two languages are activated during word processing in one of the languages is clearly inconsistent with the idea that the phonological information of two languages is organized in independent systems, namely the separate systems view.

One important question that arises next is whether these findings can be generalized to bilinguals whose languages have very different scripts (e.g., English and

Chinese). These are the bilinguals who might be most expected to have separate representations for each language. However, phonological overlap in words can occur in any pair of languages. If language non-selective activation of phonological information occurs as a result of representations shared between languages, then it should be possible to observe similar effects in different-script bilinguals.

Evidence from Different-Script Bilinguals. Although the number is somewhat limited, there are several studies that have provided evidence for non-selective phonological activation in different-script bilinguals. For example, Gollan, Forster, and Frost (1997) conducted experiments on Hebrew-English and English-Hebrew bilinguals. The researchers used a masked priming paradigm with a lexical decision task to investigate the influence of primes on the processing of target words. Their critical stimuli were Hebrew-English cognate pairs, which were words that share semantics and phonology but not orthography (+S, +P, -O), and noncognate translation pairs, which only share meaning (+S, -P, -O). The reaction times of the two conditions were compared to those of unrelated pairs (-S, -P, -O). What they found was that when L2 words were preceded by L1 words, a priming effect was observed for both cognate and noncognate translation primes in comparison to unrelated primes. Moreover, the size of the priming effect was larger for cognate primes (53 ms) compared to noncognate primes (36 ms). The researchers argued that this enhanced priming effect seen in the cognate condition was due to the influence of phonological overlap, and concluded that phonology also plays a role in the priming effect. This is one of the early studies that suggests that the influence of phonological overlap can be observed in different-script bilinguals.

Another priming study by Kim and Davis (2003) was conducted on Korean-English bilinguals. In this study, the critical pairs were Korean and English words that sound similar but have a different meaning and orthography (-S, +P, -O). The participants were asked to name English target words that were preceded either by phonologically related (-S, +P, -O) or unrelated (-S, -P, -O) Korean primes. The researchers found that the bilinguals named the English words significantly faster when they were preceded by phonologically related Korean words, compared to unrelated words. They argued that the phonological priming effect found in this study indicated that the non-selective phonological access view is supported even if the orthography of the two languages is completely different from each other.

While both Gollan et al. (1997) and Kim and Davis (2003) supported the non-selective phonological access view for different-script bilinguals, there are a couple of concerns in their studies. First, it is not clear from Gollan et al. (1997) whether the enhanced priming effect resulted purely from phonological overlap between primes and targets, because primes and targets also shared meaning. Thus, it is unclear if the phonology solely produces a cross-language priming effect. A better approach would be to use non-cognate pairs that only share phonology, as seen in Kim and Davis. However, the Kim and Davis (2003) study raises a second issue, which is whether the non-selective access view is still supported without explicit activation of phonology during the task. In their study, because the bilinguals were asked to name English words aloud, it is possible that some participants noticed the nature of the experiment. Thus, a stronger claim can be made with experiments that use an implicit task, such as lexical decision task.

These issues were addressed in a study of Japanese-English bilinguals by Nakayama, Sears, Hino, and Lupker (2011), who used a masked priming paradigm with a lexical decision task. In the experiment, participants made lexical decisions to English targets (e.g., GUIDE) that were primed by three types of Japanese primes: cognate translation equivalents (e.g., ガイド, /ga-ee-do/, meaning “guide” in English), phonologically similar but semantically unrelated words (e.g., サイド, /sa-ee-do/, meaning “side” in English), and phonologically dissimilar and semantically unrelated words (e.g., コール, /ko-o-ru/, meaning “call” in English). All Japanese primes were English loanwords and were represented in the Katakana script, which is a phonogram script mainly used to represent words from foreign languages. The researchers found that the decision latencies for both translation (+S, +P, -O) and phonologically similar (–S, +P, -O) prime conditions were faster than for the unrelated condition. Furthermore, whereas the priming effect for the cognate translation primes was modulated by target frequency (larger priming effects for high-frequency targets), the priming effect for the phonologically similar prime-target pairs was equivalent for high- and low- frequency targets, suggesting that the latter priming effect may be pre-lexical and purely phonological in nature.

Given the findings from the studies described thus far, it may be reasonable to conclude that the non-selective access view is still supported even if the writing systems of the two languages are completely different. However, the conclusion still remains tentative in that, even though the studies used two visually different scripts, those scripts used were all phonograms. That is, a type of scripts where each character solely represents sound information. For example, each character in the Korean script that was used in Kim and Davis (2003) represents phonological information but not meaning. Similarly, the Japanese script used in Nakayama et al.’s (2011) study was Katakana, where each character solely represents one Japanese syllable or mora. Moreover, with respect to Nakayama et al’s study, all of their Japanese primes were English loanwords and it is possible that the cross-language effects were obtained because English words and Katakana words might have particularly strong connections, relative to English words and Japanese words that are specific to language. Such Japanese words are typically written in a logographic script, called Kanji.

An important question then, is whether cross-language phonological priming can be still obtained when one of the languages uses a logographic script. Languages such as Japanese and Chinese use logographic scripts. For example, Japanese uses three different types of script, Katakana, Kanji, and Hiragana, which is another type of phonogram. In Kanji, each character represents not only sound but also meaning. For example, a Kanji word “害” is pronounced as /gai/ and it means “harm,” which sounds similar to English word *guy*. Would such logographic script words prime phonologically related words in English?

At this point, the only existing study that investigated cross-language phonological activation using a logographic script was conducted by Zhou, Chen, Yang, and Dunlap (2010) using Chinese-English bilinguals. In their Experiment 3, the participants were asked to make a lexical decision to English targets (e.g., door) which were preceded either by a phonologically related Chinese prime (e.g. 道, /dao/, road) or a phonologically unrelated Chinese prime. In Experiment 4, another group of Chinese-English bilinguals were asked to make a lexical decision to Chinese targets which were preceded either by a phonologically related English prime or a phonologically unrelated English prime. In both experiments, the researchers found that targets that were primed by phonologically related words were responded faster than those primed by unrelated words. Based on those findings, the researchers claimed that the language non-selective phonological access view is supported even if one of the bilinguals' languages is represented in a logographic script. Furthermore, the priming effect was produced in both L1 to L2 and L2 to L1 directions. This finding is strong support for the non-selective view because not only do Chinese and English have different writing systems, they also differ phonologically in that Chinese is a tonal language and English is not.

Japanese Kanji and English also have two very different writing systems. Furthermore, Japanese and English are quite different phonologically. English has been characterized as having a stress-timed rhythmical pattern whereas Japanese has a mora-timed pattern. Research with newborn infants from monolingual French-speaking families has shown that they can discriminate between English and Japanese (Nazzi, Bertoncini, & Mehler, 1998). It is quite possible that Japanese-English bilinguals use rhythmical differences between the two languages and create separate phonological stores, although the Nakayama et al. (2011) study suggests that these may be particularly overlapping for borrowed words.

The Present Research

As discussed above, cross-language phonological activation in different-script bilinguals is less explored, especially in cases where one of the languages uses a logographic script and the two languages have different phonological characteristics. Thus, although the non-selective phonological access view is prevalent in the current bilingual literature, it is still unclear how far this claim can be extended. Therefore, the main goal of the current research is to investigate whether there is non-selective phonological activation in Japanese-English bilinguals when Japanese Kanji (logographic) primes and English targets are used in a masked priming paradigm. Participants were asked to make a lexical decision to English words that were preceded briefly by Kanji primes. The secondary goal of the research is to see whether the Nakayama et al. (2011)'s phonological priming effect with Katakana primes (e.g., サイド) and English (e.g., guide) target words (-O, +P, -S) can be replicated, using the same parameters and participants as in the Kanji condition. The purpose of this replication was to clarify the causes (e.g., differences in parameters) in case the priming effect was absent in the Kanji condition. In Experiment 1, decision latencies and error rates on the lexical decision task were reported. In Experiment 2, ERP data was collected in addition to the behavioral data in order to obtain information about the time course of any priming effects.

Experiment 1

Using a masked priming paradigm, Experiment 1 investigated whether there is cross-language phonological priming in Japanese-English bilinguals. The participants made lexical decisions on English words which were preceded either by a phonologically related or a phonologically unrelated Japanese prime. In the first block, all the Japanese primes were in Kanji script. The second and third blocks consisted of Katakana primes, which was a replication of Nakayama et al. (2011). Therefore, if the non-selective view is also true for Japanese-English bilinguals, it is expected that the reaction times for the related condition should be faster than for the unrelated condition in both Kanji and Katakana blocks, since phonological activation of Japanese words should facilitate the processing of similar sounding English words.

Method

Participants

Fifty-six undergraduate and graduate students (33 female, mean age = 21, *SD* = 2.27) from Waseda University (Tokyo, Japan) participated in the study. They received 1000 Yen book gift card (worth about US $13) for their participation. All participants' first language was Japanese and they also had good English proficiency. To be eligible to participate in the study, they needed to have a score of 600 or higher on the TOEIC (Test of English for International Communication).

Stimuli

Kanji Condition. Sixty-four Japanese and English word pairs were selected as primes and targets (see Appendix B). Each English target word was paired with two types of Japanese Kanji word primes: (1) a phonologically related prime, and (2) a phonologically unrelated prime. The phonological relatedness between English targets and Japanese primes was assessed in a pilot study. In the study, 10 Japanese-English bilinguals from Algoma University rated approximately 100 pairs of English and Japanese words on a 1 (not at all) to 7 (very similar) scale. Pairs that were rated on average 4 or higher were used. The 64 Kanji words consisted of three types: 22 one-Kanji words (e.g. 害, “harm”), 32 two-Kanji words (e.g. 車道, “road”), and 10 one-Kanji plus Hiragana suffix (henceforth “Kanji + Kana”) words (切る, “cut”). The proportion of each type of words is unbalanced because of the difficulty of finding the homophone pairs.

For the lexical decision task, 64 pairs of Japanese words were selected to serve as primes for English-like nonword targets. The 64 Japanese filler primes consisted of 22 one-Kanji words, 32 two-Kanji words, and 10 Kanji + Kana words. The nonwords were selected from the English Lexicon Project database (Balota et al., 2007), and English target words and nonwords were matched with respect to word length (*M* = 4.12 and *M* = 4.23, respectively) and orthographic neighbors (*M* = 7.34 and *M* = 7.58, respectively).

The mean frequency of the English target words was 274.6 per million (*SD* = 892.3) based on CELEX database (Baayen, Piepenbrock, & Guilkers, 1995). By type of Kanji prime, the frequencies of the target words were 597.2 per million (*SD* = 1524.1) for the one-Kanji condition, 130.2 per million (*SD* = 206.9) for the two-Kanji condition, and 140.3 per million (*SD* = 264.8) for the Kanji + Kana condition. The mean normative frequencies based on the NTT database (Amano & Kondo, 2000) for the Japanese primes was 20.1 per million (*SD* = 31.3). By type of Kanji primes, the frequencies were 31.5, 12.1, and 20.6 per million (*SD* = 43.2, 21.3, and 20.1) for the three prime types, respectively. Prime and target frequencies were not matched across the three types of primes because of the difficulty of finding Japanese-English pseudo-homophones. A summary of the characteristics of prime and target words by Kanji type is presented in Table 1.

In order to create related and unrelated pairs, the 64 Japanese-English pairs were first divided into 2 groups (the proportion of the three types of Kanji words and the frequency of the English words in each group were similar), making related group A and related group B. Unrelated control pairs were created by re-pairing each English word with another word from the same group, making unrelated group A and unrelated group B. Two counterbalanced lists were made by combining related group A and unrelated group B, and related group B and unrelated group A. In the experiment, each participant received one of the two lists.

Table 1

Characteristics of Prime and Target words by Kanji Type.

	1 Kanji	2 Kanji	Kanji + Kana
Prime			
Frequency	31.5	12.1	20.6
Log Frequency	1.05	0.45	1.02
Percentage of multiple reading	32%	100%	100%
Target			
Length	3.18	4.94	3.60
Frequency	597.2	130.2	140.3
Log Frequency	2.02	1.57	1.66
Number of Orthographic Neighbors	10.55	4.38	10.90
Prime-Target Phonological Similarity	5.52	4.60	4.61

Katakana Condition. Sixty-four All word and nonword stimuli were taken from Nakayama et al. (2011) (See Appendix C). One hundred and twenty English words were used as targets. Half of the targets were low-frequency words (M = 14.9 occurrences per million, SD = 9.6; Kucera & Francis, 1967) and half were high-frequency words (M = 204.3 occurrences per million, SD = 149.7). The high- and low-frequency words were matched with respect to mean word length (4.6 vs. 4.7 letters, respectively) and mean number of orthographic neighbours (6.4 and 6.4, respectively). One hundred and twenty English nonwords were selected from English Lexicon Project data base (Balota et al., 2007) and were matched to the word targets with respect to length and number of neighbors (M = 4.8 and 6.2 respectively). Each target (e.g., guide) was paired with two types of Japanese Katakana word primes (see Nakayama et al., 2011, for details): (1) a phonologically similar prime (サイド, /sa-ee-do/, borrowed from the English word "side"), and (2) a phonologically dissimilar prime (コール, /co-o-ru/, borrowed from the English word "call"). Similarly to the Kanji condition, there were two lists and each participant received only one of them during the experiment.

Procedure

Each participant was tested individually. The experiment was programmed using E-Prime (Psychology Software Tools, 2002). Stimuli were presented on a 21 inch computer screen. At the beginning of each trial, a fixation sign (- -) was presented for 500 ms. Subsequently, a forward mask made of scrambled letters (see Hoshino et al., 2010) was presented for 500 ms. Then a prime was presented for 50 ms. Finally, an English target was presented in lower-case letters; the target remained on the display until the participant made a response or for a maximum of 1500 ms. The inter-trial interval was 1500 ms.

The task was to make an English lexical decision to the target. Participants were instructed to make their decisions as quickly and accurately as possible by pressing the word or nonword button on a response box placed in front of them. Participants completed 16 practice trials to familiarise themselves with the task prior to the data collection. The session was divided into 3 parts: Kanji, the first half of Katakana, and the second half of Katakana Each block took approximately 10 minutes. The order of stimuli within a block was randomized for each participant. The participants took short breaks between blocks.

Results

The data from four participants were excluded from all analysis due to high error rates (>25%) and technical failures (i.e., button box was unconnected to the computer). The analysis was therefore based on data from 53 participants. Response latencies shorter than 300 ms or longer than 1700 ms were considered as outliers and excluded from the analysis (1.3% of all trials for both Kanji and Katakana conditions).

Kanji Condition

For the Kanji condition, the mean lexical decision latencies for correct responses on the English targets and the mean error rates were analysed using 2 (Relatedness: related, unrelated) X 3 (Kanji type: one-Kanji, two-Kanji, Kanji + Kana) repeated measures analyses of variance (ANOVA). Both subject (F_1) and item (F_2) analyses were carried out. In the subject analyses, relatedness and prime type were within-subject factors. In the item analyses, relatedness was a within-item factor and prime type was a between-item factor. Table 2 presents the mean response latencies and error rates from the subject analyses.

In the decision latency data, the main effect of relatedness was significant in the by-subject analysis, F_1 (1, 51) = 7.82, $p < .01$, *MSE* = 3785.3, and approached significance in the by-item analysis, F_2 (1, 58) = 2.89, $p = .094$, *MSE* = 2155.3. Lexical decisions to the targets primed by phonologically related primes were faster (699 ms) than to the targets primed by phonologically unrelated primes (719 ms). In the error data, there was also a significant main effect of relatedness in the subjects analysis and a marginally significant effect in the items analysis, F_1 (2, 51) = 4.60, $p < .05$, *MSE* = .006; F_2 (2, 58) = 3.73, $p = .06$. Surprisingly, errors occurred slightly more often on the targets primed by phonologically related words (9.7%) compared to the targets primed by phonologically unrelated words (7.7%). There was no significant interaction between Relatedness and Kanji type for response latencies, F_1 (2, 51) =1.71, *ns*, *MSE* = 3465.2; F_2 (2, 58) = 1.32, *ns*. However, there was a significant interaction in the subject analysis of response error rates, F_1 (2, 51) = 3.16, $p < .05$, *MSE* = .006; F_2 (2, 58) = 1.68, *ns*.

Planned comparisons were carried out to examine for the phonological priming effect for each of the three prime types. In the one-Kanji condition, there was a significant priming effect in the latency data, t_1 (51) = 3.24, $p < .01$; t_2 (21) = 2.43, $p < .05$, but not in the error data, t_1 (51) = -.64, *ns*; t_2 (21) = -.56, *ns.* In this condition, participants responded faster to targets that primed by phonologically related primes (669 ms) compared to unrelated primes (701 ms), while error rates did not differ between related (7.8 %) and unrelated primes (7.0 %). However, for the two-Kanji condition, there was no significant priming effect in the latency data, t_1 (51) = .43, *ns*; t_2 (31) = .46, *ns*, nor in the error data, t_1 (51) = -.14, *ns*; t_2 (31) = -.14, *ns.* Participants' response latency and error rates did not

Table 2

Mean lexical decision latencies in millisecond (and percentage errors) in Kanji condition from Experiment 1

	Relatedness		
Kanji Type	Related	Unrelated	Priming Effect
1 Kanji	669 (7.8)	701 (7.0)	32 (-.8)
2 Kanji	752 (11.2)	756 (10.8)	4 (-.4)
Kanji + Kana	677 (10.2)	699 (5.3)	22 (-4.9)
Overall	699 (9.7)	719 (7.7)	20 (-2.0)

differ between related (752 ms, 11.2 %, respectively) and unrelated (756 ms, 10.8 %, respectively) conditions. Finally, in the Kanji + Kana condition, there was no significant priming effect in the latency data, t_1 (51) = 1.39, *ns*; t_2 (9) = .36, *ns,* but there was in the error data, t_1 (51) = -2.78, $p < .01$; t_2 (9) = -2.67, $p < .05$. While participants' mean response latency was somewhat faster in the related condition (677 ms) compared to the unrelated condition (699 ms), they made significantly more errors in related condition (10.2 %) compared to unrelated condition (5.3 %). Because the related primes were 22 ms faster but produced 4.9% more errors than the unrelated primes, there was possibly a speed/accuracy trade-off in the Kanji + Kana condition.

Katakana Condition

For the Katakana condition, three low-frequency targets (i.e. radar, tile, veil) were excluded from all analyses due to high error rates (>50%). The mean lexical decision latencies for correct responses and the mean error rates were analysed using 2 (Similarity: Similar, Dissimilar) 2 X (Target frequency: low, high) repeated measures analyses of variance (ANOVA). Both subject (F_1) and item (F_2) analyses were carried out. In the subject analyses, target frequency and similarity were within-subject factors. In the item analyses, target frequency was a between-item factor and similarity was a within-item factor. Table 3 presents the mean response latencies and error rates from the subject analyses.

The main effect of similarity was significant for response latencies, F_1 (1, 49) = 26.13, $p < .001$, *MSE* = 1258.8; F_2 (1, 113) = 28.12, $p < .001$, *MSE* =1666.1, and for errors, F_1 (1, 49) = 6.75, $p < .05$, *MSE* = .002; F_2 (1, 113) = 5.23, $p < .05$, *MSE* = .003. Lexical decisions to targets primed by phonologically similar Japanese words were faster and less error prone (712 ms, 6.7%) than lexical decisions to targets primed by

Table 3

Mean lexical decision latencies in millisecond (and percentage errors) in Katakana condition from Experiment 1

	Similarity		
Target Frequency	Similar	Dissimilar	Priming Effect
Low	748 (9.2)	771 (12.6)	23 (3.4)
High	676 (4.1)	703 (4.0)	28 (-.1)
Overall	712 (6.7)	737 (8.3)	26 (1.7)

phonologically dissimilar Japanese words (737 ms, 8.3%). There was a significant main effect of target frequency for response latencies, F_1 (1, 49) = 156.74, $p < .001$, *MSE* = 1839.8; F_2 (1, 113) = 27.47, $p < .001$, *MSE* = 11677.1, and for errors, F_1 (1, 49) = 66.77, $p < .001$, *MSE* = .004; F_2 (1, 113) = 23.22, $p < .001$, *MSE* = .011. Lexical decisions to low-frequency targets were slower and more error prone (760 ms, 10.9%) than lexical decisions to high-frequency targets (690 ms, 4.1%).

Although there was no significant interaction between target frequency and similarity for response latencies $F_1 < 1$; $F_2 <1$, there was a significant interaction for errors, F_1 (1, 49) = 8.06, $p < .01$, *MSE* = .002; F_2 (1,113) = 7.45, $p < .01$, *MSE* = .003. To evaluate this interaction effect, a post hoc test using Bonferroni's method was carried out. In the high frequency condition, there was no effect of similarity, t_1 (49) = .29, *p* = *ns*; t_2 (113) = .33, *p* = *ns*. In the low frequency condition, on the other hand, error rates for lexical decisions to the targets primed by phonologically similar primes were significantly lower than for the targets primed by phonologically dissimilar primes, t_1 (49) = 3.34, $p < .01$; t_2 (113) = 3.41, $p < .01$.

Discussion

The present study is the first demonstration of a cross-language phonological priming effect for Kanji primes and English targets in Japanese-English bilinguals. The overall results showed that the response latencies for English targets were facilitated when they were primed with phonologically related Japanese Kanji words. However, participants in fact made more errors in the related condition compared to the unrelated condition. Such a result makes it less clear whether there was a priming effect between Kanji and English words. These puzzling results were further explored by analyzing the data for each Kanji type. Subsequent analyses of reaction times revealed that there was a clear priming effect in the one-Kanji condition, but not in the two-Kanji condition or the Kanji + Kana condition. With respect to the error data, there was no difference between related and unrelated conditions in the one-Kanji and two-Kanji conditions, while there were significantly more errors in the related condition compared to the unrelated condition when primed by Kanji + Kana. Thus, in the Kanji + Kana condition, participants' response latency was somewhat facilitated but accuracy was hindered. Such contradictory results indicate that there was possibly a speed/accuracy trade off in the Kanji + Kana condition in particular.

Taken together, these findings suggest two important conclusions. First, it seems that the higher error rates in the overall related condition were mainly due to the data from the Kanji + Kana condition. Thus, while the overall results indicate that there were more errors in the related condition, this is particularly the case for the Kanji + Kana condition and not for the other Kanji types. Secondly, the results indicate that the size of the phonological priming effect is different for the three Kanji types. More specifically, there was a clear priming effect between one-Kanji and English words, while there was little priming effect between two-Kanji and English words. The presence of a priming effect in the one-Kanji condition is consistent with the Chinese-English bilingual study by Zhou et al. (2010), where all Chinese primes were single character words. This confirms that both Chinese and Japanese logographic words can phonologically prime English words. However, the finding also suggests that some logographic words may not phonologically prime English words, or at least some priming is hard to observe in behavioral data. The difference among Kanji types will be further explored in Experiment 2 and in the General Discussion.

For the Katakana condition, the current experiment successfully replicated Nakayama et al.'s (2011) cross-language phonological priming effect for Katakana primes. As in their study, the priming effect was not influenced by target frequency. Thus, the results confirmed that the phonological information activated by Katakana words facilitates the processing of English words. To summarize, the results of the current experiment suggest that the non-selective phonological access view is supported in Japanese-English bilinguals, not only by words in phonetic scripts (Katakana) but also by words in logographic scripts (Kanji). However, there was no sign of a priming effect for the two-Kanji and the Kanji + Kana conditions. Experiment 2 was conducted in order to investigate whether ERPs would be a more sensitive measure and would reveal priming effects for these stimuli. In addition, the ERPs were expected to be informative regarding the time course of the priming effects.

Experiment 2

In Experiment 2, the same task from Experiment 1 was used. One major difference from Experiment 1 is that in addition to the behavioral data, this experiment collected ERP data, which will provide information on the time course of the phonological priming effect. In previous research, Grainger, Kiyonaga, and Holcomb (2006), observed a phonological priming effect in English monolinguals in ERP data. In their data, the mean amplitude for phonologically dissimilar word pairs was more negative compared to the one for phonologically similar word pairs. The researchers found that this effect started to emerge around 250 ms after the target onset in anterior electrode sites. In the current experiment, a similar ERP modulation was expected for both Kanji and Katakana conditions.

Another difference is that the Japanese-English bilinguals for this experiment were tested in London, Ontario, Canada. Thus, unlike the participants from Experiment 1, the bilinguals who participated in this experiment are those who are living in an English-speaking environment. Thus, demographic data (e.g., daily use of English/Japanese, age) of the population is somewhat different from those in Experiment 1. However, the participants in both experiments had Japanese as their first and dominant language, while they also possessed relatively good English proficiency. Similar to Experiment 1, a cross-script phonological priming effect was expected in both Kanji and Katakana in this experiment. The ERP data was expected to reveal when this facilitation arises.

Method

Participants

Forty-three Japanese-English bilinguals (35 female; mean age = 28.4, *SD* = 8.61) residing in London, Ontario, participated in the experiment. All of them reported that their first language was Japanese, and that they used English as their second language. However, three of them reported that they were raised in Canada and English was their dominant language. Therefore, their data were removed before the analyses. The remaining 40 participants (33 female; mean age = 29.1, *SD* = 8.57) were right-handed and had normal or corrected to normal vision. All participants were paid for their time.

Stimuli

The stimuli were identical to Experiment 1.

Procedure

Participants were tested individually. Each participant completed a consent form and a short language background questionnaire, and then they were set up for the EEG. The experiment was programmed using E-Prime (Psychology Software Tools, 2002). The stimuli were presented on a 21 inch computer screen. The manner of stimuli presentation was identical to Experiment 1. In order to minimize the influence of noise in the ERP recording, participants were instructed to sit still on the chair and to try not to blink when the letter strings appeared on the screen.

In the experiment, participants were asked to make a lexical decision to each English target word. Participants were instructed to make their decisions as quickly and accurately as possible by pressing the word or the nonword button on a response box placed in front of them. Participants completed 16 practice trials to familiarise themselves with the task prior to the data collection. There were three blocks in the task, and each block took approximately 10 minutes to complete. The decision latencies, accuracy, and EEG were recorded.

Electrophysiological recording

Electrophysiological (EEG) data were recorded at 512 Hz through the Active-Two Biosemi system with a 32-channel cap (Electro-cap, Inc: Eaton, OH). The 32 electrodes were positioned at Fz, Cz, Pz, Oz, FP1/2, AF3/4, F3/4, F7/8, FC1/2, FC5/6, C3/4, T7/8, CP1/2, CP5/6, P3/4, P7/8, PO3/4, and O1/2 (see Figure 1 for the electrode configuration). Electro-oculogram (EOG) activity was recorded from active electrodes placed above, beside, and beneath the left eye, and beside the right eye. An additional active electrode (CMS - common mode sense) and a passive electrode (DRL - driven right leg) were used to comprise a feedback loop for amplifier reference. All impedances were maintained below 5 kΩ. The trials were epoched into 1000 ms trial intervals that ranged from 200 ms prior to the onset of the target word to 800 ms after the onset of the target word. The epochs were baseline corrected to target onset (0 ms). Response latencies were recorded online along with the EEG data.

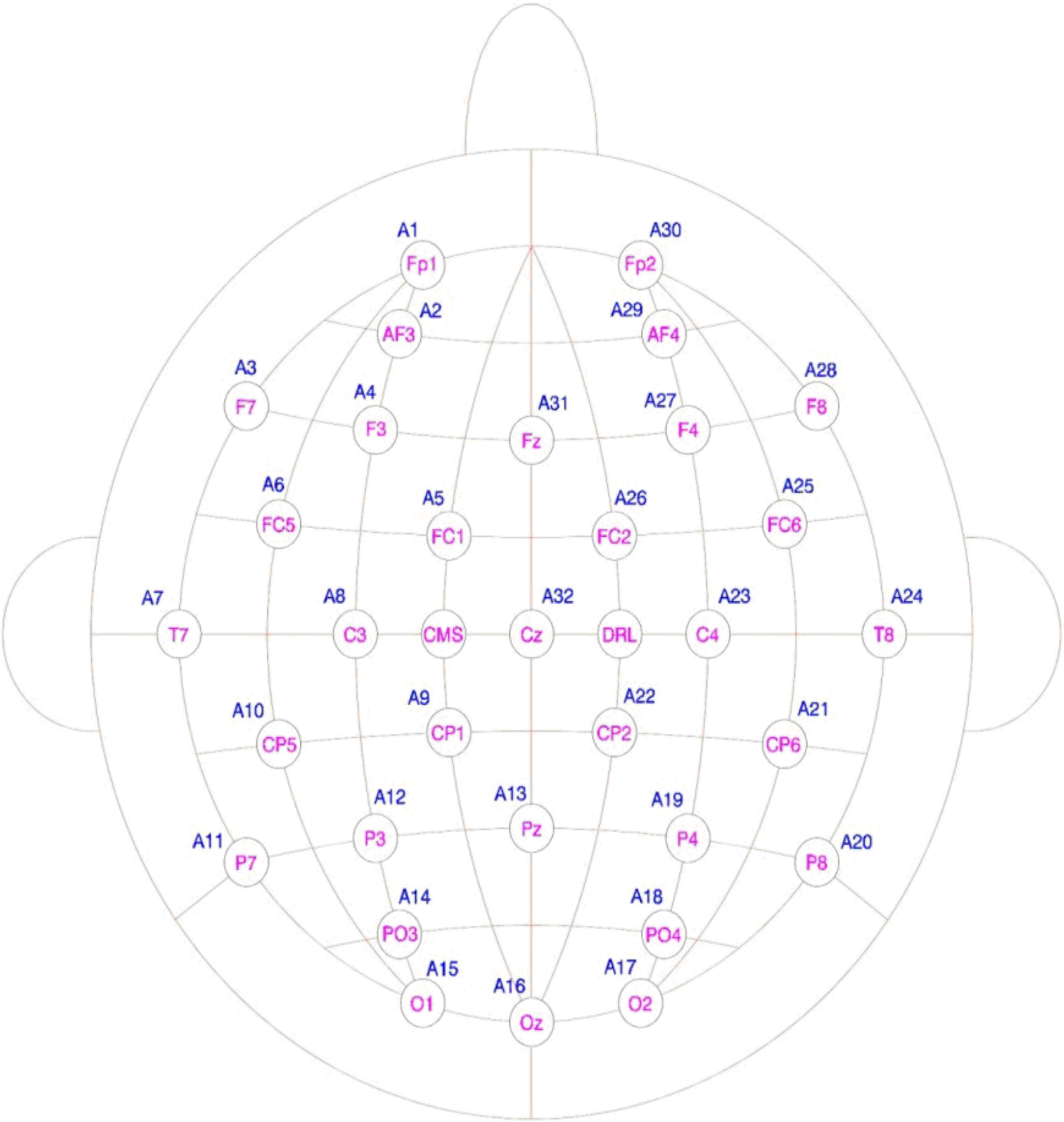

Figure 1. Representation of the 32-electrode cap used to record EEG activity in *Figure 1.*

Representation of the 32-electrode cap used to record EEG activity in Experiment 2.

Preprocessing

ERPs were preprocessed off-line using the EMSE Software (Source Signal Imaging, San Diego, CA). The 32 channels were referenced to the left and right mastoids and EEG activity were band-pass filtered (.1-30Hz). Trials containing blinks were corrected using the empirical EMSE Ocular Artifact Correction Tool and trials with nonocular artifacts (EEG activity exceeding ±75 µV at any scalp electrode) were discarded.

Results

The data from 18 participants were excluded from all analyses. One participant had a very high error rate (>50%) on the lexical decision task. The remaining 16 participants were excluded because of the significant noise in the ERP data. Fifteen of those were removed due to a high number of rejected trials (>50%) and one participant was excluded because of extremely large fluctuations observed by visual inspection. Because one of the experimental lists then had one more participant than the other, the participant with the next highest number of rejected trials was removed so that there was an equal number of participants who received each list. The analyses were therefore based on data from 22 participants (18 females, mean age = 28.8, SD = 9.35). Response latencies shorter than 300 ms or longer than 1700 ms were considered as outliers and excluded from the analysis (2.0% of all trials for both Kanji and Katakana conditions).

Behavioral Analyses

Kanji Condition. For the Kanji condition, the mean lexical decision latencies for correct responses on the English targets and the mean error rates were analysed using 2 (Relatedness: related, unrelated) X 3 (Kanji Type: one-Kanji, two-Kanji, Kanji + Kana) repeated measures ANOVAs. Both subject (F_1) and item (F_2) analyses were carried out.

In the subject analyses, relatedness and Kanji type were within-subject variables. In the item analyses, relatedness was a within-item factor and Kanji type was a between-item factor. Table 4 shows the mean response latencies and error rates from the subject analyses.

In the decision latency data, there was no main effect of relatedness F_1 (1, 21) = .26, *MSE* = 5022.45, *ns*, F_2 (1. 61) = .80, *MSE* = 3939.91, *ns.* The mean reaction times were similar in the related (788 ms) and unrelated (794 ms) conditions. Similar to the results in Experiment 1, the numerical comparisons in Table 4 indicate that the priming effect is strongest in the one-Kanji condition (23 ms), compared to the two-Kanji condition (12 ms) and the Kanji + Kana condition (-7 ms). However, there was no interaction effect between relatedness and Kanji type, F_1 (2, 42) = 1.23, *MSE* = 4120.57, *ns.*, F_2 (2, 61) = .43, *MSE* = 3939.91, *ns.*, and further planned comparison analyses indicated that there was no significant priming effect in any condition: one-Kanji, t_1 (21) = 1.47, *ns.*; t_2 (21) = 1.66, *ns.*, two-Kanji, t_1 (21) = .71, *ns.*; t_2 (31) = .80, *ns.*, and Kanji + Kana, t_1 (21) = -.71, *ns.*; t_2 (9) = -13, *ns.*

In the error data, there was no main effect of relatedness in the subject analysis F_1 (1, 21) = 2.53, *MSE* = .007, *ns.*, but the item analysis was marginally significant, F_2 (1, 61) = 3.31, *MSE* = .004, p = .07. Participants were slightly more accurate when the primes were phonologically related to the targets (5.2%) compared to unrelated targets (7.6%). As was the case in the reaction time data, the priming effect in the error data was largest in the one-Kanji condition (3.3%), next largest in the two-Kanji condition (2.8%), and smallest in the Kanji + Kana condition (0.9%). There was no interaction between relatedness and Kanji type, F_1 (1, 21) = .23, *MSE* = .008, n.s, F_2 (1. 61) = .24, *MSE* = .004, *ns.* However, further planned comparisons revealed that the priming effect in the one-

Table 4

Mean lexical decision latencies in millisecond (and percentage errors) in Kanji condition from Experiment 2

	Relatedness		
Kanji Type	Related	Unrelated	Priming Effect
1 Kanji	739 (2.9)	762 (6.2)	23 (3.3)
2 Kanji	865 (7.4)	877 (10.2)	12 (2.8)
Kanji + Kana	760 (5.5)	743 (6.4)	-7 (0.9)
Overall	788 (5.3)	794 (7.6)	6 (2.3)

Kanji condition was significant, t_1 (21) = 2.59, $p < .05$; t_2 (21) = 2.16, $p < .05$, but it was not significant in either the two-Kanji condition, t_1 (21) = 1.12, *ns*.; t_2 (31) = 1.47, *ns*, or in the Kanji + Kana condition, t_1 (21) = .25, *ns*.; t_2 (9) = .43, *ns*.

Katakana Condition. For the Katakana condition, two low-frequency targets (i.e. radar, veil) were excluded from all analyses due to high error rates (>50%). The mean lexical decision latencies for correct responses on the English targets and the mean error rates were analysed using 2 (Similarity: similar, dissimilar) X 2 (Frequency: high, low) repeated measures ANOVAs. Both subject (F_1) and item (F_2) analyses were carried out. In the subject analyses, similarity and frequency were within-subject factors. In the item analyses, similarity was a within-item factor and frequency was a between-item factor. Table 5 shows the mean response latencies and error rates from the subject analyses.

In the decision latency data, there was a main effect of similarity, F_1 (1, 21) = 8.60, *MSE* = 1241.85, $p < .01$, F_2 (1, 116) = 7.13, *MSE* = 4716.37, $p < .01$. As in Experiment 1, participants responded significantly faster when the targets were primed with phonologically similar words (786 ms) compared to phonologically dissimilar words (808 ms). Furthermore, there was a main effect of frequency, F_1 (1, 21) = 184.63, *MSE* = 748.41, $p < .01$, F_2 (1, 116) = 19.63, *MSE* = 22584.83, $p < .01$. High-frequency targets were responded to faster (758 ms) than low-frequency targets (837 ms). There was no interaction between similarity and frequency, F_1 (1, 21) = .02, *MSE* = 4784.41, *ns*., F_2 (1, 116) = .02, *MSE* = 4716.37, *ns*.

In the error data, there was no main effect of similarity in the subject analysis F_1 (1, 21) = 1.55, *MSE* = .003, *ns*., but the item analysis was marginally significant, F_2 (1, 116) = 3.11, *MSE* = .004, $p = .08$. The error rates were slightly lower in the similar condition (5.0 %) than in the dissimilar condition (6.4%). There was a main effect of

Table 5

Mean lexical decision latencies in millisecond (and percentage errors) in Katakana condition from Experiment 2

	Similarity		
Target Frequency	Similar	Dissimilar	Priming Effect
Low	827 (7.7)	847 (9.4)	20 (1.7)
High	746 (2.3)	770 (3.3)	24 (1.0)
Overall	786 (5.0)	808 (6.4)	22 (1.4)

frequency, F_1 (1, 21) = 19.00, *MSE* = .004, $p < .01$, F_2 (1, 116) = 21.79, *MSE* = .009, $p < .01$. Low-frequency targets were more error prone (8.5%) than high-frequency targets (2.8%). Finally, there was no interaction effect between similarity and frequency, F_1 (1, 21) = .13, *MSE* = .002, *ns.*, F_2 (1, 116) = .18, *MSE* = .004, *ns.*

ERP Analyses

In order to assess the influence of phonological activation from Japanese primes, peak amplitudes in five continuous windows (125-175 ms, 175-225 ms, 225-275 ms, 275-325 ms, and 325-375 ms after the target onset) and one later time window (450-600 ms) were analyzed. Grainger et al. (2006) found a phonological priming effect in the anterior region starting around 250 ms after the target onset. Visual inspection of the waveforms electrodes across scalp in the current experiment indicated that ERP modulation near this time window was particularly strong in left anterior region (F3 and FZ) in the Kanji condition (See Figure 2) and in the right anterior and central region (FZ, F4, and C4) in the Katakana condition (See Figure 3). Based on these trends, four electrodes were selected to be analyzed for Kanji (F7, F3, FZ, FC5; Figure 4) and for Katakana (FZ, F4, C4, FC2; Figure 5) conditions.

In the Kanji condition, separate repeated measures ANOVAs for each time window were conducted with factors of phonological relatedness (related, unrelated), Kanji type (one-Kanji, two-Kanji, Kanji + Kana), and electrode (F7, F3, FZ, FC5). In order to explore further, planned comparisons were conducted for each Kanji type. In the Katakana condition, separate repeated measures ANOVAs for each time window were conducted with factors of phonological similarity (similar, dissimilar), target frequency (high, low), and electrodes (FZ, F4, C4, FC2). Further planned comparisons were conducted for each target frequency. The Greenhouse-Geisser correction was used for

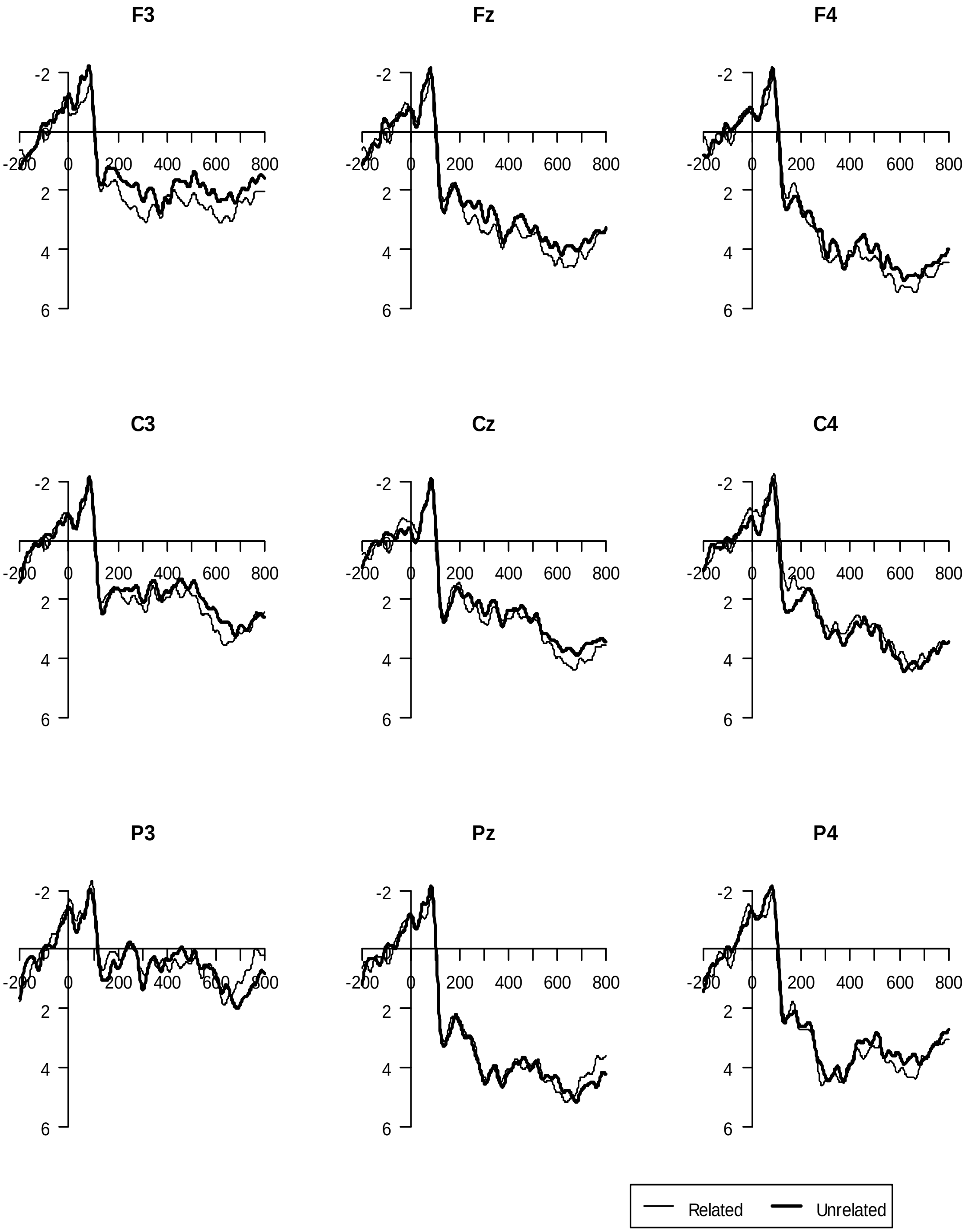

Figure 2. Effect of relatedness for 9 electrode sites across the scalp in the Kanji condition

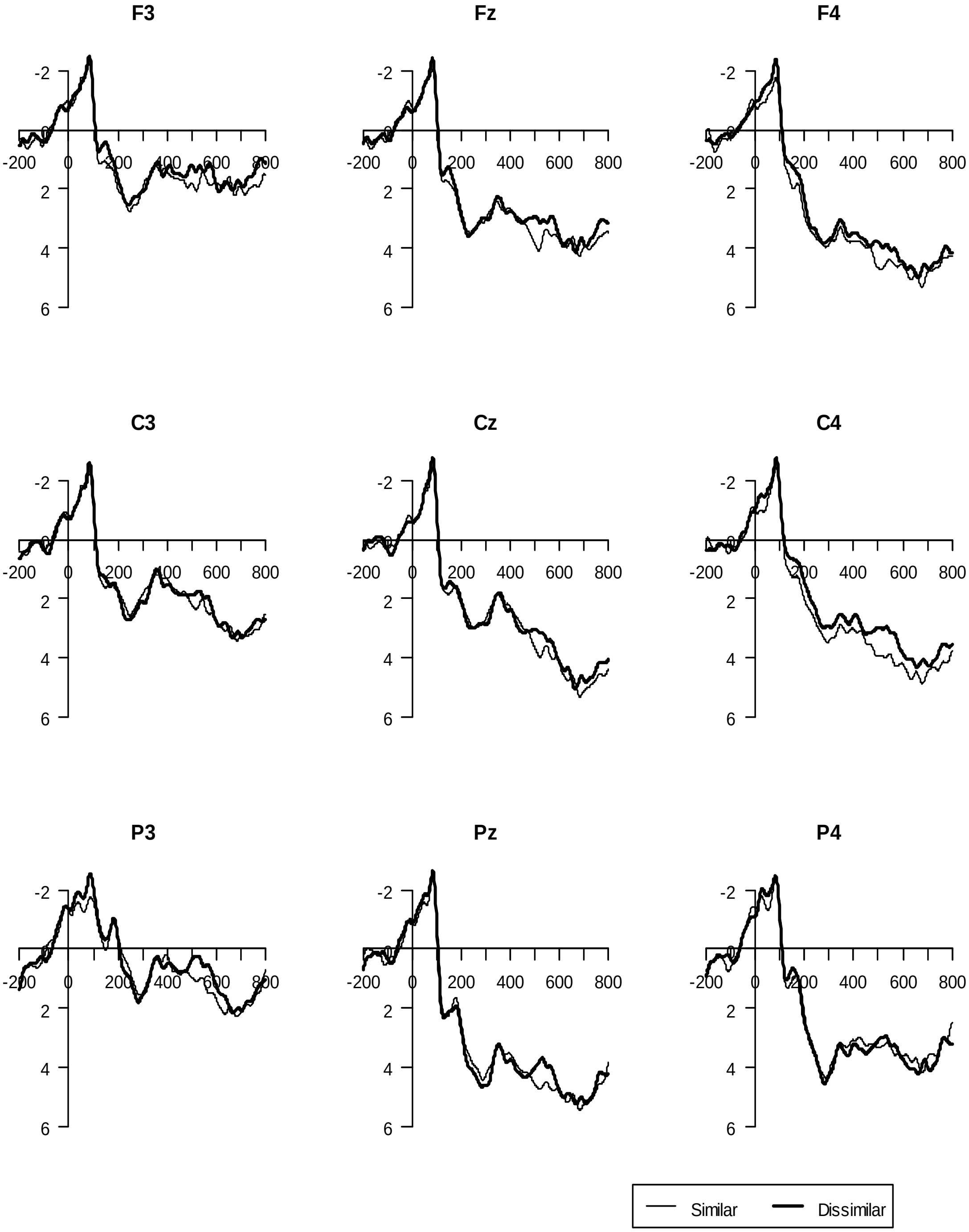

Figure 3. Effect of relatedness for 9 electrode sites across the scalp in the Katakana condition

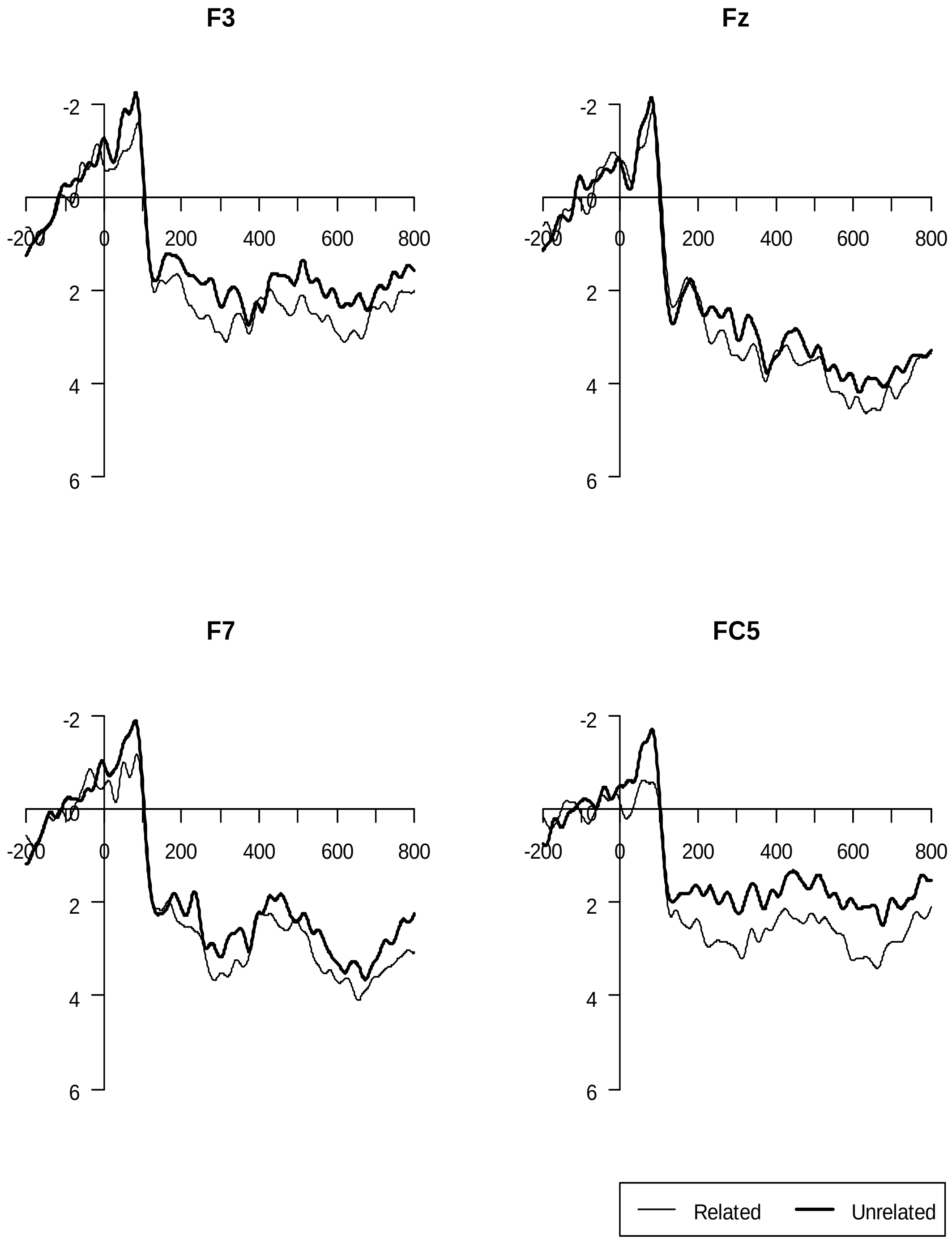

Figure 4. Effect of relatedness for the 4 analyzed electrode sites in the Kanji condition

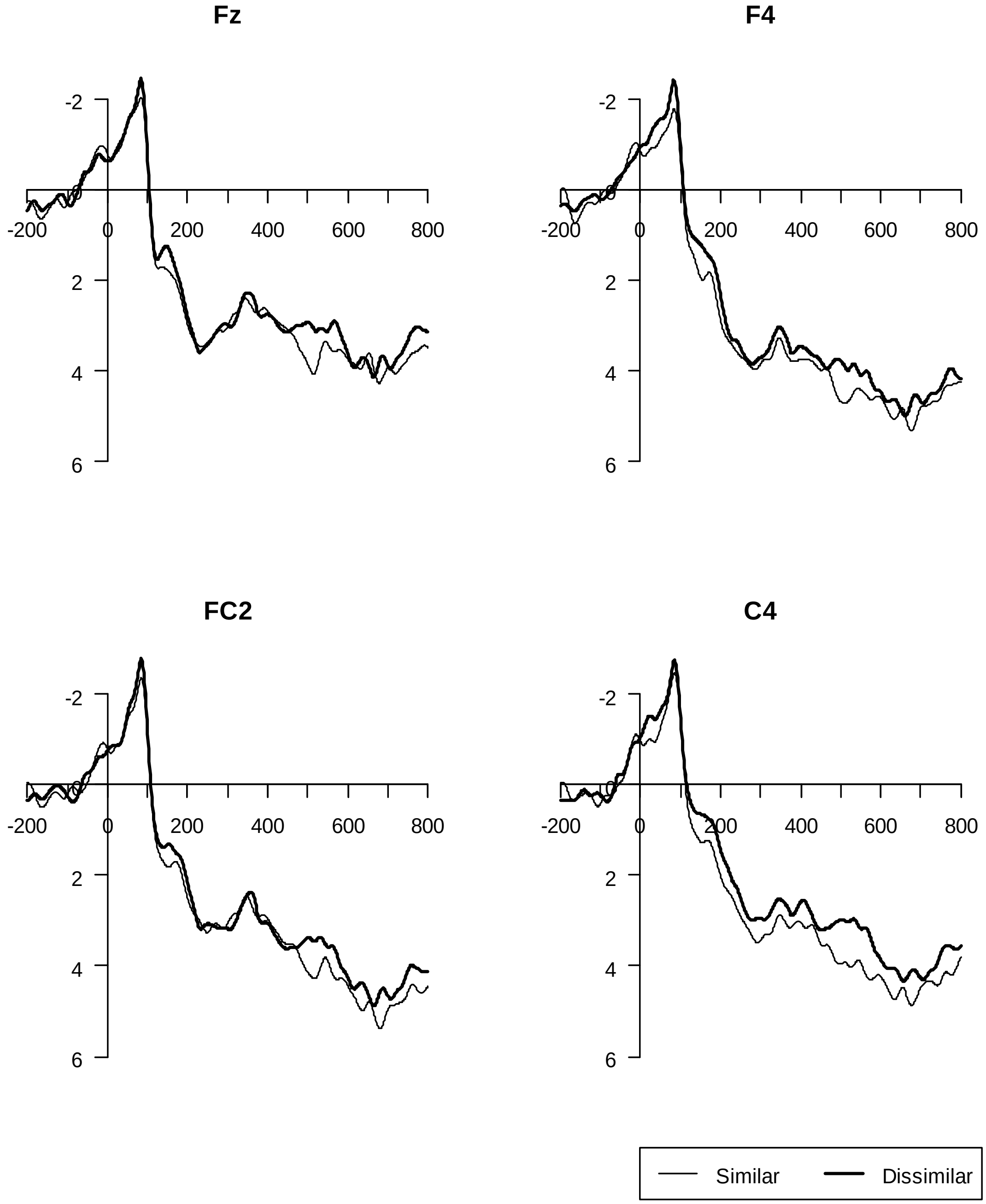

Figure 5. Effect of similarity for the analyzed 4 electrode sites in the Katakana condition

both sets of analyses. A summary of the results for each time window is presented in Table 6 for Kanji primes and Table 7 for Katakana primes. For the sake of simplicity, only the main findings will be discussed in this section. All the cases of significant priming effects revealed that the peak amplitude of unrelated (dissimilar) condition was more negative compared to that of related (similar) condition.

Kanji Condition. The main effect of relatedness approached to be significance in the 325-375 ms window, *F* (1, 21) = 3.18, *MSE* = 58.58, $p < .09$. Although the interaction between relatedness and Kanji type was not significant, *F* (2, 42) = .80, *MSE* = 43.67, *ns.*, further planned comparisons revealed that the priming effect was marginally significant in this time window in the one-Kanji condition, *t* (21) = 1.91, $p < .08$, but not in the two-Kanji condition, *t* (21) = .43, *ns.*, or in the Kanji + Kana condition, *t* (21) = .16, *ns* (See Figure 6). In the one-Kanji condition, there was also a significant priming effect in the 275-325 ms window, *t* (21) = 2.12, $p < .05$, and marginally significant priming effects in the 225-275 ms window, *t* (21) = 1.80, $p < .09$, and in the 450-600 ms window, *t* (21) = 1.78, $p < .10$. There were no other significant priming effects.

Katakana Condition. There was a significant priming effect in the 325-375 ms window, *F* (1, 21) = 4.62, *MSE* = 18.10, $p < .05$. In the same time window, there was also an interaction between similarity and frequency, *F* (1, 21) = 4.54, MSE = 18.24, $p < .05$, and further analyses revealed that the priming effect occurred in the high frequency condition, *t* (21) = 2.63, $p < .05$, but not in the low frequency condition, *t* (21) = .001, *ns* (See Figure 7). Finally, in the high frequency condition, there was a marginal priming effect in the 450-600 ms window, *t* (21) = 2.01, $p < .06$.

Table 6

Time course of priming effects: Results of tests of significance for Kanji condition from Experiment 2

	Kanji Type			
Epoch (ms)	1 Kanji	2 Kanji	Kanji + Kana	Overall
125-175	n.s.	n.s.	n.s.	n.s.
175-225	n.s.	n.s.	n.s.	n.s.
225-275	†	n.s.	n.s.	n.s.
275-325	*	n.s.	n.s.	n.s.
325-375	†	n.s.	n.s.	†
450-600	†	n.s.	n.s.	n.s.

Note. Averages of F7, F3, Fz, and FC5 were used. † $p < .10$, * $p < .05$

Table 7

Time course of priming effects: Results of tests of significance for Katakana condition from Experiment 2

	Target Frequency		
Epoch (ms)	High	Low	Overall
125-175	n.s.	n.s.	n.s.
175-225	n.s.	n.s.	n.s.
225-275	n.s.	n.s.	n.s.
275-325	n.s.	n.s.	n.s.
325-375	*	n.s.	*
450-600	†	n.s.	n.s.

Note. Averages of Fz, F4, Cz, and FC2 were used. † $p < .10$, * $p < .05$

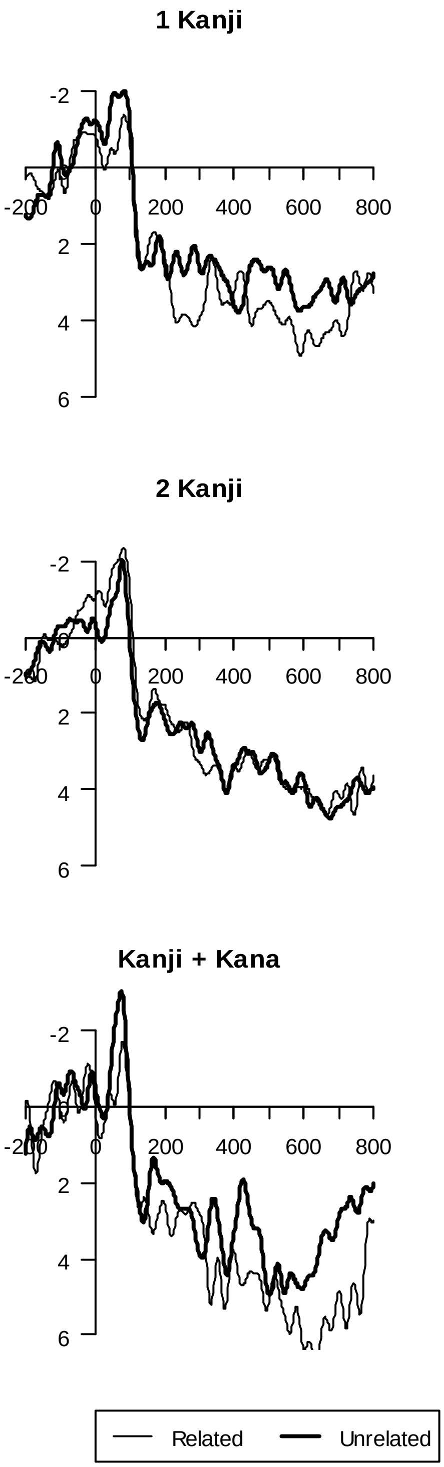

Figure 6. Effects of relatedness in the three Kanji prime conditions (FZ)

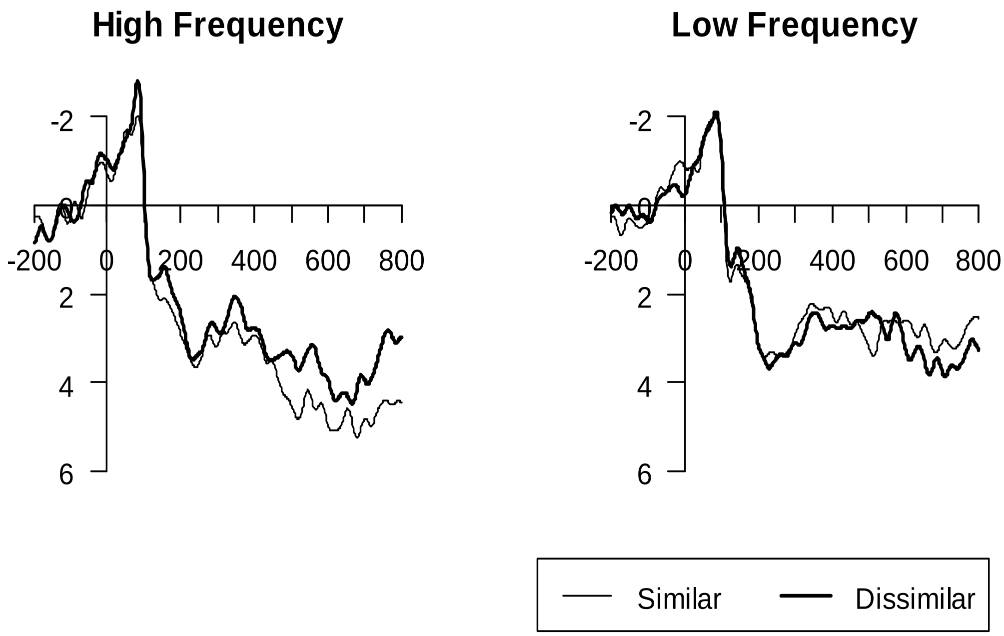

Figure 7. Effect of similarity in the high vs. low frequency conditions with Katakana primes (FZ)

Discussion

In Experiment 2, behavioral and electrophysiological measures were used to investigate whether cross-script phonological priming effects would be observed in Japanese-English bilinguals, both in Kanji and Katakana prime conditions. Although the number of participants in Experiment 2 was relatively small compared to Experiment 1, the data from Experiment 2 showed a similar trend and also provided evidence for the non-selective access view from both behavioral and ERP data.

In the decision latency data for the Kanji condition, the overall phonological priming effect was small and did not reach significance. Although the priming effect in the one-Kanji condition seemed particularly strong compared to two-Kanji and Kanji + Kana condition, none of them reached significance, probably due to less statistical power than in Experiment 1. However, in the error data, a significant priming effect was found in the one-Kanji condition. These results suggest that there was a phonological priming effect when the primes were one-Kanji words. Although the evidence was not as strong as those from Experiment 1, the results from Experiment 2 showed similar trends as those observed in Experiment 1.

In the decision latency data for the Katakana condition, a phonological priming effect was found regardless of the target frequency. Although the effect was somewhat modest, the error data concurred with the latency data. Taken together, Experiment 2 again successfully replicated the results of Nakayama et al. (2011), even if the sample size was quite a bit smaller compared to their study.

The ERP data for the Kanji condition were comparable to the behavioral data. While the overall priming effect was only marginally significant in the 325-375 ms

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window, and marginal priming effects in adjacent time windows. Finding phonological priming effects (or a sign of them) in these time windows is consistent with Grainger et al. (2006) who observed a phonological priming effect at around 250 ms after the target onset. In line with the behavioral data, these results again confirm that only the one-Kanji condition shows strong phonological priming effects, and they support the non-selective access view inasmuch as the one-Kanji primes are concerned. The possible reasons for and implication of this are considered in the General Discussion.

The ERP data of the Katakana prime condition surprisingly did not quite concur with the behavioral results, unlike the Kanji condition. Although there was an overall priming effect in the 325-375 ms window, there was also a similarity by frequency interaction, i.e., a significant priming effect was present only in the high frequency condition. Given that the size of the priming effect in the decision latency data was approximately the same in the high frequency and low frequency conditions, it is unlikely that the phonological priming effect was either particularly strong in the high frequency condition or particularly weak in the low frequency condition. A possible explanation for the ERP data pattern is that there was more variability in recognizing low frequency target words than high frequency words. That is, although all participants had a relatively good background in English, the level of proficiency varied between participants and some needed more time to process low frequency English words. Such latency variation is particularly problematic for the ERPs, because the data is analyzed within fixed time windows. If a component reflecting priming effect occurs at different time point among participants, the effect would become difficult to observe in the averaged waveform, particularly given the small sample size in the current experiment.

General Discussion

The main goal of this thesis was to examine whether Japanese-English bilinguals activate a common phonological store from Kanji and English printed words, which would be expected in the language non-selective view. Although there has been evidence from phonological priming studies for a language non-selective view, few studies have tested a language pair with different scripts. Furthermore, few have used a language pair in which the phonology of the two languages is so different as to be distinguishable by newborn infants as is the case for Japanese and English (Nazzi et al., 1998). The secondary goal of this thesis was to replicate the cross-language phonological priming by Nakayama et al., (2011), with adding the ERP data. Based on the behavioral data suggesting that there is a phonological priming effect between Katakana primes and English targets regardless of the target frequency, it was expected that clear priming effects in both high and low frequency conditions would be seen in the ERP data. The following paragraphs will summarize the findings and discuss issues on Kanji prime condition first, and then will move on to Katakana prime condition.

The behavioral data from the Kanji prime condition in both Experiment 1 and 2 found evidence for non-selective activation of phonology. In the decision latency data from Experiment 1, responses to English words were facilitated when they were preceded by a similar sounding Kanji prime word. The priming effect was particularly strong in the one-Kanji condition. The behavioral results from Experiment 2 revealed similar trends, where there was a significant priming effect in the error data of the one-Kanji condition. Furthermore, the numerical comparisons revealed that the size of priming effect was particularly large for one-Kanji condition, though it did not reach significance. In the ERP data, the priming effect in the one-Kanji condition was found to be significant in the 275-

325 ms window and was marginally significant in adjacent windows (i.e., 225-275 ms and 325-375 ms). These findings provide strong evidence for that the phonological information that was activated from the Kanji script is shared with that of English. These priming effects in the one-Kanji condition found in this study here is analogous to Zhou et al., (2010), where the researchers found a phonological priming effect between single Chinese character words (e.g., 道) and English words (e.g., door) in their behavioral data. This suggests that both Japanese and Chinese logographic words that are represented with a single character phonologically prime English words. Moreover, the ERP results indicate that the priming effect starts to emerge as early as 225 ms, which is a little surprizing given that the participants were processing the target words in their L2.

While differences between the three types of Kanji primes in their priming effects were not initially expected, the results suggest that not all Kanji words primed English words. Specifically, the two-Kanji and the Kanji + Kana conditions did not show any priming effect either in behavioral or in ERP measures. There are a several possible reasons that can account for the lack of priming effect for these stimuli. One is that the characteristics of the stimuli in each Kanji type condition were not equated (See Table7). For example, in the two-Kanji and the Kanji + Kana conditions, the word frequency of both Japanese primes and English targets were relatively lower than those of the one-Kanji condition. Another difference is that the mean ratings of phonological similarity between prime and target was relatively higher in the one-Kanji condition compared to the two-Kanji and the Kanji + Kana conditions. Given these differences, the priming effect may have been observed only in the one-Kanji condition because these primes would have activated phonological representations that were closer to those of the English targets than the primes in the other two conditions.

There are other possibilities that can account for the results in the two-Kanji and Kanji + Kana conditions. Another reason why the priming effect was not observed with these conditions may be that the 50 ms prime exposure was not long enough for a phonological representation to be sufficiently activated from multiple character words containing Kanji script. This might be the case not only because the two-Kanji and Kanji + Kana words are visually longer than one-Kanji words, but also because they might be processed differently. Although both types of Kanji words (as a whole) in most cases have only one pronunciation, each Kanji character usually has more than one pronunciation and they can be pronounced differently depending on context. In the current stimuli, some of the words in the one-Kanji condition also had such a character (e.g., the word "急" is pronounced as /kyu/ but if it has a hiragana suffix "ぐ" /gu/, the word "急ぐ" is pronounced as /iso-gu/), but such instances are much fewer in the one-Kanji condition compared to the two-Kanji condition (Table 7). Moreover, the pronunciation may be relatively apparent when only a single character was presented on the screen (i.e., participants do not have to process any other information). On the other hand, it is more likely that, for example, when two-Kanji words (e.g., 車道) were presented very briefly, phonological activation of multiple pronunciations may more likely to occur in the two-Kanji condition. That is, although "車道" is pronounced as /sha-dow/, there also might be temporal phonological activation of /kuruma/ from the character "車," and /michi/ from the character "道." If so, the English target "shadow" will be less likely to be primed because of the activation of the unrelated phonological information.

For the Kanji + Kana condition particularly, the behavioral data not only provided little evidence for priming effect, but also provided an incoherent pattern of results. In Experiment 1, while there was a trend towards a priming effect in the decision latency data, the error rates significantly increased in the related condition compared to the unrelated condition. In Experiment 2, on the other hand, there was a sign of priming effect in the error data, but the mean decision latency was longer in the related condition compared to the unrelated condition. While the reason for such speed/accuracy trade-offs is unclear at this point, it is apparent that the data from this condition caused more variability in the overall results. Further investigation using ERP did not help either, mostly because the small number of stimuli made the averaged waveform much noisier than in the other two conditions (See Figure 6).

The secondary goal of this thesis was to replicate the phonological priming effect using Katakana and English words that was observed by Nakayama et al. (2011) and to extend it by examining the timing of the effect in ERP data. While the behavioral results from both Experiment 1 and 2 successfully replicated Nakayama et al., the ERP data seemed somewhat inconsistent. In the ERP data, a priming effect was found in the high frequency target condition but not in the low frequency target condition. These findings suggest that the presence of a priming effect in the behavioral data do not necessarily guarantee the effect in the ERP data, because the ERP data is particularly sensitive to variability in processing latency.

Theoretical Implications

How does the BIA+ model account for the findings in the current study? According to the model, the inputs of printed words activate phonological information in a language non-selective manner. The findings of the current studies provide sufficient evidence for the language non-selective view, based on the fact that there were priming effects in both Katakana and Kanji conditions. These findings also provide additional evidence that the BIA+ model can also account for bilinguals whose languages are very different, even if they include a logographic script and quite different phonology. Nonetheless, this conclusion is limited to single character Kanji primes. More studies are needed in order to explore whether there would be a priming effect between other types of Kanji words and English words.

Limitations and Future Research

Although the current research generally supports the non-selective phonological activation view for Japanese-English bilinguals, there are some limitations. Although the results do show that the Japanese words in logographic scripts also show a priming effect, strong phonological priming was clearly observed only in one-Kanji words. Therefore, it is not clear from the current study whether all Kanji words prime English words. In fact, one of the big challenges in this study was to find a large number of Japanese and English word pairs that sound similar. This study paid close attention by conducting a pilot study to make sure that each Japanese and English word pair has similar pronunciation. This was one of the reasons for reducing the number of critical stimuli and the three prime types were not well controlled for other variables (e.g., frequency and length). These are particularly important in experiments using ERP because processing time variability is a serious issue in ERP. Specifically, when the components have slightly different timing, there would be flattened when creating averaged waveforms. As a way to deal with this issue, the current study used peak amplitude analyses with narrow time-windows, instead of mean amplitude analyses. Even with this method, however, not all effects came out from ERP data. In the Zhou et al. (2010) study, on the other hand, their word pairs only shared some of the phonology (道 /dao/ and door) but they still found a phonological priming effect. Thus, the extent of phonological overlap between prime and target can perhaps be decreased and future studies should more focus on controlling other variability existing among experimental stimuli and participants.

Conclusions

This thesis showed evidence for cross-script phonological priming effect using Kanji and an alphabet script. Thus, the present research has added to the growing body of evidence showing that phonological processing in bilinguals occurs in language non-selective manner regardless of what orthographic script the two languages use. However, it is still questionable whether all kinds of words in Kanji scripts can phonologically prime English words. Further studies are required to find out why some Kanji primes show clear priming effect while others do not.

References

Amano, S. & Kondo, T. (Eds.). (2000). *Nihongo no goitokusei [Lexical properties of Japanese]. Vol 7. (Frequency), NTT database series*. Tokyo: Sanseido.

Baayen, H., Piepenbrock, R., & Gulikers, L. (1995). *The CELEX Lexical Database. Release 2 (CD-ROM)*. Philadelphia, PA: Linguistic Data Consortium, University of Pennsylvania.

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., et al. (2007). The English Lexicon Project. *Behavior Research Methods, 39*, 445-459.

Brysbaert, M. & Duyck, W. (2010). Is it time to leave behind the Revised Hierarchical Model of bilingual language processing after fifteen years of service? *Bilingualism: Language and Cognition, 13*(3), 359–371. doi:10.1017/S1366728909990344

Brysbaert, M., Dyck, G. V., & Van de Poel, M. (1999). Visual word recognition in bilinguals: Evidence from masked phonological priming. *Journal of Experimental*, *25*(1), 137-148.

Coltheart, M., Davelaar, E., Jonasson, J., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), Attention and performance VI (pp. 535-555). Hillsdale, NJ: Erlbaum.

Dijkstra, T, & Jaarsveld, H. V. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism, Language and Cognition*, *1*, 51-66.

Dijkstra, T., Timmermans, M., & Schriefers, H. (2000). On being blinded by your other language: Effects of task demands on interlingual homograph recognition. *Journal of Memory and Language*, *42*(4), 445-464. doi:10.1006/jmla.1999.2697

Dijkstra, T., Van Heuven, W. J. B., & Grainger, J. (1998). Simulating cross-language competition with the bilingual interactive activation model. *Psychologica Belgica*, *38*(3-4), 177-196.

Dijkstra, T., & Van Heuven, W. J. B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, *5*(3), 175-197. doi:10.1017/S1366728902003012

Duyck, W., Diependaele, K., Drieghe, D., & Brysbaert, M. (2004). The size of the cross-lingual masked phonological priming effect does not depend on second language proficiency. *Experimental Psychology*, *51*(2), 116-124. doi:10.1027/1618-3169.51.2.116

Glanzer, M., & Duarte, A. (1971). Repetition between and within languages in free recall. *Journal of Verbal Learning and Verbal Behavior*, *10*, 625-630.

Goggin, J., & Wickens, D. D. (1971). Proactive interference and language change in short-term memory. *Journal of Verbal Learning and Verbal Behavior*, *10*, 453-458.

Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew–English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(5), 1122-1139.

Grainger, J., Kiyonaga, K., & Holcomb, P. J. (2006). The time course of orthographic and phonological code activation. *Psychological Science*, *17*(12), 1021-1026.

Haigh, C. A., & Jared, D. (2007). The activation of phonological representations by bilinguals while reading silently: Evidence from interlingual homophones. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(4), 623-644. doi:10.1037/0278-7393.33.4.623

Hoshino, N., Midgley, K. J., Holcomb, P. J., & Grainger, J. (2010). An ERP investigation of masked cross-script translation priming. *Brain Research*, *1344*, 159-72. Elsevier. doi:10.1016/j.brainres.2010.05.005

Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, *44*(1), 2-31. doi:10.1006/jmla.2000.2747

Jared, D., McRae, K., & Seidenberg, M. S. (1990). The basis of consistency effects in word naming. *Journal of Memory and Language*, *29*(6), 687-715. doi:10.1016/0749-596X(90)90044-Z

Jared, D., & Szucs, C. (2002). Phonological activation in bilinguals: Evidence from interlingual homograph naming. *Bilingualism: Language and Cognition*, *5*(3), 225-239. doi:10.1017/S1366728902003024

Kim, J., & Davis, C. (2003). Task effects in masked cross-script translation and phonological priming. *Journal of Memory and Language*, *49*(4), 484-499. doi:10.1016/S0749-596X(03)00093-7

Kroll, J., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*, 149-174.

Luck, S. J. (2005). *An introduction to the event-related potential technique*. Cambridge, MA: MIT Press.

McClelland, J., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: I. An account of basic findings. *Psychological Review*, *88*(5), 375-407.

Nakayama, M., Sears, C. R., Hino, Y., & Lupker, S. J. (2011). Cross-script phonological priming for Japanese-English bilinguals: Evidence for integrated phonological representations. *Language and Cognitive Processes*. doi:10.1080/01690965.2011.606669

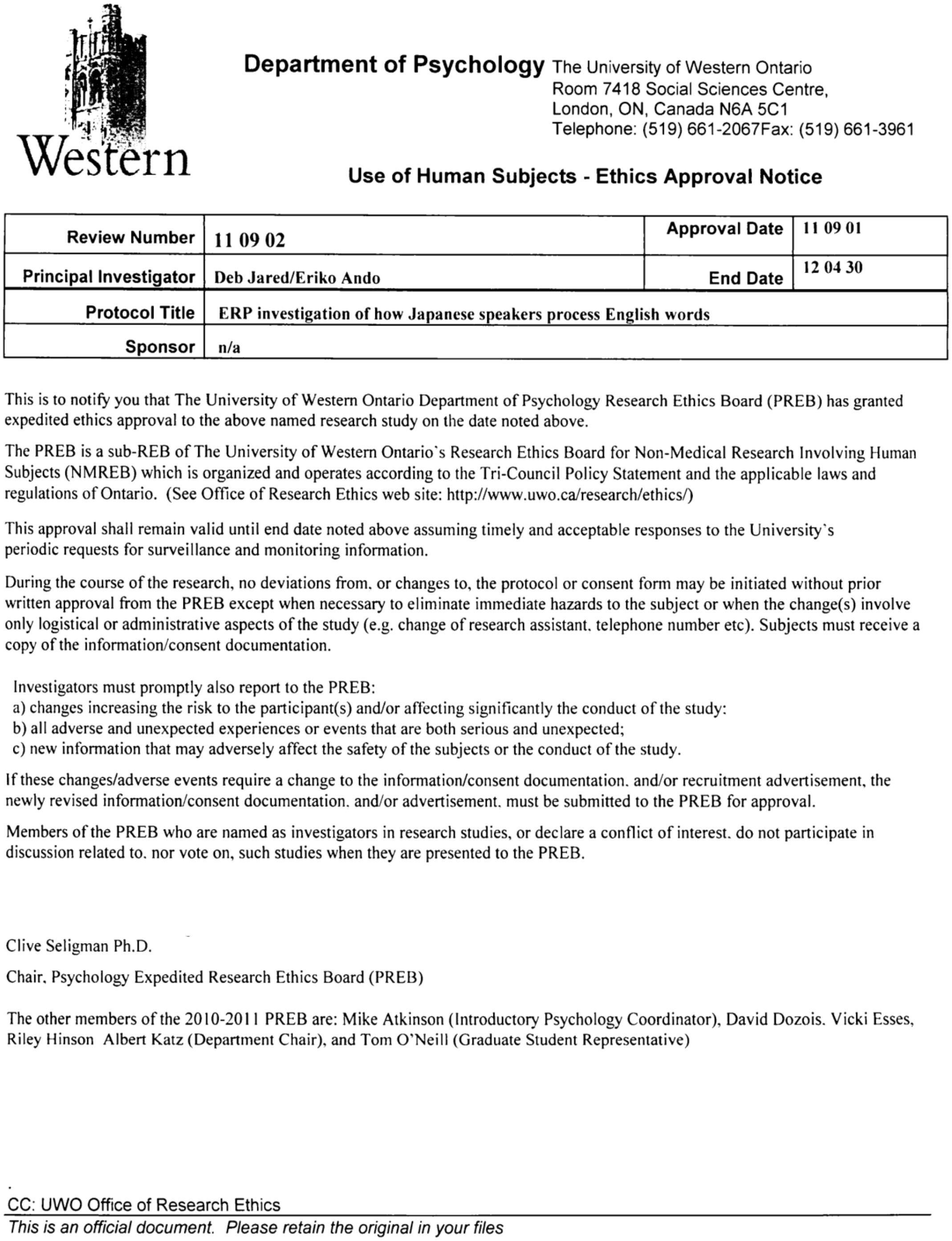
Nazzi, T., Bertoncini J., & Mehler, J. (1998). Language discrimination by newborns: Towards an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance, 24***,** 756–766.

Van Orden, G. C. (1987). A ROWS is a ROSE: Spelling, sound, and reading. *Memory & Cognition, 15*, 181-198.

Van Wijnendaele, I., & Brysbaert, M. (2002). Visual word recognition in bilinguals: Phonological priming from the second to the first language. *Journal of Experimental Psychology: Human Perception and Performance*, *28*(3), 616-627. doi:10.1037//0096-1523.28.3.616

Zhou, H., Chen, B., Yang, M., & Dunlap, S. (2010). Language nonselective access to phonological representations: Evidence from Chinese-English bilinguals. *Quarterly Journal of Experimental Psychology*, 63(10), 2051-2066. doi:10.1080/17470211003718705

Appendix A: Ethics Approval Information



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Use of Human Subjects - Ethics Approval Notice

Review Number	11 09 02	**Approval Date**	11 09 01
Principal Investigator	Deb Jared/Eriko Ando	**End Date**	12 04 30
Protocol Title	ERP investigation of how Japanese speakers process English words		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the University's periodic requests for surveillance and monitoring information.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the PREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of research assistant, telephone number etc). Subjects must receive a copy of the information/consent documentation.

Investigators must promptly also report to the PREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study:
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to the PREB for approval.

Members of the PREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the PREB.

Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2010-2011 PREB are: Mike Atkinson (Introductory Psychology Coordinator), David Dozois, Vicki Esses, Riley Hinson Albert Katz (Department Chair), and Tom O'Neill (Graduate Student Representative)

CC: UWO Office of Research Ethics

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Appendix B: Critical stimuli used in Kanji condition

Target	Phonologically Related Prime		Phonologically Unrelated Prime	
may	姪	/mei/	英字	/eizi/
sun	酸	/san/	飼う	/kau/
buy	倍	/bai/	吸う	/suu/
chew	注	/cjuu/	半分	/haNbuN/
cue	急	/kjuu/	期す	/kisu/
die	台	/dai/	微細	/bisai/
eye	愛	/ai/	嘔吐	/outo/
gay	芸	/gei/	才	/sai/
go	号	/gou/	事務	/zimu/
gun	癌	/gan/	層	/sou/
guy	害	/gai/	肺	/hai/
high	灰	/hai/	好き	/suki/
know	脳	/nou/	欧米	/oubei/
lay	例	/rei/	定期	/teiki/
men	麺	/meN/	文句	/moNku/
owe	王	/ou/	天	/teN/
saw	層	/sou/	警務	/keimu/
shoe	週	/sjuu/	脳	/nou/
sigh	才	/sai/	愛	/ai/
ten	天	/teN/	号	/gou/
toe	塔	/tou/	先生	/seNsu/
you	湯	/ju/	問い	/toi/
age	英字	/eizi/	姪	/mei/
beside	微細	/bisai/	芸	/gei/
came	警務	/keimu/	走者	/sousja/
cave	警部	/keibu/	湯	/ju/
coach	耕地	/koucji/	社員	/sjaiN/
common	顧問	/komoN/	成句	/seiku/
ego	囲碁	/igo/	強引	/gouiN/
gene	寺院	/ziiN/	警部	/keibu/
going	強引	/gouiN/	暮らす	/kurasu/
gym	事務	/zimu/	立地	/riRcji/
home	法務	/houmu/	湿布	/siQpu/
humble	半分	/haNbuN/	酸	/saN/
issue	異臭	/isjuu/	銘菓	/meika/
maker	銘菓	/meika/	台	/dai/
monk	文句	/moNku/	切る	/kiru/
obey	欧米	/oubei/	僧院	/souiN/
ought	嘔吐	/outo/	異臭	/isjuu/

Target	Phonologically Related Prime		Phonologically Unrelated Prime	
owing	押印	/ouiN/	癌	/gaN/
rich	立地	/riRcji/	押印	/ouiN/
sake	成句	/seiku/	週	/sjuu/
science	再演	/saieN/	注	/cjuu/
sense	先生	/seNsei/	単語	/tango/
sewing	僧院	/souiN/	噛む	/kamu/
shadow	車道	/sjadou/	顧問	/komoN/
shallow	社労	/sjarou/	急	/kjuu/
shine	社員	/sjain/	暗い	/kurai
ship	湿布	/siQpu/	大河	/taiga/
social	走者	/sousja/	車道	/sjadou/
sucking	殺菌	/saQkin/	害	/gai/
taking	定期	/teiki/	法務	/houmu/
tango	単語	/taNgo/	再演	/saieN/
tiger	大河	/taiga/	寺院	/ziiN/
class	暮らす	/kurasu/	殺菌	/saQkin/
come	噛む	/kamu/	王	/ou/
cow	飼う	/kau/	増す	/masu/
cry	暗い	/kurai/	倍	/bai/
kill	切る	/kiru/	社労	/sjarou/
kiss	期す	/kisu/	麺	/meN/
mass	増す	/masu/	塔	/tou/
ski	好き	/suki/	囲碁	/igo/
sue	吸う	/suu/	耕地	/koucji/
toy	問い	/toi/	例	/rei/

Appendix C: Critical stimuli used in Katakana condition

Target	Phonologically Similar Prime		Phonologically Dissimilar Prime	
medal	ペダル	/pedaru/	モード	/moRdo/
peak	パーク	/paRku/	ヨット	/joQto/
rocket	ポケット	/pokeQto/	チャイム	/tjaimu/
cheese	ビーズ	/biRzu/	カメラ	/kamera/
guitar	スター	/sutaR/	シード	/siRdo/
melody	パロディー	/parodiR/	ハリケーン	/harikeRN/
nude	ムード	/muRdo/	ホラー	/horaR/
tank	リンク	/riNku/	トレー	/toreR/
soup	キープ	/kiRpu/	ベンチ	/beNcji/
cable	ノーブル	/noRburu/	ドクター	/dokutaR/
boots	シーツ	/siRtu/	コピー	/kopiR/
peach	コーチ	/koRcji/	ナイフ	/naihu/
radar	リーダー	/riRdaR/	コマンド	/komaNdo/
map	カップ	/kaQpu/	ボタン	/botaN/
cue	ニュー	/njuR/	パック	/paQku/
spoon	ストーン	/sutoRN/	セミナー	/seminaR/
stamp	スランプ	/suraNpu/	シューズ	/sjuRzu/
panel	パール	/paRru/	ロック	/roQku/
release	リバース	/ribaRsu/	ジャンプ	/zjaNpu/
rat	ラップ	/raQpu/	コラム	/koramu/
lighter	ライダー	/raidaR/	バラード	/baraRdo/
skirt	スカウト	/sukauto/	タイトル	/taitoru/
maker	メーター	/meRtaR/	ストレス	/sutoresu/
bat	バッグ	/baQgu/	スコア	/sukoa/
spy	スパン	/supaN/	ルック	/ruQku/
trumpet	トランジット	/toraNziQto/	プロデュース	/purodjuRsu/
stake	ステッキ	/suteQki/	トランク	/toraNku/
skate	スケール	/sukeRru/	ウイルス	/uirusu/
tent	テンポ	/teNpo/	プラス	/purasu/
lens	レンジ	/reNzi/	ビーチ	/biRcji/
goal	メール	/meRru/	マイク	/maiku/
test	ロスト	/rosuto/	ワゴン	/wagoN/
wide	エイド	/eido/	ルビー	/rubiR/
stage	コテージ	/koteRzi/	オーバー	/oRbaR/
table	マーブル	/maRburu/	エンジン	/eNziN/
play	ベレー	/bereR/	キット	/kiQto/
town	ダウン	/dauN/	ベビー	/bebiR/
word	カード	/kaRdo/	リアル	/riaru/
young	キング	/kiNgu/	ケージ	/keRzi/

Target	Phonologically Similar Prime		Phonologically Dissimilar Prime	
note	カート	/kaRto/	バレエ	/baree/
mind	ウインド	/uiNdo/	クレヨン	/kurejoN/
part	ビート	/biRto/	グラフ	/kurahu/
trouble	シラブル	/siraburu/	ハンガー	/haNgaR/
hair	ペア	/pea/	バー	/baR/
hit	セット	/seQto/	ハーフ	/haRhu/
spot	スキット	/sukiQto/	チェーン	/cjeRN/
chief	チーク	/cjiRku/	タッチ	/taQcji/
race	レタス	/retasu/	ホルン	/horuN/
dance	ダンプ	/daNpu/	ページ	/peRzi/
moral	モール	/moRru/	シェフ	/sjehu/
power	パター	/pataR/	エース	/eRsu/
boat	ボーイ	/boRi/	シンク	/siNku/
list	リフト	/rihuto/	ポップ	/poQpu/
single	シンボル	/siNboru/	アシスト	/asisuto/
ground	グラインド	/guraiNdo/	ディベート	/dibeRto/
black	ブランク	/buraNku/	エリート	/eriRto/
home	ホール	/hoRru/	ペット	/peQto/
size	サイン	/saiN/	ネット	/neQto/
place	プレート	/pureRto/	リベラル	/riberaru/
night	ナイス	/naisu/	シーン	/siRN/
cookie	ラッキー	/raQkiR/	メソッド	/mesoQdo/
racket	チケット	/cjikeQto/	アレンジ	/areNzi/
boom	ビーム	/biRmu/	エラー	/eraR/
lease	ホース	/hoRsu/	ナイン	/naiN/
rush	ダッシュ	/daQsju/	ガソリン	/gasoriN/
tape	ロープ	/roRpu/	ランチ	/rancji/
mask	モスク	/mosuku/	ミール	/miRru/
beer	シール	/siRru/	テニス	/tenisu/
bus	ロス	/rosu/	ベル	/beru/
wax	サックス	/saQkusu/	ユーモア	/juRmoa/
guide	サイド	/saido/	コール	/koru/
poster	マスター	/masutaR/	タレント	/tareNto/
belt	ボルト	/boruto/	マーク	/maRku/
eagle	ゴーグル	/goRguru/	リゾート	/rizoRto/
zero	キロ	/kiro/	ミニ	/mini/
bubble	バレル	/bareru/	カット	/kaQto/
bowl	ボトル	/botoru/	タブー	/tabuR/
pipe	パルプ	/parupu/	シネマ	/sinema/
gym	ジン	/ziN/	ビザ	/biza/

Target	Phonologically Similar Prime		Phonologically Dissimilar Prime	
salad	サラミ	/sarami/	シャツ	/sjatu/
shower	シャドー	/sjadoR/	フライト	/huraito/
sensor	センサス	/seNsasu/	デジタル	/dezitaru/
coin	コイル	/koiru/	リレー	/rireR/
tile	タイヤ	/taija/	マッチ	/maQcji/
brand	ブラッド	/buraQdo/	ピストル	/pisutoru/
veil	ベース	/beRsu/	ルアー	/ruaR/
fork	フォーム	/foRmu/	アナログ	/anarogu/
shock	ショット	/sjoQto/	リサーチ	/risaRcji/
pin	ピル	/piru/	カー	/kaR/
gum	ガス	/gasu/	キー	/kiR/
tree	ツアー	/tuaR/	プラン	/puraN/
dress	プレス	/puresu/	シェア	/sjea/
couple	アップル	/aQpuru/	リタイア	/ritaia/
bed	キッド	/kiQdo/	ボイス	/boisu/
care	エア	/ea/	ヨガ	/joga/
best	ペスト	/pesuto/	ニーズ	/eNziN/
sound	バウンド	/bauNdo/	アイデア	/aidea/
south	マウス	/mausu/	カーブ	/kaRbu/
area	アリア	/aria/	ネール	/neRru/
number	アンバー	/aNbaR/	プラント	/puraNto/
pool	セール	/seRru/	ランク	/raNku/
sample	シンプル	/siNpuru/	マイナー	/mainaR/
course	ピース	/piRsu/	ノズル	/nozuru/
support	リポート	/ripoRto/	オープン	/oRpuN/
balance	トランス	/toraNsu/	ハードル	/haRdoru/
risk	リーク	/riRku/	チキン	/cjikiN/
cover	カヌー	/kanuR/	ジャズ	/zjazu/
film	フォルム	/forumu/	ライバル	/raibaru/
season	シチズン	/sicjizuN/	ブロック	/buroQku/
record	レパード	/repaRdo/	オレンジ	/oreNzi/
short	シュート	/sjuRto/	ベランダ	/beraNda/
cost	コート	/koRto/	バナナ	/banana/
bank	バンド	/baNdo/	ドーム	/doRmu/
trade	トレンド	/rihuto/	シナリオ	/sinario/
hope	ホーン	/hoRN/	ヒント	/hiNto/
type	タイム	/taimu/	アート	/aRto/
line	ライフ	/raihu/	ゲーム	/geRmu/
speech	スピード	/supiRdo/	ユーザー	/juRzaR/
world	ワイルド	/wairudo/	コンテナ	/koNtena/

Target	Phonologically Similar Prime	Phonologically Dissimilar Prime
heart	ハード /haRdo/	シェル /sjeru/

Curriculum Vitae

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EDUCATION

2010 to 2012	University of Western Ontario M.Sc. Psychology, Cognition and Perception
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AWARDS AND SCHOLARSHIP

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CONFERENCE PRESENTATIONS

Ando, E., Jared, D., Hino, Y., Nakayama, M., & Ida, K. (2012, February). *Interlingual phonological priming in Japanese-English bilinguals.* Poster presented at the 41st Annual meeting of Lake Ontario Visionary Establishment Meeting of Minds, Niagara Falls, Ontario, Canada.

Ando, E., Jared, D., Hino, Y., Nakayama, M., & Ida, K. (2012, March). *Interlingual phonological priming in Japanese-English bilinguals.* Talk presented at the Fourth Annual Western Interdisciplinary Student Symposium on Language Research, London, Ontario, Canada.

Ando, E., Jared, D., Hino, Y., Nakayama, M., & Ida, K. (2012, June). *Phonological Priming in Japanese-English Bilinguals: Evidence from Lexical Decision and ERP.* Poster presented at the 22nd Annual Meeting of The Canadian Society for Brain, Behavior and Cognitive Science, Kingston, Ontario, Canada.