Doctoral Dissertation

Masked Morphological Priming with Past-Tense Verbs in the L2: A Study with Japanese-English Bilinguals

(第二言語過去形動詞を用いたマスク下の形態的プライミング --日英バイリンガルを対象とした研究--)

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Masked Morphological Priming with Past-Tense Verbs in the L2:

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Abstract

For first language (L1) English readers, the masked presentation of past-tense verb primes (e.g., looked, fell) facilitates lexical decisions to their present-tense targets (e.g., LOOK, FALL) when compared to orthographically similar (e.g., loose, fill) and unrelated (e.g., master, bank) primes. This type of facilitation based on prime-target morphological relationship is generally considered evidence of morphological connections in the lexicon. However, whether such connections also exist for second language (L2) readers of English is unclear, as previous studies have shown mixed results. Therefore, three experiments were conducted to examine whether morphologically based connections of L2 English are present in the lexicon of readers whose L1 is Japanese and L2 is English (Japanese-English bilinguals). Specifically, the experiments examined whether the masked presentation of past-tense primes facilitates responses relative to orthographic and unrelated control primes for Japanese-English bilinguals. Experiments 1 and 2 examined Japanese-English bilinguals who were relatively proficient in English. Overall, past-tense primes facilitated responses relative to both orthographic and unrelated controls, similar to the pattern typically observed with L1 English readers. Experiment 3 examined Japanese-English bilinguals who were much less proficient in their L2. Past-tense primes facilitated responses compared to unrelated controls but not when compared to orthographic controls. Thus, the facilitation from past-tense primes was likely due to prime-target orthographic similarity rather than morphological relationship. These results suggest that the morphological connections of L2 English have yet to be established for low-proficient Japanese-English bilinguals but are present for relatively proficient Japanese-English bilinguals.

CHAPTER 1:

Introduction

Background

The present study belongs to a branch of psycholinguistic research known as word recognition research. Studies in this field examine how information about words is represented in the lexicon: a mental construct thought to store information about known words, including their orthography, phonology, morphology, and meaning. For monolinguals, this information pertains only to the first language (L1). However, for bilinguals, information for both the L1 and the second language (L2) is stored in the lexicon. Note that the term *bilingual* does not imply the simultaneous acquisition of two languages from birth, an equal degree of competence in the languages, or no knowledge of more than two languages. Instead, the term includes a broader population of language users who have learned to use two (or more) languages within their daily lives. In this view, those typically characterized as second language learners are also bilinguals, thereby making bilingualism the norm rather than an exception (see Grosjean, 2010).

In recent years, studies on the bilinguals' lexicon have become an important part of word recognition research. One question of vital interest is whether bilinguals access representations for the language other than the input language (for a review, see Jiang, 2015). Previous studies have shown that input in either of a bilingual's languages can access representations for both languages; therefore, it is likely that the L1 and L2 lexicons are integrated (for a review, see Dijkstra, 2005).

However, this does not mean that the bilinguals' lexicon is simply a fusion of two (or more) monolingual lexicons. The L2 representations in the bilinguals' lexicon deserve research in their own right (e.g., Bordag, Gor, & Opitz, 2022), as some previous studies have shown that the L2 representations of bilinguals can differ from the L1 representations of monolinguals for the same language (see, e.g., Jiang, 1999; Nakayama & Lupker, 2018; Witzel & Forster, 2012). Differences could arise because of the bilinguals' L1 influencing the representations, their structure, and processing in the L2; the bilinguals' development of incomplete or premature representations in the L2; fundamental differences in the underlying mechanisms for storing and processing the L1 versus the L2; or a combination of these factors.

This study focused on morphological information for L2 English in the bilinguals' lexicon. Specifically, the study examines whether there are connections for the morphological relationship between past- and present-tense verbs[1]. The English language has regular verbs and irregular verbs. Regular verbs (e.g., walk) have past-tense forms that end with the letters "-ed." Most verbs in English are regular verbs, and their past-tense forms (e.g., walked) are formed through a relatively simple set of rules that might involve making minimal changes to the stem (i.e., sometimes the final "y" is changed to an "i" or the final consonant is doubled) and adding "-d" or "-ed." Irregular verbs (e.g., drive) are an idiosyncratic subset of verbs that cannot form their past tense through these rules. Instead, past-tense forms of irregular verbs (e.g., drove) are typically formed by changing the verb stem. This study examined whether there are connections for the L2 morphological relationship between regular and irregular past- and present-tense English verbs in the bilinguals' lexicon.

The Lexicon

In this dissertation, a connectionist view of the lexicon is taken: the lexicon is a network of representations that encode information relating to words like orthography, phonology, morphology, and meaning. Visual input of a word (e.g., boil) activates representations that encode abstract letter information (e.g., "b", "B" and "o", "O") and their position in the word. In localist models (e.g., Dijkstra & van Heuven, 2002; McClelland & Rumelhart, 1981; see Figure 1 for a simplified structure of the Interactive Activation Model), these representations feed into the activation of representations for whole words (e.g., boil). Representations at this level of the lexicon are sometimes termed lexical-level or word-level representations. In distributed models, there are no lexical-level representations. Orthographic information about words is encoded in the activation patterns of distributed representations (e.g., Seidenberg & McClelland, 1989).

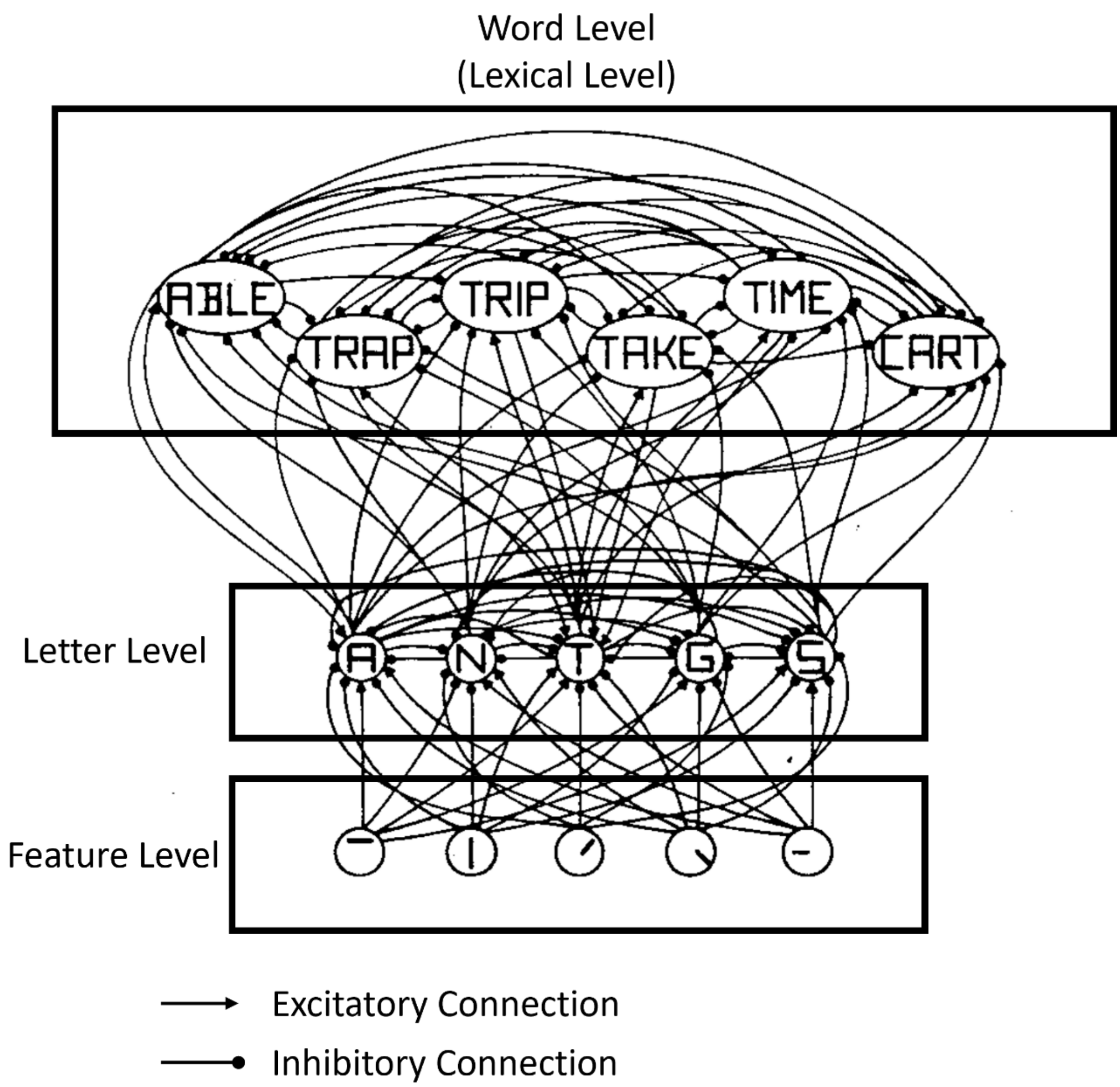

Figure 1. The Interactive Activation Model

The figure is adapted from Figure 3 of McClelland and Rumelhart (1981, p. 380). It is a simplified illustration of the Interactive Activation Model, which is a localist connectionist model. The figure shows connections between some letter level representations which share features with the letter T in the first position of a word and their connections to feature- and word-level representations. Feature-level representations encode the visual features which make up letters. Connections between representations can be excitatory or inhibitory. While excitatory connections add to the activation level of representations, inhibitory connections decrease the level of activation.

A localist connectionist view of the lexicon, similar to that of Crepaldi et al. (2010), is adopted when discussing the results of this study. However, note that whether words are represented locally or in a distributed manner depends on how one defines the lexical level and its words. This means that the degree of dispersion for representations in the lexicon is a relative concept that depends on how one defines a unit. In this sense, discussions based on the localist view in this dissertation may be interpreted as a somewhat simplified model of the lexicon by proponents of a more distributed lexicon (for similar reasoning, see Taft, 2003).

Masked Priming Lexical Decision Experiments

All experiments conducted in this study used the masked priming paradigm (Forster & Davis, 1984) in a lexical decision task. Although some previous studies with L1 readers have used overt priming techniques (e.g., Fowler, Napps, & Feldman, 1985; Stanners, Neiser, Hernon, & Hall, 1979), masked priming (Forster & Davis, 1984) is increasingly becoming the preferred method for examining morphological connections in the lexicon (e.g., Crepaldi et al., 2010; Pastizzo & Feldman, 2002; Silva & Clahsen, 2008). This is because masked priming is thought to tap into relatively early stages of word processing with arguably small influences from episodic and strategic factors (e.g., Forster, 1998; Forster & Davis, 1984).

In masked priming lexical decision experiments (e.g., Forster & Davis, 1984), researchers record the speed and accuracy (i.e., response latency and error rate) with which participants respond if a target is a word or nonword. An equal number of word and nonword targets are prepared in experiments to avoid participants making strategic responses to targets. At the beginning of each trial, participants are presented with a fixation point (i.e., “+”) directing their attention to the center of a screen. Following the fixation point, a forward mask (e.g., #####) is presented for a recognizable duration (e.g., 500 ms). Then, a prime with or without a relationship (e.g., orthographic, morphological, semantic) to the target is presented very briefly (typically 40-60 ms) in lower-case letters. The target is presented immediately after the prime in upper-case letters. It is standard procedure to present the prime in lower-case letters and the target in upper-case letters to avoid visual overlap between the prime and target.Thus, the target also functions as a backward mask. This presentation sequence, together with the brief prime duration, prevents participants from intentionally using any information of the prime when responding to targets. The target remains on screen till a response is made or a preset time duration elapses. An example of a trial sequence in a masked priming lexical decision experiment is shown in Figure 2.

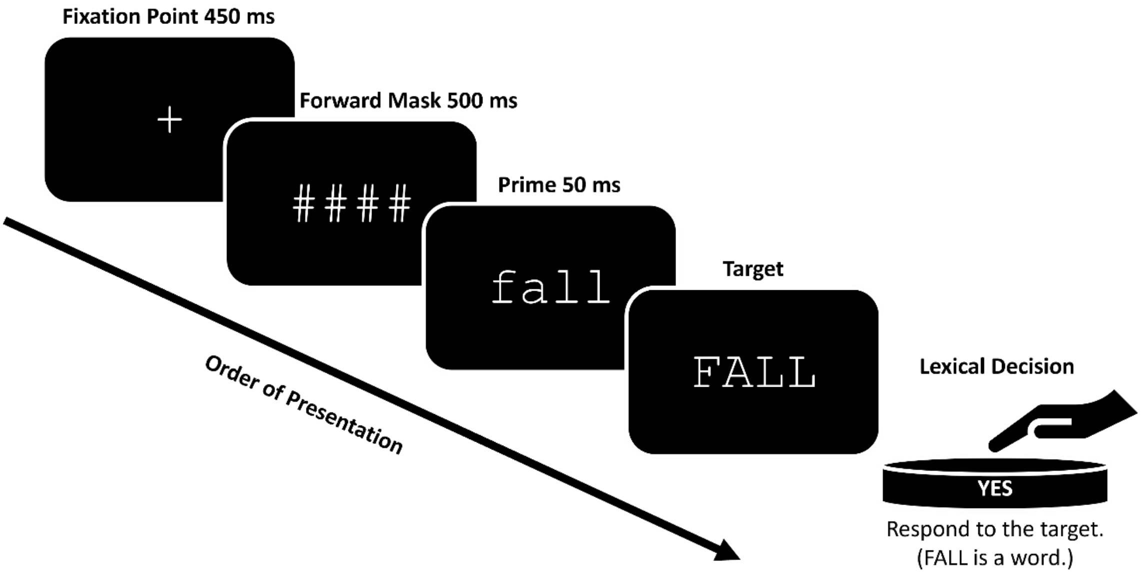

Figure 2. A Trial in a Masked Priming Lexical Decision Experiment.

The figure shows an example of a trial in a typical masked priming lexical decision experiment. A fixation point is presented at the beginning of each trial, followed by the presentation of a forward mask. The forward mask is then replaced by a prime which is presented for a very brief duration (50 ms in this example) in lower-case letters. The target is presented immediately after the prime in upper-case letters. Participants are requested to make lexical decisions for the target as fast and accurately as possible. In the figure, "FALL" is a word. Therefore, participants should respond by pressing a YES button. (Is "FALL" a word?—Yes, it is.)

When the presentation of related primes affects the latencies or error rates of responses to the target words compared to when control primes are presented, the difference in the two conditions is called a priming effect (see Figure 3). Priming effects are thought to result when the representations of the prime and target are shared or connected in the lexicon. They can either facilitate (i.e., speed up) or inhibit (i.e., slow down) the time it takes to respond to the target (i.e., latency).

For instance, (A) of Figure 3 shows an inhibitory priming effect observed by Davis and Lupker (2006). The prime-target pairs in the related condition have an orthographic relationship (e.g., axle-ABLE): all letters but one is the same and in the same position. Such word pairs are generally called orthographic neighbors (see Coltheart, Davelaar, Jonasson, & Besner, 1977). The prime-target pairs in the control condition, on the other hand, are unrelated (e.g., thug-ABLE): there is no orthographic, morphological, or semantic relationship. As the masked presentation of orthographically related primes slowed down the time it took participants to respond to the targets, it is likely that there are inhibitory connections between the prime and target representations for orthography.

A facilitatory priming effect observed by Pastizzo and Feldman (2002) is shown in (B) of Figure 3. The prime-target pairs in the related condition have a morphological relationship (e.g., fell-FALL): they are the same verb in the past- and present-tense forms. The prime-target pairs in the control condition serve as an orthographic baseline (e.g., fill-FALL): there is no morphological or semantic relationship, but the prime-target pairs are just as orthographically similar as in the related condition. As the masked presentation of morphologically related primes sped up the time it took participants to respond to the targets, it is possible that there are excitatory connections or shared representations between the prime and target representations for morphology.

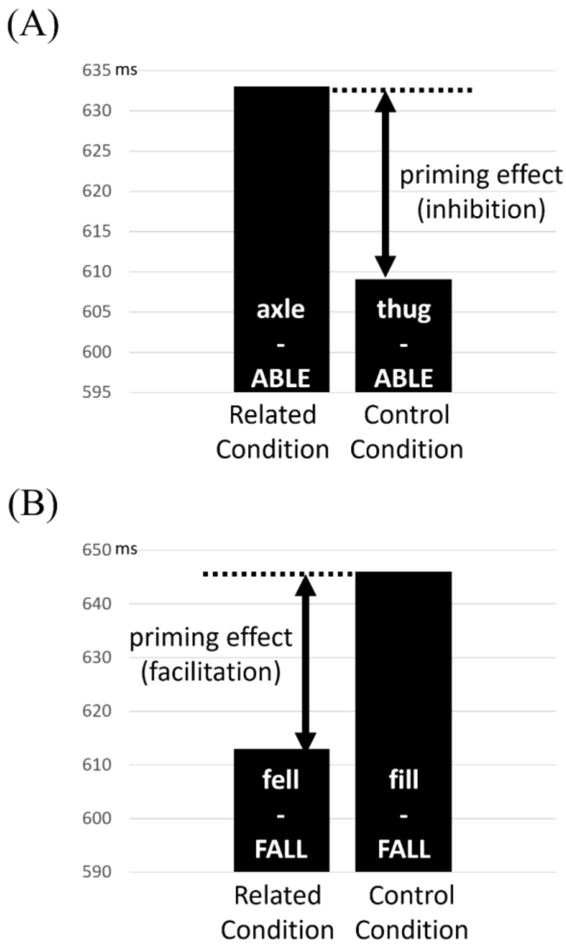

Figure 3. Priming Effects in Masked Priming Lexical Decision Experiments

The figure shows the latencies to some experimental conditions from masked priming lexical decision experiments conducted by Davis and Lupker (2006) and Pastizzo and Feldman (2002).

The latency for the related condition in (A) is the average of high- and low-frequency related word primes for word targets in Table 1 of Davis and Lupker (2006, p. 673). The latency for the control condition in (A) is the average of high- and low-frequency unrelated word primes for word targets of the same table.

The latency for the related condition in (B) is taken from the morphological condition of the irregular high overlap verb targets in Table 2 of Pastizzo and Feldman (2002, p. 247). The latency for the control condition in (B) is taken from the orthographic control condition of irregular high overlap verb targets in the same table.

The most robust priming effect in masked priming lexical decision experiments is observed with a repetition condition. Repetition primes have the ultimate relationship with targets because the primes are identical to the targets. Studies involving both L1 and L2 readers have shown that the masked presentation of repetition primes facilitates lexical decisions to words compared to when unrelated control primes are presented (e.g., Forster & Davis, 1984; Gollan, Forster, & Frost, 1997; Nakayama & Lupker, 2018; Silva & Clahsen, 2008). For example, in Silva and Clahsen (2008), L1 English readers, Chinese-English bilinguals, and German-English bilinguals made lexical decisions to regular verb targets. When these targets were preceded by the masked presentation of repetition primes (e.g., boil-BOIL) and unrelated primes (e.g., jump-BOIL), participants responded faster to the repetition condition. Note that the prime is presented in lower-case letters while the target is presented in upper-case letters as per the standard procedure of masked priming lexical decision experiments. If the prime and target were presented in the same case, there would be no visual distinction between the repetition primes and targets.

In a localist connectionist view, facilitatory priming effects, such as the repetition priming effect, are interpreted as the result of activation spreading and persisting in the lexicon. Visual input of a repetition prime (e.g., boil) induces activation of abstract letter-level representations for the word. These representations eventually feed into the activation of a lexical-level representation, though they may first feed into morpho-orthographic representations depending on the model (e.g., Crepaldi et al., 2010). Given enough processing time (i.e., SOA: stimulus onset asynchrony), activation for the prime should spread beyond the lexical level to representations for morphology and semantics (see Kielar, Joanisse, & Hare, 2008; Rastle, Davis, Marslen-Wilson, & Tyler, 2000). As the target word (e.g., BOIL) is presented immediately after the repetition prime, its representations in the lexicon are in a pre-activated state. This pre-activation is thought to shorten the time required for the target representation's activation to reach a recognition threshold, speeding up lexical decisions.

Models for Morphological Processing

The morphological relationship between past- and present-tense English verbs has been the focus of much research due to its theoretical implications. One disagreement among morphological processing models is related to whether past-tense forms are processed differently based on their regularity (for a review, see Feldman & Weber, 2012; Marslen-Wilson, 2007; Milin, Smolka, & Feldman, 2018). In what follows, a brief explanation of the dual-mechanism and single-mechanism views is provided.

Dual-Mechanism Models

In a branch of morphological processing models known as dual mechanism models, past-tense forms can be processed by two different cognitive mechanisms based on their regularity (see Pinker, 1991; for a summary, see Pinker & Ullman, 2002; see also Silva & Clahsen, 2008). These models posit the involvement of a rule-based mechanism that parses regular past-tense forms (e.g., walked = walk + -ed) via the application of morpho-syntactic rules (e.g., verb stem + regular past-tense suffix; see Figure 4). Hence, regular past-tense forms do not need to be represented as a whole (e.g., walked) in the lexicon. Meanwhile, irregular past-tense forms (e.g., fell) are thought to be represented in the lexicon and connected to their present-tense representations (e.g., fall).

The Declarative/Procedural (DP) model (e.g., Ullman, 2001) is one example of a dual mechanism account of morphological processing. Two types of memory systems are assumed in this model: declarative memory and procedural memory. Declarative memory stores information about words, such as their meaning, while procedural memory handles rule-based processing, such as grammar. More generally, the former is thought to store explicit information, whereas the latter is used for implicit procedures. The model's conception was influenced by findings from patients with brain lesions (Ullman et al., 1997). Patients with impairments of declarative memory show more difficulty in producing correct past-tense forms for irregular than regular verbs. On the other hand, patients with impairments of procedural memory have more difficulty producing regular past-tense forms.

Though the model can be understood as a neural explanation for the theory in Pinker (1991), it puts forward an interesting proposition for late L2 readers. According to the DP model, late L2 readers are likely to rely on declarative memory for the processing of regular past-tense verbs, whereas L1 readers are likely to rely on procedural memory (Ullman, 2001). The implication, in terms of representations in the lexicon (i.e., declarative memory), is that late L2 readers need representations for regular past-tense verbs as they cannot be accessed as their present-tense forms. For L1 readers, representations for regular past- and present-tense verbs are identical, with perhaps the exception of some high-frequency regular past-tense verbs. A more recent summary of the DP model and its implications for bilinguals, however, can be found in Morgan-Short and Ullman (2022).

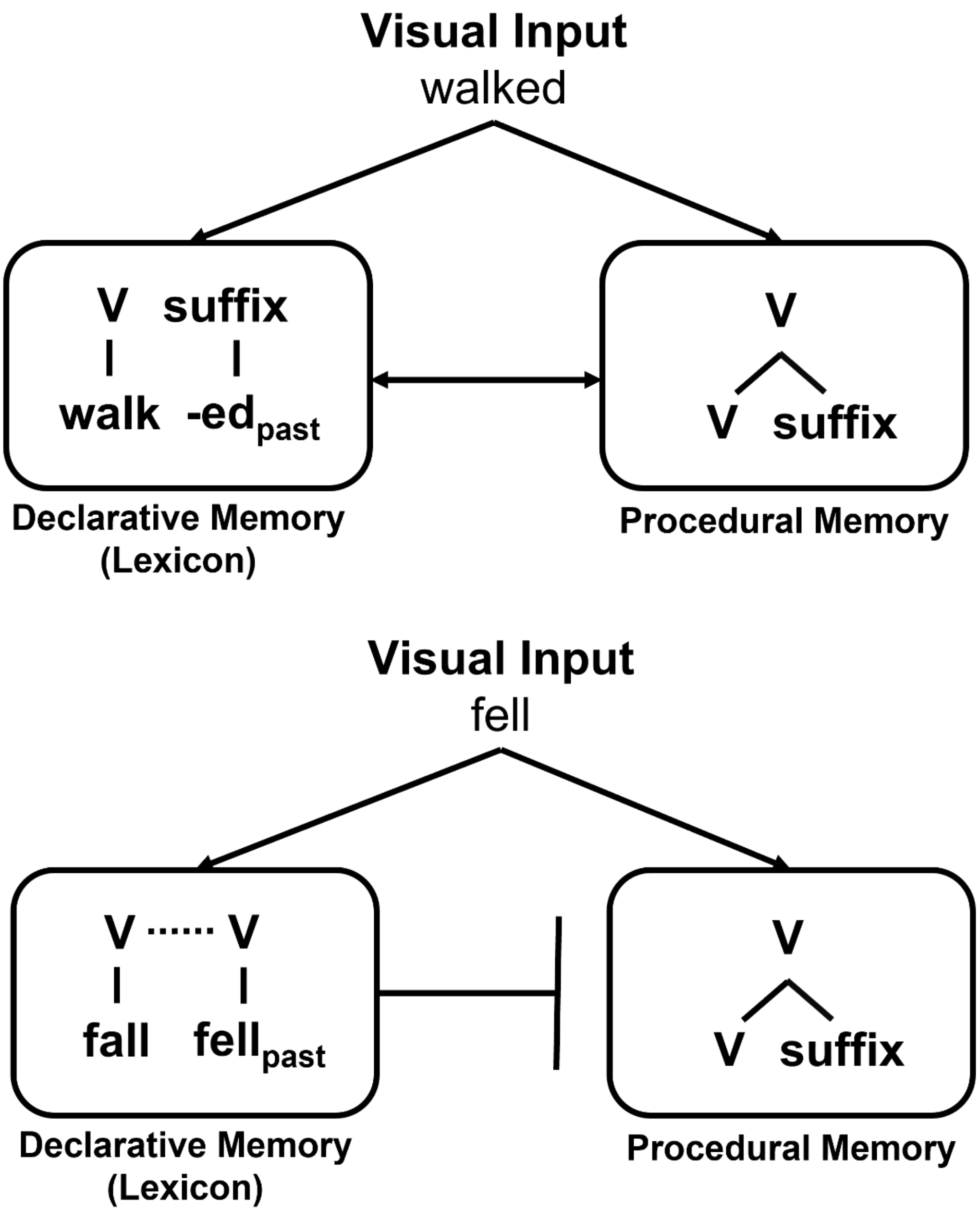

Figure 4. The Declarative/Procedural Model

The figure is a simple illustration of the Declarative/Procedural Model created by the author based on Figure 1 of Pinker and Ullman (2002, p. 457). Representations of regular past-tense forms such as "walked" are not found in the lexicon. Thus, they are decomposed by procedural memory into their stems (e.g., walk) and suffixes (e.g., -ed). In this way, the representations for the stem may be accessed in the lexicon. Representations of irregular past-tense forms such as "fell" are found in the lexicon and are connected to their present-tense (root) representations. They cannot be decomposed by procedural memory.

Single Mechanism Models

Another branch of models can be categorized as single-mechanism models. Models in this group do not posit the involvement of different cognitive mechanisms. Some of them propose that morphological relationships in the lexicon are not represented explicitly but are formed through an interaction of connections related to shared information such as orthography, phonology, and semantics (for a summary, see McClelland & Patterson, 2002; see also Kielar, Joanisse, & Hare, 2008; Pastizzo & Feldman, 2002). Others suggest that explicit representations related to the morphological structure of words exist (e.g., Crepaldi et al., 2010; Taft, 2003). In either case, a single cognitive mechanism (the lexicon) processes regular and irregular past-tense forms.

The model proposed by Crepaldi et al. (2010) is one example of a single mechanism account of morphological processing (see Figure 5 and Figure 6). It was proposed to explain priming effects observed with regular (e.g., hatched-HATCH, Pastizzo & Feldman, 2002) and irregular inflectional morphology (e.g., fell-FALL, Pastizzo & Feldman, 2002), derivational morphology (e.g., cleaner-CLEAN, Rastle, Davis, & New, 2004), and morpho-orthographic structure (e.g., corner-CORN, Rastle et al., 2004) by building on the work of Taft (2003). The model consists of three levels: the morpho-orthographic segmentation level, the lexical level (termed the orthographic lexicon), and the lemma level.

At the morpho-orthographic segmentation level, visual input of regular past-tense forms (e.g., hatch + -ed), derivational words (e.g., clean + -er), and words with morpho-orthographic structure (e.g., corn + -er) activate their constituent representations. Irregular past-tense forms cannot be decomposed based on their morpho-orthographic structure and have a single representation (e.g., fell). Thus, regular past- and present-tense verbs, derived words and their stems, and morpho-orthographically structured words and their pseudo-stems share representations at this level. Irregular past- and present-tense verbs do not. Also note that morpho-orthographic representations do not exist for non-morphological letter clusters (e.g., -el in brothel).

The lexical level (orthographic lexicon) is where whole word representations exist. Word representations at this level are activated via their connections with representations of the words' morpho-orthographic constituents. Thus, regular past-tense verbs have two representations at this level (e.g., hatch, hatched), as do derived words (e.g., clean, cleaner) and words with morpho-orthographic structure (e.g., corn, corner), with one of the two representations (e.g., hatch, clean, corn) shared with their present-tense, stem, and pseudo-stem forms, respectively. Lexical-level representations for irregular past-and present-tense verbs are not shared. Note that representations at this level are necessary to distinguish between existing inflected words (e.g., falls) and ill-formed words (e.g., falled). In this model, lexical decisions are made when the activation of representations at this level reaches a recognition threshold.

Representations at the lemma level act as an abstract heading for inflectional relationships. Thus, past- and present-tense verbs share the same representation at this level regardless of their inflectional regularity. Derived words and words with morpho-orthographic structure do not share representations with their stems or pseudo-stems at this level. As a result, "cleaner" should prime "clean" just as much as "corner" primes "corn" (e.g., Rastle et al., 2004): their representations are shared similarly at the morpho-orthographic and lexical level. Past-tense verbs like "fell" and "hatched" should prime their present-tense verbs “fall” and “hatch” (e.g., Pastizzo & Feldman, 2002): they are connected at the lemma level. In fact, regular past- and present-tense verbs share representations at not only the lemma level but also the lexical level. A prediction of this model, then, is that the size of priming effects for regular verbs (e.g., hatched-HATCH) should be larger than those for irregular verbs (e.g., fell-FALL).

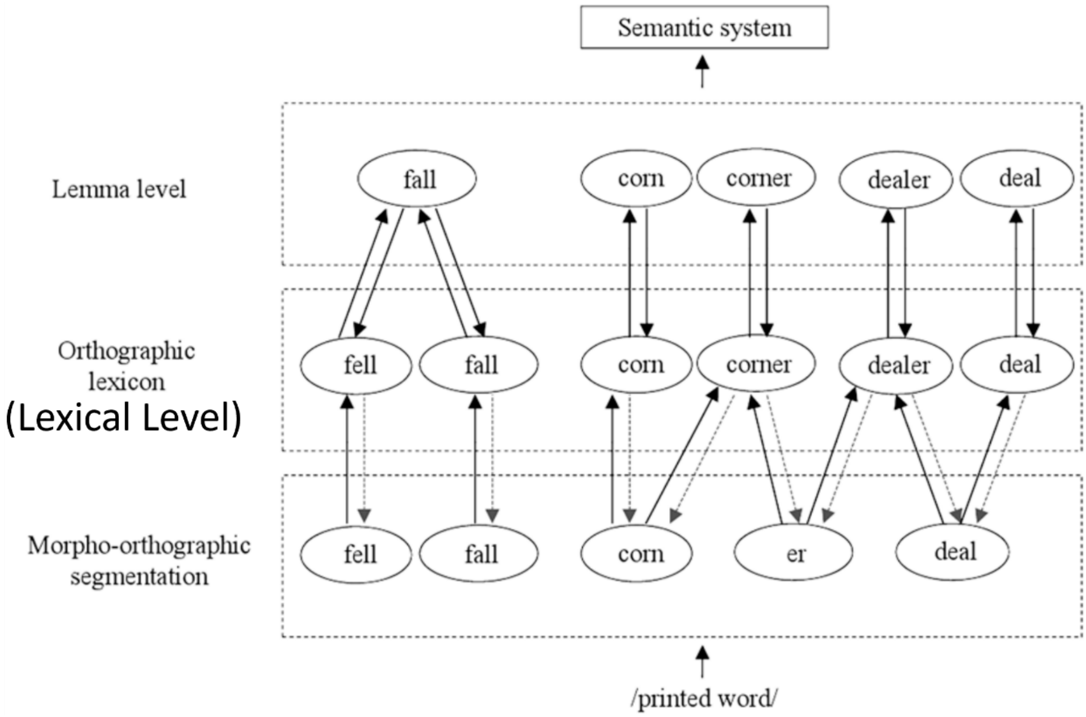

Figure 5. Crepaldi et al.'s (2010) Model

The figure is adapted from Figure 1 of Crepaldi, Rastle, Coltheart, and Nickels (2010, p. 93). The bold arrows indicate excitatory connections between the representations. The dashed arrows indicate where feedback from the lexical level to the morpho-orthographic segmentation level may occur. Irregular past-tense verbs (e.g., fell) cannot be decomposed into their stems in a similar fashion to derived words (e.g., dealer) and words that have morpho-orthographic structures (e.g., corner). Thus, the figure shows separate morpho-orthographic representations for irregular past-tense (e.g., fell) and present-tense (e.g., fall) verbs. These representations activate their respective lexical-level representations and are connected through a shared representation at the lemma level.

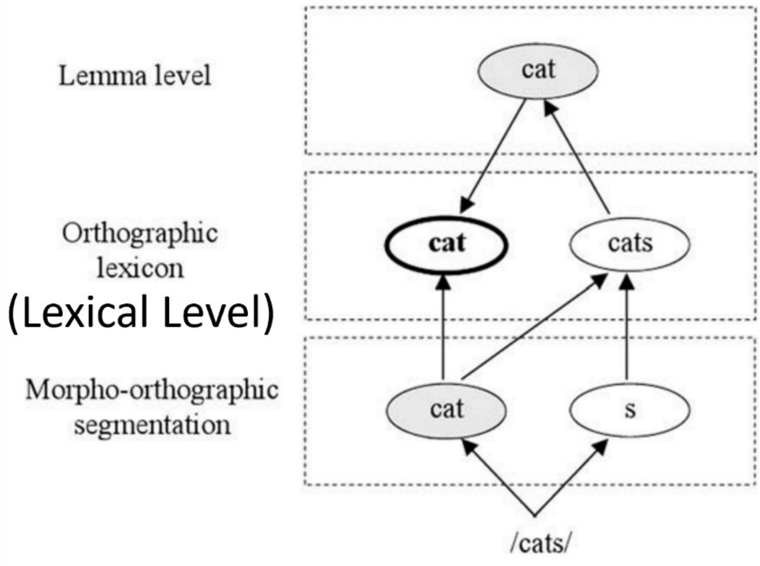

Figure 6. Regular Inflections in Crepaldi et al.'s (2010) Model

The figure is adapted from Figure 2 of Crepaldi, Rastle, Coltheart, and Nickels (2010, p. 95). Regularly inflected words, such as “walked” and “cats”, are first decomposed into their morphological constituents. These representations are likely to be connected to lexical-level representations in the same manner as derived words and words with morpho-orthographic structures. Note, however, that representations for regularly inflected words (e.g., cat-cats, walk-walked) are connected by a shared representation at the lemma level. Derived words and words with morpho-orthographic structures, on the other hand, do not share a representation at this level.

The Position Taken in the Present Study

The current study did not aim to examine which type of model, a dual-mechanism model, or a single mechanism model, is better for explaining morphological priming effects with L1 English readers. Therefore, it does not add to the debate among these different types of morphological processing models. When discussing the results, however, a single-mechanism view similar to that described by Crepaldi et al. (2010) is assumed. This choice was made for two reasons. First, there was no evidence from the experiments in the present study to favor a dual mechanism view over a single mechanism view. One mechanism, the connectionist lexicon, can explain the results. Therefore, it was unnecessary to complicate the picture by adding another mechanism. Second, the single mechanism view appears to be prevalent in the recent masked priming lexical decision literature that obtained similar results to the present study (Feldman, Kostić, Basnight-Brown, Đurđević, & Pastizzo, 2010; Viviani & Crepaldi, 2022; Voga, Anastassiadis-Syméonidis, & Giraudo, 2014).

Morphological Connections between Past- and Present-Tense Verbs in L1 English

Notwithstanding the ongoing debate on how past-tense forms are processed, priming effects from regular and irregular past-tense primes have been observed reliably among L1 English readers in masked priming studies, suggesting that morphological connections between the past- and present-tense verbs exist in the lexicon. Forster, Davis, Schoknecht, and Carter (1987) were among the first to observe morphological priming effects in a masked priming study for L1 English readers. In their study, the latencies to word targets (e.g., KEEP) were compared for instances that were preceded by primes related by irregular inflection (e.g., kept), repetition primes (e.g., keep), and primes unrelated to the targets (e.g., navy). Primes were presented for a brief duration of 60 ms, and participants performed the lexical decision task by pressing one of two buttons corresponding to YES or NO. Nonword targets (e.g., NORB) were also included in the experiment for the NO responses. The results showed that participants responded to word targets (e.g., KEEP) significantly faster (by 36 ms) when preceded by morphologically related primes (e.g., kept) instead of unrelated primes (e.g., navy). This effect was as large as the priming effect (37 ms) when latencies to repetition primes (e.g., keep) were compared to unrelated primes (i.e., repetition priming effect).

Similar results were obtained for L1 English readers by Silva and Clahsen (2008), who applied a prime duration of 60 ms and found that responses to regular present-tense verb targets (e.g., BOIL) were faster (by 55 ms) when preceded by past-tense primes (e.g., boiled) instead of unrelated primes (e.g., jump). As in Forster et al.'s (1987) experiment, this morphological priming effect was as large as the repetition priming effect (67 ms). Because the repetition priming effect is theoretically the strongest priming effect possible, the equivalent sizes of priming effects indicate robust connections between the representations for past- and present-tense verbs.

Experiments have confirmed that the facilitatory effect of past-tense primes is morphological and not due to the orthographic similarity between the past- and present-tense verb forms. In English, past-tense verbs tend to have a high degree of formal overlap with their present-tense forms (and vice versa). Hence, a morphological condition may be compared to an orthographic control condition to ensure that the morphological priming effect does not originate in the formal overlap.

Pastizzo and Feldman (2002) compared latencies for irregular and regular targets preceded by their past-tense forms (e.g., hatched-HATCH, fell-FALL, taught-TEACH) to latencies for targets preceded by orthographic control primes that mimicked the orthographic overlap between targets and their past-tense forms (e.g., hatchet-HATCH, fill-FALL, taunts-TEACH). Masked primes were presented for 48 ms. The results showed morphological priming effects for irregular verbs with the same length between past- and present-tense forms (e.g., fell-FALL vs. fill-FALL; a 33-ms effect) and for regular verbs (e.g., hatched-HATCH vs. hatchet-HATCH; a 44-ms effect).

Morphological priming effects relative to an orthographic baseline were also observed by Crepaldi et al. (2010), who examined English irregular verbs (e.g., FALL) among L1 readers. In their experiment, which had a 42-ms prime duration, irregular past-tense primes (e.g., fell-FALL) facilitated lexical decisions when compared to orthographic control primes (e.g., full-FALL). Therefore, the morphological priming effects observed with past-tense verbs for L1 English readers are not due to a simple orthographic similarity between the past- and present-tense verbs; instead, they are due to connections in the lexicon based on the prime-target morphological relationship.

To recapitulate, in masked priming lexical decision studies with L1 English readers, latencies to both regular and irregular present-tense verb targets (e.g., HATCH, FALL) are sped up when these targets are preceded by a brief masked presentation of their past-tense forms (e.g., hatched-HATCH, fell-FALL). Such priming effects have been measured against an unrelated baseline condition (e.g., phantom-HATCH, pair-FALL) and an orthographic baseline condition (e.g., hatchet-HATCH, fill-FALL) and are thought to reflect connections between past-tense and present-tense verbs in the lexicon.

Latencies to a past-tense condition can also be compared to those of a repetition condition (e.g., hatch-HATCH, fall-FALL), allowing researchers to make inferences about the strength of connections between past- and present-tense verbs. Finally, the matter of precisely how past-tense forms are represented and processed by L1 English readers is still heavily debated; however, the present study does not address this topic in depth.

Morphological Connections between Past-and Present-Tense Verbs in L2 English

Researchers have examined whether English morphological relationships are represented similarly for L2 and L1 English readers. However, previous masked priming lexical decision studies have shown mixed results. Some studies have observed similar priming patterns among L2 and L1 readers (e.g., Feldman et al., 2010; Voga et al., 2014), suggesting that English morphological connections in the bilinguals' lexicon are similar to those in the monolinguals' lexicon. However, other studies did not observe similar priming patterns among L2 and L1 readers (e.g., Clahsen, Balkhair, Schutter, & Cunnings, 2013; Silva & Clahsen, 2008), suggesting that morphological connections in English similar to those of L1 readers may not be present in the bilinguals' lexicon.

Silva and Clahsen (2008) were among the first to observe different priming patterns between L2 and L1 English readers. When regular verb targets were preceded by masked presentations of past-tense forms (e.g., boiled-BOIL), Chinese-English and German-English bilinguals showed no significant priming effects when compared with an unrelated baseline condition (e.g., jump-BOIL). As discussed above, L1 English participants performing the same task showed a significant priming effect (55 ms), which was not statistically different from the repetition priming effect (e.g., boil-BOIL vs. jump-BOIL; 67 ms). For bilinguals, however, latencies in the repetition condition were significantly faster than in the morphological condition (646 ms vs. 757 ms for Chinese-English bilinguals, 553 ms vs. 618 ms for German-English bilinguals). Furthermore, latencies to the morphological condition did not differ statistically from the unrelated baseline condition (757 ms vs. 730 ms for Chinese-English bilinguals; 618 ms vs. 612 ms for German-English bilinguals). Therefore, it was suggested that L2 English readers process regular past-tense verbs differently than L1 English readers.

Clahsen et al.'s (2013) study on Arabic-English bilinguals shows that the different patterns of priming between L2 and L1 English readers cannot be explained by L2 readers requiring more time to process the masked primes. This study used the same stimuli as Silva and Clahsen (2008), but there were two versions of the experiment. The first version followed the standard experimental procedure of masked priming lexical decision experiments by presenting the target immediately after the prime. The prime duration was 60 ms, just as in Silva and Clahsen (2008). The second version introduced a temporal delay by inserting a blank screen for 200 ms immediately after the prime. This way, participants had more time to process the masked primes. Both versions of the experiment showed results similar to those of Silva and Clahsen (2008): latencies to the past-tense condition (e.g., boiled-BOIL) did not differ significantly from latencies to the unrelated condition (e.g., jump-BOIL).

Results similar to Silva and Clahsen's (2008) have also been obtained for L1 and L2 readers of languages other than English, adding to the evidence supporting the processing difference between monolinguals and bilinguals (e.g., Jacob, Heyer, & Veríssimo, 2018; Kirkici & Clahsen, 2013; Neubauer & Clahsen, 2009). This difference has typically been attributed to the somewhat weaker rule-based processing of the L2 compared to the L1 (see Clahsen & Felser, 2006a; Clahsen & Felser, 2006b, 2018; Clahsen, Felser, Neubauer, Sato, & Silva, 2010).

However, some studies have found similar priming patterns between L1 and L2 English readers. For instance, Voga et al. (2014), using the same critical stimuli as Silva and Clahsen (2008), showed that Greek-English bilinguals made lexical decisions significantly faster (by 66 ms) when regular past-tense primes were presented compared to when unrelated primes were presented (e.g., boiled-BOIL < jump-BOIL). The priming effect from past-tense primes was also as large as the repetition priming effect (e.g., boil-BOIL < jump-BOIL; 54 ms). Silva and Clahsen (2008) observed the same pattern of priming among L1 English readers. Therefore, it is likely that there are robust connections between regular past- and present-tense verbs of L2 English.

Feldman et al. (2010) also observed similar patterns between L1 and L2 English readers. They conducted an experiment with Serbian-English bilinguals using the same material as Pastizzo and Feldman (2002). Items to which the bilinguals had low response accuracies were removed from both the L1 and L2 readers' data before the results were compared. When the priming effects were measured against an orthographic control condition, regular past-tense primes produced significant priming effects (e.g., billed-BILL < billion-BILL) for both L1 English readers (42 ms) and Serbian-English bilinguals (23 ms). Thus, there was no evidence that rule-based processing was weaker in the L2 than in the L1, and regular past- and present-tense verbs were likely to be connected similarly in the lexicon for both L1 English readers and Serbian-English bilinguals.

For irregular verbs, the comparison between L1 English readers and Serbian-English bilinguals was somewhat unclear. Irregular verbs with the same length between past- and present-tense forms (e.g., fell-FALL) did not show a significant priming effect relative to orthographic controls (e.g., fill-FALL) for the Serbian-English bilinguals (a 3-ms effect). For the L1 English readers in Pastizzo and Feldman (2002), this comparison showed a significant priming effect (e.g., fell-FALL < fill-FALL; 33 ms). When the items with low response accuracies in the Serbian-English bilinguals' experiment were also removed from the L1 dataset, however, the priming effect was only significant for the subject analysis (a 20-ms effect).

Although it is unknown what factors caused the discrepant results with L2 English readers, one possible source of the mixed results is the baseline against which priming patterns from past-tense primes were measured. As discussed above, some studies have used unrelated primes as the baseline for measuring priming effects from past-tense primes, while others have also used primes that are orthographically similar to past-tense primes. The orthographic similarity between primes and their targets generally has inhibitory effects for L1 readers (e.g., Davis & Lupker, 2006; Nakayama, Sears, & Lupker, 2008; Segui & Grainger, 1990). For L2 readers, however, a growing body of evidence suggests that prime-target similarity has a facilitatory effect (e.g., Diependaele, Duñabeitia, Morris, & Keuleers, 2011; Heyer & Clahsen, 2015; but see Bijeljac-babic, Biardeau, & Grainger, 1997). Different-script bilinguals, in particular, can show facilitatory effect for prime-target orthographic overlap in their L2 (Jiang, 2021; Kida, Barcroft, & Sommers, 2022; Nakayama & Lupker, 2018; Qiao & Forster, 2017).

Hence, the inclusion of an orthographic baseline is critical when testing bilinguals. Priming from past-tense primes should be measured against both an orthographic and unrelated baseline to ensure that the priming effect is due to morphological relationships rather than prime-target orthographic similarity (e.g., Pastizzo & Feldman, 2002; Voga et al., 2014; see Ciaccio & Jacob, 2019 for a similar discussion with overt priming).

Another possible source of the discrepant results across experiments is differences in participants' L2 proficiency levels. For example, as discussed above, Feldman et al. (2010) found significant priming effects from regular past-tense primes relative to both orthographic and unrelated controls (e.g., billed-BILL < billion-BILL; careful-BILL). However, when the data were separated for L2 proficiency level, a facilitatory priming effect was found only for high-proficiency bilinguals. Past-tense primes did not facilitate responses for low-proficient bilinguals, which is similar to the result reported by Silva and Clahsen (2008).

Therefore, a certain degree of proficiency in the L2 may be required for morphological relationships to be observed. However, whether the bilinguals in Silva and Clahsen's (2008) study were less proficient in English than those in Feldman et al.'s (2010) study is unknown. Participant variables, such as the age of acquisition of the L2 (e.g., Veríssimo, Heyer, Jacob, & Clahsen, 2018; see also Bosch, Veríssimo, & Clahsen, 2019) and L1 background (e.g., see Portin et al., 2008) should also be considered when comparing studies, as they may affect L2 morphological processing.

To summarize, there is a debate on whether the L2 English readers' lexicon contains morphological connections between past- and present-tense English verbs that are similar to those in the L1 English readers' lexicon. Some studies have shown that past-tense verbs do not prime present-tense targets for L2 readers; this result differs from the priming pattern observed for L1 readers, suggesting that bilingual readers do not form similar morphological connections as L1 readers.

However, some studies have observed that past-tense primes facilitate target recognition for bilinguals. While measures must be taken to ensure that the facilitatory effect is due to the prime-target morphological relationship, this pattern of priming is the same as that observed with L1 readers. This outcome suggests that L2 morphological connections in the bilinguals' lexicon are similar to L1 morphological connections in the monolinguals' lexicon. Two possible sources for the mixed results have been discussed: the baseline against which priming effects are measured and the participants' L2 proficiency level. These two factors were considered in the present study, which investigated whether priming patterns for L2 past-tense primes are similar to those observed among L1 English readers.

The Present Study

Three experiments were conducted to investigate whether the masked presentation of past-tense verbs facilitates lexical decisions to present-tense targets among Japanese-English bilinguals. The general research question is, "Are morphological connections between past- and present-tense verbs in L2 English observed in Japanese-English bilinguals similar to how the connections in L1 English are observed in monolingual readers?"

To the best of the author's knowledge, there is only one previous study that has examined connections between past- and present-tense English verbs with Japanese-English bilinguals using a masked priming lexical decision experiment. When Silva and Clahsen (2008) examined L1 English readers with a prime duration of 60 ms, regular past-tense forms facilitated responses compared to unrelated primes (e.g., boiled-BOIL vs. jump-BOIL; 55 ms). The size of this priming effect was just as large as that obtained with repetition primes (e.g., boil-BOIL vs. jump-BOIL; 67 ms). Silva and Clahsen (2008) reasoned that one possible explanation for the equivalent sizes of priming is the semantic relatedness between past-tense and present-tense forms rather than their morphological relationship. As priming effects based on semantic relationships are not likely to be observed with short prime durations (e.g., see Forster, Mohan, & Hector, 2003), Silva and Clahsen (2008) examined L1 English readers and Japanese-English bilinguals with a shorter prime duration of 30 ms aiming to replicate their findings from German-English bilinguals, Chinese-English bilinguals, and L1 English readers.

The short prime duration of 30 ms in Silva and Clahsen (2008) could introduce another complication, however. Previous studies with L1 English readers have shown that the size of the priming effect from the formal overlap between prime-target pairs hits a ceiling at prime durations of about 30 ms (e.g., Forster et al., 2003). Therefore, assuming that activation spreads from lower-level to higher-level representations, a 30 ms prime duration may not be enough time for the prime's activation to spread past the lexical level where representations for morphological connections may exist. Furthermore, it is possible that the 30 ms prime duration wasn't long enough for the Japanese-English bilinguals' processing to fully reach the lexical level, as the bilinguals could require more processing time than L1 readers. Thus, while Silva and Clahsen's (2008) comparison between Japanese-English bilinguals and L1 English readers with a 30 ms prime duration mirrored the findings from German-English bilinguals, Chinese-English bilinguals, and L1 English readers with a 60 ms prime duration, it is unclear if Japanese-English bilinguals do not show patterns of priming similar to L1 English readers when given more processing time.

The experiments in the present study examined whether past-tense primes facilitate responses compared to both orthographic control primes and unrelated primes for Japanese-English bilinguals. If they do, then morphological connections similar to those of L1 readers are present in the Japanese-English bilinguals' lexicon. If not, such connections may not be present. A prime duration of 50 ms was used, as this duration is within the range with which priming effects of morphological relationships are typically observed (e.g., Crepaldi et al., 2010; Feldman et al., 2010; Pastizzo & Feldman, 2002).

While the design of all three experiments drew heavily from the previous study by Feldman et al. (2010), the word stimuli were carefully selected in each experiment to better suit the breadth of the participants' English vocabulary. Experiment 1 and Experiment 2 tested bilinguals who were relatively proficient in English to increase the chance of observing priming patterns similar to those of L1 English readers. Experiment 3 tested a group of Japanese-English bilinguals who were less proficient in English than those examined in Experiment 1 and Experiment 2.

CHAPTER 2:

Experiment 1

Introduction

It is unknown whether L2 morphological connections in the bilinguals' lexicon differ from those in the L1 in the monolinguals' lexicon. Results from experiments with English monolinguals have suggested that connections for the morphological relationship between past- and present-tense English verbs exist in the L1 English readers' lexicon (e.g., Forster et al., 1987; Pastizzo & Feldman, 2002; Silva & Clahsen, 2008). Studies have also focused on bilinguals to examine whether similar connections are present in bilingual readers' L2. Some experiments have found similar results between bilinguals and monolinguals (e.g., Feldman et al., 2010; Voga et al., 2014), suggesting that connections for morphological relationships in the L2 are similar to those in the L1 for monolinguals. However, other experiments have not yielded similar results between bilinguals and monolinguals (e.g., Clahsen et al., 2013; Silva & Clahsen, 2008), suggesting that morphological connections in the L2 similar to those in the L1 for monolinguals do not develop for bilinguals.

In Experiment 1, Japanese-English bilinguals who were relatively proficient in English were tested. The objective of the experiment was to examine whether morphological connections similar to those in the L1 English readers' lexicon can be observed through behavioral data patterns similar to those in previous studies examining L1 English readers.

The behavioral data for Experiment 1 were collected in a masked priming lexical decision experiment (Forster & Davis, 1984). In this type of experiment, participants decide whether targets are words (i.e., they make a lexical decision). Each target's presentation is preceded briefly (typically for 40-60 ms) by a prime, which either has or does not have some relationship to the target (e.g., orthographic, morphological, semantic). When this prime-target relationship affects the participants' performance regarding word targets (i.e., response latencies and error rates), a priming effect exists. For example, L1 English readers respond to present-tense verb targets significantly faster when primed by past-tense primes (e.g., kept-KEEP, boiled-BOIL) than when primed with unrelated primes (e.g., shoe-KEEP, jump-BOIL; Forster et al., 1987; Silva & Clahsen, 2008).

Priming effects signify connections between the prime and target words within the lexicon (in the case mentioned above, a morphological connection between the past and present tenses). Stronger priming effects of past-tense primes have also been observed when compared to orthographically similar word primes (e.g., fell-FALL < fill-FALL; billed-BILL < billion-BILL), irrespective of the verb's regularity (Crepaldi et al., 2010; Pastizzo & Feldman, 2002). Therefore, the priming effects in these studies involving past-tense primes reflect that the relationship between past- and present-tense verbs in the L1 English readers' lexicon is morphological and not due to the orthographic similarity between past- and present-tense verbs.

Whether morphological connections similar to those of L1 English readers are present in bilinguals is unclear: Some studies have observed priming patterns similar to L1 readers (e.g., Feldman et al., 2010; Voga et al., 2014), but others have not (e.g., Clahsen et al., 2013; Silva & Clahsen, 2008). Feldman et al. (2010) tested Serbian-English bilinguals and showed that regular past-tense primes facilitated responses compared to unrelated primes (e.g., billed-BILL < careful-BILL). Regular past-tense primes also facilitated responses relative to orthographically similar word primes (e.g., billed-BILL < billion-BILL). Such results demonstrating similar priming patterns between L1 and L2 readers indicate English morphological connections in the L2 English readers' lexicon that are similar to those of L1 readers.

Meanwhile, empirical observations of different priming patterns suggest differences in how English morphology is represented by L1 and L2 readers. For example, Silva and Clahsen (2008) examined Chinese-English and German-English bilinguals and found that regular past-tense primes (e.g., boiled-BOIL) did not prime present-tense verbs when compared to unrelated primes (e.g., jump-BOIL). Similar results have also been obtained by Clahsen et al. (2013) for Arabic-English bilinguals. However, Voga et al. (2014) examined Greek-English bilinguals using the same critical stimuli as Silva and Clahsen (2008) and observed that regular past-tense primes facilitated responses compared to unrelated primes (boiled-BOIL < jump-BOIL). This is the same priming pattern observed by Silva and Clahsen (2008) for L1 English readers. These studies show that even experiments with similar stimuli and designs can yield contradicting results.

Although the reason for the mixed findings with bilingual participants cannot be determined, two potential factors are worth noting. The first possibility is the types of control primes used. Some studies have included only unrelated primes as a control condition. However, priming effects from past-tense primes should be measured against both unrelated and orthographically similar primes (e.g., Pastizzo & Feldman, 2002). For typical L1 readers, prime-target orthographic overlap can inhibit responses (e.g., Davis & Lupker, 2006; Nakayama et al., 2008; Segui & Grainger, 1990). Therefore, the facilitation effect of past-tense primes measured against unrelated primes with L1 readers is not likely due to the high degree of orthographic similarity between past- and present-tense verb forms in English.

For bilinguals, however, it is more difficult to discern if priming effects relative to only an unrelated baseline result from orthographic similarity or morphological relationships. The orthographic similarity between the prime and target can facilitate responses for bilinguals (e.g., Diependaele et al., 2011), particularly different-script bilinguals, such as Japanese-English and Chinese-English bilinguals (Jiang, 2021; Kida et al., 2022; Nakayama & Lupker, 2018; Qiao & Forster, 2017). Therefore, the priming effects of past-tense primes need to be compared with the effects of both an orthographically similar and unrelated baseline to clarify whether the effects of past-tense primes are due to prime-target morphological relationships, orthographic relationships, or a combination of both.

Another factor that could lead to mixed results is differential levels of L2 proficiency. Morphological connections can be observed for more proficient bilinguals but not for less proficient bilinguals. For example, recall Feldman et al.'s (2010) finding that regular past-tense primes (e.g., billed-BILL) facilitated responses to a greater extent than both unrelated (e.g., careful-BILL) and orthographically similar primes (e.g., billion-

BILL). When the participants were analyzed separately for L2 proficiency levels, this priming pattern was only observed for high-proficiency bilinguals. Regular past-tense primes did not facilitate responses to a greater extent than orthographically similar primes for low-proficient bilinguals. Therefore, the different levels of L2 proficiency among participants across studies could be responsible for the different priming patterns.

Experiment 1 explored whether morphological connections in the L2 similar to those in the L1 for monolinguals can exist in the Japanese-English bilinguals' lexicon. Specifically, the experiment tested whether masked English past-tense verb primes significantly facilitate lexical decisions to their present-tense targets. The overall research design and procedures were similar to those of Feldman et al. (2010). Both unrelated and orthographically similar conditions were included, as past-tense primes were expected to facilitate responses based on their orthographic similarity to the targets, if not also due to the prime-target morphological relationship.

Only participants who were relatively proficient in English were recruited for Experiment 1. This was done to increase the likelihood of observing a significant priming effect from past-tense primes relative to orthographically similar primes. If past-tense primes facilitated responses to a greater extent than this orthographic control, it could be concluded that morphological connections between past- and present-tense verbs are present in the bilinguals' lexicon.

Method

Participants

A total of 93 Japanese-English bilinguals participated in Experiment 1 (45 from Tohoku University and 48 from Waseda University). Data were collected from participants at their respective institutions. The participants' L1 was Japanese, and they were reasonably proficient in English (i.e., they all had obtained scores of at least 610 on TOEIC, 530 on TOEFL ITP, or Grade 2 on EIKEN).[2]

Fifty-one participants were male, and 42 were female. The age of participants at the time of the experiment ranged from 18-40 (M = 20.85, SD = 3.22). The age at which they started learning English ranged from 0-15 (M = 9.81, SD = 3.40). Although most participants had spent no time in an English-speaking region, for those who had spent some time in such regions (n = 32), the time ranged from 0.5-120 months (M = 18.36, SD = 29.90). Each participant received a 1,000-yen gift card (roughly equivalent to US$9.00 at the time of the experiment) for their participation.

Stimuli

A total of 81 verbs were selected as targets. Following Feldman et al. (2010), the experiment included three types of verb conditions, each involving 27 targets. These verb conditions were (a) Regular Verbs, which are verbs that take the "-ed" ending to form the past tense (e.g., look-looked; dream-dreamed); (b) Irregular Length Preserved Verbs, which are verbs that do not take the "-ed" ending and, therefore, have irregular past tenses, though their present- and past-tense forms have the same number of letters (e.g., fell-fall; sold-sell); and (c) Irregular Length Varied Verbs, which are verbs that do not take the "-

ed" ending and have irregular past tenses with a different number of letters than their present-tense forms (e.g., met-meet; paid-pay).

Each target verb was paired with three types of primes (Prime Types). A Morphological prime is the past-tense form of its target (e.g., looked-LOOK, fell-FALL, met-MEET). An Orthographic Control prime is orthographically similar to (but not morphologically or semantically related to) its target and is similar in length to the Morphological prime (e.g., loose-LOOK, fill-FALL, men-MEET). An Unrelated prime is orthographically, morphologically, and semantically unrelated to its target and is the same length as the Morphological prime (e.g., master-LOOK, bank-FALL, lab-MEET). The critical stimuli are listed in Appendix A. Information concerning prime and target characteristics is shown in Table 1.

Table 1

Lexical Characteristics and Examples of Prime-Target (Verb) Pairs in Experiment 1

		Prime Type			Target
		MORPH	ORTH	UNREL	
IRLP		**fell**	**fill**	**bank**	**FALL**
	Frequency	91 (152.2)	69 (138.3)	95 (143.1)	512 (1131.7)
	Length	4.3 (0.5)	4.3 (0.5)	4.3 (0.5)	4.3 (0.5)
	Neighbors	8.0 (4.9)	7.6 (4.1)	7.0 (5.7)	8.8 (4.5)
	% Overlap	60 (20.9)	56 (18.9)	8 (11.4)	
IRLV		**paid**	**pair**	**jump**	**PAY**
	Frequency	139 (195.1)	63 (120.8)	104 (147.2)	444 (852.3)
	Length	4.5 (1.1)	4.4 (1.1)	4.5 (1.1)	4.3 (0.9)
	Neighbors	6.7 (4.7)	7.4 (5.3)	6.6 (4.6)	8.6 (5.2)
	% Overlap	54 (27.7)	50 (23.4)	6.0 (10.5)	
REG		**looked**	**loose**	**master**	**LOOK**
	Frequency	97 (141.5)	40 (73.8)	97 (165.1)	450 (613.6)
	Length	6.2 (0.8)	5.9 (1.0)	6.2 (0.8)	4.2 (0.8)
	Neighbors	4.4 (2.4)	1.9 (2.3)	4.1 (2.5)	7.9 (4.2)
	% Overlap	67 (4.0)	52 (12.1)	5.0 (8.1)	

Note: Values given as word frequencies (SUBTLEX frequency per million words) and numbers of neighbors are based on the English Lexicon Project (Balota et al., 2007).

An effort was made to select Orthographic Control primes that were as orthographically similar to their targets as Morphological primes, as it was expected that morphological priming effects would need to be calculated in comparison to the Orthographic Control primes. Following Feldman et al. (2010), the proportion of letters repeated in the same position between the prime and target was used as a measure of orthographic similarity. This measure was calculated by dividing the number of identical characters in the same letter position between primes and targets by the number of letters of the prime and then multiplying the result by 100. Therefore, a value of 100 means that the prime and target are orthographically identical, whereas a value of 0 means that the prime and its target share no letters in the same position.

Regular, Irregular Length Preserved, and Irregular Length Varied Verb targets were matched in terms of mean word frequency, word length, and the number of neighbors as defined by Coltheart, Davelaar, Jonasson, and Besner (1997; all *F*s < 1). For primes, strict matches were difficult to achieve for some lexical characteristics in certain conditions, largely due to the limited number of irregular verbs in the English language. Further, as the Japanese-English bilinguals examined in this experiment would know fewer words in English than L1 English readers, the stimulus selection process had to be even more restrictive. Nevertheless, an effort was made to match the lexical characteristics of the primes as much as possible.

For the primes paired with Regular Verb targets, repeated-measures analyses of variance (ANOVAs) confirmed that the Morphological, Orthographic Control, and Unrelated primes were matched based on their mean word frequencies, *M*s = 97, 40, 97, respectively, $F(2, 52) = 1.75$, $p > .18$, and word lengths, *M*s = 6.2, 5.9, and 6.2, $F(2, 52)$

= 2.75, $p > .07$. Despite the effort to match the prime-target orthographic similarities for Morphological and Orthographic Control primes, Morphological primes ($M = 67\%$; e.g., looked-LOOK) had more orthographic similarity with their targets than Orthographic Control primes, $M = 52\%$ (e.g., loose-LOOK), $t(26) = 6.06$, $p < .001$. Unrelated primes had significantly lower prime-target orthographic similarity than Morphological and Orthographic Control primes ($M = 5\%$; e.g., master-LOOK; ps < .001). Lastly, Morphological and Unrelated primes had a statistically equivalent number of neighbors, Ns = 4.4 and 4.1, $t(26) = 1.0$, $p = .33$). However, Orthographic Control primes had significantly fewer neighbors than Morphological and Unrelated primes ($N = 1.9$, ps < .001) because matching on prime-target orthographic similarity was prioritized over the primes' neighborhood sizes.

For the primes paired with Irregular Length Preserved Verb targets, Morphological, Orthographic Control, and Unrelated primes were statistically matched in terms of their mean word frequency (Ms = 91, 69, 95, $F < 1$), word length (all Ms = 4.3) and neighborhood size (Ms = 8.0, 7.6, 7.0, $F < 1$). The prime-target orthographic similarity was matched between Morphological primes ($M = 60\%$; e.g., fell-FALL) and Orthographic Control primes, $M = 56\%$ (e.g., fill-FALL), $t(26) = 1.28$, $p > .21$. Unrelated primes had significantly lower prime-target orthographic similarity than both Morphological and Orthographic Control primes ($M = 8\%$; e.g., bank-FALL; ps < .001).

Finally, the Morphological, Orthographic Control, and Unrelated primes paired with Irregular Length Varied Verb targets were statistically matched in terms of their mean number of letters, Ms = 4.5, 4.4, 4.5, $F(2, 52) = 2.85$, $p > .06$, and mean numbers of neighbors (Ms = 6.7, 7.4, 6.6, $F < 1$). The prime-target orthographic similarity was matched between Morphological primes and their targets (*M* = 54%; e.g., fell-FALL) and Orthographic Control primes and the same targets (*M* = 50%; e.g., fill-FALL; $t < 1$). Unrelated primes had significantly lower prime-target orthographic similarity than Morphological and Orthographic Control primes (*M* = 6%, *p*s < .001).

Mean word frequency could not be statistically matched in this condition. Morphological primes had a statistically higher mean word frequency (*M* = 139) than Orthographic Control primes (*M* = 63) and Unrelated primes (*M* = 104, *p*s < .05), which were not statistically different, $t(26) = -1.55$, $p > .10$. The low frequency of the Orthographic Control primes was not likely to be problematic, as Nakayama and Lupker (2018) showed that the facilitation effect of orthographically similar primes for Japanese-English bilinguals is not affected by whether they are words or nonwords (nonwords have a frequency of 0).

The Latin square design was used to present the stimuli. For word targets, three presentation lists (List A, List B, and List C) were created such that, within a list, one-third of the word targets were primed by Morphological primes, one-third were primed by the Orthographic Control primes, and one-third were primed by the Unrelated primes. Across the lists, each word target was primed by each of the three Prime Types equally frequently.

A total of 81 nonword targets were also selected for "NO" responses in a lexical decision task. The nonword targets consisted of three sets of 27 nonwords: Nonword Regular, Nonword Irregular Length Preserved, and Nonword Irregular Length Varied Verb targets, which served as counterparts to the Regular, Irregular Length Preserved, and Irregular Length Varied Verb targets. Within each set of nonword targets, one-third (n = 9) were primed by words that mimicked the relationship between Morphological prime-target word pairs (Nonword Morphological condition; e.g., father-FATH, slam-SLOG, ticket-TIVE). Another third of the targets were primed by words that were orthographically similar to their targets (Nonword Orthographic Control condition; e.g., carbon-CARN, box-BOP, nag-NAGE). The final third of the targets were primed by words that were orthographically unrelated to their targets (Nonword Unrelated condition; e.g., corner-TOAK, carry-PONER, team-TATCH).

As nonwords do not have morphological representations, for the 81 nonwords, two-thirds of the targets were primed by orthographically similar word primes, and one-third were primed by unrelated word primes. The lexical characteristics of the primes (e.g., mean word frequency, length, number of neighbors, and orthographic similarity) were similar to their counterparts in the word target conditions. The lexical characteristics of the stimuli in the nonword target conditions are shown in Table 2. Prime Type was not manipulated for nonwords; therefore, there was only one presentation list for nonword targets. None of the word primes preceding nonword targets was used as a critical stimulus (i.e., in the word prime-target pairs).

Table 2

Lexical Characteristics and Examples of Prime-Target (Nonword) Pairs in Experiment 1

		Prime Type			Target
		MORPH	ORTH	UNREL	
IRLP		**slam-SLOG**	**box-BOP**	**carry-PONER**	
	Frequency	65 (53.7)	49 (64.4)	113 (166.8)	
	Length	4.1 (0.3)	4.2 (0.6)	4.4 (0.7)	4.3 (0.6)
	Neighbors	8.6 (4.2)	9.0 (6.3)	6.0 (5.1)	7.9 (4.1)
	% Overlap	68 (10.6)	54 (11.0)	4 (8.3)	
IRLV		**top-TOPIN**	**sum-SULL**	**kit-CASP**	
	Frequency	81.6 (114.1)	69 (57.9)	55 (49.2)	
	Length	4.6 (1.0)	4.3 (1.2)	4.3 (1.2)	4.3 (0.7)
	Neighbors	7.1 (5.2)	7.4 (4.6)	7.0 (4.5)	7.5 (3.2)
	% Overlap	57 (21.6)	57 (24.0)	11 (17.1)	
REG		**father-FATH**	**carbon-CARN**	**corner-TOAK**	
	Frequency	101 (175.6)	26 (47.8)	76 (104.2)	
	Length	6.1 (0.3)	6.1 (0.6)	6.1 (0.3)	4.1 (0.4)
	Neighbors	4.1 (1.5)	1.8 (3.0)	3.4 (2.7)	6.2 (3.3)
	% Overlap	66 (3.0)	50 (9.9)	7 (8.3)	

Note: Values given in word frequencies (SUBTLEX frequency per million words) and numbers of neighbors are based on the English Lexicon Project (Balota et al., 2007).

Apparatus and Procedure

The presentation of stimuli and the recording of responses were controlled by DMDX (Forster & Forster, 2003). Participants were tested individually in a quiet room. The presentation sequence of each trial was identical to that of Feldman et al. (2010) and was as follows: A fixation point (i.e., "+") was first presented for 450 ms, which was followed by a blank screen for 50 ms. Then, a string of number signs (i.e., "#") matching the word length of the prime was presented for 500 ms as a forward mask. Immediately after the presentation of the forward mask, a prime was presented for 50 ms in lower-case letters and was immediately replaced by a target in upper-case letters. Targets remained on the screen for 3,000 ms or until a response was given. The inter-trial interval was 1,000 ms. The stimuli were presented in 18 pt Courier New font at the center of the display.

Participants were asked to decide whether each target stimulus was a real English word and indicate their decision by pressing the "YES" or "NO" button on a gamepad (Tohoku University) or a response box (Waseda University) as fast and accurately as possible. Prior to the presentation of the experimental trials, 36 practice trials were presented to familiarize participants with the task. Participants were asked to repeat the practice session until they felt comfortable with the task. The presentation lists were counterbalanced across participants, and the order of trials within each list was randomized for each participant. Approval for the experiments was obtained by the ethics review board of the Graduate School of International Cultural Studies, Tohoku University, and the ethics review committee on research with human subjects of Waseda University.

Results

Data from two participants were removed because they made errors on more than 25% of the items (one participant each from List A and List C). The numbers of participants among the presentation lists were equated by removing the data from one additional participant (the last participant from List B). As a result, data from 90 participants were analyzed. Responses with latencies greater than 1,500 ms were considered outliers (0.32% of word data) and were also removed from the analyses.

Response latencies of correct trials to word targets and error rates were analyzed with 3 (Verb Type: Regular Verb, Irregular Length Preserved Verb, Irregular Length Varied Verb) x 3 (Prime Type: Morphological, Orthographic Control, and Unrelated) ANOVAs. By-subject (F_s) and by-item (F_i) ANOVAs were conducted to generalize the findings across subjects and items. In the subject analyses, Verb Type and Prime Type were within-subject factors. In the item analyses, Prime Type was a within-item factor, and Verb Type was a between-item factor. No corrections were applied for multiple testing in the follow-up analyses.

Mean response latencies and error rates are shown in Table 3. Note that according to initial analyses, including Institution (Waseda and Tohoku), data patterns were not significantly different between the two universities (all *p*s > .10), with two exceptions in the item analysis: Response latencies were significantly faster (by 23 ms) for Waseda University than for Tohoku University, $F_s(1, 88) = 1.41$, $p > .23$; $F_i(1, 78) = 65.04$, $MSE = 953.57$, $p < .001$, $\eta^2_p = .45$, and error rates were smaller (by 3.2%) for Waseda University compared to Tohoku University, $F_s(1, 88) = 8.39$, $p < .01$; $F_i(1, 78) = 26.58$,

MSE = 47.67, $p < .001$, $\eta^2_p = .25$. Therefore, data from both institutions were analyzed together in the following analyses.

Table 3
Mean Response Latencies (and Error Rates) for Verb Targets in Experiment 1

Verb type	Prime Type			Priming effect	
	MORPH (M)	ORTH (O)	UNREL (U)	O - M	U-O
IRLP	608 (9.5)	613 (11.4)	647 (10.9)	5 (1.9)	34 (-0.5)
IRLV	596 (6.3)	600 (8.0)	623 (8.3)	4 (1.7)	23 (0.3)
REG	591 (8.5)	604 (7.2)	633 (8.2)	13 (-1.4)	29 (1.0)

Note. IRLP = Irregular Length Preserved Verbs; IRLV = Irregular Length Varied Verbs; REG = Regular Verbs.

Response Latencies

The main effect of Prime Type was significant, $F_s(1.81, 161.09) = 45.03$, MSE = 2,384.72, $p < .001$, $\eta^2_p = .34$; $F_i(2, 156) = 35.45$, MSE = 862.56, $p < .001$, $\eta^2_p = .31$.[3] Therefore, there was at least one significant difference between the contrasts of the three Prime Types. The main effect of Verb Type was significant only in the subject analysis, $F_s(2, 178) = 10.29$, MSE = 1,919.36, $p < .001$, $\eta^2_p = .10$; $F_i < 1$. The interaction between Verb Type and Prime Type was not significant in either analysis (both Fs < 1), meaning that the patterns of priming effects did not differ among the Regular, Irregular Length Preserved, and Irregular Length Varied targets.

Follow-up analyses of the significant main effect of Prime Type were conducted to examine which contrasts were significant. The results revealed that across Verb Type, targets primed by Morphological primes were responded to significantly faster than the same targets primed by Unrelated primes, $F_s(1, 89) = 70.34$, MSE = 2,483.40, $p <.001$, $\eta^2_p = .44$; $F_i(1, 78) = 79.22$, MSE = 707.20, $p < .001$, $\eta^2_p = .50$. As expected based on the results of previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018), targets primed by Orthographic Control primes were also responded to significantly faster than the same targets primed by Unrelated primes, $F_s(1, 89) = 43.13$, MSE = 2,531.62, $p < .001$, $\eta^2_p = .33$; $F_i(1, 78) = 30.17$, MSE = 1,078.69, $p < .001$, $\eta^2_p = .28$. Importantly, targets primed by Morphological primes were responded to significantly faster than targets primed by Orthographic Control primes, $F_s(1, 89) = 5.25$, MSE = 1,459.47, $p = .024$, $\eta^2_p = .06$; $F_i(1, 78) = 3.95$, MSE = 801.79, $p = .05$, $\eta^2_p = .05$.

These priming patterns were not modulated by target Verb Types (all ps > .25). The stronger facilitation effect of Morphological primes relative to Unrelated and

Orthographic Controls, regardless of the verb's regularity, is the same pattern of priming as previous studies with L1 English readers (e.g., Crepaldi et al., 2010; Forster et al., 1987; Pastizzo & Feldman, 2002; Silva & Clahsen, 2008). Therefore, these results may indicate that the morphological connections in the L2 of the Japanese-English bilinguals' lexicon are similar to those in the L1 for monolinguals.

Error Rates

The only significant effect was the main effect of Verb Type in the subject analysis, $F_s(2, 178) = 8.71$, $p < .001$, $\eta^2_p = .09$; $F_i(2, 78) = 1.33$, $p > .27$. All other effects, including the main effect of Prime Type and the interaction between Prime Type and Verb Type, were not significant (all *F*s < 1).

Discussion

In Experiment 1, targets primed by Orthographic Control primes were responded to significantly faster than targets primed by Unrelated primes. This effect supports the results of previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018) in which orthographically similar English word primes facilitated lexical decision latencies to English targets (e.g., time-TIDE < doll-TIDE). Similar results have also been found in L2 morphological priming experiments when the readers' L1 was the same script (alphabetic) as the L2 (Diependaele et al., 2011, but see Bijeljac-babic, Biardeau, & Grainger, 1997). However, this result contrasts sharply with the findings of orthographic neighbor priming experiments for L1 readers, in which the direction of the effect was typically inhibitory (e.g., time-TIDE > doll-TIDE; Davis & Lupker, 2006; Nakayama et al., 2008; Segui & Grainger, 1990).

One possible explanation for the facilitation effect of the prime-target orthographic similarity observed among the Japanese-English bilinguals in Experiment 1 is that lexical (word)-level representations have yet to be consolidated for these bilingual readers. As discussed by Cook and Gor (2015) and Perfetti (1992), underspecified representations in a lexicon can lead to behavioral results that differ from those typically observed among proficient L1 readers. Indeed, individual differences have been found in the degree to which prime-target orthographic similarity inhibits lexical decisions, even for L1 English readers. Andrews and Lo (2012) reported that the inhibitory effects decrease for readers who are relatively unskilled in certain aspects of reading. This result was attributed to the possibility of underspecified lexical (word)-level representations in such L1 readers. A similar interpretation may explain the facilitation effect of orthographically similar primes observed in Experiment 1 of the present work.

In Experiment 1, targets were also responded to significantly faster when primed by Morphological primes than when primed by Unrelated primes. This facilitation effect of Morphological primes might be due to their orthographic similarity with the targets and not due to their morphological relationship. This is because, as described above, orthographic similarity can facilitate bilinguals' lexical decision latencies in L2. Nevertheless, in Experiment 1, the post-hoc analysis showed that across Verb Type, the size of the priming effect was significantly larger for Morphological primes than Orthographic Control primes, although the difference was numerically small (7 ms). This additional facilitation effect of Morphological prime-target pairs over Orthographic Control prime-target pairs suggests that connections reflecting morphological relationships are present in the L2 English lexicon of Japanese-English bilinguals.

Regular Verb targets produced a more considerable numerical advantage (13 ms) than the other two Verb Types (4 ms and 5 ms) despite the non-significant interaction of Prime Type by Verb Type. The non-significant interaction suggests that the priming advantage for Morphological over Orthographic Control primes was not different among the three Verb Types. However, this pattern is somewhat difficult to interpret because prime-target orthographic similarity was higher for Morphological primes (67%) than for Orthographic Control primes (52%) in the Regular Verb condition. Thus, the priming effect from Morphological primes in the Regular Verb condition could involve additional facilitation due to orthographic similarity. This would indicate that the results of Experiment 1 might overestimate the size of the morphological priming effect in the Regular Verb condition.

Meanwhile, the prime-target orthographic similarity between Morphological and Orthographic Control primes was matched in the Irregular Length Preserved and Irregular Length Varied Verb conditions. Therefore, any priming advantage for Morphological primes in those conditions would firmly indicate the impact of morphology. When the data in the Irregular Length Preserved and Irregular Length Varied Verb conditions were analyzed, the data from the Regular Verb condition were removed. However, the priming advantage for Morphological over Orthographic Control primes became statistically non-significant, $t_s(89) = 1.06$, $SEM = 4.33$, $p = .29$; $t_i(53) = 1.38$, $SEM = 4.89$, $p = .17$. At the same time, when the data in the Regular condition alone were analyzed, even the 13-ms difference was no longer statistically significant in the item analysis, $t_s(89) = 2.27$, $SEM = 5.93$, $p = .03$; $t_i(26) = 1.45$, $SEM = 8.99$, $p = .16$. Thus, although morphological connections in L2 appeared to be present in the lexicon of Japanese-English bilinguals, the evidence is not robust. Therefore, this issue was investigated further in Experiment 2.

The overall patterns of priming, as well as the patterns of priming when regular and irregular verbs were analyzed separately, are depicted in Figure 7.

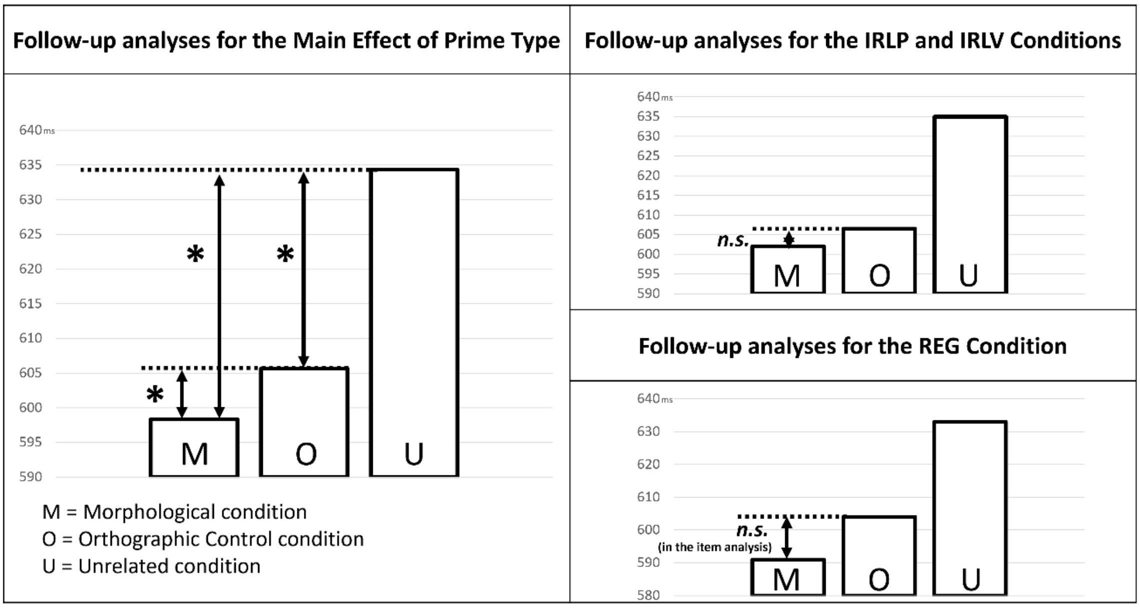

Figure 7. Latencies in Experiment 1

The patterns of priming observed in Experiment 1 are depicted in the figure. Results from the overall analyses suggested that the priming effect from Morphological primes relative to Unrelated primes was at least partially of morphological origin. When regular verbs and irregular verbs were analyzed separately, however, this pattern of priming was less evident.

CHAPTER 3:

Experiment 2

Introduction

Masked priming lexical decision experiments with L1 English readers have shown that morphological connections between past- and present-tense verbs exist in the monolingual lexicon (e.g., Forster et al., 1987; Pastizzo & Feldman, 2002; Silva & Clahsen, 2008). In those experiments, past-tense primes facilitated responses to present-tense targets to a greater extent than both orthographically similar primes (e.g., Pastizzo & Feldman, 2002) and unrelated primes (e.g., Forster et al., 1987; Silva & Clahsen, 2008).

Regarding the bilingual lexicon, it is unclear whether the morphological connections in the L2 are similar to those in the L1 for monolinguals. To date, studies examining bilinguals have yielded mixed results. If patterns of the facilitation effect of past-tense primes similar to those observed with L1 readers can be observed in the L2, then morphological connections similar to those of L1 readers are also likely to exist in the bilinguals' lexicon. Indeed, some researchers have observed priming patterns similar to those of monolinguals (e.g., Feldman et al., 2010; Voga et al., 2014), while others have not (e.g., Clahsen et al., 2013; Silva & Clahsen, 2008). The results of Experiment 1 add to the empirical literature on L2 morphological connections by testing Japanese-English bilinguals, a group that has rarely been examined for L2 morphological connections (but see Silva & Clahsen, 2008).

Two factors that may be partially responsible for the mixed results in previous studies were considered in Experiment 1. One issue with some previous studies was the baseline against which priming from past-tense primes was measured. While some studies measured morphological priming against only an unrelated condition (e.g., Clahsen et al., 2013; Silva & Clahsen, 2008; Voga et al., 2014), others measured it against both an unrelated condition and an orthographic control condition (e.g., Feldman et al., 2010). As past-tense forms have a high degree of orthographic similarity with present-tense forms in English, when compared only to an unrelated condition, it can be somewhat difficult to know whether priming from past-tense primes is due to the morphological relationship between the prime and target or its orthographic similarity.

When examining L1 English readers, using only an unrelated baseline does not present much of a problem. Studies have found that prime-target orthographic similarity can lead to inhibitory (but not facilitatory) priming effects (e.g., Davis & Lupker, 2006). When examining L2 English readers, however, measuring priming from past-tense primes against only an unrelated condition can be problematic. Prime-target orthographic similarity in the L2 can have a facilitatory effect for bilinguals (e.g., Diependaele et al., 2011, but see Bijeljac-babic, Biardeau, & Grainger, 1997), especially for different-script bilinguals, such as Japanese-English bilinguals (e.g., Kida et al., 2022; Nakayama & Lupker, 2018). Therefore, priming from past-tense primes was measured against both an unrelated and orthographically similar baseline in Experiment 1 to examine whether the priming effect (if one was present) was morphological or orthographic.

The second issue considered was the bilingual participants' level of L2 proficiency. In their study examining Serbian-English bilinguals, Feldman et al. (2010)

reported that priming patterns from regular past-tense verbs were similar to those of L1 English readers for more proficient bilinguals but not for less proficient bilinguals. This result suggests that L2 morphological connections similar to those of monolinguals in the L1 have developed only for bilinguals who are proficient in their L2. The present study examined whether such connections can be present (or can be developed) among bilinguals. Therefore, to increase the chances of observing a morphological priming effect, Experiment 1 focused on Japanese-English bilinguals who were relatively proficient in English.

The results of Experiment 1 provided some evidence, albeit weak, for L2 morphological connections in the Japanese-English bilinguals' lexicon. In the experiment, three types of present-tense verbs were examined: regular verbs (e.g., LOOK, DREAM), irregular verbs for which the past- and present-tense forms contain the same number of letters (e.g., FALL, SELL), and irregular verbs for which the past- and present-tense forms have different numbers of letters (e.g., MEET, PAY). Each of these verb targets was paired with three types of primes: Morphological primes (e.g., looked-LOOK, fell-FALL, met-MEET), Orthographic Control primes (e.g., loose-LOOK, fill-FALL, men-MEET), and Unrelated primes (e.g., master-LOOK, bank-FILL, lab-MEET). According to the results of Experiment 1, Orthographic Control primes facilitated responses compared to Unrelated primes, thus replicating the findings of previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018). Therefore, the importance of including an orthographic baseline in the experiment was confirmed.

The results of the omnibus analyses showed that Morphological primes facilitated responses to a greater extent than Unrelated primes and Orthographic Control primes.

The same pattern of priming has been observed with L1 English readers in previous studies (e.g., Pastizzo & Feldman, 2002). At first glance, morphological connections similar to those of L1 English readers appear to be present in the Japanese-English bilinguals' lexicon. A closer look at the results of Experiment 1, however, reveals that it was difficult to conclude that the priming effect from the past-tense primes was due to a prime-target morphological relationship. This is because the Morphological primes did not facilitate responses relative to Orthographic Control primes when the data for regular and irregular verbs were examined separately.

Experiment 2 was conducted to re-examine whether L2 morphological connections similar to those of the L1 in monolinguals are present in the Japanese-English bilinguals' lexicon. One reason for the somewhat ambiguous results of Experiment 1 could be its design. The experiment included 27 items for each of the three types of verb targets, and these targets were paired with three types of primes. Therefore, there were only nine items per cell for any given participant. A large number of participants were examined in Experiment 1 ($N = 90$) because response latencies to L2 targets tend to vary more than response latencies to L1 targets. Unfortunately, this did not appear to have the anticipated effect of stabilizing the data.

Therefore, in Experiment 2, a larger set of items needed to be selected as critical stimuli to stabilize the data. This was done by dropping the Irregular Length Varied condition examined in Experiment 1. Relatively few irregular English verbs have past- and present-tense forms with different lengths. Furthermore, critical stimuli must comprise words that are known by the bilingual participants, which further limits stimuli selection. Dropping the Irregular Length Varied condition and limiting the Verb Type conditions to Regular Verbs and Irregular Length Preserved Verbs (henceforth referred to as "Irregular") made it possible to select more items per condition in Experiment 2. This change in design did not impede the research goal, as the effect of word length (varied or preserved) on the connections of morphological relationships in the lexicon was not of interest in this study.

The bilinguals recruited for Experiment 2 had about the same level of English proficiency as those in Experiment 1. As in Experiment 1, an effort was made to match the prime-target orthographic similarity for the Morphological and Orthographic Control conditions in Experiment 2. However, it was not possible to fully equate the values for Regular Verbs because even relatively proficient Japanese-English bilinguals have fairly limited vocabularies.

Therefore, in the Regular Verb condition, further analysis needed to be conducted if the past-tense primes facilitated responses compared to Orthographic controls. If the higher degree of orthographic similarity between Morphological primes and their targets compared to the Orthographic Control primes does not affect the priming patterns in the Regular Verb condition, then the facilitation is likely due to the morphological relationship (rather than the orthographic similarity) between the prime and target. In the Irregular Verb condition, the orthographic similarity was fully matched between the Morphological and Orthographic Control prime-target pairs. Therefore, any priming effects observed relative to Orthographic Control primes in this condition can be attributed to the morphological relationship between the primes and targets.

Method

Participants

The participants were 84 Japanese-English bilinguals recruited at Tohoku University (n = 44) and Waseda University (n = 40). They spoke Japanese as their first language and were reasonably proficient in English (they all had a TOEIC score of 605 or higher or a TOEFL ITP score of 510 or higher). Their reported TOEFL ITP scores ranged from 104-650 (n = 36, M = 541.00, SD = 81.52). Their TOEIC scores ranged from 605-965 (n = 66, M = 790.76, SD = 93.33). As one participant reported a score that was not a multiple of five (all scores on the TOEIC are multiples of five), this score was rounded to the nearest multiple of five.

Thirty-eight of the participants were male, and 46 were female. The mean age of participants (excluding one who did not report their age) at the time of the experiment was 21.65 (range: 18-43, SD = 3.20). The average age at which they started learning English was 9.74 (range: 0-13, SD = 3.37). Twenty-six participants reported having spent time in an English-speaking region. Despite the relatively large mean (M = 12.38 months), most of them had not spent an extensive amount of time in an English-speaking region (range: 0.23-107, SD = 26.43). Each participant received a 1,000-yen gift card (roughly equivalent to US$9.00 at the time of the experiment) for their participation.

Stimuli

The targets consisted of two Verb Types: Irregular Verbs and Regular Verbs. Irregular Verbs (n = 48) are verbs that do not take the "-ed" ending in their past tense (i.e., their past-tense is formed irregularly) and for which the past- and present-tense forms have the same length (e.g., fell-FALL). These verbs are the same type of verbs as the irregular verbs in the Irregular Length Preserved Verb condition in Experiment 1. Regular Verbs (*n* = 48) were verbs that take the "-ed" ending to form the past tense (e.g., looked-LOOK). Each target was paired with three types of primes: Morphological (e.g., fell, looked), Orthographic Control (e.g., fill, locker), and Unrelated primes (e.g., joke, rather). The critical stimuli are listed in Appendix B. Their examples and lexical characteristics are shown in Table 4.

Table 4

Lexical Characteristics and Examples of Prime-Target (Verb) Pairs in Experiment 2

		Prime Type			Target
		MORPH	ORTH	UNREL	
IREG		**fell**	**fill**	**joke**	**FALL**
	Frequency	105 (177.4)	120 (343.4)	97 (160.6)	371 (668.1)
	Length	4.2 (0.7)	4.2 (0.7)	4.2 (0.7)	4.2 (0.7)
	Neighbors	8.9 (5.3)	9.2 (5.6)	8.4 (4.5)	8.9 (4.5)
	% Overlap	64 (18.8)	66 (11.7)	0.0 (0.0)	
REG		**looked**	**locker**	**rather**	**LOOK**
	Frequency	76 (112.2)	61 (234.3)	73 (102.3)	360 (545.7)
	Length	6.2 (0.6)	6.2 (0.6)	6.2 (0.6)	4.2 (0.6)
	Neighbors	5.3 (2.9)	2.2 (2.4)	2.2 (2.1)	9.3 (4.7)
	% Overlap	67 (2.8)	46 (10.2)	0.0 (0.0)	

Note. Values given in word frequencies (SUBTLEX frequency per million words) and the numbers of neighbors were based on the English Lexicon Project (Balota et al., 2007).

Targets in the Irregular Verb and Regular Verb conditions were matched in terms of their mean word frequencies, word lengths, and numbers of neighbors (all *t*s < 1). For primes paired with IREG targets, the Morphological, Orthographic Control, and Unrelated primes were matched in terms of their mean word frequencies (*M*s = 105, 120, 97, $F < 1$), word lengths (all *M*s = 4.2), and numbers of neighbors (*M*s = 8.9, 9.2, 8.4, $F < 1$). Prime-target orthographic overlap was statistically equivalent for Morphological primes and Orthographic Control primes (*M*s = 64 and 66%, $t < 1$). Unrelated primes had no orthographic overlap with their targets ($M = 0\%$).

For the primes paired with Regular targets, Morphological, Orthographic Control, and Unrelated primes were matched in terms of their mean word frequencies (*M*s = 76, 61, 73, $F < 1$) and word lengths (all *M*s = 6.2), as all primes for a given target had the same length. As in Experiment 1, the prime-target orthographic overlap was inevitably significantly higher for Morphological primes ($M = 67\%$) than for Orthographic Control primes, $M = 46\%$, $t(47) = 13.03$, $SEM = 1.62$, $p < .001$. This mismatch in orthographic similarity occurred because words that are likely to be known by the bilingual participants were prioritized in the selection process. Unrelated primes had no orthographic overlap with their targets ($M = 0\%$). Morphological primes also had significantly more neighbors ($N = 5.3$) than Orthographic Control, $N = 2.2$, $t(47) = 6.92$, $SEM = .46$, $p < .001$, or Unrelated primes, $N = 2.1$, $t(47) = 6.44$, $SEM = .50$, $p < .001$, which did not differ from one another ($t < 1$).

As in Experiment 1, three presentation lists were created for the word targets (Lists A, B, and C). The Latin square design was used to present the stimuli. In each list, one-third of the word targets were paired with Morphological primes, one-third were paired with Orthographic Control primes, and one-third were paired with Unrelated primes. Each word target was primed once by either the Morphological, Orthographic Control, or Unrelated prime across the three presentation lists.

A total of 96 nonword targets were selected for "NO" responses to the lexical decision task. More than half of the nonwords were generated with Wuggy (Keuleers & Brysbaert, 2010). The nonword targets consisted of two sets of 48 nonwords that served as counterparts to the Regular Verb (Nonword Regular) and the Irregular Verb targets (Nonword Irregular). These nonword targets had similar mean word lengths and numbers of neighbors as the word targets. Nonwords were paired with word primes following the same method as Experiment 1 (Nonword Morphological, Nonword Orthographic Control, and Nonword Unrelated primes). The lexical characteristics of the primes (e.g., mean word frequencies, lengths, numbers of neighbors, and orthographic similarity) were similar to those of their counterparts in the word target condition. The lexical characteristics of the nonword target condition are shown in Table 5. None of the word primes preceding nonword targets was used in the critical stimuli (i.e., word prime-word target pairs).

Table 5

Lexical Characteristics and Examples of Prime-Target (Nonword) Pairs in Experiment 2

		Prime Type			Target
		NWMORPH	NWORTH	NWUNREL	
NWIREG		**scarf-SCALM**	**mild-MIRD**	**snare-BRINT**	
	Frequency	92 (124.0)	68 (81.4)	107 (177.5)	
	Length	4.3 (0.8)	4.2 (0.5)	4.3 (0.6)	4.3 (0.6)
	Neighbors	8.3 (5.3)	9.4 (5.3)	8.1 (5.3)	8.0 (4.4)
	% Overlap	68 (9.8)	69 (10.5)	0.0 (0.0)	
NWREG		**rumble-RUMB**	**shield-SAZE**	**chaser-LARE**	
	Frequency	42 (133.0)	65 (188.9)	92 (146.7)	
	Length	6.1 (0.5)	6.1 (0.7)	6.1 (0.5)	4.1 (0.6)
	Neighbors	4.9 (2.1)	2.3 (3.0)	2.1 (1.9)	8.3 (4.9)
	% Overlap	67 (2.6)	43 (14.1)	0.0 (0.0)	

Note. Values given in word frequencies (SUBTLEX frequency per million words) and the numbers of neighbors are based on the English Lexicon Project (Balota et al., 2007).

Apparatus and Procedure

The apparatus used in Experiment 2 was identical to that used in Experiment 1. DMDX (Forster & Forster, 2003) was used to present stimuli in a timed manner, collect responses, and measure latencies. Each participant was tested individually in a quiet room. The order of stimulus presentation and timing was identical to Experiment 1. Each trial began with a fixation point (i.e., "+"), which was presented for 450 ms, followed by a blank screen for 50 ms. Then, a series of number signs (i.e., "#") corresponding to the number of letters in the prime was presented for 500 ms. The prime was presented in lower-case letters immediately after the forward mask and remained on screen for 50 ms.

The target was then presented in upper-case letters immediately after the 50-ms presentation of the prime. The presentation of primes in lower-case letters and targets in upper-case letters is standard practice in masked priming lexical decision experiments. This difference in letter case minimizes visual similarity between the prime and target, allowing the target to also function as a backward mask. The target remained on the screen until a response was given but timed out after 3,000 ms if no response was given. All stimuli were presented in white 18 pt Courier New font in the center of a screen with a black background. The inter-trial interval was 1,000 ms.

Participants were given an explanation of the tasks they were to perform, both orally and in writing, before signing a form to give their consent for participation and data collection. After signing the consent form, participants were given a 1,000-yen gift card (approximately US$9.00 at the time of the experiment).

Participants then filled in a demographic background survey, which included questions about their scores on English proficiency tests, such as the TOEIC and TOEFL

ITP. Next, participants were asked to perform the masked priming lexical decision task. Participants were not explicitly informed of the masked primes and were asked to respond to each target as fast and accurately as possible by deciding whether it was an English word. Participants gave their responses by pressing a button corresponding to their lexical decision (“YES”: word, “NO”: nonword) on a gamepad (at Tohoku University) or a response box (at Waseda University). Thirty-six practice trials preceded the experimental trials to familiarize participants with the task; these trials were repeated until participants were familiar with the task.

Results

Data from six participants were removed due to high error rates (25% or more). Data from one additional participant were removed due to non-compliance with the instructions. Data for these seven participants were replaced by those obtained from additional participants while maintaining the counterbalancing of the presentation lists. Responses with latencies greater than 1,500 ms were considered outliers and were removed from the analyses (0.69% of word data). Six word items were excluded from the analysis because they produced more than 40% error rates. Four of these were Regular Verbs (“lick,” “jail,” “sail,” and “bust”), one was an Irregular Verb (“stink”), and one was a verb in the Irregular condition that also has a regular ending (“lie”), as this verb has the past-tense forms of both “lay” and “lied,” depending on its meaning.

Latencies and error rates for the data related to the word targets were analyzed with 2 (Verb Type: Irregular, Regular) x 3 (Prime Type: Morphological, Orthographic Control, Unrelated) ANOVAs. No corrections were applied for multiple testing in the follow-up analyses. As in Experiment 1, analyses including Institution (Tohoku and

Waseda) showed main effects of Institution in the latency analysis, $F_s(1, 82) = 15.77$, $MSE = 52{,}266.39$, $p < .001$, $\eta^2_p = .16$; $F_i(1, 88) = 591.65$, $MSE = 1{,}581.01$, $p < .001$, $\eta^2_p = .87$ (with faster responses in Waseda than Tohoku by 81 ms) and in the item analysis of error analysis, $F_s(1, 82) = 1.66$, $p > .20$; $F_i(1, 88) = 5.57$, $MSE = 71.21$, $p = .021$, $\eta^2_p = .06$. However, Institution did not significantly interact with any other variables (*p*s > .30). The mean response latencies and error rates of Experiment 2 are shown in Table 6.

Table 6

Mean Response Latencies (and Error Rates) for Verb Targets in Experiment 2

Verb type	Prime Type			Priming effect	
	MORPH (M)	ORTH (O)	UNREL (U)	O - M	U - O
IREG	637 (9.1)	655 (11.8)	675 (12.0)	18 (2.6)	20 (0.2)
REG	628 (8.2)	657 (11.0)	676 (11.9)	28 (2.8)	20 (0.9)

Note. IREG = Irregular verbs for which the past and present tenses have the same length; REG = Regular verbs.

Response Latencies

The main effect of Prime Type was significant in both the subject and item analyses, $F_s(2, 166) = 63.87$, $MSE = 1{,}235.42$, $p < .001$, $\eta^2_p = .43$; $F_i(2, 176) = 31.55$, $MSE = 1{,}453.96$, $p < .001$, $\eta^2_p = .26$, indicating that at least one of the comparisons between the three Prime Types was significant. The main effect of Verb Type was not significant in either the subject or item analysis (both *F*s < 1). This result indicates that there was no significant difference in how quickly participants responded to Regular vs. Irregular targets. Furthermore, the interaction between Verb Type and Prime Type was not significant in either the subject or item analysis, $F_s(2, 166) = 1.06$, $p = .35$; $F_i < 1$. Therefore, the patterns of priming effects for regular and irregular targets were not significantly different.

Follow-up analyses for the significant main effect of Prime Type revealed that across Verb Types, targets primed by Morphological primes were responded to significantly faster than targets primed by Unrelated primes, $F_s(1, 83) = 150.00$, $MSE = 1{,}049.58$, $p < .001$, $\eta^2_p = .64$; $F_i(1, 88) = 53.25$, $MSE = 1{,}708.42$, $p < .001$, $\eta^2_p = .38$. Targets primed by Orthographic Control primes were also responded to significantly faster than targets primed by Unrelated primes, $F_s(1, 83) = 25.43$, $MSE = 1{,}297.34$, $p < .001$, $\eta^2_p = .23$; $F_i(1, 88) = 12.09$, $MSE = 1{,}328.17$, $p < .001$, $\eta^2_p = .12$, corroborating the findings of previous studies (e.g., Nakayama & Lupker, 2018). Importantly, targets primed by Morphological primes were responded to significantly faster than targets primed by Orthographic Control primes, $F_s(1, 83) = 34.05$, $MSE = 1{,}359.35$, $p < .001$, $\eta^2_p = .29$; $F_i(1, 88) = 23.08$, $MSE = 1{,}325.30$, $p < .001$, $\eta^2_p = .21$.

Paralleling the patterns in the omnibus analysis, none of these contrasts interacted with Verb Type (all *p*s > .15). The overall pattern of priming replicated the results of Experiment 1. The finding that Morphological primes facilitated responses to a greater extent than both Unrelated primes and Orthographic Control primes implies that morphological connections between past- and present-tense verbs similar to those of L1 English readers were present in the lexicon of the Japanese-English bilingual participants in this study.

Although the interaction was not significant, the patterns of morphological priming effects were analyzed separately for the Regular and Irregular Verb conditions to confirm that the priming patterns of Morphological primes did not differ from when both Verb Types were analyzed together. The results of this analysis showed that in the Irregular condition, targets primed by Morphological primes were responded to 18 ms faster than targets primed by Orthographic Control primes. This difference was statistically significant, $t_s(83) = -3.27$, $SEM = 5.65$, $p = .002$; $t_i(45) = -2.99$, $SEM = 7.42$, $p < .01$. In the Regular condition, targets primed by Morphological primes were responded to 28 ms faster than Orthographic Control primes, again indicating a significant difference, $t_s(83) = -5.15$, $SEM = 5.52$, $p < .001$; $t_i(43) = -3.78$, $SEM = 7.94$, $p < .001$.

Unlike in Experiment 1, a clear result was obtained. For both Regular and Irregular Verbs, Morphological primes facilitated lexical decisions to their present-tense targets to an extent beyond the facilitatory effect of prime-target orthographic similarity. Therefore, consistent with the analyses conducted when Verb Type was collapsed, morphological connections between past- and present-tense verbs similar to those of L1

English readers appeared to be present in the lexicon of the Japanese-English bilingual participants in this study.

Error Rates

The main effect of Verb Type was not significant (Fs < 1), indicating that error rates did not differ between Irregular and Regular Verbs. The main effect of Prime Type was significant, $F_s(2, 166) = 7.93$, $MSE = 63.90$, $p < .001$, $\eta^2_p = .09$; $F_i(2, 176) = 8.78$, $MSE = 32.02$, $p < .001$, $\eta^2_p = .09$. Therefore, at least one of the contrasts between the three levels of Prime Type was significant when collapsed across Verb Type. The interaction between Prime Type and Verb Type was not significant (Fs < 1), indicating that the patterns of error rates between the three levels of Prime Type were not modulated by Verb Type.

Follow-up analyses were conducted for the main effect of Prime Type. As expected, across Verb Types, error rates were significantly lower for targets primed by Morphological primes than those primed by Unrelated primes, $F_s(1, 83) = 15.65$, $MSE = 56.55$, $p < .001$, $\eta^2_p = .16$; $F_i(1, 88) = 14.10$, $MSE = 34.83$, $p < .001$, $\eta^2_p = .14$. Error rates were also significantly lower for targets primed by Morphological primes (M = 8.7%) than targets primed by Orthographic Control primes, M = 11.4%, $F_s(1, 83) = 9.04$, $MSE = 67.32$, $p = .004$, $\eta^2_p = .10$; $F_i(1, 88) = 13.02$, $MSE = 25.95$, $p < .001$, $\eta^2_p = .13$. Thus, as was found with the response latencies, Morphological primes had a significantly stronger priming effect than Orthographic Control primes and Unrelated primes. Error rates were not statistically different for targets primed by Orthographic Control primes and those primed by Unrelated primes (Fs < 1).

Discussion

The results of Experiment 2 replicated the patterns of priming observed in Experiment 1. In the experiment, Morphological primes facilitated lexical decisions to targets to a greater extent than Orthographic Control primes. Importantly, this pattern did not appear to vary by Verb Type. This was indicated by the nonsignificant interaction and the similarity of the priming patterns of Morphological primes when Irregular and Regular Verb targets were analyzed separately (see Figure 8). The implication of this finding is that connections between past- and present-tense verbs in the L2 similar to those in the L1 for monolinguals are present in the bilingual participants' lexicon. Past-tense primes facilitated responses to present-tense targets to a greater extent than Orthographic Controls and Unrelated primes in the two experiments with Japanese-English bilinguals. The same priming pattern has been observed for L1 English readers in previous studies (e.g., Pastizzo & Feldman, 2002).

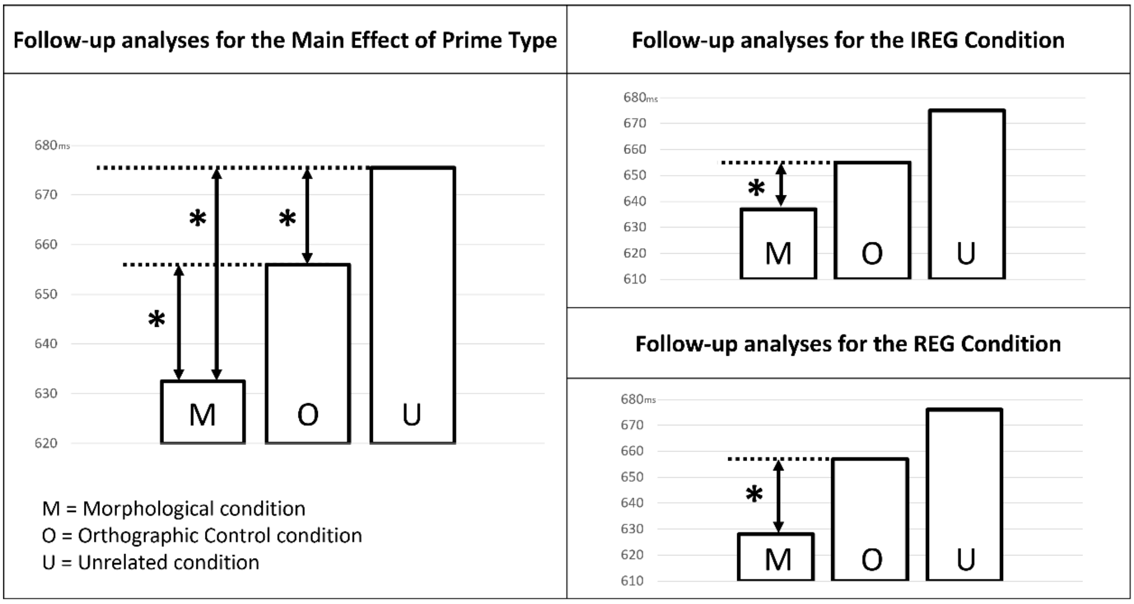

Figure 8. Latencies in Experiment 2

The patterns of priming observed in Experiment 2 are depicted in the figure. The overall analyses suggested that the priming effect from Morphological primes relative to Unrelated primes was at least partially of morphological origin, replicating the results of Experiment 1. Furthermore, this pattern was evident even when regular verbs and irregular verbs were analyzed separately.

However, the greater facilitation effect of Morphological primes compared to Orthographic controls in the Regular Verb condition might not be entirely due to the morphological connections between past-tense primes and present-tense targets. The orthographic similarity between the two conditions in Experiment 2 was not matched due to a constraint in the stimulus selection. In creating the stimuli for the experiment, choosing words that the participants would likely know, especially for the masked primes, was prioritized over ensuring prime-target orthographic similarity. As a result, Morphological primes were more orthographically similar to their targets than the Orthographic Control primes were to the same targets (67% and 46%, respectively).

Therefore, the greater facilitation effect of Morphological primes relative to Orthographic Control primes might have been partially due to prime-target orthographic similarity. This issue was examined by regressing the size of the morphological priming effect on each target against the difference in the orthographic overlap between the Morphological and Unrelated pairs vs. the Orthographic Control and Unrelated pairs in the Regular Verb condition.

Of note, the additional orthographic overlap had no association with the size of the morphological priming effect observed in the Regular Verb condition ($t < 1$, $\beta = .12$, *n.s.*). Regression analysis was not needed for the Irregular Verb condition, as the degree of orthographic overlap between the Morphological and Orthographic Control conditions was the same in this condition (64% and 66%). Considering this and the fact that Verb Type did not significantly interact with the pattern of morphological priming effects, it seems safe to conclude that the morphological priming effect observed in both the Regular Verb condition and Irregular Verb condition, when measured against Orthographic

Control primes, mainly reflected the impact of the morphological relationships between primes and targets.

Whether morphological connections are present among Japanese-English bilinguals who are less proficient in English also remains unclear from the results of Experiments 1 and 2. The study by Feldman et al. (2010), on which the two present experiments were based, found that for regular verbs, only the more proficient participants showed patterns of morphological priming similar to English monolinguals. In Experiment 2, Japanese-English bilinguals who were less proficient in English might not have shown the same pattern of priming effects as those who were more proficient in English.

Through post-hoc analyses using participants' TOEIC scores to quantify English proficiency, the possibility that L2 proficiency affected the patterns of morphological priming effects for the Japanese-English bilinguals was investigated. The TOEIC is a standardized test for English proficiency with a focus on English used in business settings. This method of quantifying the participants' English proficiency was chosen over the method in Feldman et al. (2010), which calculated a proficiency index for each participant based on their reaction times and error rates. The reasoning was that TOEIC scores are a more direct measure of English proficiency than measurements based on participants' performance in lexical decision tasks.

Of the 84 participants in Experiment 2, 66 reported their TOEIC scores on the demographic background survey. As one participant reported a TOEIC score that was not a multiple of five, this score was rounded up to the nearest multiple of five (all TOEIC scores are multiples of five). All other scores reported by participants were multiples of five.

Participants were categorized into two proficiency groups: Those with higher TOEIC scores and those with lower TOEIC scores served as the More Proficient group and Less Proficient group, respectively. The grouping was done such that participants in the More Proficient group had TOEIC scores above the median (802.50), and those in the Less Proficient group had scores below the median. Furthermore, participants in each group were chosen such that the difference between the average scores of the two groups was maximized while maintaining counterbalancing for presentation lists and including as many participants as possible. This procedure resulted in 48 participants being selected for the post-hoc analyses (24 in the More Proficient group and 24 in the Less Proficient group).

The factor of Proficiency Group was entered into the post-hoc omnibus test. In the subject analysis, Verb Type and Prime Type were within-subject factors, and Proficiency Group was a between-subject factor. In the item analysis, Prime Type and Proficiency Group were within-item factors, and Verb Type was a between-item factor. The results revealed no significant two- or three-way interactions with Proficiency Group (all ps $> .10$). Therefore, the participants' English proficiency did not significantly modulate the priming patterns.

Interestingly, however, some differences in priming patterns between the two Proficiency groups might not have been detected in the omnibus ANOVAs. When the priming effect between the Unrelated condition and Orthographic Control condition collapsed across Verb Types for each subject was entered as the dependent variable in a hierarchical regression, the participants' TOEIC scores predicted the priming effect beyond the effect of presentation lists alone (t = -2.8, β = -0.34, p = .007). The negative coefficient indicates that as the participants' TOEIC scores increase (i.e., as participants are more proficient in English), the priming effect from Orthographic Control primes relative to Unrelated primes decreases. Similarly, when the priming effect between the Unrelated condition and the Morphological condition was entered as the dependent variable, the effect of the TOEIC score was marginally significant (t = -1.92, β = -0.28, p = .06). This outcome indicates that as participants' TOEIC scores increased, the morphological priming effect relative to the unrelated baseline decreased.

The finding mentioned above could result from a decrease in priming based on prime-target orthographic overlap, which leads to a decrease in the overall morphological priming effect observed against the unrelated baseline. Indeed, when the morphological priming effect relative to the Orthographic Control primes was entered as the dependent variable, the TOEIC score had no predictive power beyond the effect of the presentation lists (t = .70, β = 0.10, p = .49).

Thus far, the results of Experiment 2 suggest that past- and present-tense verbs in the L2 are connected in the Japanese-English bilinguals' lexicon similarly to how they are connected in the L1 for English monolinguals. This is the case for both more proficient and less proficient bilinguals. However, even the less proficient bilinguals in Experiment 2 were relatively proficient in English. Whether similar results would be obtained by testing Japanese-English bilinguals who are even less proficient in English than those tested in Experiments 1 and 2 has yet to be examined. Furthermore, the results of Nakayama and Lupker (2018) were replicated in Experiments 1 and 2, showing that orthographically similar English words facilitate lexical decisions to English targets for Japanese-English bilinguals. A post-hoc regression analysis of the results of Experiment 2, however, showed an interesting trend suggesting that the facilitation effect of orthographic similarity decreases as English proficiency improves.

Therefore, Experiment 3 further investigated the possibility that patterns of facilitation effect of prime-target morphological relationships and orthographic similarity may differ based on the participants' English proficiency. This was done by testing Japanese-English bilinguals who were even less proficient in English than those examined in Experiments 1 and 2.

CHAPTER 4:

Experiment 3

Introduction

The results of Experiment 1 and Experiment 2 suggest that connections between past- and present-tense verb forms in the Japanese-English bilinguals' lexicon are similar to those of L1 English readers. At the very least, this appears to be the case for bilinguals who are relatively proficient in English. The results of Experiment 2, in particular, provided strong evidence that such connections exist for both regular and irregular verbs.

In the experiment, two types of present-tense verbs were selected as word targets: regular verbs (e.g., LOOK) and irregular verbs for which the past- and present-tense forms have the same number of letters (e.g., FALL). These present-tense targets were paired with past-tense Morphological primes (e.g., looked-LOOK, fell-FALL), Orthographic Control primes (e.g., locker-LOOK, fill-FALL), and Unrelated primes (e.g., rather-LOOK, joke-FALL), which were presented for 50 ms in a masked priming lexical decision task. Past-tense primes facilitated decisions compared to Unrelated primes (a 43-ms effect).

As expected for Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018), Orthographic Control primes also facilitated lexical decisions compared to Unrelated primes (a 20-ms effect). Importantly, past-tense primes facilitated lexical decisions to a greater extent than Orthographic Control primes (a 24-ms effect). This result indicates that the facilitation effect of Morphological primes relative to Unrelated primes was at least partially due to the morphological relationship between the prime and target. The priming patterns did not change when latencies to Regular and Irregular verb targets were analyzed separately. Thus, there was no evidence that Japanese-English bilinguals process L2 morphological relationships any differently from L1 readers (cf. Clahsen et al., 2013; Silva & Clahsen, 2008).

At the orthographic level of the lexicon, however, the L2 connections of proficient Japanese-English bilinguals appear to differ from L1 English readers. For the proficient Japanese-English bilinguals in Experiment 1 and Experiment 2, primes that were orthographically similar to their targets facilitated lexical decisions. This result is consistent with the findings of previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018).

Meanwhile, for L1 English readers, the prime-target orthographic overlap inhibits latencies (e.g., Davis & Lupker, 2006; Nakayama et al., 2008). This inhibitory effect is believed to occur because of lexical competition, a process by which a word is distinctly identified from other orthographically similar words in the lexicon. When the representation of a prime orthographically similar to the target is activated, it suppresses the activation of representations for orthographically similar words, including the target. Hence, upon the presentation of the target following an orthographically similar prime, the activation of the target word's representation is met with inhibition, and more time is required for the target's representation to reach the recognition threshold. Consequently, the facilitatory effect observed among Japanese-English bilinguals suggests a weaker (or ineffective) lexical competition process in the L2 for this group (e.g., Nakayama & Lupker, 2018).

As discussed by Cook and Gor (2015), the weaker competition process in the L2 could result from imprecise encoding for L2 prime words. If the encoding of representations lacks precision (i.e., if the representations are underspecified), orthographically similar representations are harder to distinguish. Therefore, when Japanese-English bilinguals perform masked priming lexical decision tasks, L2 target representations are, in effect, in a pre-activated state when preceded by orthographically similar primes, which manifests as a facilitatory priming effect.

One limitation of Experiments 1 and 2 is that their findings cannot be generalized to Japanese-English bilinguals of all English proficiency levels. The two experiments only examined bilinguals who were relatively proficient in English. Hence, their results may differ from those presented by low-proficient Japanese-English bilinguals.

This possibility is evident from the post-hoc regression analyses of Experiment 2. The TOEIC scores of the bilingual participants were shown to have a predictive value for the priming effect from orthographically similar primes relative to Unrelated primes (e.g., locker-LOOK vs. rather-LOOK). That is, the size of priming from orthographically similar primes decreased as TOEIC scores increased. Considering TOEIC scores as a measure of English proficiency, this pattern would be expected if L2 orthographic representations were underspecified for less proficient participants (low TOEIC scores) compared to more proficient participants (high TOEIC scores).

The underspecified nature of representations discussed above has been termed "fuzziness" in the fuzzy lexicon hypothesis (e.g., Cook & Gor, 2015) and as "low-quality" in the lexical quality hypothesis (e.g., Perfetti, 1992). In both hypotheses, the specificity of representations can improve with increased exposure to and experience with a language. Therefore, the post-hoc regression analysis results in Experiment 2 potentially captured the developmental inclination of L2 orthographic-level representations.

Connections for L2 morphological relationships may also differ depending on participants' L2 proficiency. In an examination of Serbian-English bilinguals, Feldman et al. (2010) reported that connections between regular past- and present-tense verb forms were present in these bilinguals' lexicon, as past-tense primes facilitated responses to a greater extent than orthographic controls (e.g., billed-BILL < billion-BILL). However, when they divided the participants into two groups based on their L2 proficiency level (more proficient vs. less proficient), the facilitation effect of past-tense primes was significant only for the more proficient group. This result suggests that bilinguals must be sufficiently proficient in English to develop morphological connections in the L2.

The post-hoc regression for Experiment 2, however, did not show a clear reduction in the amount of facilitation provided by past-tense primes (e.g., looked-LOOK vs. locker-LOOK) among participants with low TOEIC scores (i.e., L2 proficiency), as might be expected based on the results of Feldman et al. (2010). This may have been a ceiling effect. If all the participants in Experiment 2 were sufficiently proficient in English and if the L2 morphological connections were well developed, the participants' L2 proficiency level might not have had an effect on morphological facilitation. Thus, whether morphological connections are present for Japanese-English bilinguals who are much less proficient in English than those examined in Experiment 2 has yet to be examined empirically.

Experiment 3 builds upon Experiment 2 by investigating whether L2 morphological connections are present for Japanese-English bilinguals who are much less proficient in English than those tested in Experiments 1 and 2. The research question addressed in Experiment 3 is, "Does the masked presentation of English past-tense forms facilitate low-proficient Japanese-English bilinguals' lexical decisions to their present-tense targets to a greater extent than orthographic control primes?"

The low-proficient bilinguals examined in this experiment had TOEIC scores that, overall, were much lower than those of the participants in the post-hoc analyses of Experiment 2. Based on the results reported by Feldman et al. (2010), it is conceivable that no significant priming effect from past-tense primes (relative to orthographic controls) will be observed for Japanese-English bilinguals with this level of English proficiency. Such a result suggests that low-proficient bilinguals have not developed morphological connections between past- and present-tense verbs in their L2.

The design of Experiment 3 was similar to that of Experiment 2, but with one modification: repetition primes (e.g., fall-FALL, look-LOOK) were included in the stimuli. As low-proficient bilinguals may not be able to process masked primes as fast as proficient bilinguals, the observation of a repetition priming effect (e.g., fall-FALL, look-LOOK < rather-LOOK, joke-FALL) would indicate that the bilinguals can process masked primes. If past-tense primes do not facilitate responses relative to orthographic controls (e.g., fell-FALL, looked-LOOK = locker-LOOK, fill-FALL), as hypothesized, it could be due to a lack of morphological connections between past- and present-tense verbs rather than the participants' inability to process the past-tense primes.

The inclusion of repetition primes also serves a second purpose: They provide another opportunity to examine whether morphological connections between past- and present-tense verbs in low-proficient Japanese-English bilinguals' L2 are similar to those of L1 English readers. Previous studies with L1 English readers have shown that the priming effect of past-tense primes (relative to unrelated primes) can be as large as the repetition priming effect (e.g., kept-KEEP, boiled-BOIL = keep-KEEP, boil-BOIL < shoe-KEEP, jump-BOIL, Forster et al., 1987; Silva & Clahsen, 2008).

Prime-target pairs in a repetition condition have the ultimate morphological relationship since they are identical. Thus, the equivalent priming effects suggest robust connections between past- and present-tense verbs for L1 English readers. As morphological connections between past- and present-tense verbs in the L2 are not likely to be present for the low-proficient Japanese-English bilinguals in Experiment 3, the repetition priming effect is expected to be significantly larger than the morphological priming effect (if one exists). The strength of the facilitation effect of repetition primes is also expected to be significantly higher than that of orthographic controls, as repetition primes have shared representations with the target at the orthographic (lexical) level and beyond.

To recapitulate, Experiment 3 builds upon Experiment 2 by testing Japanese-English bilinguals who are much less proficient in English than those in the previous experiment. Experiment 3 aims to further explain the L2 morphological connections in the lexicon of bilingual participants who are at an earlier stage of L2 acquisition than the participants in Experiments 1 and 2. It is expected that morphological connections between past- and present-tense verbs are not present in the lexicon of bilinguals at this low level of English proficiency. Therefore, past-tense primes are not expected to facilitate responses to a greater extent than orthographic controls. Nevertheless, past-tense primes and orthographic controls are likely to facilitate responses relative to unrelated controls due to their orthographic similarity with the targets. Repetition primes are likely to facilitate responses relative to not only unrelated primes (i.e., they are expected to have a repetition priming effect) but also orthographic controls and past-tense primes.

Method

Participants

Seventy-seven Japanese-English bilinguals were recruited at the National Institute of Technology, Sendai College (NIT, Sendai College). NIT, Sendai College, offers a five-year higher education program that students typically begin at the age of 15-16. Upon completing the five-year program, some students continue their studies in a two-year advanced course. As the participants in this experiment were recruited from both the five-year program and the advanced course, some of them were younger than the university students examined in Experiments 1 and 2. It was anticipated that the inclusion of these younger participants might provide clearer differences in priming patterns between participants based on their English proficiency level (assuming that younger participants are less proficient in English).

All participants spoke Japanese as their first language and had scores for at least one of the English proficiency exams: TOEIC L&R (n = 16, range: 330-720, M = 590.63; SD = 104.25), TOEIC L&R IP (n = 30, range: 245-885, M = 452.83, SD = 140.68), TOEIC L&R IP Online (n = 6, range: 425-770, M = 573.33, SD = 115.67), or TOEIC Bridge L&R (n = 38, range: 32-100, M = 59.76, SD = 16.60). The TOEIC Bridge L&R scores for two participants were removed from the demographic survey results, as they reported scores outside of the possible range (30-100). These two participants had valid scores on at least one of the other English proficiency exams.

Of the 77 participants, 66 were male, and 10 were female. The average age of participants at the time of the experiment was 19 years (range: 16-22, *SD* = 2.04). The average age at which they started learning English was 11 years (range: 4-15, *SD* = 2.42), excluding one participant who did not respond. All but one participant (a few weeks) had spent no time in an English-speaking region. Participants received a 500-yen gift card (roughly equivalent to US$3.70) for taking part in the study.

A unified Proficiency Score on the same scale as the TOEIC L&R was computed for each participant to represent their English proficiency level. If a participant had a score on more than one exam (TOEIC L&R, TOEIC L&R IP, and TOEIC L&R IP Online), the highest score was taken as their Proficiency Score, as these variants of the TOEIC have the same scale. TOEIC Bridge L&R scores were converted to Proficiency Scores for 37 participants who had no scores for the TOEIC L&R, TOEIC L&R IP, or TOEIC L&R IP Online. Their TOEIC Bridge L&R scores ranged from 32-88 (*M* = 58.68, *SD* = 15.43).

According to a conversion table released by the Institute for International Business Communication ("TOEIC Bridge L&R to TOEIC L&R no sukoa hikaku hyo [TOEIC Bridge L&R and TOEIC L&R Score Comparison Table]," 2020), a test taker with a TOEIC Bridge L&R score of 30 is likely to obtain a score of no higher than 120 on the TOEIC L&R. Following the conversion table, TOEIC Bridge L&R scores of 40, 50, 60, 70, 80, and 90 correspond to TOEIC L&R scores of 210, 265, 325, 400, 490, and 605, respectively. Test takers with scores above 91 on the TOEIC Bridge L&R are likely to score 610 or more on the TOEIC L&R. Therefore, the Proficiency Scores of the 37 participants who only had TOEIC Bridge L&R scores were calculated by linear interpolation between the two nearest (lowest and highest) TOEIC L&R scores provided on the conversion table. The resulting values were rounded to the nearest multiple of five since all TOEIC L&R scores are multiples of five. The resulting Proficiency Scores for these 37 participants ranged from 140-580 (M = 331.49, SD = 116.52).

The average Proficiency Score for all 77 participants was 421.82 (range: 140-885, SD = 159.65). This score is much lower than the TOEIC scores of participants in the post-hoc analyses of Experiment 2 (range: 605-965).

Stimuli

Following Experiment 2, two types of verbs (Verb Types) were used as verb targets: irregular verbs (Irregular Verbs) and regular verbs (Regular Verbs). Irregular Verbs (n = 36) did not take the "-ed" suffix in their past tense, and their past and present-tense forms had the same number of letters as the present-tense forms (e.g., fell-FALL). The past-tense forms of Regular Verbs (n = 36) took the "-ed" suffix (e.g., looked-LOOK). All targets were simple verbs likely to be learned at the junior high school level in Japan ("Chugaku de manabu eitango [English vocabulary learned in junior high school]," 2011; Kasajima et al., 2021). Each target was paired with four types of primes (Prime Type). In addition to the Morphological (e.g., fell, looked), Orthographic Control (e.g., fill, lonely), and Unrelated primes (e.g., slow, danger) examined in Experiment 2, this experiment included Repetition primes (e.g., fall, look). The critical stimuli are listed in Appendix C. Their lexical characteristics are shown in Table 7.

Table 7

Lexical Characteristics and Examples of Prime-Target (Verb) Pairs in Experiment 3

		Prime Type				Target
		MORPH	ORTH	UNREL	REP	
IREG		**fell**	**fill**	**slow**	**fall**	**FALL**
	Frequency	131 (170.7)	127 (197.2)	101 (107.5)	638 (1131.6)	638 (1131.6)
	Length	4.3 (0.6)	4.3 (0.6)	4.3 (0.6)	4.3 (0.6)	4.3 (0.6)
	Neighbors	8.9 (5.8)	8.4 (5.5)	8.9 (5.8)	8.7 (5.0)	8.7 (5.0)
	% Overlap	65 (16.8)	60 (13.1)	0.0 (0.0)	100 (0.0)	
REG		**looked**	**lonely**	**danger**	**look**	**LOOK**
	Frequency	90 (112.7)	92 (184.7)	78 (107.4)	492 (563.1)	492 (563.1)
	Length	6.3 (0.6)	6.3 (0.6)	6.3 (0.6)	4.3 (0.6)	4.3 (0.6)
	Neighbors	4.1 (2.4)	1.2 (1.6)	4.2 (1.8)	8.1 (4.0)	8.1 (4.0)
	% Overlap	68 (2.7)	38 (12.3)	0.0 (0.0)	100 (0.0)	

Note. Values given in word frequencies (SUBTLEX frequency per million words) and the numbers of neighbors are based on the English Lexicon Project (Balota et al., 2007).

The lexical characteristics of targets in the Irregular and Regular conditions were matched in terms of mean word frequency, number of orthographic neighbors, and word length (all *t*s > .38). In the Irregular condition, Morphological, Orthographic Control, and Unrelated primes were matched for mean word frequencies (*M*s = 131, 127, 101, *F* < 1). Repetition primes, however, had a significantly higher mean word frequency (*M* = 638) than Morphological primes, *t*(35) = 2.94, *SEM* = 172.28, *p* = .006. This difference was inevitable, as most verbs tend to be used in their present tense more frequently than in their past tense. Repetition primes also had a significantly higher mean word frequency than Orthographic Control, *t*(35) = 2.61, *SEM* = 195.45, *p* = .01, and Unrelated primes, *t*(35) = 2.84, *SEM* = 188.76, *p* = .007, as they were matched with the mean word frequency of Morphological primes during the stimuli-creation process.

Such a design was maintained so that morphological priming effects relative to the Unrelated condition might be calculated similarly to those in Experiment 2. The number of neighbors were matched for Morphological, Orthographic Control, Unrelated, and Repetition primes (*M*s = 8.9, 8.4, 8.9, 8.7, *F* < 1) and word length (all *M*s = 4.3). Prime-target orthographic overlap was statistically equivalent for Morphological primes and Orthographic Control primes, *M*s = 65% and 60%, *t*(35) = 1.13, *p* = .27. Unrelated primes had no orthographic overlap (*M* = 0%), and Repetition primes had complete orthographic overlap (*M* = 100%) with their targets.

In the Regular condition, Morphological, Orthographic Control, and Unrelated primes were matched for their mean word frequencies (*M*s = 90, 92, 78, *F* < 1). Repetition primes had a significantly higher mean word frequency (*M* = 492) than Morphological, *t*(35) = 4.64, *SEM* = 86.68, *p* < .001, Orthographic Control, *t*(35) = 3.94, *SEM* = 101.80,

$p < .001$, and Unrelated primes, $t(35) = 4.22$, $SEM = 98.11$, $p < .001$. Morphological, Orthographic Control, and Unrelated primes were matched for word length (all *M*s = 6.3). However, Repetition primes were inevitably shorter by two letters (i.e., "-ed"; $M = 4.3$).

As in Experiment 2, the degree of orthographic overlap between primes and targets was significantly higher for Morphological primes than Orthographic Control primes, *M*s = 68% and 38%, $t(35) = 13.03$, $SEM = 2.28$, $p < .001$. Unrelated primes had no orthographic overlap ($M = 0\%$), and Repetition primes had complete orthographic overlap ($M = 100\%$) with their targets. Repetition primes had significantly more neighbors than Morphological primes, *M*s = 8.1, 4.1, $t(35) = 7.99$, $SEM = .50$, $p < .001$, Orthographic Control primes, $M = 1.2$, $t(35) = 10.29$, $SEM = .68$, $p < .001$, and Unrelated primes, $M = 4.2$, $t(35) = 7.13$, $SEM = .56$, $p < .001$. Morphological primes and Unrelated primes also had more neighbors than Orthographic Control primes, $t(35) = 6.34$, $SEM = .47$, $p < .001$; $t(35) = 7.89$, $SEM = .38$, $p < .001$. The number of neighbors did not differ between Morphological and Unrelated primes ($t < 1$).

Four presentation lists were created for the word targets (Lists A, B, C, and D). In each list, one-quarter of the word targets were paired with Morphological primes, one-quarter were paired with Orthographic Control primes, one-quarter were paired with Unrelated primes, and one-quarter were paired with Repetition primes. Each word target was primed once by each type of word prime (Morphological, Orthographic Control, Unrelated, and Repetition) across the four presentation lists.

Seventy-two nonword targets were selected. These nonword targets consisted of two sets of 36 nonwords, which served as counterparts to the Irregular and Regular Verb targets (henceforth referred to as "Nonword Irregular" and "Nonword Regular" targets).

The word length and numbers of neighbors of nonword targets were similar to those of their verb target counterparts. Within each set of nonword targets, one-quarter (n = 9) were paired with word primes that mimicked the relationship between Morphological primes and their verb targets (Nonword Morphological; e.g., heal-HEAK, course-COUR), Orthographic Control primes and their verb targets (Nonword Orthographic Control; e.g., wild-WINA, country-COGUE), and Unrelated primes and their verb targets (Nonword Unrelated; e.g., flash-ZONET, mister-JAME). The remaining quarter of nonword targets were paired with nonword primes identical to the targets (Nonword Repetition; e.g., basp-BASP, chan-CHAN).

The lexical characteristics of the primes for nonword targets were similar to their counterparts in the verb target conditions and are shown in Table 8. There was only one presentation list for nonword targets, and none of the word primes preceding nonword targets was used as a critical stimulus.

Table 8

Lexical Characteristics and Examples of Prime-Target (Nonword) Pairs in Experiment 3

		Prime Type				Target
		NWMORPH	NWORTH	NWUNREL	NWREP	
NWIREG		**heal- HEAK**	**wild- WINA**	**flash- ZONET**	**basp- BASP**	
	Frequency	115 (135.5)	110 (127.6)	65 (54.4)		
	Length	4.1 (0.6)	4.3 (0.5)	4.1 (0.7)	4.2 (0.4)	4.2 (0.6)
	Neighbors	10.4 (5.1)	9.1 (5.7)	8.9 (5.9)	7.9 (4.2)	9.0 (4.8)
	% Overlap	65 (13.8)	62 (12.7)	0.0 (0.0)	100 (0.0)	
NWREG		**course- COUR**	**country- COGUE**	**mister- JAME**	**chan- CHAN**	
	Frequency	102 (141.1)	78 (73.0)	108 (141.8)		
	Length	6.2 (0.4)	6.4 (0.7)	6.2 (0.4)	4.2 (0.6)	4.3 (0.6)
	Neighbors	3.4 (1.6)	0.8 (1.3)	4.0 (2.8)	7.1 (3.3)	7.5 (3.8)
	% Overlap	68 (2.0)	40 (8.0)	0.0 (0.0)	100 (0.0)	

Note. Values given in word frequencies (SUBTLEX frequency per million words) and the numbers of neighbors are based on the English Lexicon Project (Balota et al., 2007).

Apparatus and Procedure

The timing control for stimulus presentation, response recording, and latency measurements were done with DMDX (Forster & Forster, 2003). Up to three participants were tested in the same room using three sets of computers, monitors, and gamepads. The sequence and timing of stimulus presentation were identical to those in Experiment 2.

Each trial consisted of a fixation point (i.e., "+") presented for 450 ms, followed by a 50-ms blank screen. Then, a forward mask consisting of a string of number signs (i.e., "#") corresponding to the number of letters contained by the prime was presented for 500 ms. Immediately after the forward mask, a prime was presented in lower-case letters for 50 ms. A target was then presented in upper-case letters immediately after the prime was displayed. This mode of presentation (i.e., displaying the prime in lower-case letters and the target in upper-case letters) is standard practice to minimize the visual similarity between the prime and target. The target remained on the screen until a response was given but timed out after 3,000 ms if no response was given. All stimuli were presented in white 18 pt Courier New font on a black background on the center of a screen. The inter-trial interval was 1,000 ms.

After entering the room where the test was conducted, participants were given an oral explanation of the tasks they were to perform. Participants signed consent forms indicating their consent for data collection and participation in the experiment, and each participant was given a gift card worth 500-yen (approximately US$3.70).

Next, participants were asked to perform the masked priming lexical decision task. Participants were not explicitly informed of the masked primes and were asked to respond to each target as fast and accurately as possible by deciding whether the displayed word was an English word. Responses were given by pressing one of two buttons on a gamepad (“YES”: word, “NO”: nonword).

Thirty-two practice trials preceded the experimental trials to familiarize participants with the task; these trials were repeated until participants were familiar with the task. Two breaks were offered—one halfway through the practice trials and one halfway through the experimental trials. No participants voiced any comments suggesting their awareness of the primes.

Next, participants were asked to complete a demographic background and vocabulary survey. Scores on English proficiency tests were collected during the demographic background survey. In the vocabulary survey, participants marked words that they did not know. Responses to the vocabulary survey were used to clean the lexical decision data of irrelevant and error responses; this process was anticipated to reduce noise in the priming patterns.

The survey included 279 of the 288 masked primes (about 97%) paired with verb (word) targets (due to an error in the survey creation). For each participant, all 279 items in the vocabulary survey were randomly selected from the 288 masked primes and were printed in random order on survey sheets. Approval for the experiments was obtained by the ethics review board of research with human subjects of the NIT, Sendai College, and the Graduate School of International Cultural Studies, Tohoku University.

Results

Error rates for items were monitored during data collection, and when a participant’s error rate was 25% or higher, the participant was replaced while maintaining counterbalancing between the presentation lists and apparatuses. The analyses described below were performed for the data of 72 participants (five participants were removed due to their high error rates). Responses with latencies equal to or greater than 1,500 ms were considered outliers and were removed from the analyses (0.41% of responses to word targets and 1.25% to nonword targets). Two items in the Irregular Verb condition ("build" and "steal") were excluded from all analyses, as they produced an error rate of 40% or more.

Data collected in the lexical decision task were compared with the survey results to increase reliability. If a word target was responded to correctly in the lexical decision task but marked as unknown in the survey, the correct response in the lexical decision task was treated as an error (0.08% of responses to word targets). Furthermore, incorrect responses on the lexical decision task to target words marked as unknown in the survey were removed from the analyses (0.12% of responses to word targets). Correct responses to known targets were also removed from the analyses when paired with unknown primes (3.40% of responses to word targets). Additionally, if the response was incorrect, it was treated as an error (0.73% of responses to word targets).

Omnibus tests for latencies and error rates to word targets were conducted by entering two factors into the ANOVA. The first factor was Verb Type, which had two levels (Irregular and Regular). The second factor was Prime Type, which had four levels (Morphological, Repetition, Orthographic Control, and Unrelated). Both by-subject (F_s) and by-item (F_i) ANOVAs were conducted. In the subject analyses, Verb Type and Prime Type were within-subject factors. In the item analyses, Prime Type was a within-item factor, and Verb Type was a between-item factor. No corrections were applied for multiple testing in the follow-up analyses. The mean response latencies and error rates are shown in Table 9.

Table 9

Mean Response Latencies (and Error Rates) for Verb Targets in Experiment 3

Verb type	Prime Type				Priming effect			
	R	M	O	U	U-R	M-R	O-M	U-O
Irregular	609	642	650	678	69	33	8	28
	(9.7)	(10.0)	(11.3)	(15.5)	(5.8)	(0.3)	(1.3)	(4.2)
Regular	587	619	639	665	78	32	20	26
	(7.9)	(7.4)	(10.2)	(11.6)	(3.7)	(-0.5)	(2.8)	(1.4)

Note. R = Repetition condition; M = Morphological condition; O = Orthographic Control condition; U = Unrelated condition.

Response Latencies

The main effect of Prime Type was significant, $F_s(3,213) = 66.92$, $MSE = 2,010.68$, $p < .001$, $\eta^2_p = .49$; $F_i(3,204) = 39.05$, $MSE = 1,708.47$, $p < .001$, $\eta^2_p = .36$, indicating that at least one of the six comparisons between the four levels of Prime Type was significant when collapsed by Verb Type. Numerically, Regular Verbs were responded to slightly faster than Irregular Verbs ($M = 627$ ms vs. $M = 645$ ms). However, the difference (i.e., the main effect of Verb Type) was only significant in the subject analysis, $F_s(1,71) = 13.55$, $MSE = 3,150.49$, $p < .001$, $\eta^2_p = .16$; $F_i(1,68) = 2.31$, $MSE = 11,674.60$, $p = .13$. The interaction between Verb Type and Prime Type was not significant, indicating that the priming patterns did not differ between Irregular and Regular Verbs (*F*s < 1).

Follow-up analyses were conducted for the main effect of Prime Type to investigate which of the six comparisons between the four levels of Prime Type was (or were) significant. First, the contrast between the Repetition condition ($M = 598$ ms) and Unrelated condition ($M = 671$ ms) was significant, $F_s(1,71) = 189.81$, $MSE = 2,049.21$, $p < .001$, $\eta^2_p = .73$; $F_i(1,68) = 114.04$, $MSE = 1,727.57$, $p < .001$, $\eta^2_p = .63$. This result was expected, as repetition priming in the L2 has been reported in many studies (e.g., Gollan et al., 1997; Nakayama & Lupker, 2018; Silva & Clahsen, 2008). This result also implies that the participants were sufficiently proficient in English for the processing of masked L2 primes to reach the lexical level.

The next contrast of interest was between the Orthographic Control and Unrelated conditions. Targets were responded to significantly faster in the Orthographic Control condition ($M = 644$ ms) than in the Unrelated condition, $F_s(1,71) = 29.21$, $MSE = 1,817.10$, $p < .001$, $\eta^2_p = .29$; $F_i(1,68) = 16.88$, $MSE = 1,992.96$, $p < .001$, $\eta^2_p = .20$. This outcome supports the results of Experiments 1 and 2, as well as the results of Nakayama and Lupker (2018). As orthographically similar English words can facilitate lexical decisions to English targets for Japanese-English bilinguals, morphological priming effects should be examined against both an orthographic control condition and an unrelated condition.

The Morphological condition (M = 631 ms) significantly facilitated lexical decisions compared to the Unrelated condition, $F_s(1,71) = 69.23$, $MSE = 1{,}741.66$, $p < .001$, $\eta^2_p = .49$; $F_i(1,68) = 23.87$, $MSE = 2{,}347.28$, $p < .001$, $\eta^2_p = .26$. However, in the item analysis, the strength of the facilitation effect of the Morphological condition was not significant when compared to the Orthographic Control condition, $F_s(1,71) = 7.00$, $MSE = 1{,}951.31$, $p = .01$, $\eta^2_p = .09$; $F_i(1,68) = 1.86$, $MSE = 1{,}527.29$, $p = .18$, $\eta^2_p = .03$. Hence, the 40-ms facilitation provided by the Morphological condition when compared with the Unrelated condition seems to have been mainly driven by the orthographic similarity of the past-tense primes to their present-tense targets rather than their morphological relationship.

Finally, the Repetition condition was responded to significantly faster than the Orthographic Control condition, $F_s(1,71) = 61.43$, $MSE = 2{,}517.82$, $p < .001$, $\eta^2_p = .46$; $F_i(1,68) = 57.26$, $MSE = 1{,}184.85$, $p < .001$, $\eta^2_p = .46$, and the Morphological condition, $F_s(1,71) = 38.45$, $MSE = 1{,}986.99$, $p < .001$, $\eta^2_p = .35$; $F_i(1,68) = 29.18$, $MSE = 1{,}470.89$, $p < .001$, $\eta^2_p = .30$. This outcome suggests that the repetition priming effect was greater than the priming effect due to orthographic similarity or the priming effect due to morphological relatedness (if such an effect was present). Paralleling the patterns observed in the omnibus analysis, none of these contrasts interacted with Verb Type (all ps > .20).

Although the interaction between Verb Type and Prime Type was not significant, further analyses were conducted separately for Irregular Verbs and Regular Verbs to search for morphological priming patterns. In the Irregular condition, response latencies were faster in the Morphological condition than in the Unrelated condition, $t_s(71) = -4.91$, *SEM* = 7.37, $p < .001$; $t_i(33) = -3.05$, *SEM* = 9.87, $p = .005$, but did not differ statistically from the Orthographic Control condition, $t_s(71) = -1.00$, *SEM* = 7.93, $p = .321$; $t_i > -1$. As expected, the Orthographic Control condition facilitated responses compared to the Unrelated condition, $t_s(71) = -3.49$, *SEM* = 8.10, $p < .001$; $t_i(33) = -2.88$, *SEM* = 9.82, $p = .007$. Furthermore, the Repetition condition facilitated responses to a greater extent than the Unrelated condition, $t_s(71) = -8.53$, *SEM* = 8.08, $p < .001$; $t_i(33) = -7.43$, *SEM* = 9.02, $p < .001$, the Orthographic Control condition, $t_s(71) = -4.81$, *SEM* = 8.46, $p < .001$; $t_i(33) = -5.09$, *SEM* = 7.61, $p < .001$, and the Morphological condition, $t_s(71) = -4.21$, *SEM* = 7.79, $p < .001$; $t_i(33) = -4.13$, *SEM* = 8.96, $p < .001$.

In the Regular condition, response latencies were faster in the Morphological condition than in the Unrelated condition, $t_s(71) = -6.24$, *SEM* = 7.32, $p < .001$; $t_i(35) = -3.87$, *SEM* = 12.91, $p < .001$. Furthermore, when compared to the Orthographic Control condition, the facilitation in the Morphological condition was significant for the subject analysis and marginally significant for the item analysis, $t_s(71) = -2.50$, *SEM* = 7.86, $p = .015$; $t_i(35) = -1.85$, *SEM* = 8.78, $p = .073$. However, this might have been because the primes in the Orthographic Control condition were not as orthographically similar to the targets as the primes in the Morphological condition for Regular Verbs.

As expected, the Orthographic Control condition facilitated responses compared to the Unrelated condition, $t_s(71) = -3.23$, *SEM* = 8.06, $p = .002$; $t_i(35) = -2.96$, *SEM* =

11.37, p = .005. Additionally, the Repetition condition facilitated responses to a greater extent than the Unrelated condition, $t_s(71) = -11.71$, $SEM = 6.67$, $p < .001$; $t_i(35) = -7.78$, $SEM = 10.68$, $p < .001$, the Orthographic Control condition, $t_s(71) = -5.90$, $SEM = 8.82$, $p < .001$; $t_i(35) = -5.65$, $SEM = 8.73$, $p < .001$, and the Morphological condition, $t_s(71) = -4.69$, $SEM = 6.91$, $p < .001$; $t_i(35) = -3.54$, $SEM = 9.34$, $p = .001$.

The priming patterns for each Verb Type did not differ from the patterns of priming for the overall analyses, except for the marginally significant result that the Morphological condition may facilitate lexical decisions to a greater extent than the Orthographic Control condition for Regular Verbs. Initially, this facilitation of Regular Verbs was suspected to be caused by the mismatch in the prime-target orthographic similarity between the Morphological and Orthographic Control conditions. However, the difference in the orthographic overlap between the Morphological and Orthographic conditions was not associated with the size of the facilitation effect in a regression analysis ($t < 1$, $\beta < .001$, *n.s.*). Therefore, the Morphological condition's facilitation for Regular Verbs could be partially due to the morphological relationship between primes and targets. This implies that representations of morphological relationships for Regular Verbs developed among the participants tested in the present experiment.

However, this possibility is rather unlikely, as the contrast's marginally significant result in the item analysis and the nonsignificant interactions in the omnibus analyses indicate low power. Nevertheless, based on the post-hoc analyses in Experiment 2, participants who were more proficient in English may have developed representations for morphological relationships of past- and present-tense regular verbs, whereas the less proficient participants had not. If there was such a difference among participants, it could explain the inconclusive results for this simple main effect.

Proficiency Scores were used to investigate whether L2 proficiency influences priming patterns. A median split on the Proficiency Score (median = 417.5) was conducted to create a new categorical factor, Proficiency Group, with two levels (More Proficient and Less Proficient). The subset of participants with higher Proficiency Scores formed the More Proficient group, and the subset of participants with lower Proficiency Scores formed the Less Proficient group. This grouping was done to maximize the difference in the average Proficiency Scores for the two groups and ensure that as many participants as possible were included. The grouping process also ensured that both groups had the same number of participants while maintaining counterbalancing for the presentation lists. As a result, 24 participants were grouped into the Less Proficient group (mean Proficiency Score = 274.58; range: 140-400), and 24 participants were grouped into the More Proficient group (mean Proficiency Score = 606.67; range: 455-885).

The Proficiency Group factor was entered into the omnibus test. In the subject analysis, Verb Type and Prime Type were within-subject factors, and Proficiency Group was a between-subject factor. In the item analysis, Prime Type and Proficiency Group were within-item factors, and Verb Type was a between-item factor. In addition to the items already removed from the analyses, two Regular Verb items (“finish” and “call”) were removed, as there was no average latency in the Orthographic Control or Unrelated condition cells, respectively, for the Less Proficient group in the item analysis. The results revealed no significant two- or three-way interactions with the Proficiency Group (all *F*s

< 1). Therefore, the participants' English proficiency did not modulate the priming patterns.

Error Rates

The main effect of Verb Type was significant in the subject analysis, $F_s(1,71) = 6.88$, $MSE = 116.00$, $p = .01$, $\eta^2_p = .09$, but was not significant in the item analysis, $F_i(1,68) = 1.80$, $MSE = 268$, $p = .184$. This outcome implies that error rates did not differ between the Irregular and Regular conditions when collapsed across Prime Type. The main effect of Prime Type was significant in both the subject and item analysis, $F_s(3,213) = 6.99$, $MSE = 104.94$, $p < .001$, $\eta^2_p = .09$; $F_i(3,204) = 7.65$, $MSE = 47.6$, $p < .001$, $\eta^2_p = .10$. Therefore, at least one of the six contrasts between the levels of Prime Type was significant when collapsed across Verb Type. The interaction between Prime Type and Verb Type was not significant, indicating that the patterns of error rates between the levels of Prime Type did not differ between the Irregular and Regular conditions.

Follow-up analyses were conducted for the main effect of Prime Type. Error rates were the highest for the Unrelated condition ($M = 13.5$), as it exhibited significant contrasts with the Orthographic Control condition, $M = 10.7$, $F_s(1,71) = 4.44$, $MSE = 125.21$, $p = .04$, $\eta^2_p = .06$; $F_i(1,68) = 5.30$, $MSE = 55.44$, $p = .02$, $\eta^2_p = .07$, the Repetition condition, $M = 8.8$, $F_s(1,71) = 15.74$, $MSE = 101.79$, $p < .001$, $\eta^2_p = .18$; $F_i(1,68) = 13.02$, $MSE = 61.69$, $p < .001$, $\eta^2_p = .16$, and the Morphological condition, $M = 8.70$, $F_s(1,71) = 15.65$, $MSE = 106.75$, $p < .001$, $\eta^2_p = .18$; $F_i(1,68) = 16.96$, $MSE = 48.74$, $p < .001$, $\eta^2_p = .20$.

The error rates of the Orthographic Control condition were the second highest. This condition's contrast with the Repetition condition was marginally significant in both the subject and item analysis, $F_s(1,71) = 2.82$, $MSE = 95.90$, $p = .10$, $\eta^2_p = .04$; $F_i(1,68) = 2.91$, $MSE = 42.97$, $p = .09$, $\eta^2_p = .04$. The contrast between the Morphological and Orthographic conditions was not significant in the subject analysis but was marginally significant in the item analysis, $F_s(1,71) = 2.67$, $MSE = 112.22$, $p = .11$, $\eta^2_p = .04$; $F_i(1,68) = 3.56$, $MSE = 37.80$, $p = .06$, $\eta^2_p = .05$. Finally, the contrast between the Repetition and Morphological conditions was not significant (*F*s < 1). Paralleling the patterns in the omnibus analysis, none of these contrasts interacted with Verb Type (all *p*s > .20). The pattern of error rates, together with the priming patterns for latencies, suggests that there was no speed-accuracy trade-off.

Discussion

Experiment 3 investigated whether the masked presentation of English past-tense forms significantly facilitates lexical decisions to their present-tense targets to a greater extent than orthographic control primes (morphological priming) among Japanese-English bilinguals who are not proficient in English. Regular (e.g., LOOK) and Irregular (e.g., FALL) present-tense targets were paired with four types of primes: Morphological primes (e.g., looked-LOOK, fell-FALL), Orthographic Control primes (e.g., lonely-LOOK, fill-FALL), Unrelated primes (e.g., danger-LOOK, slow-FALL), and Repetition primes (e.g., look-LOOK, fall-FALL).

The results showed that Morphological primes facilitated decisions to targets relative to Unrelated primes but did not facilitate decisions to a greater extent than Orthographic Control primes. Meanwhile, as expected, Orthographic Control primes facilitated responses relative to Unrelated primes. In addition, responses were significantly faster when Repetition primes were presented than when Morphological and

Orthographic Control primes were presented. As expected, Repetition primes also facilitated responses relative to Unrelated primes. These results suggest that the facilitation effect of Morphological primes compared with Unrelated primes was driven mainly by prime-target orthographic similarity rather than the morphological relationship between words. Furthermore, the Morphological primes were not as effective as Repetition primes in facilitating responses. Such a result is reasonable considering that the facilitation effect of Morphological primes is driven by prime-target orthographic similarity because Morphological primes only partially overlap with their targets, whereas Repetition primes overlap entirely. The major priming patterns observed in Experiment 3 are depicted in Figure 9.

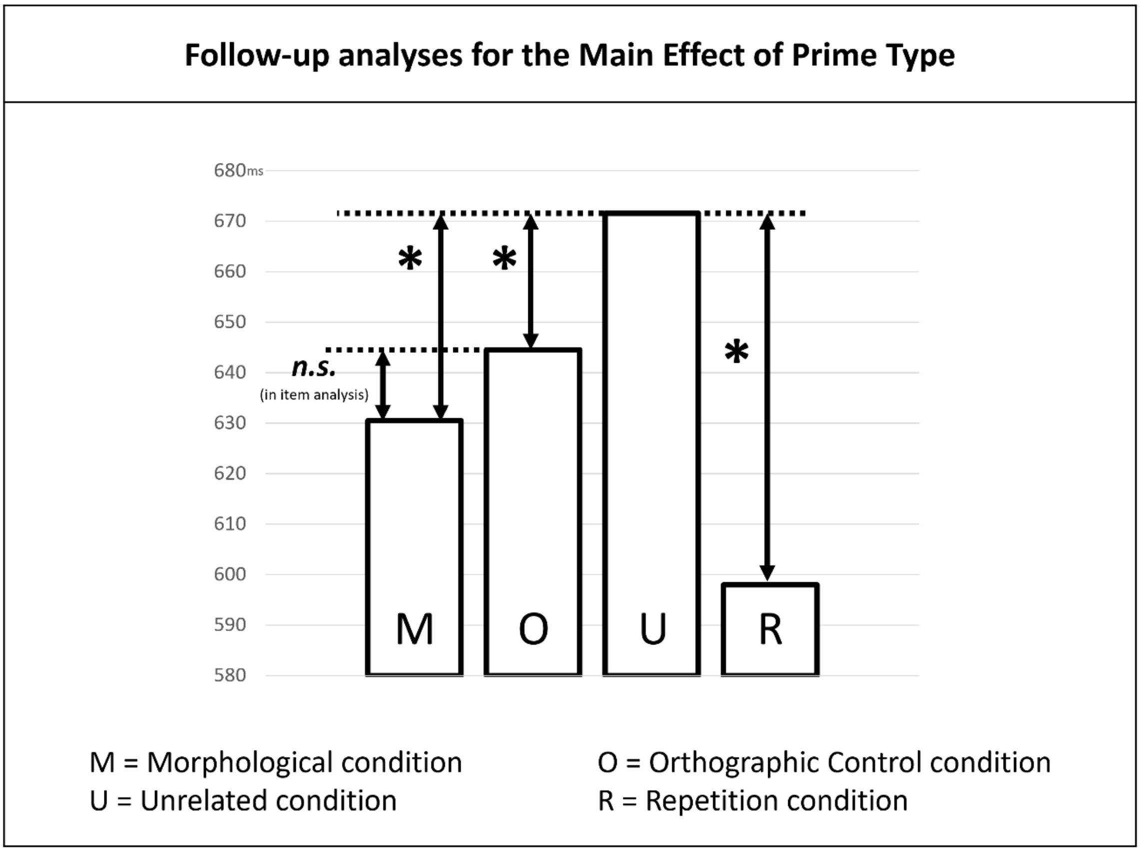

Figure 9. Latencies in Experiment 3

The patterns of priming observed in Experiment 3 are depicted in the figure. The significant repetition priming effect indicated that participants were able to process the masked primes. Orthographic primes facilitated responses relative to Unrelated primes, replicating the results of Experiments 1 and 2. Morphological primes also facilitated responses relative to Unrelated primes. The facilitation from Morphological primes was likely to be driven by prime-target orthographic similarity, however, as the effect was not significant in the item analysis.

The general implication of the results is that connections between L2 past- and present-tense verbs are not present in the lexicon of less proficient Japanese-English bilinguals. When Regular Verb items were analyzed alone, Morphological primes had a marginally significant facilitation effect compared to Orthographic Control primes. However, this effect is likely to reflect the greater orthographically based facilitation effect of the Morphological condition compared to the Orthographic Control condition due to a mismatch in the orthographic similarity between the two conditions. One may speculate that connections for regular past-tense inflections develop earlier than those for irregular past-tense inflections (see Crepaldi et al., 2010; Rastle, Lavric, Elchlepp, & Crepaldi, 2015). However, the marginally significant result for the contrast between Morphological and Orthographic Control conditions in Experiment 3 is not sufficient to attribute the facilitation effect of Morphological primes to any factors other than the prime-target orthographic similarity. This view is supported by the fact that Morphological (regular past-tense) primes were not as effective as Repetition primes in facilitating responses.

The post-hoc analyses conducted in Experiment 2 raise the question of whether facilitation originating from prime-target orthographic similarity decreases as English proficiency increases. This was not the case for the data in Experiment 3, in which participants were divided into two groups based on their Proficiency Scores. The participants' English proficiency did not modulate the priming patterns when entered into the omnibus ANOVAs. In case the ANOVAs failed to detect modulation, a post-hoc regression was performed on the same data set. This post-hoc regression confirmed that the participants' Proficiency Scores did not predict the size of the orthographic facilitation effect for past-tense primes or orthographic controls. This could be because the English proficiency level of most participants in Experiment 3 was lower than the proficiency level at which L2 lexical competition begins to develop.

Similarly, a post-hoc regression analysis confirmed that the participants' Proficiency Scores did not predict the size of the morphologically based facilitation effect (relative to Orthographic Controls). This outcome—together with the finding that the morphologically based facilitation was not significant for the low-proficient participants in Experiment 3 but was significant for relatively proficient participants in Experiment 2—indicates that most participants in Experiment 3 were not sufficiently proficient in English for morphological connections to develop between past- and present-tense verbs in the L2.

The results of Experiments 2 and 3, taken together, show that morphological priming can be observed for relatively proficient L2 English readers but not for L2 readers who are not proficient. The results of Feldman et al. (2010) and Voga et al. (2014) are consistent with this view. However, the results reported by Silva and Clahsen (2008) are not consistent with this view, as they did not find L2 morphological connections, even for proficient bilinguals. Even though the participants were proficient Chinese-English and German-English bilinguals, past-tense primes did not facilitate responses relative to unrelated primes. These results are somewhat puzzling, especially those for the Chinese-English bilinguals. If there was no morphologically based facilitation effect of the morphological primes, then strong orthographically based facilitation would be expected when compared to the unrelated primes.

Previous studies have shown that prime-target orthographic similarity in the L2 can facilitate lexical decisions for different-script bilinguals (Jiang, 2021; Kida et al., 2022; Nakayama & Lupker, 2018; Qiao & Forster, 2017). Therefore, perhaps the results of Silva and Clahsen (2008) indicate that their bilingual participants' L2 lexical competition process is similar to that of L1 readers, whereas L2 representations of morphological relationships have not (yet) developed. Further research is needed to investigate this possibility.

In summary, the results of Experiment 3 suggest that morphological connections between past- and present-tense verbs in English are not present in the lexicon of Japanese-English bilinguals who are not as proficient in English as the bilinguals examined in Experiments 1 and 2. Taken together with the results of Experiments 1 and 2, the results of Experiment 3 indicate that a bilingual's L2 proficiency level affects the development of such connections. This view is consistent with the results reported by Feldman et al. (2010), which suggest that a sufficient level of L2 proficiency is necessary for such connections to develop in the bilinguals' lexicon.

CHAPTER 5:

Conclusion

Studies have focused on how L1 and L2 representations are shared or connected in the bilinguals' lexicon (see Dijkstra, 2005). As for the L2 representations themselves, researchers have generally assumed that they are similar to the representations for the same language in the monolinguals' lexicon. Recently, however, studies focusing on L2 representations suggest that there could be some differences from L1 representations (see Bordag et al., 2022). For Japanese-English bilinguals, in particular, Nakayama and Lupker (2018) suggested that connections at the lexical level of the bilinguals' L2 are somewhat different from those of L1 English readers. Thus, it is possible that connections for the L2 at other levels of the Japanese-English bilinguals' lexicon also differ from those in the L1 of English monolinguals.

The present study examined whether morphological connections between English past- and present-tense verbs, similar to those of L1 English readers, are present in the Japanese-English bilinguals' lexicon. The L2 representations of this morphological relationship had not been studied extensively in masked priming lexical decision experiments with Japanese-English bilinguals (but see Silva & Clahsen, 2008), and studies with L2 English bilinguals of different L1 backgrounds showed mixed results. As there is still debate on how exactly morphological relationships are represented in the lexicon of L1 English readers (see Chapter 1), the present study did not aim to examine which view better explains morphological processing in the L2.

Instead, it focused on whether morphological connections in the L2 of Japanese-English bilinguals differ from those of the L1 in English monolinguals.

Three masked priming lexical decision experiments were conducted in this study: two with relatively proficient Japanese-English bilinguals (Experiment 1 and Experiment 2) and one with low-proficient Japanese-English bilinguals (Experiment 3). Results indicated that connections for L2 morphological relationships are present in the lexicon of relatively proficient Japanese-English bilinguals. For low-proficient bilinguals, these connections are not present. Thus, the general implication of the results was that connections of morphological relationships in the L2 do differ from those of L1 readers for low-proficient Japanese-English bilinguals, but become similar to those of L1 English readers when L2 proficiency increases. This finding contributes greatly to our understanding of L2 morphological connections in the Japanese-English bilinguals lexicon.

After summarizing the main results of the three experiments conducted in this study, two sections are devoted to a detailed discussion of L2 orthographic connections and L2 morphological connections in the Japanese-English bilinguals' lexicon. As noted above, previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018) suggest that L2 orthographic connections in the Japanese-English bilinguals' lexicon are somewhat different from those in the L1 for L1 English readers. This was confirmed in the present study as well. While there was some evidence that L2 orthographic connections can improve with increased proficiency, it is unclear whether these connections become as robust as those of L1 English readers. Discussion is also provided for how morphological connections in the L2 may develop, and how this may relate to the development of L2 orthographic connections.

Comparisons between the present study's results and those of previous studies are made before discussing some of the limitations in this study and potential solutions for future studies. This discussion is not meant to enumerate all limitations of the study in a comprehensive manner. Rather, it is meant to share some thoughts on how one may build on the present study to gain a better understanding of L2 morphological connections in the bilinguals' lexicon. Finally, a concise summary of the present study is provided.

General Implications of the Study

The present study involved three experiments investigating whether morphological connections between past- and present-tense verbs in the L2 are present in the lexicon of Japanese-English bilinguals.

A Summary of Experiment 1

In Experiment 1, which examined Japanese-English bilinguals who were relatively proficient in English, orthographically similar primes facilitated decisions to targets as observed in previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018). Importantly, past-tense primes had a significantly stronger facilitating effect than orthographic controls. Hence, the overall results provided some evidence for L2 morphological connections in the bilinguals' lexicon.

There was no noticeable difference in the pattern of morphological priming between the Regular Verbs and the two types of Irregular Verbs examined—those for which the past- and present-tense forms have the same length (Irregular Length Preserved Verbs) and those for which the past- and present-tense forms have different lengths (Irregular Length Varied Verbs). However, the critical contrast between the Morphological and Orthographic Control conditions was not significant when latencies to Irregular Verb targets and Regular Verb targets were analyzed separately. Given that in the Regular Verb condition, the Morphological primes had more orthographic similarity with targets than the Orthographic Control primes, the results of Experiment 1 did not clearly indicate whether the priming effects of Morphological primes were a manifestation of the morphological relationship between the prime and target. This is because the significant facilitation observed across Verb Types may have been partly driven by the orthographic similarity between Morphological primes and targets in the Regular Verb condition. Thus, Experiment 2 was conducted to examine if the results of Experiment 1 could be replicated.

A Summary of Experiment 2

The results of Experiment 1 were replicated in Experiment 2, which had a slightly different experimental design. There are relatively few irregular verbs in English for which the past- and present-tense forms differ in length (i.e., Irregular Length Varied Verbs in Experiment 1). Therefore, the irregular verbs examined in this experiment were limited to those for which the past- and present-tense forms have the same length (i.e., Irregular Verbs, corresponding to Irregular Length Preserved Verbs in Experiment 1). The decision to reduce the levels of Verb Types examined from three to two made it possible to increase the number of items tested in each Verb Type.

Experiment 2 yielded clearer results than Experiment 1. Facilitation based on the morphological prime-target relationship (i.e., the Morphological vs. Orthographic Control condition) was significant for both Regular and Irregular Verbs. Hence, the results of Experiment 1 and Experiment 2, when considered together, suggest that morphological connections are present for Japanese-English bilinguals who are relatively proficient in English.

It was still unclear, however, whether such connections were also present for Japanese-English bilinguals who were less proficient in English. Therefore, post-hoc hierarchical regressions were conducted with a subset of the data in Experiment 2. The results suggested that facilitation based on prime-target orthographic similarity decreases as proficiency increases. However, the size of facilitation based on the prime-target morphological relationship was not affected by changes in the proficiency level of participants.

These results suggest that morphological connections in the L2 are present regardless of the bilinguals' L2 proficiency level. However, this is not necessarily the case, as even the less proficient bilinguals in the post-hoc analyses were quite proficient in English. Therefore, Experiment 3 further examined the possibility that priming patterns based on orthographic similarity and morphological relationships may differ based on participants' English proficiency. This experiment included Japanese-English bilinguals who, overall, were much less proficient in English than the participants in Experiment 1 and Experiment 2.

A Summary of Experiment 3

The priming patterns observed in Experiment 3, which examined low-proficient Japanese-English bilinguals, were somewhat different from those observed in Experiment 2. Consistent with the results of previous studies on Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018) and the post-hoc analysis of Experiment 2, facilitation based on prime-target orthographic similarity was significant in Experiment 3. In contrast to the results of Experiment 2, however, the facilitation effect of the morphological relationship was not significant. This finding suggests that connections for L2 morphological relationships between past- and present-tense verbs are not present in the low-proficient Japanese-English bilinguals' lexicon.

However, when Regular and Irregular Verb items were analyzed separately, the morphologically based priming effect was marginally significant for Regular Verb items. Therefore, the results of Experiment 3 were somewhat inconclusive in this aspect. The marginally significant effect observed for Regular Verbs is likely to reflect the greater orthographically based facilitation effect of the Morphological condition compared to the Orthographic Control condition due to a mismatch in the orthographic similarity between the two conditions. Nevertheless, the possibility that morphological connections may be present for Regular Verbs in the low-proficient bilinguals' lexicon is entertained in the following discussion.

Implications

The results from all experiments conducted in this study, taken together, suggest that L2 morphological connections can develop in Japanese-English bilinguals who are sufficiently proficient in English. The results of Experiment 2—in particular, the finding that morphologically based facilitation was observed for both Regular and Irregular Verbs—have implications for understanding how past-tense verbs are processed by Japanese-English bilinguals. Some studies with a dual mechanism view of morphological processing (e.g., Silva & Clahsen, 2008) have proposed that morpho-syntactic processing in L2 readers is somewhat weaker than in L1 readers. Such accounts of morphological processing show that morphological priming effects are not observed (or are weaker) for regular verbs among L2 readers.

However, the present experiments provide no evidence to support this view, as morphological priming effects were observed for both Regular and Irregular Verb items with bilinguals who are relatively proficient in English (Experiment 1 and Experiment 2). Even for bilinguals who are not proficient in English (Experiment 3), instead of a priming effect being observed only for Irregular Verb items, no morphological priming effects were observed for either Regular or Irregular Verb items. Furthermore, when follow-up analyses were conducted in Experiment 3, a slight degree of morphologically based priming was detected for Regular Verbs (this effect was significant in the subject analysis and marginally significant in the item analysis); however, no such effect was detected for Irregular Verbs. Therefore, among Japanese-English bilinguals, the connections of morphological relationships between L2 past- and present-tense verbs likely become similar to those in the L1 for English monolingual readers as L2 proficiency increases.

Given that morphological priming is observed for both regular and irregular verbs among Japanese-English bilinguals who are sufficiently proficient in English, the discussion in the following sections of morphological and orthographic connections in the lexicon assumes a single-mechanism view of morphological processing. Proponents of a single-mechanism view agree that regular and irregular verbs' past- and present-tense forms are processed similarly.

Some points of contention, however, are whether past- and present-tense forms of verbs are connected in qualitatively different ways and whether explicit morphological representations exist (see Feldman & Weber, 2012; Milin et al., 2018, for a review). One approach to addressing these questions is to examine whether the regularity of past-tense inflections is related to the size of morphological priming effects and to look for contrasts between morphological priming effects and formal and semantic priming effects (e.g., Kielar & Joanisse, 2010; Kielar et al., 2008).

Although the present study does not offer insights into these questions, the results align with the view that the connections between past- and present-tense verbs in the lexicon reflect a morphological relationship and are more than simply the sum of connections in formal and semantic overlap. This view seems to be prevalent in the current literature (e.g., Crepaldi et al., 2010; Fruchter, Stockall, & Marantz, 2013; Kielar et al., 2008; Morris & Stockall, 2012; Stockall & Marantz, 2006).

L2 Orthographic Connections in the Japanese-English Bilinguals' Lexicon

Orthographic connections in the Japanese-English bilinguals' lexicon appear to differ somewhat from those in the English monolinguals' lexicon. For L1 English readers, the masked presentation of orthographically similar primes generally inhibits lexical decisions to targets (e.g., Davis & Lupker, 2006; Nakayama et al., 2008). This inhibitory effect is assumed to occur because of lexical competition, a process by which words are distinguished from other orthographically similar words in the lexicon. Presenting a masked prime that is orthographically similar to the target suppresses the activation of representations for orthographically similar words, including the target. As a result, more time is required for the target's representation to reach the recognition threshold.

However, this lexical competition process appears to be much weaker, or even absent, for some L2 English readers (e.g., Diependaele et al., 2011; Qiao & Forster, 2017). Indeed, facilitation was observed as a result of prime-target orthographic overlap rather than inhibition in all three experiments conducted in this study. This result supports previous studies with Japanese-English bilinguals (e.g., Nakayama & Lupker, 2018), confirming that the lexical competition process is weaker for Japanese-English bilinguals than for L1 English readers.

One possible explanation for the weaker lexical competition process among Japanese-English bilinguals is the imprecise encoding of words in the Japanese-English bilinguals' lexicon. If the encoding of word-level representations lacks precision in these bilinguals, orthographically similar words should be harder to distinguish. This underspecified nature of the representations has been termed "fuzziness" in the fuzzy lexicon hypothesis (e.g., Cook & Gor, 2015) and described as "low-quality" in the lexical quality hypothesis (e.g., Perfetti, 1992). When representations are fuzzy, primes that are orthographically similar to targets can put target representations (among other representations for orthographically similar words) in a pre-activated state. This reduces the time bilingual participants take to respond in masked priming lexical decision tasks. However, it appears that the fuzziness or quality of a representation can improve with increased exposure to and experience with the language.

The results of the post-hoc hierarchical regression analyses in Experiment 2 suggest that the size of the facilitation effect of prime-target orthographic similarity decreases as the level of English proficiency increases. This finding indicates that the specificity of lexical representations can improve and that the lexical competition process can be strengthened by more extensive experience with English. It is unclear, however, if lexical competition in the L2 can develop to become as robust as that observed with L1 readers.

Connections for L2 Morphological Relationships in the Japanese-English Bilinguals' Lexicon

When bilinguals are relatively proficient in their L2, connections for the morphological relationship between past- and present-tense L2 verbs can develop, even if lexical-level representations are not fully specified. In Experiment 1 and Experiment 2 of the present study, morphologically based priming effects were observed among Japanese-English bilinguals who were relatively proficient in English. Prime-target orthographic similarity also had a significant facilitatory effect on these participants. Connections in semantic relationships can likely also develop, even if lexical-level representations are underspecified. Nakayama and Lupker (2018) showed that word neighbor primes (e.g., room-ROOF) that facilitate target identification also facilitate the recognition of their Japanese translations (e.g., room-部屋).

Language transfer is one way by which such higher-level connections can develop despite the underspecified nature of lower-level representations in the bilinguals' lexicon. According to the Ontogenesis Model (Bordag et al., 2022), a model for L2 word processing that can account for L2 learners' different stages of acquisition, L2 lexical representations in the bilingual's lexicon can be mapped onto pre-existing semantic representations. In other words, an L2 word can be assigned to semantic knowledge from the bilingual's L1. A similar process could also be possible for L2 morphological relationships in the Japanese-English bilinguals' lexicon. Representations of the past-tense morphological relationship in Japanese (e.g., kaku-kaita, taberu-tabeta, suru-shita) could also be mapped onto the lexical representations of past- and present-tense English verbs.

When bilinguals are not sufficiently proficient in their L2, connections for L2 morphology are not present. The results of Experiment 3 showed no morphologically based priming among Japanese-English bilinguals who were not proficient in English. This result suggests that connections for L2 morphological relationships do not exist (or are extremely weak) at a low level of English proficiency. The lexical competition process for such bilinguals is also likely to be extremely weak, as suggested by the post-hoc regression analysis of Experiment 2 and the significant priming effect based on orthographic similarity observed in Experiment 3.

One possibility for this outcome is that post-lexical representations, such as those for morphological information, cannot be activated with precision for low-proficient bilinguals because of the fuzzy nature of lexical-level representations. As reported by Viviani and Crepaldi (2022), morphological connections in the L2 may begin to develop as the L2 lexical competition process becomes more robust. The results of the post-hoc hierarchical regressions of Experiment 2 are consistent with this view. When the morphologically based priming effects (i.e., Orthographic Control condition – Morphological condition) were entered as the dependent variable, the orthographically based priming effect (i.e., Unrelated condition – Orthographic Control condition) had predictive value beyond the effect of the presentation lists ($t = -4.24$, $\beta = -0.57$, $p < .001$).

The negative coefficient indicates that as the orthographically based priming effect increased (i.e., as lexical competition became weaker), the morphologically based priming effect decreased.

A Comparison of the Current Results with the Results of Previous Studies

The results of Experiment 1, Experiment 2, and Experiment 3 were consistent with the results of Feldman et al. (2010) and Voga et al. (2014) in terms of the morphological priming effects observed relative to an unrelated baseline. As was the case with the Serbian-English and Greek-English bilinguals examined in the previous studies, past-tense verb forms primed their present-tense targets relative to an unrelated baseline for the Japanese-English bilinguals examined in the current study. However, when considering the morphologically based priming effect observed with the Orthographic Control primes as a baseline, the results of the present study differed somewhat from those of Feldman et al. (2010). In Experiment 1 and Experiment 2 of the present study, morphologically based priming effects were significant for both regular and irregular verbs. Meanwhile, Feldman et al. observed morphological priming effects for regular verbs only. This result is somewhat similar to the result of Experiment 3, which indicated a slight morphologically based priming effect for regular verbs only (significant in the subject analysis and marginally significant in the item analysis).

One may speculate that this discrepancy could be due to connections for L2 regular verbs developing earlier than those of irregular verbs (see Ervin, 1964), thus making them easier to be observed with bilinguals. In Crepaldi et al.'s (2010) framework, regular verbs and irregular verbs have a different basis for priming (see also Rastle et al., 2015). This framework proposes that three levels of the lexicon explain the morphological processing of L1 English readers: the morpho-orthographic level, the lexical level, and the lemma level. At the morpho-orthographic level, morphologically complex words are rapidly decomposed into their constituents. At the lexical level, words are represented in their whole-word forms. The lemma level provides an abstract level of representation that can act as a heading for words with the same lexeme.

As regular verbs can be decomposed (e.g., “looked” = “look” + “ed”), their past- and present-tense forms share representations at the morpho-orthographic level and the lemma level. Meanwhile, past- and present-tense irregular verbs do not share representations at the morpho-orthographic level; they share representations only at the lemma level. This idea implies that the morphologically based priming effect with regular verbs should be greater than that with irregular verbs, as there are at least two sources of shared representations compared to the one for irregular verbs. If this is the case, it should be easier to detect morphologically based priming effects for regular verbs than for irregular verbs. This may be especially true for bilinguals who are not yet proficient in their L2, such as the participants examined in Experiment 3. Representations at the morpho-orthographic level may develop before higher-level representations, such as those at the lemma level. This explanation of the discrepancy between the results of Experiments 1 and 2 in the present study and the findings presented by Feldman et al. (2010) is not entirely convincing, however, as the bilingual participants in Feldman et al. (2010) may have been more proficient in English than the participants in Experiment 3.

It is unclear why morphologically based priming effects were not observed for irregular verbs by Feldman et al. (2010), if not due to the participants’ level of L2 proficiency. Perhaps the degree to which L2 verbs were entrenched in the participants’ lexicon offers some insight into this matter. In the three experiments conducted in the present study, all critical target items were high-frequency words ($M > 350$ occurrences per million) with which the Japanese-English bilinguals were likely to be familiar. Meanwhile, the target words in Feldman et al.'s experiments had a much lower frequency (60-85 occurrences per million). Thus, even if the bilinguals in Feldman et al.'s experiment were more proficient in English than those in the present study, they might not have had extensive experience with or exposure to the critical target words. That is, relatively proficient bilinguals may perform similarly to much less proficient bilinguals when given critical stimuli with the same degree of entrenchment.

However, a simple comparison between the reaction times for word targets in the present experiments and Feldman et al.'s (2010) experiments does not quite support this possibility. Higher levels of entrenchment do not necessarily mean that L1-like morphologically-based priming is more likely to be observed. In Feldman et al.'s experiment, the bilinguals' mean response times ranged from 725-800 ms. These response times are relatively slow, not only in comparison to the same researchers' results for L1 English readers (606-664 ms) but also in comparison to Experiment 1 and Experiment 2 in the present work (591-676 ms). Thus, the representations of words used in Experiments 1 and 2 might have had a higher overall level of entrenchment than those examined by Feldman et al. Importantly, though, the latencies of participants in Experiment 3 ranged from 587-678 ms, suggesting that the degree of entrenchment for word targets was similar to that of Experiments 1 and 2. Therefore, despite the high degree of entrenchment of these words in the participants' lexicon, morphologically based priming effects were not significant for irregular verbs (or regular verbs) in Experiment 3.

Another possible reason for the discrepancy is that the design of Feldman et al. (2010), and perhaps that of Experiment 3, was underpowered. Recall that in Experiment 1, the morphologically based priming effect for regular and irregular verbs was not significant when analyzed separately. In this experiment, which included a dataset obtained from 90 participants, there were 27 items for each of the three Verb Types, all of which were primed by three types of primes. Hence, there were nine items per cell for any given participant. Experiment 3, which examined 72 participants, had the same number of items per cell as Experiment 1. Though this was not ideal, the inclusion of repetition primes and the lower level of participants' English proficiency (which limited the words that could be chosen as stimuli for the two verb conditions) made it impossible to increase the number of items per cell.

Meanwhile, Feldman et al.'s (2010) experiment included more participants than Experiment 1 but had fewer items for each Verb Type (n = 21). This meant that, with three Prime Types for each target verb, there were only seven items per cell. Therefore, the morphologically based priming effects for irregular verb items might have been detected in Experiment 3 and Feldman et al.'s (2010) study if more items had been tested per cell.

The results of the present study are also inconsistent with the findings of Silva and Clahsen (2008) and Clahsen et al. (2013), who reported no significant priming effect of regular past-tense primes when compared to an unrelated baseline. As the design of the experiments in the present study was based on Feldman et al. (2010), it is difficult to draw comparisons between the present study and the studies of Silva and Clahsen (2008) and Clahsen et al. (2013). Possible sources of the discrepancy include variables related to the experimental design, such as the number of filler trials and the type of nonword targets included in the stimuli.

Moreover, the absence of a significant priming effect in Silva and Clahsen's (2008) and Clahsen et al.'s (2013) studies could be due to participant variables, such as the participants' L2 proficiency level and first language background. If L2 proficiency affects the development of representations for morphological relationships, as discussed above, the absence of a significant priming effect could indicate that the participants in the two studies were not as proficient in their L2 as the participants in the present experiments. Unfortunately, the overall L2 proficiency of participants between the studies cannot be compared, as different measures were used for this factor—namely, the present study considered TOEIC scores, while Silva and Clahsen (2008) and Clahsen et al. (2013) used Oxford Placement Test scores.

Differences in participants' L1 backgrounds may have also played some role in the absence of a significant priming effect. Even if past-tense primes have no facilitation effect based on morphological relationships, facilitation based on orthographic similarity can be expected for L2 readers. In addition to the present experiments, several other studies have shown that L2 prime-target orthographic similarity can facilitate lexical decisions among different-script bilinguals (Jiang, 2021; Kida et al., 2022; Nakayama & Lupker, 2018; Qiao & Forster, 2017). Such facilitatory effects have also been observed in same-script bilinguals (Diependaele et al., 2011; but see Bijeljac-babic, Biardeau, & Grainger, 1997).

Therefore, when compared to an unrelated baseline, the similarity of orthography between past-tense primes and their present-tense targets alone should have led to some facilitatory priming effects, at least for the Chinese-English bilinguals tested by Silva and Clahsen (2008). The fact that past-tense primes had no facilitation effect among the bilinguals in Silva and Clahsen's (2008) study raises the question of whether the L2 lexical competition process of their bilingual participants operated similarly to that of L1 readers but that L2 morphological connections had not (yet) developed. This issue requires additional research.

Limitations and Future Directions

In what follows, a number of limitations of the present study are discussed. Some suggestions for how such limitations may be overcome in future studies are also provided.

Comparing Priming Patterns between Different Sets of Stimuli

One limitation of this study is that the stimuli haven't been tested with L1 English readers. The study did not confirm that facilitatory priming effects for the morphological relationship between past- and present-tense verbs can be observed for L1 English readers. It also did not confirm that orthographic control primes of the stimuli have inhibitory priming effects for L1 English readers. In the study, results obtained with Japanese-English bilinguals were compared to the priming patterns typically observed for L1 English readers. The rationale is that these patterns can be expected, even with a different set of stimuli, as they have been observed consistently in previous studies examining L1 English readers. The choice to only examine Japanese-English bilinguals was also a practical one; it is difficult to recruit a large number of L1 English readers in Japan, where the experiments were conducted. Ideally, however, both L1 and L2 English readers should be tested with the same set of stimuli as in previous studies examining L2 morphological priming with bilinguals (e.g., Feldman et al., 2010; Silva & Clahsen, 2008).

The Effect of the L1 on L2 Processing

As the present study only examined Japanese-English bilinguals, the results are not generalizable to bilinguals of other language pairs. In some cases, the bilinguals' L1 may have an effect on their L2 processing. For instance, Nakayama and Lupker (2018) suggest that the lexical competition process in L2 may differ between same- and different-script bilinguals. Thus, it is possible that differences in the characteristics of a bilingual's two languages have effects on the processing of L2 morphological relationships too.

The robust L2 morpho-syntactic processing observed in Experiment 2, for example, could be a process that is affected by the bilinguals' L1. One may speculate that the morpho-syntactic processing of L1 Japanese can transfer to L2 English. In Japanese, past-tense forms of verbs are formed in a relatively regular manner; -ta or -da are inflectional suffixes for the past-tense, similar to -ed in English. Future research may investigate whether L2 English readers whose L1 does not have inflectional suffixes for the past-tense (e.g., Chinese-English and Malay-English bilinguals) also show no evidence for weaker morpho-syntactic processing.

Regular Past-Tense vs. Irregular Past-Tense

Though it has been stated that there was no evidence for weaker morpho-syntactic processing in Experiment 2, this statement is based on the significant morphological priming effect observed for regular verbs. A weaker morpho-syntactic processing should result in the size of priming from regular past-tense verbs being quite small or none for L2 readers, and this was not the pattern observed. The design of this study, however, did not allow a proper assessment of how strong the morpho-syntactic processing is.

One way to assess the strength of L2 morpho-syntactic processing is to compare morphological priming effects from regular past-tense primes to repetition priming effects. If their sizes do not differ significantly, as observed with L1 English readers (e.g., Silva & Clahsen, 2008), it may be inferred that morpho-syntactic processing of L2 English is just as robust as L1 English. Unfortunately, a repetition condition was not included in Experiment 2. In fact, including a repetition condition in this design is rather difficult, as seen in Experiment 3. Because L2 readers tend to have a much more limited vocabulary compared to English monolinguals, including the extra prime type leads to a decrease in the number of items per cell.

Another way to assess the strength of morpho-syntactic processing is to compare the size of morphological priming between regular and irregular verbs. If it is weaker in the L2, morphological priming from regular past-tense verbs could be weaker than that from irregular past-tense verbs. This is because irregular past-tense verbs cannot be decomposed in quite the same way as regular past-tense verbs.

Indeed, comparing the size of morphological priming between regular and irregular verbs is also important to deduce whether they are represented and processed similarly or differently. Unfortunately, this comparison was not possible in the present study because of the mismatch in the orthographic similarity between the orthographic control primes and the morphological primes of regular verbs. Recall that in all three of the experiments, morphological primes had more orthographic overlap with targets than the orthographic controls. Although efforts were made to match this lexical characteristic, it proved difficult to find suitable items with as much orthographic overlap as the morphological primes due to the L2 readers' limited vocabulary.

One way to remedy this issue, at least for Japanese-English bilinguals, could be to use nonword items as orthographic control primes. For L1 English readers, orthographically similar word primes (e.g., axle-ABLE) can have an inhibitory priming effect, while orthographically similar nonword primes (e.g., ible-ABLE) can have a facilitatory priming effect (e.g., Davis & Lupker, 2006). According to Nakayama and Lupker (2018), however, this lexicality effect is not observed with Japanese-English bilinguals. Both orthographically similar nonword primes (e.g., lity-PITY) and word primes (e.g., city-PITY) facilitate lexical decisions, and the sizes of facilitation do not differ statistically.

In conducting a study using nonwords as orthographic control primes with Japanese-English bilinguals, it could be beneficial to conduct an additional experiment testing the effects of orthographic overlap between primes and targets. In the study by Nakayama and Lupker (2018), orthographically similar word and nonword primes are orthographic neighbors of the targets; they are likely to have a higher degree of prime-target orthographic overlap than the orthographic controls used for examining morphological priming effects. This difference may lead to some differences in the effect of orthographic facilitation. For instance, recall that in the post-hoc regression analysis of Experiment 2, the degree of orthographic facilitation decreased with increased proficiency. While there was some hint of orthographic facilitation shrinking with increased proficiency in Nakayama and Lupker (2018), the evidence was not significant in their study.

Thus, to examine the effects of orthographic controls in morphological priming with Japanese-English bilinguals, an experiment would have two prime types: orthographically similar words and orthographically similar nonwords. Items should be similar to those used as orthographic controls in the experiment for morphological priming with similar frequencies (for word primes and targets), word lengths, number of neighbors, and degrees of orthographic overlap (between primes and targets). By testing both high-proficient and low-proficient Japanese-English bilinguals, it would be possible to examine if orthographic facilitation from word primes really decreases for the more proficient bilinguals and whether the sizes of orthographic facilitation from both word and nonword primes do not differ regardless of proficiency.

Regularity as a Gradable Concept

If there are differences in how regular and irregular past-tense verbs are processed and represented by L2 readers, one must ask if the distinction is binary or gradable. Some irregular verbs involve a vowel change in the stem (e.g., come-came, blow-blew), some change the final consonant (e.g., lend-lent, spend-spent), some are a combination of the two (e.g., sell-sold, think-thought), some don't change (e.g., shut-shut, hurt-hurt), and there are even instances of suppletion (e.g., go-went, be-was) (Kielar et al., 2008). Some of these changes could be more regular (i.e., predictable) than others.

Several previous studies with L1 readers of English suggest that regularity may be better understood as a gradable concept. For example, Kielar et al. (2008) examined three types of verbs with L1 English readers: regular verbs (e.g., walked-walk), suffixed irregulars (e.g., slept-sleep), and vowel change irregular verbs (e.g., drank-drink). Suffixed irregular verbs are not regular because their past-tense forms cannot be decomposed into the stem and past-tense suffix (i.e., -ed) in quite the same way as regular verbs. However, they are somewhat similar in the sense that their past-tense forms take on an alveolar suffix. Thus, suffixed irregular verbs have an intermediary degree of regularity in comparison to regular verbs and vowel change irregular verbs.

In the results of the experiment by Kielar et al. (2008), with a prime duration of 67 ms (the interstimulus interval was 0 ms), regular and suffixed irregular verbs showed similar priming patterns compared to irregular verbs for L1 English readers. Similar results have been obtained in Kielar and Joanisse (2010) as well. However, it is unclear whether there are processing and representational differences based on regularity for Japanese-English bilinguals, whether the difference (if any) is gradable, and whether it interacts with English proficiency level. Future studies could investigate this issue with Japanese-English and other types of L2 English readers.

Proficiency

The main implication of the present study was that a sufficient level of L2 proficiency is necessary for morphological connections to develop in the L2. However, it is unclear what component of L2 proficiency is necessary and what level is sufficient. The TOEIC scores, used as a measure of English proficiency in the study, are a general assessment of listening and reading skills in English. Therefore, the scores are not very informative when one asks which specific language skills or what representations and cognitive processes must be developed to what degree for morphological connections to develop in the L2. One approach to this issue is to develop and conduct a battery of tests with scores that correlate to specific language skills or the level of development for specific representations and cognitive processes which are likely to be involved in L2 morphological processing.

Indeed, several previous studies with monolinguals have examined what processes and language skills may be necessary for the development of morphological connections in the lexicon. For example, there is some indication that representations of morpho-syntactic regularities may not develop till a relatively late stage compared to representations of morpho-semantic relationships for L1 English readers (Beyersmann, Castles, & Coltheart, 2012). This is to say that representations at the lexical level and beyond can develop earlier than those at the morpho-orthographic level. There is also some indication that participants with relatively higher levels of vocabulary ability, compared to spelling, rely more on these higher-level representations, at least for the early stages of morphological processing (Andrews & Lo, 2013). Furthermore, as shown with L1 French readers, higher levels of proficiency in vocabulary and reading may be necessary for efficient mapping of sub-lexical orthographic representations to lexical level representations (Beyersmann, Casalis, Ziegler, & Grainger, 2015; Beyersmann, Grainger, Casalis, & Ziegler, 2015). These mappings, too, appear to develop earlier than those for morpho-syntactic regularities (Beyersmann, Grainger, et al., 2015). Therefore, future studies with L2 readers may investigate whether the development of representations for L2 morphological processing is related to the same language skills as L1 readers and develop in a similar order.

Another limitation of the present study is that it did not track how L2 morphological connections develop in participants as their L2 proficiency increases. Rather, the study examined different groups of participants (relatively proficient in Experiments 1 and 2, low-proficient in Experiment 3) from the same population (Japanese-English bilinguals) with different sets of stimuli. Thus, it only offers a view into the state of morphological connections within the bilinguals' lexicon at the time the experiment was conducted. Future studies may consider a longitudinal approach to better understand how exactly morphological representations for certain words (the same set of stimuli) develop as (the same) participants become more proficient in L2 English. However, this type of study would require a lot of time (as one must wait for the low-proficient participants' L2 skills to improve) and many participants (as it is possible that only a small portion of the low-proficient bilinguals will become relatively proficient).

One approach to this issue, at least for higher-level morphological representations, could be to conduct a cross-sectional study that manipulates the items for which morphological connections are being examined. It is a reasonable assumption that morphological connections should develop earlier for words that bilinguals encounter more frequently or are more familiar with. After all, it is difficult to imagine how morphological connections beyond those of morpho-syntactic regularities or embedded stems could exist for a word that has been encountered for the first time. The new word has probably not even been lexicalized. If more familiar words have morphological connections whereas less familiar words do not, manipulating the familiarity of the items tested may offer more detailed insight into how morpho-semantic connections for words develop as L2 proficiency increases.

Connections for Different Kinds of Morphological Relationships

The present study focused on only one kind of morphological relationship—the relationship between past- and present-tense verbs. However, one can speculate that connections similar to those of L1 English readers could develop in Japanese-English bilinguals for other kinds of L2 morphological relationships as well.

Connections for L2 derivational morphology, for instance, appear to be present for some bilinguals. Silva and Clahsen (2008) compared latencies to adjectives preceded by the masked presentation of derived nouns and unrelated controls for Chinese-English bilinguals, German-English bilinguals, and L1 English readers. The derived condition facilitated recognition for both L1 and L2 English readers (e.g., weakness-WEAK < numb-WEAK), suggesting the presence of derivational connections in their lexicons.

Despite the presence of L2 derivational connections observed in Silva and Clahsen (2008), a difference in the size of the morphological priming effect did suggest that the connections may not be as robust for bilinguals. The derived nouns facilitated responses just as much as repetition primes (e.g., weakness-WEAK = valid-VALID) for L1 readers but not for L2 readers. Latencies of L2 readers were significantly longer to the derived condition than to the repetition condition (e.g., weakness-WEAK > valid-VALID).

This result was not replicated in Diependaele et al. (2011), however. Their study examined Spanish-English and Dutch-English bilinguals who had begun learning English at a younger age on average than the bilinguals in Silva and Clahsen (2008). Results showed that morphological priming from derived words was significant relative to unrelated controls (e.g., viewer-VIEW < lastly-VIEW), replicating the significant morphological priming measured against unrelated controls in Silva and Clahsen (2008). This priming effect was greater than the effect of orthographically similar primes (e.g., freeze-FREE < kindly-FREE), confirming that the priming effect from derived words was of morphological origin. Crucially, patterns of priming in their experiments were not modulated by the participants' L1.

As noted by Diependaele et al. (2011), it is conceivable that the derivational connections had not fully developed for the bilinguals tested in Silva and Clahsen (2008), assuming that bilinguals with an early age of acquisition (AoA) are more proficient in the L2 than those with a late AoA. This possibility is supported by the recent findings of Viviani and Crepaldi (2022) with Italian-English bilinguals. Derivational priming effects are barely distinguishable from orthographic controls at lower proficiency levels but become robust with increased proficiency. Therefore, future studies with Japanese-English bilinguals testing English derivational priming may consider examining both relatively proficient and low-proficient bilinguals to confirm whether the results mirror those obtained with past-tense priming in the present study.

Summary

The present research involved three experiments investigating whether morphological connections similar to those in L1 English for monolinguals are present in the L2 of Japanese-English bilinguals. In Experiment 1 and Experiment 2, past-tense primes facilitated responses to present-tense verb targets in a masked priming lexical decision task. A facilitation effect was observed in this condition when compared to an orthographic control and unrelated condition, suggesting that morphological connections between past- and present-tense English verbs develop in Japanese-English bilinguals.

As the bilinguals examined in these two experiments were relatively proficient in English, Experiment 3 examined whether the connections were also present in the lexicon of less proficient bilinguals. The results showed that morphological primes did not facilitate responses to a greater extent than orthographic controls in this case, suggesting that such connections are not present among low-proficient bilinguals. Taken together, the results from the three experiments suggest that morphological connections similar to L1 readers are present in Japanese-English bilinguals who are sufficiently proficient in English. Though further investigation is required to understand how and when such connections develop, morphological connections of this kind may develop as lexical (word)-level representations become consolidated (see Viviani & Crepaldi, 2022).

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Footnotes

1. In this dissertation, the terms "present-tense verb" and "present-tense form" refer to the root form of the verb.

2. The TOEIC is a standardized test developed by the Educational Testing Service (ETS) that focuses on English used in business settings. Its maximum score is 990, and its minimum score is 10. The TOEFL ITP is also a standardized test developed by the ETS. It focuses on English for academic settings. Its maximum score is 677, and its minimum score is 200. High scores on these tests indicate that a test taker is proficient in English. Finally, the EIKEN (Test in Practical English Proficiency) is an English proficiency test that focuses mainly on daily communication in English. The Eiken Foundation of Japan administers the test with backing from the Ministry of Education, Culture, Sports, Science, and Technology. The test results are a "pass" or "fail" for a test level. The difficulty of the test levels increases in the following order: Grade 5, Grade 4, Grade 3, Grade Pre-2, Grade 2, Grade Pre-1, and Grade 1.

3. When Mauchly's test of sphericity indicated that the assumption of sphericity was not met, the Greenhouse-Geisser correction was applied to the degrees of freedom of the reported values.

Appendix A Chapter 2: Critical Stimuli in Experiment 1

IRLP				IRLV				REG			
Prime				Prime				Prime			
MORPH	ORTHO	UR	Target	MORPH	ORTHO	UR	Target	MORPH	ORTHO	UR	Target
bore	burn	pose	BEAR	bit	bin	law	BITE	switched	swindle	employer	SWITCH
bent	bond	hack	BEND	bought	bright	middle	BUY	owned	owl	sweet	OWN
fell	fill	bank	FALL	caught	candy	lovely	CATCH	checked	cherish	mission	CHECK
grew	glow	tiny	GROW	chose	chase	grass	CHOOSE	cleaned	clever	lighter	CLEAN
held	hole	butt	HOLD	fed	fee	jam	FEED	fixed	fifth	noise	FIX
knew	knot	easy	KNOW	flew	flaw	junk	FLY	counted	country	feather	COUNT
sold	solo	warm	SELL	froze	front	juicy	FREEZE	cooked	cookie	rumble	COOK
drew	drag	ruin	DRAW	went	wept	year	GO	helped	helmet	summer	HELP
sang	sand	mars	SING	heard	heavy	since	HEAR	killed	kitten	dinner	KILL
stole	steel	river	STEAL	hid	hip	tub	HIDE	asked	assume	usual	ASK
spoke	speed	color	SPEAK	laid	land	rush	LAY	acted	across	screw	ACT
drove	drone	crash	DRIVE	led	lid	pee	LEAD	worked	worthy	police	WORK
took	tone	else	TAKE	left	leak	many	LEAVE	called	calm	forget	CALL
shook	shock	cycle	SHAKE	met	men	lab	MEET	talked	talent	battle	TALK
wrote	wrong	proud	WRITE	paid	pair	jump	PAY	washed	waste	bitter	WASH
swept	sweat	camel	SWEEP	shot	shoe	side	SHOOT	passed	passion	fellow	PASS
lent	lens	mint	LEND	slid	slim	spun	SLIDE	picked	pickle	better	PICK
hung	hunt	skip	HANG	taught	target	island	TEACH	walked	waltz	settle	WALK
ate	age	hot	EAT	thought	through	believe	THINK	dreamed	dreadful	leather	DREAM
broke	brick	fault	BREAK	bound	blind	pitch	BIND	wanted	wander	excuse	WANT
gave	game	hard	GIVE	bled	blot	puff	BLEED	looked	loose	master	LOOK

rode	rope	pace	RIDE	sought	seed	robber	SEEK	rested	result	gender	REST
kept	kite	evil	KEEP	dealt	delta	weigh	DEAL	rained	raisin	puddle	RAIN
sank	silk	pear	SINK	fought	flight	yellow	FIGHT	matched	matter	charter	MATCH
slept	slice	fancy	SLEEP	found	funds	honey	FIND	marked	market	ginger	MARK
threw	three	naked	THROW	lit	lip	ape	LIGHT	stayed	status	finger	STAY
told	tool	kind	TELL	meant	meal	buddy	MEAN	happened	harmful	language	HAPPEN

Appendix B Chapter 3: Critical Stimuli in Experiment 2

IREG				REG			
Prime				Prime			
MORPH	ORTHO	UR	Target	MORPH	ORTHO	UR	Target
woke	wave	slip	WAKE	licked	little	thrust	LICK
bent	bead	tick	BEND	failed	fairly	borrow	FAIL
began	brain	crack	BEGIN	mailed	mallet	render	MAIL
shook	shell	fuzzy	SHAKE	packed	picket	insist	PACK
built	blind	chest	BUILD	checked	chicken	mission	CHECK
grew	glow	dump	GROW	jailed	jargon	attack	JAIL
spent	speed	favor	SPEND	cooked	cookie	humble	COOK
told	tall	away	TELL	happened	heavenly	tomorrow	HAPPEN
lay	lid	gay	LIE	opened	orange	racial	OPEN
took	tape	door	TAKE	posted	pistol	ginger	POST
drove	drill	shock	DRIVE	rocked	rocket	nipple	ROCK
broke	brown	mouth	BREAK	started	stadium	welcome	START
rode	rice	boot	RIDE	killed	kidney	second	KILL
held	hole	main	HOLD	watched	warthog	deliver	WATCH
dug	did	wax	DIG	waited	writer	lesson	WAIT
sent	sand	pull	SEND	looked	locker	rather	LOOK
lent	lens	pact	LEND	sailed	salary	brunch	SAIL
sank	sick	barn	SINK	busted	butter	flower	BUST
rose	risk	band	RISE	fixed	first	model	FIX
drew	dean	soup	DRAW	worked	worthy	unless	WORK
hung	hand	wise	HANG	reached	reality	obvious	REACH

sold	seat	warm	SELL	kicked	kindly	freeze	KICK
stuck	stock	round	STICK	washed	warmth	rubber	WASH
swept	swamp	grain	SWEEP	learned	leather	discuss	LEARN
wrote	white	knock	WRITE	picked	pickle	normal	PICK
drank	drift	scout	DRINK	murdered	mulberry	national	MURDER
won	wig	guy	WIN	seemed	sermon	flight	SEEM
stood	staff	chick	STAND	played	planet	notice	PLAY
ate	ear	bud	EAT	missed	mister	charge	MISS
felt	full	kiss	FEEL	stayed	status	prefer	STAY
sang	silk	cape	SING	asked	aside	funny	ASK
saw	set	job	SEE	backed	buckle	puzzle	BACK
stank	sting	graze	STINK	lacked	latter	export	LACK
swung	swipe	jerky	SWING	wished	wisdom	mature	WISH
swam	slim	poll	SWIM	finished	fraction	interest	FINISH
gave	game	hurt	GIVE	burned	burger	switch	BURN
tore	team	fold	TEAR	jumped	jungle	shadow	JUMP
rang	rink	mock	RING	turned	turkey	simple	TURN
blew	blob	rush	BLOW	passed	pastry	bottle	PASS
fell	fill	joke	FALL	signed	sinner	throat	SIGN
threw	three	light	THROW	walked	wallet	corner	WALK
stole	steak	bunch	STEAL	locked	locate	spirit	LOCK
spoke	spare	color	SPEAK	showed	shower	ticket	SHOW
slept	steel	candy	SLEEP	headed	health	spring	HEAD
ran	rub	bag	RUN	talked	tackle	wonder	TALK
kept	knee	fool	KEEP	heated	hearty	napkin	HEAT
made	male	word	MAKE	called	collar	minute	CALL
came	care	part	COME	wanted	winter	course	WANT

Appendix C Chapter 4: Critical Stimuli in Experiment 3

IREG					REG				
Prime					Prime				
REP	MORPH	ORTHO	UR	Target	REP	MORPH	ORTHO	UR	Target
ride	rode	ring	tall	RIDE	power	powered	popular	weather	POWER
wear	wore	weak	sale	WEAR	post	posted	police	racket	POST
drive	drove	drill	sunny	DRIVE	wash	washed	within	bright	WASH
sleep	slept	speed	apple	SLEEP	wait	waited	wallet	corner	WAIT
rise	rose	rice	hour	RISE	show	showed	should	winter	SHOW
spend	spent	spell	month	SPEND	need	needed	needle	dinner	NEED
keep	kept	knee	rich	KEEP	finish	finished	finalist	employee	FINISH
give	gave	girl	part	GIVE	work	worked	wooden	master	WORK
see	saw	set	car	SEE	kill	killed	keeper	pocket	KILL
sing	sang	sink	bean	SING	fold	folded	follow	nearly	FOLD
draw	drew	drop	cake	DRAW	hand	handed	hammer	report	HAND
grow	grew	gray	rule	GROW	listen	listened	language	computer	LISTEN
speak	spoke	steak	brave	SPEAK	stay	stayed	statue	farmer	STAY
sell	sold	seal	food	SELL	seem	seemed	second	father	SEEM
write	wrote	worth	lemon	WRITE	play	played	planet	diving	PLAY
break	broke	bread	floor	BREAK	miss	missed	minute	weight	MISS
lose	lost	last	head	LOSE	turn	turned	turtle	sister	TURN
come	came	cold	bear	COME	call	called	calmly	letter	CALL
swim	swam	skin	hope	SWIM	thank	thanked	traffic	concert	THANK
stand	stood	stage	large	STAND	wish	wished	winner	yellow	WISH
begin	began	below	glass	BEGIN	watch	watched	welcome	contest	WATCH

throw	threw	three	block	THROW	open	opened	omelet	either	OPEN
hold	held	hole	warm	HOLD	pass	passed	pastry	simple	PASS
fall	fell	fill	slow	FALL	pick	picked	picnic	faster	PICK
feel	felt	feet	camp	FEEL	pull	pulled	public	flower	PULL
take	took	tale	poor	TAKE	look	looked	lonely	danger	LOOK
make	made	mark	rock	MAKE	happen	happened	hospital	mountain	HAPPEN
drink	drank	daily	sport	DRINK	list	listed	living	spring	LIST
wake	woke	wave	lion	WAKE	cook	cooked	cookie	matter	COOK
sit	sat	six	bag	SIT	kick	kicked	kindly	poster	KICK
build	built	blind	local	BUILD	help	helped	health	middle	HELP
steal	stole	still	train	STEAL	walk	walked	weapon	jungle	WALK
run	ran	red	low	RUN	learn	learned	leather	college	LEARN
send	sent	seed	book	SEND	talk	talked	talent	strong	TALK
know	knew	knit	bird	KNOW	start	started	station	content	START
tell	told	team	word	TELL	want	wanted	window	ticket	WANT