Journal of Cognitive Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pecp21

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Published online: 04 Oct 2013.

To cite this article: Mariko Nakayama, Christopher R. Sears, Yasushi Hino & Stephen J. Lupker (2013) Masked translation priming with Japanese-English bilinguals: Interactions between cognate status, target frequency and L2 proficiency, Journal of Cognitive Psychology, 25:8, 949-981, DOI: 10.1080/20445911.2013.839560

To link to this article: http://dx.doi.org/10.1080/20445911.2013.839560

Journal of Cognitive Psychology, 2013
Vol. 25, No. 8, 949–981, http://dx.doi.org/10.1080/20445911.2013.839560

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Masked translation priming with Japanese–English bilinguals: Interactions between cognate status, target frequency and L2 proficiency

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Masked translation priming effects were examined for Japanese–English bilinguals using both cognate and noncognate translation equivalents. In Experiment 1, L1 primes and L2 targets were used to examine translation priming effects as a function of target frequency and bilinguals' L2 proficiency. Translation priming effects for cognates were significantly larger than for noncognates, replicating the cognate priming advantage previously reported with different-script bilinguals. In addition, translation priming effects were significantly larger for low- than for high-frequency targets and for less- than for more-proficient bilinguals, whereas the size of the cognate priming advantage was unaffected by either target frequency or L2 proficiency. In Experiment 2, cognate translation priming effects were tested in the L2–L1 direction. There was a significant cognate translation priming effect regardless of L2 proficiency. These results are consistent with the phonological account of the cognate priming advantage, which proposes that cognate translation priming effects are due to the additive effects of phonological and conceptual factors.

Keywords: Bilingualism; Cognate; Cognate priming advantage; Cross-script masked translation priming; Masked priming; Noncognate.

An important question for language researchers is how bilinguals process and represent their multiple languages. A key issue in this area of research is the representational status of cognate translation equivalents. Cognates are translation equivalents in two languages that are similar phonologically (e.g., the Japanese–English cognate translation equivalents, レモン/remoN/—lemon) and, for languages that employ similar writing systems (e.g., alphabets), are also similar orthographically (e.g., the Spanish–English cognate translation equivalents, *rico—rich*). Noncognates are translation equivalents that are not similar either orthographically or phonologically (e.g., the Japanese–English noncognate translation equivalents 女性 /josei/—woman; the Spanish–English noncognate translation equivalents *mujer—woman*). How these differences influence the lexical processing of bilinguals is a question that has attracted the attention of a number of researchers (e.g., De Groot & Nas, 1991; Dijkstra, Grainger, & Van Heuven, 1999; Gollan, Forster, & Frost, 1997;

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We thank Jon Duñabeitia and an anonymous reviewer for their excellent feedback and suggestions.
This research was supported by a grant from the Japan Society for the Promotion of Science (JSPS) to Mariko Nakayama.

Lemhöfer & Dijkstra, 2004; Midgley, Holcomb, & Grainger, 2011; Sánchez-Casas & García-Albea, 2005), and it is also the central question in the present research.

An experimental procedure often used to examine bilingual lexical processing is the masked priming paradigm (Forster & Davis, 1984), using translation equivalents as primes and targets. That is, in a masked translation priming experiment with bilinguals, responses to a target are compared when that target is preceded by its (masked) translation equivalent (レモン—LEMON) versus when the same target is preceded by an unrelated word in the other language (テニス—LEMON). In most experiments, participants respond to the target by making a speeded lexical decision. The key assumption is that upon presentation of a masked prime, the prime's orthographic, phonological and semantic representations begin to be activated. As a consequence, when the target is orthographically, phonologically, or semantically related to the prime, responses to the target are often facilitated compared to when the prime and target are unrelated.

Many previous masked priming studies investigating bilingual lexical processing have reported that the cognate translation priming effect is significantly larger than the noncognate translation priming effect. This priming advantage for cognates is observed not only for same-script bilinguals whose cognate translation equivalents have orthographic, phonological and conceptual similarities (e.g., Davis et al., 2010; De Groot & Nas, 1991; Duñabeitia, Perea, & Carreiras, 2010; Sánchez-Casas, Davis, & García-Albea, 1992), but also for different-script bilinguals whose cognate translation equivalents are not orthographically similar and thus have only phonological and conceptual similarities (e.g., Gollan et al., 1997; Voga & Grainger, 2007; but see Kim & Davis, 2003). We will refer to the larger priming effects for cognates than for noncognates as the *cognate priming advantage*.

THE COGNATE PRIMING ADVANTAGE—THE MORPHOLOGICAL ACCOUNT

One theoretical account that has been proposed to explain the cognate priming advantage is called the "morphological account" (Cristoffanini, Kirsner, & Milech, 1986; Davis et al., 2010; García-Albea, Sánchez-Casas, & Igoa, 1998; Kirsner, Lalor, & Hird, 1993; Lalor & Kirsner, 2001; Sánchez-Casas et al., 1992; Sánchez-Casas & García-Albea, 2005), and it has, most often, been invoked to explain data from bilinguals whose two languages use the same script. According to the morphological account, the cognate priming advantage reflects an underlying structural difference in how cognate and noncognate translation equivalents are represented in the bilingual lexicon. As noted, cognate translation equivalents for same-script (e.g., Spanish–English) bilinguals are similar, both phonologically and orthographically, in addition to being virtually identical conceptually (e.g., *rico—rich*). This set of similarities between cognate translation equivalents is presumed to result in their representations being organised in much the same way that the representations for within-language morphologically related words (e.g., *rich* and *richer*) are presumed to be organised. That is, because of the strong overlap in their form-to-meaning correspondences, cognate translation equivalents, like morphologically related words in both languages, are postulated to be represented in a unified fashion through a common root word (e.g., *rich*, *richer*, *rico* and *rica*). Due to the integrated nature of these representations, significant priming effects will emerge for cognates more readily than for noncognates, because noncognates would not be represented in this fashion. Empirical data that are in agreement with the predictions of the morphological account, particularly data showing very similar priming effects from morphologically similar primes and translation equivalents, have been reported in many previous studies (Davis et al., 2010; Duñabeitia, Dimitropoulou, Morris, & Diependaele, 2013; García-Albea et al., 1998; Sánchez-Casas et al., 1992; Sánchez-Casas & García-Albea, 2005; but see Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010; Midgley et al., 2011, for results that are not necessarily consistent with the morphological account with same-script bilinguals).

The morphological account maintains, therefore, that the representation of cognate translation equivalents is fundamentally different from the representation of noncognate translation equivalents. That is, the cognate priming advantage (i.e., robust cognate priming effects vs. smaller noncognate priming effects) is presumed not to be due to simply the sum of lexical and conceptual similarities between cognate primes and targets, but is instead interpreted to reflect a qualitatively different type of mental representation for cognates and noncognates.

THE COGNATE PRIMING ADVANTAGE—THE PHONOLOGICAL ACCOUNT

As noted, different-script bilinguals also show a cognate priming advantage in masked translation priming studies (Gollan et al., 1997; Voga & Grainger, 2007; but see Kim & Davis, 2003; in all of these experiments, the primes were presented in L1 and the targets in L2). However, given that cognates in languages involving different scripts are not at all similar orthographically, it is somewhat more difficult to draw parallels between those cognates and morphologically similar words in the same language. Therefore, on the surface, it seems less likely that the morphological account would provide a good explanation of the nature of cognate lexical representations for different-script bilinguals. Further, as will be discussed directly below, different-script bilinguals do show priming patterns that are not necessarily compatible with the morphological account. Therefore, it seems likely that a somewhat different account of the representational status of cognate translation equivalents will be needed for different-script bilinguals.

To our knowledge, Voga and Grainger (2007) are the only researchers to specifically examine the underlying mechanism of the cognate priming advantage for different-script bilinguals. The participants in their study were French–Greek bilinguals. In their Experiment 1, Voga and Grainger contrasted the priming effects for cognate translation L1–L2 pairs (e.g., κανόνι—canon; the prime and target both meaning *cannon* in English) and for morphologically related L1–L2 pairs (e.g., κανονιά—canon; the prime meaning *cannon-shot*), relative to unrelated L1–L2 pairs (κανόνας—canon; the prime meaning *rule*). According to the morphological account, the prediction is that the pattern of priming effects should be comparable when L2 targets are primed by L1 cognate translation primes and when the same L2 targets are primed by morphologically related L1 primes because cognate translation equivalents are assumed to be represented in a unified fashion in the lexicon along with other morphologically related concepts. Contrary to this prediction, Voga and Grainger found that the pattern of priming effects was quite different for cognate translation pairs and morphologically related pairs. With a 50-ms prime duration, there was a significant priming effect for L2 targets primed by L1 cognate translation equivalents (a 36-ms effect), whereas there was no priming effect for targets primed by morphologically related L1 words. With a 67-ms prime duration, there were significant priming effects from both types of primes; however, the priming effect was significantly larger for cognate pairs (50 ms) than for morphologically related pairs (34 ms). Voga and Grainger concluded that the different patterns of priming effects for cognate translation equivalents and morphologically related L1–L2 words were not consistent with the morphological account of the cognate priming advantage, suggesting that, at least for Greek–French bilinguals, this account does not adequately describe the nature of their lexical representations.

Voga and Grainger (2007) proposed that a different account, the phonological account, would better explain the cognate priming advantage observed for their bilinguals. According to the phonological account, the cognate priming advantage is explained by the additional effect of phonological facilitation that is available for cognates relative to noncognates. According to this view, the cognate translation priming effect is composed of two additive facilitative effects, one due to the phonological similarity between the prime and target, and the other due to the conceptual similarity between the prime and target. The noncognate translation priming effect, in contrast, is due to conceptual similarity alone. Thus, according to this account, the cognate priming advantage for different-script bilinguals is taken to reflect the impact of phonological similarity for cognate translation equivalents that is not available for noncognate translation equivalents.

In their Experiments 2 and 3, Voga and Grainger (2007) reasoned that if the cognate priming advantage is due to the facilitative effect of phonological similarity between a prime and a target, then the advantage would no longer be observed when the effect of phonological similarity is accounted for. In order to estimate the impact of phonological similarity in producing the cognate translation priming effect (in the L1–L2 direction), Voga and Grainger used phonologically similar primes as control primes for cognates; that is, primes that are as phonologically similar to their targets as cognate primes are to theirs but are not conceptually similar. For example, for the cognate prime–target pair "πιάνο"(/piano/, meaning *piano*)—piano, the phonologically similar control prime "πιάνω"(/piano/, meaning *grasp*) was used to measure the cognate translation priming effect independent of the impact of phonological similarity. Phonologically (and conceptually) unrelated control primes ("τζάκι", /tzaki/, meaning *chimney*) were also included.

Voga and Grainger's (2007) results were consistent with the phonological account. Specifically, when phonologically similar primes were used as control primes in the cognate condition (in order to factor out the effect of phonological similarity between primes and targets), the cognate translation priming effect was not any larger than the noncognate translation priming effect (26- vs. 27-ms effects). In contrast, when a phonologically and conceptually unrelated control word was used to evaluate the priming effects in these conditions (as is the case in typical masked translation priming studies), a significant cognate priming advantage was observed (48- vs. 22-ms effects). These results suggest that for different-script bilinguals, any difference in the size of the priming effects is due to cognates benefiting from additional facilitation due to phonology. Voga and Grainger's results, therefore, also imply that when a bilingual reader's L1 and L2 have different scripts, there is no structural difference in the lexical/conceptual representations for cognate and noncognate translation equivalents in the reader's lexicon.

Additional support for the phonological account of the cognate priming advantage has been provided by recent masked priming studies with other types of different-script bilinguals (Japanese–English bilinguals in Nakayama, Sears, Hino, & Lupker, 2012; Chinese–English bilinguals in Zhou, Chen, Yang, & Dunlap, 2010). Nakayama et al., for example, found that lexical decisions to L2 English targets (e.g., *guide*) were significantly faster when they were primed by phonologically similar but conceptually unrelated L1 Japanese words (e.g., サイド, /saido/, *side*), relative to when they were primed by unrelated L1 Japanese words (e.g., コール, /koRru/, *call*). The phonological priming effects in these experiments show that even for different-script bilinguals, there is phonological facilitation across languages, a result that lends support to the claim that it is facilitation due to phonological similarity that is responsible for the cognate priming advantage. Of course, the fact that there is cross-script facilitation on the basis of phonological similarity does not necessarily mean that cognate translation priming effects consist of two additive facilitation components, it is merely consistent with this interpretation. It could still be the case that cognate translation priming effects reflect a type of interactive effect produced by the prime and target's phonological and conceptual similarity.

THE PRESENT RESEARCH

The purpose of the present experiments was to examine the phonological account of the cognate priming advantage, the account that best explains Voga and Grainger's (2007) results, with another group of different-script bilinguals (i.e., Japanese–English bilinguals). Unlike the written scripts for Greek–French bilinguals (both of which are alphabets), the written scripts for Japanese–English bilinguals have virtually no orthographic similarity, and hence, these bilinguals would appear to allow for an even stronger test of the phonological account for different-script bilinguals.

Several results reported by Nakayama et al. (2012) are relevant to the present experiments. Nakayama et al. examined the impact of target frequency and L2 proficiency on the size of the cognate translation priming effect and the phonological priming effect in the L1–L2 direction. They reported that the phonological priming effect was statistically equivalent for low- and high-frequency targets, and for less- and more-proficient bilinguals, indicating that these "fluency" factors have very little impact on the process responsible for phonological priming. These results are consistent with previous masked priming studies that reported statistically equivalent phonological priming effects for more- and less-proficient bilinguals (Duyck, Diependaele, Drieghe, & Brysbaert, 2004; Zhou et al., 2010, Experiment 3). In contrast, Nakayama et al. also found that the cognate translation priming effect was significantly larger for low-frequency targets, and for less-proficient bilinguals, suggesting that there is a component of the cognate priming effect, presumably the conceptual component, that is directly affected by L2 fluency factors.

The conclusion that L2 fluency factors affect the conceptual component of the cognate translation priming effect, although having little, if any, effect on the phonological component, leads to two new predictions that were tested in the present research, both of which are relevant to the phonological account of the cognate priming advantage. First, this account predicts that translation priming effects for noncognates (which were not used in Nakayama et al.'s, 2012, experiments) will also be modulated by target frequency and L2 proficiency. More specifically, extrapolating from

Nakayama et al.'s results, noncognate translation priming effects should be larger for low-frequency targets than for high-frequency targets and for less-proficient bilinguals than for more-proficient bilinguals. These predictions follow from the idea that priming for noncognate translation equivalents is presumed to be conceptually based.

The second prediction examined concerns the phonological component of these priming effects. If the cognate priming advantage reflects phonological facilitation, and if the impact of phonological similarity is essentially independent of L2 processing fluency factors (Duyck et al., 2004; Nakayama et al., 2012; Zhou et al., 2010, Experiment 3), then the size of the cognate priming advantage should be statistically equivalent across L2 processing fluency factors. More specifically, the size of the cognate priming advantage should be similar for low- and high-frequency targets and for less- and more-proficient bilinguals.

To our knowledge, these specific predictions have not been examined previously. However, a series of similar experiments examining the effect of L2 proficiency on noncognate priming effects with different-script bilinguals were recently reported by Dimitropoulou, Duñabeitia, and Carreiras (2011c, Experiment 1A, 2A, 3A). They tested three groups of Greek–English bilinguals of varying English proficiency levels and reported that the sizes of L1–L2 noncognate priming effects were equivalent across their groups (approximately 30 ms). This result appears to be inconsistent with our first prediction that translation priming effects for noncognates are modulated by L2 proficiency.

What should be noted, however, is that it is likely that even Dimitropoulou et al.'s (2011c) least fluent bilinguals were actually quite fluent. Those authors very carefully matched their three fluency groups on a number of variables, most importantly, age of first exposure to their L2 (i.e., English). As a result, performance differences between groups were rather small. For example, response latencies to English words for their least fluent group were actually shorter than the latencies for their medium fluent group. In the present experiments, the fluency factor was manipulated to a greater degree (although still using reasonably fluent bilinguals), allowing a better test of the prediction that L2 fluency factors affect the conceptual component of the cognate translation priming effect.

EXPERIMENT 1

In Experiment 1, we tested our predictions in a masked translation priming task with Japanese–English bilinguals. Target frequency was manipulated, with half of the targets being high-frequency words and the other half being low-frequency words. We used the Test of English as International Communication (TOEIC) as an objective measure of L2 proficiency.[1] We also used the vocabulary section of the Nelson-Denny English test to measure the size of our bilinguals' English vocabulary. If the phonological account of the cognate priming advantage is correct, then both cognate and noncognate translation priming effects should be modulated by target frequency and L2 proficiency, whereas the size of the cognate priming advantage should be relatively constant across target frequency and L2 proficiency.

Before proceeding, we should note that Experiment 1 was different from Voga and Grainger's (2007) experiments in that different types of prime words were used to measure cognate and noncognate priming effects. That is, we used Katakana words (e.g., カタカナ) as cognate primes, and Kanji words (e.g., 漢字) as noncognate primes, rather than using the same type of words to examine cognate and noncognate priming effects. In the Japanese language, English cognates are usually loan words and, therefore, are typically written in Katakana, whereas translation equivalents typically written in Kanji are almost always noncognates. Therefore, it was necessary to use different script types, because the number of cognate translation equivalents written in Kanji and the number of noncognate translation equivalents written in Katakana is quite limited.

For those unfamiliar with written Japanese, Kana scripts (both Katakana and Hiragana) are

[1] The Test of English as International Communication (TOEIC) is administered by the Educational Testing Service (ETS) and consists of two sections of 100 questions each (listening and reading). The test requires about 2.5 hours to complete and assesses a broad range of English skills, especially in business settings. The test scores range from 0 to 990, with higher values indicating greater fluency in English. In Japan, approximately 750,000 people take the test annually, and the test scores are accepted by many schools and organizations as a measure of English proficiency. Bilinguals with a score in the range of 860–990 are deemed to be highly proficient non-native English speakers. Bilinguals with scores in the range of 730–855 are regarded as less proficient in English by comparison, but still highly fluent in English.

shallow scripts and each Kana character corresponds to a unique mora (a rhythmic unit with constant duration consisting of a vowel or a combination of a consonant and a vowel). In contrast, Kanji is a deep orthography (i.e., a logographic script) and Kanji characters generally possess multiple pronunciations (i.e., Kun-reading and On-reading pronunciations). Words written in Kana, and Kanji, consequently, have different characteristics. Although most Kanji words are polymorphemic (compound words), most Kana words are monomorphemic. Katakana words are generally longer than Kanji words; about 80% of Kanji words are two characters long, whereas about 80% of Kana words are 3–5 characters long (Hino, Miyamura, & Lupker, 2011). Kanji characters are more complex than Katakana characters; the mean number of strokes for commonly used Kanji characters is reported to be approximately 11, whereas the mean number of strokes for Katakana characters is approximately 3 (Tamaoka, Kirsner, Yanase, Miyaoka, & Kawakami, 2002). As such, although Kanji words are generally shorter than Katakana words, they are more visually complex than Katakana words.

The use of different scripts for cognate and noncognate primes meant that the two types of primes were different in several respects. This aspect of the stimuli was not a concern in testing our first prediction (i.e., both cognate and noncognate effects would be modulated by L2 processing fluency factors) because evaluating effects of L2 processing fluency does not involve a contrast between the cognate and noncognate conditions. However, this aspect of the stimuli was not ideal for testing our second prediction (the cognate priming advantage would be constant across L2 processing fluency factors) because in this case, the sizes of priming effects for cognates and noncognates are being directly compared.

To equate the two types of primes on as many important dimensions as possible, we selected our stimuli based on findings from previous studies comparing Kana and Kanji words. Previous studies reported that despite their apparent differences, the speed of semantic and lexical access is equivalent when the orthographic familiarities are both moderately high (Amano & Kondo, 2000; Goryo, 1987; Hirose, 1984). Especially relevant to the present research is the finding that the sizes of masked priming effects are not modulated by the prime's script type when the orthographic familiarities of the two types of primes are comparable (Nakamura, Dehaene, Jobart, Le Bihan, & Kouider, 2005; Nakamura, Dehaene, Jobart, Le Bihan, & Kouider, 2007). These studies suggest that Kanji and Katakana primes can be functionally comparable, if the two types of primes are both highly orthographically familiar to Japanese readers. We therefore selected highly orthographically familiar words for cognate and noncognate primes. The two types of primes were also matched on orthographic familiarity ratings and word frequencies. Our expectation, therefore, was that there should be no overall difference in the effectiveness of the primes as a function of script type.

Method

Participants. The participants were 66 Japanese–English bilinguals from Waseda University (Tokyo, Japan). All participants were native speakers of Japanese and had studied English for an average of 10.5 years (SD = 2.9). Their mean score on the TOEIC was 850 (range = 705–990, maximum score = 990), and their mean score on the Nelson-Denny vocabulary test was 39.2 (range = 16–65, maximum score = 80); these scores correspond to the English vocabulary of 10th-grade English-speaking students. As expected, the TOEIC scores and Nelson-Denny vocabulary test scores were positively correlated with one another, $r(64) = 0.43$, $p < 0.001$.

Stimuli. Primes were always Japanese words and targets were always English words or nonwords. The critical stimuli consisted of 60 cognate translation equivalents (e.g., リスト—LIST) and 60 noncognate translation equivalents (e.g., 少女—GIRL). For cognate and for noncognate targets, half of the words were low-frequency words (M = 24.9 and 26.8 occurrences per million words, respectively; Kućera & Francis, 1967), and the other half were high-frequency words (M = 196.3 and 182.3, respectively). Word length (i.e., the number of letters) for the English targets was matched for the cognate and noncognate priming conditions across target frequency; M = 5.1 (range = 4–7), and 5.2 (range = 4–9) for low- and high-frequency cognate targets; M = 5.1 (range = 4–7) and 5.1 (range = 3–8), for low- and high-frequency noncognate targets.

As noted, we used Katakana words for cognate primes and Kanji words for noncognate primes. Word frequencies of the Japanese primes were matched closely across conditions; in the high- and low-frequency target conditions, M = 25.5 and

21.6, for cognate primes, and $M = 25.5$ and 22.3 for noncognate primes [Nippon Telegraph and Telephone Corporation (NTT) database, Amano & Kondo, 2000].[2] The Japanese primes had high mean orthographic familiarity ratings ($M > 6.1$ on a 7-point scale; NTT database, Amano & Kondo, 2000). The mean orthographic familiarity ratings for cognate and noncognate primes were closely matched; they were identical in the low-frequency target condition ($M = 6.1$ and 6.1) and the high-frequency target condition ($M = 6.2$ and 6.2). Cognate primes were on average 3.6 characters in length (range = 3–7) and noncognate primes were on average 1.8 characters in length (range = 1–2), which were equivalent across target frequency conditions. As noted, this difference in the length of the Kanji and Katakana primes reflects a general characteristic of words written in Kanji and Katakana scripts, and a similar difference in length was also present in the previous studies showing no effect of script type on lexical access (Amano & Kondo, 2000; Goryo, 1987; Hirose, 1984; Nakamura et al., 2005; 2007).

Although it has not often been discussed in the previous literature, it is possible that cognate translation equivalents may be more conceptually similar than noncognate translation equivalents, due to the fact that cognate translation equivalents may have similar etymologies. Specifically, they may share additional conceptual senses in the two languages, which could, potentially, explain at least part of the cognate priming advantage (e.g., see the distributed lexical/conceptual features model; Kroll & de Groot, 1997). The present stimuli were selected with this possibility in mind. Both types of translation equivalents were simple nouns that clearly shared one or two dominant meanings/senses in the two languages. In order to evaluate the question of conceptual similarity, the number of meanings/senses shared by cognate and noncognate translation equivalents was calculated. First, using WordNet (www.wordnet.princeton.edu), the meanings/senses of the English targets were determined. Next, the first author, who is a Japanese–English bilingual, and two other proficient Japanese–English bilinguals, who were not aware of the purpose of the present research, independently inspected all of the senses/meanings associated with a given (English) target word (of its noun form) and counted the number of senses/meanings that were considered to be clearly shared by its Japanese translation equivalent.

Inter-rater agreement of the three raters was assessed using the r_{wg} statistic (James, Demaree, & Wolf, 1984, 1993; LeBreton, James, & Lindell, 2005; see also Liao, Hunt, & Chen, 2010). The r_{wg} coefficient quantifies the extent to which multiple individuals rating the identical target produce similar ratings. A value of 1 denotes perfect agreement among raters, whereas a value of 0 denotes a complete absence of agreement. The mean r_{wg} coefficient for the 120 items was quite high ($M = 0.93$), indicating that the three raters judged the number of senses very similarly to one another. The mean numbers of shared senses/meanings, collapsed across the three raters, were 1.67 for cognates and 1.52 for noncognates. This difference was not statistically significant, $t(118) = 1.17$, $p > 0.20$.

Unrelated prime–target pairs were created by re-pairing the words in the prime–target translation equivalent pairs. Within each target condition (low-frequency cognates, high-frequency cognates, low-frequency noncognates, high-frequency noncognates), half of the targets were paired with their translation equivalents; the other half of the targets were re-paired with primes from that same condition that were both phonologically and conceptually unrelated to the targets. Two experimental lists were created for counterbalancing, with a target paired with a translation prime in one list being paired with an unrelated prime in the other list, and vice versa. An equal number of participants were assigned to the two lists.

One hundred and twenty nonwords ($M = 5.1$ letters, range = 4–5) were selected from the English Lexicon Project database (Balota et al., 2007). For the nonword targets, 60 Japanese cognates and 60 Japanese noncognates were selected to serve as primes. Half the primes (the cognates) preceding nonword targets were presented in Katakana and had a mean length of 3.8 characters (range = 2–6). The other half of the primes (the noncognates) preceding nonword targets were presented in Kanji and had a mean length of 1.8 characters (range = 1–2). The mean normative frequencies of the Katakana and Kanji primes for nonword targets were 22.8 and 24.3, respectively. As there are no translation equivalents for nonword targets, prime type (translation prime vs. unrelated prime) was not manipulated for the nonword trials, and only one presentation list was used for the nonword targets.

[2] Normative frequencies were based on the NTT database (Amano & Kondo, 2000), which provides frequency counts based on a corpus of 287,792,797 words. The normative frequencies reported here are per million words, created by dividing the original frequencies by 287.8.

Apparatus and procedure. Each participant was tested individually. The experiment was programmed using the DMDX software package (Forster & Forster, 2003). Stimuli were presented on a 21-inch video display driven by a desktop microcomputer. Each trial began with the presentation of a forward mask (######) for 500 ms followed by a 50-ms presentation of a Japanese prime. Immediately following the prime, an English target was presented (in upper case letters). The target remained on the display until the participant made a response. The target was flanked by brackets (>>>> and <<<<) so that the prime was completely masked by the target (this was necessary because some of the Japanese primes were slightly longer than their English targets).[3] The existence of the prime was not mentioned. The task was to make a lexical decision to the target. Participants were instructed to make their decisions as quickly and accurately as possible by pressing the *yes* or *no* button on a response box placed in front of them. Participants completed 16 practice trials to familiarise themselves with the task prior to the collection of data.

Results

Participants with error rates greater than 20% (n = 6) were replaced with six new participants who received the appropriate stimulus sets such that the proper counterbalancing of lists could be maintained across participants. Response latencies less than 300 ms or greater than 1500 ms were considered outliers and were replaced by these values (this treatment applied to less than 0.6% of all "word" responses).

Effect of target frequency. To examine the effect of target frequency on the pattern of translation priming effects, mean response latencies of correct "word" responses and mean error rates were submitted to a 2 (cognate status: cognate, noncognate) × 2 (prime type: translation prime, unrelated prime) × 2 (target frequency: high, low) factorial analysis of variance (ANOVA). Both subject (F_s) and item (F_i) analyses were carried out. In the subject analysis, all factors were within-subject factors. In the item analysis, prime type was a within-item factor, and cognate status and target frequency were between-item factors. The mean response latencies for correct responses and the mean error rates from the subject analysis are listed in Table 1.

In general, cognate targets were processed faster than noncognate targets; however, the main effect of cognate status was significant only in the subject analysis, $F_s(1, 65) = 6.18$, $p < 0.05$, MSE = 1485.2; $F_i < 1$. As expected, high-frequency targets were processed faster and more accurately (611 ms and 5.1% errors) than low-frequency targets (667 ms and 13.3% errors), $F_s(1, 65) = 182.05$, $p < 0.001$, MSE = 2337.0; $F_i(1, 116) = 30.81$, $p < 0.001$, MSE = 7474.0, for response latencies, and $F_s(1, 65) = 141.48$, $p < 0.001$, MSE = 63.2; $F_i(1, 116) = 28.45$, $p < 0.001$, MSE = 142.9, for errors. For response latencies, the frequency effect was numerically larger for noncognates than for cognates (62 vs. 52 ms), but the interaction was not statistically significant, $F_s(1, 65) = 3.07$, $p = 0.08$; $F_i < 1$.

In terms of priming effects, there was a significant L1–L2 translation priming effect, $F_s(1, 65) = 119.04$, $p < 0.001$, MSE = 5423.9; $F_i(1, 116) = 270.16$, $p < 0.001$, MSE = 1286.0, for response latencies, and $F_s(1, 65) = 56.31$, $p < 0.001$, MSE = 147.4; $F_i(1, 116) = 88.43$, $p < 0.001$, MSE = 42.7, for errors. Responses to targets primed by translation equivalents were faster and less error prone (604 ms and 5.2% errors) than responses to targets primed by unrelated words (674 ms and 13.2% errors). In addition, the priming effects were significantly larger for low-frequency targets (84 ms and 11.6%) than high-frequency targets (55 ms and 4.3%), $F_s(1, 65) = 10.80$, $p < 0.01$, MSE = 2527.1; $F_i(1, 116) = 15.58$, $p < 0.001$, MSE = 1286.0, for response latencies, and $F_s(1, 65) = 25.14$, $p < 0.001$, MSE = 71.4; $F_i(1, 116) = 19.12$, $p < 0.001$, MSE = 42.7, for errors. As expected, there was also a cognate priming advantage on response latencies; priming effects were significantly larger for cognates than for noncognates (81 vs. 59 ms, respectively), $F_s(1, 65) = 9.50$, $p < 0.01$, MSE = 1713.9; $F_i(1, 116) = 5.84$, $p < 0.05$, MSE = 1286.0. There was no cognate priming advantage for errors (both Fs < 1). The cognate priming advantage on response latencies did not interact with target frequency, as the three-way interaction

[3] An alternative way of degrading the prime would have been to have used a backward mask between the prime and target. We chose to present brackets to serve as a backward mask for any prime letters extending beyond the target so that our procedures would be as close as possible to the standard three-field masked priming procedure adopted in many previous masked priming studies (see Kinoshita & Lupker, 2003), in which targets are shown immediately after primes that are presented for less than 60 ms.

TABLE 1

Experiment 1: mean response latencies and percentage errors for high- and low-frequency cognate and noncognate targets primed by translation equivalents and by unrelated primes

	L1–L2 cognate prime–target			*L1–L2 noncognate prime–target*			
	Translation	*Unrelated*	*Priming*	*Translation*	*Unrelated*	*Priming*	*Cognate priming advantage*
LF targets	617 (6.7)	714 (19.0)	97 (12.3)	633 (8.3)	704 (19.2)	71 (10.9)	26 (1.4)
HF targets	572 (2.8)	636 (6.6)	64 (3.8)	594 (3.0)	640 (7.8)	46 (4.8)	18 (–1.0)

Error percentages in parentheses.
LF = low frequency; HF = high frequency.

of target frequency, prime type and cognate status was not significant (both *F*'s < 1).

Because we were predicting a null interaction (i.e., that the cognate priming advantage would be equivalent for low- and high-frequency targets), we statistically analysed the probability of the null hypothesis being true given the observed data (e. g., Masson, 2011; Wagenmakers, 2007). Values larger than 0.75 are generally considered positive evidence of the null hypothesis being true (Masson, 2011; Raftery, 1995). Our analyses of the interaction showed $p(H_0|D) = 0.86$ and 0.90 for the subject and item analyses of response latencies, respectively, and $p(H_0|D) = 0.81$ and 0.86 for the subject and item analyses of errors. These results support the conclusion that the cognate priming advantage was statistically constant across target frequency.

Finally, we conducted an additional analysis to further strengthen our conclusions. Recall that cognate and noncognate translation equivalents had statistically equivalent numbers of shared senses across the two languages. However, numerically, cognates had slightly more shared senses than noncognates ($M = 1.67$ vs. 1.52). To examine the possibility that this small difference could have at least partly accounted for the pattern of results we observed, we carried out an analysis of covariance (ANCOVA) on the item latency data using the mean number of shared senses/meanings as a covariate. The key results did not change; there was still a cognate priming advantage, $F_i(1, 115) = 6.58$, $p < 0.05$, MSE = 1276.9, a larger priming effect for low-frequency words, $F_i(1, 115) = 9.48$, $p < 0.01$, MSE = 1276.9, and the cognate priming advantage did not vary as a function of target frequency ($F_i < 1$). Taken together, these results support the predictions of the phonological account tested in this experiment; namely, that both cognate and noncognate translation priming effects would be modulated by target frequency (i.e., larger for low-frequency targets), but that the size of the cognate priming advantage would be independent of target frequency.

Effect of L2 proficiency. To examine the effect of L2 proficiency on the pattern of translation priming effects, median split analyses were conducted, using the TOEIC scores as the measure of L2 proficiency (as was done by Nakayama et al., 2012). In these analyses, the data from the 32 bilinguals with low TOEIC scores ($M = 782$, range = 705–840) and the data from the 30 bilinguals with high TOEIC scores ($M = 924$, range = 860–990) were compared using ANOVAs, while maintaining the counterbalancing of the stimulus presentation lists. The data from four participants whose TOEIC scores fell close to the median of 850 (range 850–855, $n = 4$) were excluded. The mean response latencies of correct responses and the mean error rates were submitted to a 2 (L2 proficiency: low, high) × 2 (cognate status: cognate, noncognate) × 2 (prime type: translation prime, unrelated prime) × 2 (target frequency: high, low) factorial ANOVA. L2 proficiency was a between-subject factor in the subject analysis and a within-item factor in the item analysis. The mean response latencies and error rates from the subject analysis are listed in Table 2.

With respect to the impact of the L2 proficiency factor, more-proficient bilinguals were faster and made significantly fewer errors (625 ms and 7.6%) than less-proficient bilinguals (652 ms and 10.6%), $F_s(1, 60) = 1.11$, $p > 0.10$; $F_i(1, 116) = 68.64$, $p < 0.001$, MSE = 1440.6, for response latencies, and, $F_s(1, 60) = 5.50$, $p < 0.05$, MSE = 240.0; $F_i(1, 116) = 27.60$, $p < 0.01$, MSE = 14.2, for errors. The most important results were that less-proficient bilinguals produced significantly larger translation priming effects (83 ms and 9.8% effects) than more-proficient bilinguals (49 ms and 5.5% effects), $F_s(1, 60) = 7.64$, $p < 0.01$, MSE = 4740.3; $F_i(1, 116) = 25.95$, $p < 0.001$, MSE = 1804.4, for

TABLE 2

Experiment 1: mean response latencies and percentage errors for high- and low-frequency cognate and noncognate targets primed by translation equivalents and by unrelated primes, for more proficient bilinguals and less proficient bilinguals

	L1–L2 cognate prime–target			*L1–L2 noncognate prime–target*			
	Translation	*Unrelated*	*Priming*	*Translation*	*Unrelated*	*Priming*	*Cognate advantage*
More proficient bilinguals (n = 30)							
LF targets	614 (6.4)	694 (16.0)	80 (9.6)	628 (6.2)	678 (16.2)	50 (10.0)	30 (–0.2)
HF targets	576 (3.1)	610 (3.8)	34 (0.7)	584 (2.7)	615 (6.2)	31 (1.8)	3 (–1.1)
Less proficient bilinguals (n = 32)							
LF targets	625 (6.9)	731 (21.5)	106 (14.6)	643 (10.2)	726 (21.3)	83 (11.1)	23 (3.5)
HF targets	568 (2.7)	655 (8.3)	87 (5.6)	604 (3.1)	660 (11.0)	56 (7.9)	31 (–2.3)

Error percentages in parentheses.
LF = low frequency; HF = high frequency.

response latencies, and $F_s(1, 60) = 4.01$, $p = 0.05$, MSE = 142.2; $F_i(1, 116) = 22.91$, $p < 0.001$, MSE = 6.6, for errors. There was no three-way interaction between prime type, L2 proficiency and cognate status (all ps > 0.10; $p(H_0|D) = 0.86$ and 0.87 for the subject and item analyses of response latencies, and 0.86 and 0.91 for the analyses of errors), nor were there any other interactions with L2 proficiency, including the four-way interaction between prime type, L2 proficiency, cognate status and target frequency (all p's > 0.10; $p(H_0|D) = 0.67$ and 0.83 for the subject and item analyses of response latencies, and 0.78 and 0.83 for the subject and item analyses of errors).

In addition, as was done previously, the item latency data were also analysed using an ANCOVA, with the mean number of shared senses/meanings as a covariate. This analysis produced the same key findings as the ANOVA analysis. Most importantly, there was, again, no difference in cognate priming advantages for the two groups of bilinguals ($F_i < 1$). The absence of any three- or four-way interaction with L2 proficiency, along with the relatively high probability values of null hypotheses being true, support the remaining predictions derived from the phonological account tested in this experiment—that priming effects would be larger for less-proficient bilinguals, but the cognate priming advantage would be similar for less- and more-proficient bilinguals.

We also looked at the relationship between TOEIC scores and cognate and noncognate priming effects using mixed-model regression analyses, thereby treating TOEIC score as a continuous variable, rather than a dichotomous variable (which was the case in the ANOVA and ANCOVA analyses). Because the subject means for these priming effects were based on two counterbalanced lists, the list factor was effect-coded and included in the regression to partial out the variance associated with that manipulation. TOEIC scores accounted for a significant percentage of the variance in the cognate translation priming effects, $t(65) = 2.85$, $p < 0.01$, $\beta = -0.33$, with lower TOEIC scores associated with larger priming effects. The same result was obtained in the analysis of the noncognate translation priming effects, with lower TOEIC scores associated with larger priming effects, $t(65) = 2.63$, $p < 0.05$, $\beta = -0.29$. In fact, the regression coefficients for the cognate and noncognate translation priming effects were statistically equivalent, $t < 1$.[4] Thus, the results of the ANOVAs, the ANCOVAs and the regression analyses all indicate that the cognate and noncognate translation priming effects were modulated similarly by L2 proficiency.

Discussion

The purpose of this experiment was to test two key predictions derived from the phonological account of the cognate priming advantage (Voga & Grainger, 2007). The first was that both cognate and noncognate translation priming effects would be modulated by L2 processing fluency factors (target frequency and L2 proficiency). The second was that the size of the cognate priming advantage would be relatively constant across these two

[4] In this analysis, regression slopes for cognate and noncognate translation priming effects were statistically compared. The inter-correlation between the two measures (i.e., cognate and noncognate priming effects, which were provided by the same group of participants) was taken into consideration when computing the t-statistic value (Steiger, 1980).

processing fluency factors. The results of Experiment 1 supported both of these predictions.

With respect to the first prediction, priming from both cognate and noncognate translation equivalents was significantly modulated by target frequency, with larger priming effects for low-frequency targets than for high-frequency targets. Similarly, priming effects were larger for less-proficient bilinguals than for more-proficient bilinguals regardless of cognate status. The latter prediction was evaluated not only by considering the interaction between priming and fluency level in the ANOVA, but also through our regression analysis of the two priming effects, which showed that decreases in bilinguals' TOEIC scores were associated with increases in both priming effects. These results all point to the conclusion that both types of translation priming effects are modulated by L2 processing fluency.

Note that our finding that noncognate priming effects are modulated by L2 processing fluency factors does not appear to be consistent with Dimitropoulou et al.'s (2011c) results; in their experiments, they found that the sizes of noncognate priming effects were equivalent across their three different proficiency groups of Greek–English bilinguals. We will consider this potential inconsistency in the General Discussion section. What should be noted at present, however, is that this discrepancy cannot be due to the fact that we used different script types for cognate and noncognate primes, as the effect in question, the noncognate priming effect, is based on the same type of prime (i.e., Kanji) for both translation and unrelated targets.

With respect to our second prediction that the size of the cognate priming advantage should not be influenced by L2 processing fluency factors, our results indicated that the cognate priming advantage was statistically equivalent for low- and high-frequency targets (28 vs. 18 ms) and for less- and more-proficient bilinguals (27 vs. 17 ms advantage). Moreover, regression analyses showed that the relationships between the priming effects and TOEIC scores were essentially the same for cognates and noncognates. In addition, the ANCOVA analysis demonstrated that the cognate priming advantage could not be attributed to the small difference in the degrees of conceptual similarities between cognates and noncognates. Thus, taken together, our results support the conclusion that the cognate priming advantage was not modulated by target frequency or L2 proficiency.

These results, therefore, support the claims that (1) the cognate priming advantage is due to the phonological similarity between primes and targets, and (2) for cognate translation equivalents, conceptual facilitation occurs independently of phonological facilitation, given that the cognate advantage was not modulated by L2 processing fluency, although (3) conceptual facilitation for both types of translation equivalents is sensitive to L2 processing fluency factors. These claims are, of course, the core claims of Voga and Grainger's (2007) phonological account, in which differences between the representations for cognates and noncognates exist only at the phonological level.

We should also point out, however, that although the overall pattern of the data fit well with the predictions of Voga and Grainger's (2007) phonological account, the size of the cognate priming advantage was numerically smaller when high-frequency targets were responded to by more-proficient bilinguals (3 ms) in comparison with the other three situations (23–31 ms advantages). This fact does not seem to be completely in line with our prediction that phonological priming effects would be equivalent across L2 processing fluency. However, what should be noted is that a very similar pattern of results was also observed by Nakayama et al. (2012) in their examination of cross-script phonological priming effects with Japanese–English bilinguals. Nakayama et al. also found that the phonological priming effect was numerically smallest for more-proficient bilinguals responding to high-frequency targets (an 11-ms effect), whereas in the other conditions of their experiment (when high-frequency targets were responded to by less-proficient bilinguals and when low-frequency targets were responded to by less- or more-proficient bilinguals), the priming effects were similar in size, ranging from 33 to 43 ms, effects that are quite similar in size to the cognate priming advantages observed here). The fact that these two, presumably phonological, priming effects showed such similar patterns in the two studies reinforces the claim that they have the same source as well as indicating that, in certain circumstances, processing fluency can have a small effect on phonological priming.

Although the results of Experiment 1 nicely support the phonological account proposed by Voga and Grainger (2007), it is worth considering the possibility that our results may have been compromised by the fact that different scripts were used for cognate (Katakana) and noncognate (Kanji) primes. As noted, our cognate and noncognate primes were equated in terms of orthographic familiarities (and also word frequencies). Therefore, based on the findings of previous studies (Amano & Kondo, 2000; Goryo, 1987; Hirose, 1984; Nakamura et al., 2005, 2007), there is no reason to believe that the script type of the prime would have significantly affected the observed pattern of the priming effects. Nonetheless, it is important to evaluate whether there might be some other general processing differences associated with our cognate and noncognate primes that could have compromised our results.

One of the differences between Kanji and Katakana words is that Kanji scripts are far more frequently encountered in everyday life than Katakana scripts. According to Kess and Miyamoto (1999), in a corpus of 54,606,769 Japanese words, 42.9% of the words were in Kanji script and 6.6% were in Katakana script. This difference, however, is unlikely to have been responsible for the larger priming effects for cognates for two reasons. First, even though Kanji words are seen more frequently than Katakana words, Japanese readers are very proficient at processing both types of scripts. More importantly, if frequency of exposure to a script type does cause words in that script to be processed more efficiently, the expected result in our experiment would have been a larger priming effect for noncognate (Kanji) primes, a result that is opposite of what we observed.

Similarly, when considering the difference in word lengths of our translation primes, the noncognate (Kanji) primes were shorter than the cognate (Katakana) primes, and, hence, one could argue that our noncognate primes would have been processed more efficiently than our cognate primes. However, because we observed a larger priming effect for the longer, cognate primes than for the shorter, noncognate primes, the difference in word length of our translation primes also cannot explain the cognate priming advantage we have observed.

Another difference between Kanji and Katakana is that Kanji script is more perceptually complex than Katakana script. Therefore, one could argue that Kanji primes may require more time to be fully processed. If this were true, it could explain the smaller priming effects for noncognates (Kanji primes) than cognates. It seems unlikely, however, that this aspect of Kanji primes was responsible for the cognate priming advantage either. Although it is true that Kanji words are perceptually more complex than Katakana words, a previous study (Yamada, Mitarai, & Yoshida, 1991) showed that single Kanji characters and Kanji words were identified significantly better than Katakana characters and Katakana words when those targets were presented for a very short duration (30 ms). Yamada et al. also showed that perceptually more complex Kanji characters were identified significantly better than perceptually less complex Katakana characters. These results indicate that perceptual complexity does not necessarily lead to difficulty in processing words (also see Kess & Miyamoto, 1999). In fact, Yamada et al.'s data show that perceptual complexity seems to facilitate, rather than interfere with, the processing of characters and words. Therefore, if the difference in the perceptual complexity had affected the pattern of the priming effects, it would be the noncognate (Kanji primes) that would have produced larger priming effects.

One might also wonder whether Kanji and Katakana words differ in terms of their speed and/or strengths of activating conceptual information. Although the cognates and noncognates used in the present study were similar in terms of the degrees of shared concepts across languages, if a word's conceptual information is retrieved more slowly and/or more weakly from Kanji than from Katakana primes, then translation priming effects would be smaller for noncognates relative to cognates, as the major source of the L1–L2 translation priming effect is thought to be due to the activation of shared conceptual information. However, as noted earlier, previous research indicates that semantic facilitation is essentially equivalent from Kanji and Katakana prime words that are matched on orthographic familiarity (Goryo, 1987; Hirose, 1984; Nakamura et al., 2005, 2007). In fact, it is worth noting that previous studies even suggest that semantic facilitation might occur slightly faster for Kanji than Kana words (e.g., Yamada, 1998). At the very least, these studies indicate that Kanji primes are at least as efficient at accessing semantic information as Katakana primes.

Yet another possibility is that Kanji and Katakana primes could differ in terms of their speed and/or strengths of activating phonological information. In previous studies, it has been reported that Katakana words access phonology faster than Kanji words, especially when the task is one that requires overt articulation (e.g., naming; Feldman & Turvey, 1980; Shimamura, 1987; Yamada, 1998). In addition, previous studies suggest that phonological activation from Kanji words may be relatively weak (e.g., Chen, Yamauchi, Tamaoka, & Vaid, 2007; Kimura, 1984). Such a difference, of course, would be problematic if one contrasted equally phonologically similar Katakana–English prime–target pairs with Kanji–English prime–target pairs, because in such a situation, phonological facilitation may be smaller from the phonologically similar Kanji primes. However, noncognate translation equivalents (the prime–target pairs involving Kanji primes) are not phonologically related at all, and thus, there is no reason to expect there would be any facilitation from noncognate primes on the basis of phonology. Thus, this potential Kanji–Katakana difference would not explain the present pattern of results either.

We should also note that one other way the cognate and noncognate primes used in Experiment 1 were different is that although the Katakana primes were all monomorphemic words, 80% of the Kanji primes were polymorphemic (compound words). If polymorphemic primes are more difficult to process than monomorphemic primes, then we may have underestimated the size of the noncognate priming effect. However, a post hoc analysis showed that the noncognate priming effect from two-character primes (compound words, $n = 48$, which were equally distributed across target frequency) was not any smaller than the noncognate priming effect from single-character primes (monomorphemic words, $n = 12$, which were also equally distributed across target frequency), $F_i < 1$, implying that differences in morphological complexity also likely played no role in producing the cognate priming advantage.

Finally, recall that the patterns observed for the cognate priming advantage were very similar to the patterns Nakayama et al. (2012) observed for phonological priming effects using only Katakana primes, including a somewhat smaller priming effect when L2 processing fluency was very high. This observation provides additional support for our interpretation that the observed cognate priming advantage reflects the phonological facilitation available for cognate prime–target pairs rather than being due to some general processing difference associated with script types. Everything considered, it seems unlikely that the script type of the masked primes, per se, was responsible for the data pattern observed in Experiment 1.

Although we have provided many reasons why the script type difference between cognate and noncognate primes was likely irrelevant, we are not able to completely rule out the possibility that the cognate priming advantage observed in Experiment 1 reflects something other than phonological facilitation (i.e., there may very well be general processing differences between Katakana and Kanji primes that are not among those considered here). Since the use of the same script type for cognate and noncognate primes is virtually impossible when using Japanese primes and English targets, in Experiment 2, we conducted an additional test of the phonological account in a way that does not involve a direct comparison of the relative sizes of priming effects for cognates and noncognates.

EXPERIMENT 2

If our conclusion that the cognate priming advantage for different-script bilinguals is due to phonological facilitation is correct, then a further prediction follows; a cognate translation priming effect should be observed in a situation where phonological facilitation is typically observed but conceptual facilitation is typically not observed. The most straightforward way of testing this prediction is to determine if there is a significant L2–L1 cognate translation priming effect.

In previous masked priming studies with bilinguals, one finding reported by many researchers is that a *phonological* priming effect occurs not only in the L1–L2 direction (Brysbaert, Van Dyck, & Van de Poel, 1999; Dimitropoulou, Duñabeitia, & Carreiras, 2011b; Duyck et al., 2004; Nakayama et al., 2012; Zhou et al., 2010), but also in the L2–L1 direction (Brysbaert & Van Wijnendaele, 2003; Duyck, 2005; Van Wijnendaele & Brysbaert, 2002), even for different-script bilinguals (Dimitropoulou et al., 2011b, with Spanish–Greek bilinguals; Zhou et al., 2010, with Chinese–English bilinguals). This L2–L1 phonological priming effect indicates that for these bilinguals, L2 phonology facilitates L1 target identification even in a task that does not require explicit use of phonology (lexical decision), provided that bilinguals are proficient enough to process masked L2 words.

In contrast, researchers have found that a noncognate masked translation priming effect is typically not observed in the L2–L1 direction (Dimitropoulou, Duñabeitia, & Carreiras, 2011a; Finkbeiner, Forster, Nicol, & Nakamura, 2004, Experiment 2; Gollan et al., 1997; Grainger & Frenck-Mastre, 1998; Jiang, 1999; Jiang & Forster, 2001; Sánchez-Casas et al., 1992; Witzel & Forster, 2012, but see Dimitroploulou et al., 2011c). Indeed, L2–L1 noncognate masked translation priming effects have been observed almost exclusively among very proficient balanced bilinguals (e.g., Duñabeitia et al., 2010; Wang, 2013) or when bilinguals are given extra time to process L2 primes (i.e., Basnight-Brown & Altarriba, 2007, Experiment 2; Duyck &Warlop, 2009; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009). In these studies, either prime durations were longer than in typical masked priming experiments (e.g., 100 ms) or a backward-mask/blank (50–100 ms in duration) was inserted after a 50–60 ms prime presentation, making the overall stimulus onset asynchrony longer.

Most important for present purposes, the absence of an L2–L1 noncognate translation priming effect in a lexical decision task is always the outcome in studies with unbalanced different-script bilinguals whose two languages are distinctively different; for example, Japanese–English bilinguals (Finkbeiner et al., 2004), Chinese–English bilinguals (Jiang, 1999; Jiang & Forster, 2001; Wang, 2013; Witzel & Forster, 2012) and Hebrew–English/English–Hebrew bilinguals (Gollan et al., 1997). A recent ERP study with Japanese–English bilinguals also reported no L2–L1 noncognate translation priming effect in a semantic categorisation task (Hoshino, Midgley, Holcomb, & Grainger, 2010).

For bilinguals whose written scripts are orthographically similar, one could argue that the absence of an L2–L1 noncognate translation priming effect is due to inhibitory competition at the orthographic level that cancels out any conceptual facilitation. However, for bilinguals whose written scripts are not at all orthographically similar, the absence of this effect cannot be attributed to orthographic competition—the absence of a priming effect must mean that, in this type of situation, L2 primes do not facilitate L1 target identification on the basis of conceptual similarity alone.

Taken together, the results of previous phonological priming studies and noncognate translation priming studies examining different-script bilinguals indicate that phonological facilitation occurs for L2–L1 prime–target pairs, whereas conceptual facilitation does not. The question addressed in Experiment 2 was whether it would be possible to observe a significant L2–L1 cognate translation priming effect for different-script bilinguals. If the cognate translation priming effect truly does consist of two independent sources of facilitation (phonological facilitation and conceptual facilitation), then a significant L2–L1 cognate translation priming effect should be observed due to the phonological similarity of primes and targets (rather than the conceptual similarity of primes and targets).

To our knowledge, only Gollan et al. (1997) have looked for evidence of an L2–L1 cognate translation priming effect with different-script bilinguals (Experiment 3 with Hebrew–English bilinguals, and Experiment 4 with English–Hebrew bilinguals). In those experiments, there were no significant L2–L1 cognate translation priming effects (9- and 4-ms facilitory trends in Experiments 3 and 4, respectively). Given that the English–Hebrew bilinguals also showed no L2–L2 repetition priming effects (Experiment 4), one could argue that their L2 skills were simply too weak to produce L2–L1 translation priming. However, such was not the case for the Hebrew–English bilinguals (Experiment 3), who showed a significant L2–L2 repetition priming effect (a 57-ms effect with English stimuli). These results, therefore, suggest that L2 primes do not facilitate L1 target identification on the basis of phonological similarity even when bilinguals can efficiently process masked L2 words.

It should be noted, however, that a possible reason for the absence of an L2–L1 cognate translation effect for Hebrew-English bilinguals in Gollan et al.'s (1997) Experiment 3 is that Hebrew is read from right to left, whereas English is read from left to right. For prime–target repetitions (i.e., L2–L2), this distinction likely would not matter. As long as bilinguals process primes in the same way as they process targets, robust repetition priming effects may be observed. However, in the L2–L1 cognate translation priming condition, L2 primes may not have been processed very efficiently because the L1 targets biased the participants to read stimuli in the direction appropriate to that of the targets (in Gollan et al.'s Experiment 3, bilinguals believed that they were engaged in a monolingual Hebrew lexical decision task). Of course, this would not explain why Gollan et al. found significant translation priming effects in the L1 to L2 direction in other experiments, because the same problem would seem to apply in that situation. However, in the case of the L1 to L2 direction, this factor is likely much less important because L1 primes are processed in a much more automatic and efficient manner than L2 primes, even when those primes are masked. Therefore, the possibility remains that the absence of a significant L2–L1 cognate translation priming effect in Gollan et al.'s Experiment 3 for the Hebrew–English bilinguals was due to this difference between Hebrew and English words.

In Experiment 2, we examined the cognate translation priming effect in the L2 to L1 direction with Japanese–English bilinguals. Unlike Hebrew and English words, Japanese and English words are both read from left to right (Japanese words can also be written vertically; however, most adult Japanese readers are equally proficient reading words presented horizontally and vertically.) We also examined the L2–L2 repetition priming effect in order to ensure that our bilinguals were proficient enough to process masked English primes, given that alphabets are not part of the traditional Japanese writing system.

Our prediction for Experiment 2 was that significant L2–L1 cognate translation priming effects would be observed for Japanese–English bilinguals, provided that the same bilinguals showed reliable L2–L2 repetition priming effects. To assess the importance of L2 proficiency, we tested two groups of bilinguals with different English proficiency, which allowed us to ascertain what effect L2 proficiency would have on the pattern of cognate translation priming effects. As noted, consistent with our analysis of the cognate priming advantage examined in Experiment 1, previous phonological priming studies have shown that phonological facilitation is not typically affected by bilinguals' proficiency in the language of the primes once a certain level of competence has been reached. Thus, if an L2–L1 cognate translation priming effect is observed in Experiment 2, due to the phonological similarity between primes and targets, then the expectation would be that the size of the cognate translation priming effect would be equivalent for more- and less-proficient bilinguals.

Method

Participants. The participants were 62 Japanese–English bilinguals from Waseda University (Tokyo, Japan). None of these individuals had participated in Experiment 1.

Unlike Experiment 1, more- and less-proficient bilinguals were recruited and tested in different experimental sessions. Experiment 2A involved more-proficient bilinguals (n = 30), with an average TOEIC score of 918 (range = 870–990), who had studied English for an average of 11.9 years, and Experiment 2B involved less-proficient bilinguals (n = 32), with an average TOEIC score of 740 (range = 660–820), who had studied English for an average of 9.4 years. More-proficient bilinguals (Experiment 2A) were presented with L2–L1 cognate priming and L2–L2 repetition priming conditions. In addition to these two conditions, less-proficient bilinguals (Experiment 2B) were also presented with an L2–L1 noncognate priming condition.

Stimuli. To assess L2–L1 cognate translation priming, 60 low-frequency Japanese cognate words were selected to serve as targets (M = 7.7 occurrences per million words; Amano & Kondo, 2000). All the cognate targets were Katakana words, with a mean length of 3.5 characters (range = 3–5). Each target was paired with its English translation equivalent or an unrelated English word (e.g., slim—スリム vs. rush—スリム). Unrelated English words were not phonologically or semantically similar to their Japanese targets. The English primes were higher in normative frequency than the Japanese targets; the mean normative frequencies were 53.2 for the cognate translation primes and 52.5 for the unrelated primes (Kućera & Francis, 1967). We used high-frequency L2 primes in an attempt to increase the likelihood of observing L2–L1 priming effects. The mean lengths of the English cognate primes and the unrelated primes were identical (M = 4.5, range = 4–5). Note that in Experiment 2 a different set of words was selected for unrelated primes rather than re-pairing the original cognate prime–target pairs, because more words were available to satisfy the requirement of equating the prime characteristics in the related (i.e., cognate pairs) and unrelated conditions. Most of the unrelated English words were Japanese cognates (55 out of the 60 were listed in the NTT database; Amano & Kondo, 2000). Two experimental lists were created for counterbalancing; a target paired with a translation prime in the first list was paired with an unrelated prime in the second list, and vice versa.

Sixty pronounceable Katakana nonwords (M = 3.5 characters, range = 3–5) were created for the purposes of the lexical decision task. The nonword targets were preceded by English words. The English primes were a mean of 4.5 letters in length (range = 4–5) and had a mean normative frequency of 48.7. As in Experiment 1, prime type (translation prime vs. unrelated prime) was not manipulated for the nonword trials. One presentation list was created for the nonword targets.

Also assessed in Experiment 2 was the ability of our participants to produce L2–L2 repetition priming. To do so, 60 English targets were selected. Half of the targets were high-frequency words (*M* = 62.8), and the other half were low-frequency words (*M* = 12.0). The mean lengths of the high- and low-frequency targets were identical (*M* = 4.7, range = 4–5). The mean number of orthographic neighbours (Coltheart, Davelaar, Jonasson, & Besner, 1977) for high- and low-frequency targets was 4.7 and 4.6, respectively. These targets were primed by either the target themselves (repetition primes) or by unrelated primes (e.g., roof—ROOF vs. wage—ROOF). Unrelated and repetition primes were matched on word frequency, length and number of neighbours. For high-frequency unrelated primes the mean word frequency, length and number of neighbours were 61.2, 4.7 (range = 4–5) and 4.7; for low-frequency unrelated primes the means were 12.0, 4.7 (range = 4–5) and 5.1, respectively. Unrelated primes were not orthographically or semantically similar to their targets.

Sixty English nonwords were selected from the English Lexicon Database (Balota et al., 2007) to serve as targets. The mean length of targets was 4.7 (range = 4–5), and the targets had on average 4.6 orthographic neighbours. Like the word targets, the nonword targets were primed by either the target themselves (repetition primes) or by unrelated primes. The unrelated nonword primes were matched to the repetition primes on length (*M* = 4.7, range = 4–5) and number of neighbours (*M* = 4.6). For both word and nonword targets, two counterbalanced lists were created so that if a target was paired with a repetition prime in the first list it was paired with an unrelated prime in the second list, and vice versa.

In addition to the L2–L1 cognate priming and L2–L2 repetition priming conditions, an L2–L1 noncognate priming condition was also included in Experiment 2B. The purpose for including this condition was to confirm that this group of Japanese–English bilinguals does not show an L2–L1 noncognate priming effect, as was the case for Japanese–English bilinguals in previous studies (e.g., Finkbeiner et al., 2004; Hoshino et al., 2010). For this condition, 60 low-frequency Japanese noncognate words were selected to serve as targets (*M* = 8.3 occurrences per million words). All the noncognate targets were two-character Kanji words. Each target was paired with its English translation equivalent or an unrelated English word (e.g., king—王様 vs. gain—王様). The mean normative frequencies of the noncognate primes and unrelated primes were 50.8 and 50.1, respectively. The mean word lengths of the two types of primes were identical, 4.4 (range = 3–5). As with the cognate priming condition, two experimental lists were created for counterbalancing. Sixty 2-character Kanji nonwords were also selected. Nonwords were created by combining two Kanji characters in such a way that the particular combination does not constitute a word in the Japanese vocabulary. The mean word frequency of English primes preceding the nonwords was 50.4. The mean word length of the English primes was 4.4 (range = 3–5).

Apparatus and procedure. The apparatus was identical to that used in Experiment 1. In Experiment 2A, the more-proficient bilinguals received the L2–L1 cognate priming condition and the L2–L2 repetition condition in separate blocks, with the presentation order of the conditions (and the list used in each condition) counterbalanced across participants. In Experiment 2B, the less-proficient bilinguals received the extra L2–L1 noncognate priming condition in addition to the cognate and repetition conditions. Again, each condition was presented in a different block, with the presentation order of the conditions (and lists) being counterbalanced. In both Experiments, English primes were always presented in lower-case letters; English targets were presented in upper-case letters when the L2–L2 repetition priming effect was examined.

Results

The data for three low-frequency English targets (*GRIEF, FUEL, ELBOW*) in the L2–L2 repetition condition were excluded from all analyses because the error rates for these words were greater than 50% in Experiment 2B (less-proficient bilinguals). As in Experiment 1, participants with error rates greater than 20% were replaced. In the L2–L2 repetition condition, one participant in Experiment 2A and four participants in Experiment 2B had error rates greater than 20% and were replaced (their data from the L2–L1 cognate and noncognate priming condition were also replaced). In the L2–L1 cognate and noncognate priming conditions, no participant made more than 20% errors.

For the Japanese targets (i.e., the L2–L1 conditions) response latencies less than 300 ms or greater than 1200 ms were considered outliers. For the English targets (i.e., the L2–L2 repetition condition) response latencies less than 300 ms or greater than 1500 ms were considered outliers (a slightly longer cutoff was used for English targets to accommodate the fact that the participants were not native English speakers). Response latencies that fell outside of these limits were replaced by the respective cut-off values. In Experiment 2A, for the L2–L1 cognate condition, these treatments were applied to 0.2% of the word target data; in the L2–L2 repetition condition, these treatments were applied to 0.5% of the word target data and 0.6% of the nonword target data. In Experiment 2B, the corresponding percentages were 0.7%, 2.4% and 3.0%. In addition, this data treatment was applied to 2.1% of the word target data in the L2–L1 noncognate condition included in Experiment 2B. The mean response latencies for correct responses and the mean error rates are listed in Table 3.

Experiment 2A (more-proficient bilinguals). There was a significant L2–L1 cognate priming effect for response latencies, $F_s(1, 29) = 30.25$, $p < 0.001$, MSE = 446.9; $F_i(1, 59) = 42.99$, $p < 0.001$, MSE = 790.1, and for errors, $F_s(1, 29) = 6.69$, $p < 0.05$, MSE = 13.4; $F_i(1, 59) = 5.54$, $p < 0.05$, MSE = 32.36. Responses to Japanese targets were faster and more accurate when primed by English cognate primes (513 ms and 3.7% errors) than when primed by unrelated English primes (543 ms and 6.1% errors).

There was also a significant L2–L2 repetition priming effect; response was faster and more accurate when targets were preceded by repetition primes (565 ms and 6.0%) than by unrelated primes (631 ms and 10.4%), $F_s(1, 29) = 84.67$, $p < 0.001$, MSE = 1564.2; $F_i(1, 55) = 52.61$, $p < 0.001$, MSE = 2791.6, for response latencies, and $F_s(1, 29) = 9.79$, $p < 0.01$, MSE = 58.9; $F_i(1, 55) = 5.93$, $p < 0.05$, MSE = 90.1, for errors. As expected, high-frequency English targets were responded to significantly faster and more accurately (588 ms and 5.7%) than low-frequency English targets (608 ms and 10.7%), $F_s(1, 29) = 8.52$, $p < 0.01$, MSE = 1497.8; $F_i(1, 55) = 3.86$, $p = 0.05$, MSE = 4524.8, for response latencies, and $F_s(1, 29) = 14.13$, $p < 0.01$, MSE = 52.5; $F_i(1, 55) = 6.89$, $p < 0.05$, MSE = 101.2, for errors. The priming effects, however, did not vary as a function of target frequency (all Fs < 1); the repetition priming effect was nearly equivalent for low- and high-frequency targets (62- and 70-ms effects), a common finding in monolingual masked repetition priming experiments (e.g., Bodner & Masson, 2003; Forster & Davis, 1984, 1991). For nonword targets, there was no main effect of prime type for response latencies (both Fs < 1) or for errors, $F_s(1, 29) = 2.53$, $p > 0.10$; $F_i(1, 59) = 3.35$, $p = 0.07$, MSE = 48.8.

Experiment 2B (less-proficient bilinguals). As was the case with the more-proficient bilinguals, a significant L2–L1 cognate translation priming was observed. Responses to Japanese targets were faster when they were primed by English cognate primes (540 ms) than when the same targets were primed by unrelated English primes (555 ms), $F_s(1, 31) = 8.04$, $p < 0.01$, MSE = 423.3; $F_i(1, 59) = 3.92$, $p = 0.05$, MSE = 1737.8. For errors, the

TABLE 3

Experiment 2: mean response latencies and percentage errors for low-frequency Japanese targets primed by English cognate words (L2–L1 cognate translation priming) and for English targets primed by English words (L2–L2 repetition priming), for more proficient bilinguals and less proficient bilinguals

	L2–L1 cognate translation prime–target			*L2–L2 repetition prime–target*		
	Translation	*Unrelated*	*Priming*	*Repetition*	*Unrelated*	*Priming*
More proficient bilinguals (n = 30)						
LF targets	513 (3.7)	543 (6.1)	30 (2.4)	577 (8.4)	639 (13.0)	62 (4.6)
HF targets	–	–	–	553 (3.6)	623 (7.8)	70 (4.2)
NW targets	–	–	–	652 (8.9)	651 (6.6)	−1 (2.3)
Less proficient bilinguals (n = 32)						
LF targets	540 (4.2)	555 (6.0)	15 (1.8)	705 (13.0)	765 (19.1)	60 (6.1)
HF targets	–	–	–	686 (6.3)	715 (10.0)	29 (3.7)
NW targets	–	–	–	807 (12.1)	798 (9.0)	−9 (3.1)

Error percentages in parentheses.
LF = low frequency; HF = high frequency; NW = nonword.

effect was significant in the item analysis only (4.2% vs. 6.0% errors), $F_s(1, 31) = 2.54$, $p = 0.12$; $F_i(1, 59) = 5.44$, $p < 0.05$, MSE = 19.4.

Statistically significant L2–L2 repetition priming effects were also observed, with targets primed by identity primes being responded to faster and more accurately (696 ms and 9.7%) than when primed by unrelated primes (740 ms and 14.6%), $F_s(1, 31) = 32.77$, $p < 0.001$, MSE = 1934.9; $F_i(1, 55) = 19.76$, $p < 0.001$, MSE = 3553.1, for response latencies, and $F_s(1, 31) = 8.54$, $p < 0.01$, MSE = 92.1; $F_i(1, 55) = 10.19$, $p < 0.01$, MSE = 76.4, for errors. High-frequency targets were responded to significantly faster and more accurately (701 ms and 8.2%) than low-frequency targets (735 ms and 16.1%), $F_s(1, 31) = 15.91$, $p < 0.001$, MSE = 2498.0; $F_i(1, 55) = 3.63$, $p = 0.06$, MSE = 14,143.2, for response latencies, and $F_s(1, 31) = 36.50$, $p < 0.001$, MSE = 55.2; $F_i(1, 55) = 7.99$, $p < 0.01$, MSE = 212.7, for errors. Unlike the data for the more-proficient bilinguals, for less-proficient bilinguals, the repetition factor marginally interacted with target frequency in the latency analysis, $F_s(1, 31) = 3.55$, $p = 0.07$, MSE = 2112.9; $F_i(1, 55) = 3.19$, p =0.08, MSE = 3553.1. This marginal interaction reflected a larger priming effect for low-frequency targets (60 ms) than for high-frequency targets (29 ms). For errors this interaction was not significant (both *F*s < 1). For nonword targets, there was no main effect of prime type for response latencies (both *F*s < 1), but the prime type effect was significant for errors, $F_s(1, 30) = 5.19$, $p < 0.05$, MSE = 30.1; $F_i(1, 57) = 8.27$, $p < 0.01$, MSE = 35.4. Less-proficient bilinguals made more errors to nonword targets when they were primed by the nonwords themselves (identity primes) than when they were primed by unrelated nonwords (12.1% vs. 9.0%).

Finally, consistent with many previous studies with unbalanced different-script bilinguals (Dimitropoulou et al., 2011a; Finkbeiner et al., 2004; Gollan et al., 1997; Hoshino et al., 2010; Jiang, 1999; Jiang & Forster, 2001; Wang, 2013; Witzel & Forster, 2012, but see Dimitropoulou et al., 2011c), there was no L2–L1 noncognate priming effect. The mean response latencies and error rates for Japanese targets preceded by noncognate English translation primes were 557 ms and 6.4%, and those for the same targets preceded by unrelated English words were 556 ms and 6.3% (all *F*s < 1; $p(H_0|D) = 0.84$, and 0.88 for the subject and item analyses of response latencies, and 0.85 and 0.89 for the corresponding analyses of errors).

Combined analyses of Experiment 2A (more-proficient bilinguals) and Experiment 2B (less-proficient bilinguals). Combined analyses of the data in the L2–L1 cognate priming and L2–L2 repetition priming conditions were carried out to compare the more- and less-proficient bilinguals directly. For Japanese targets (the L2–L1 cognate priming condition), more-proficient bilinguals responded to targets faster than less-proficient bilinguals (528 vs. 548 ms), although this difference was significant in the item analysis only, $F_s < 1$; $F_i(1, 59) = 31.89$, $p < 0.001$, MSE = 846.4. The L2–L1 cognate priming effect was significantly larger for more-proficient bilinguals than for less-proficient bilinguals (a 30- vs. a 15-ms effect), $F_s(1, 60) = 4.24$, $p < 0.05$, MSE = 434.7; $F_i(1, 59) = 5.79$, $p < 0.05$, MSE = 893.5. There was no significant difference for errors (both *F*s < 1).

For English targets (the L2–L2 repetition condition), more-proficient bilinguals responded to English targets faster and more accurately (598 ms and 8.2%) than less-proficient bilinguals (718 ms and 12.1%), $F_s(1, 60) = 17.51$, $p < 0.001$, MSE = 50,798.6; $F_i(1, 55) = 242.90$, $p < 0.001$, MSE = 3781.5, for response latencies, and $F_s(1, 60) = 9.55$, $p < 0.01$, MSE = 100.6; $F_i(1, 55) = 12.06$, $p < 0.01$, MSE = 69.8, for errors. For response latencies, the L2–L2 repetition priming effect was significantly larger for more-proficient bilinguals than for less-proficient bilinguals, $F_s(1, 60) = 4.24$, $p < 0.05$, MSE = 1755.7; $F_i(1, 55) = 4.51$, $p < 0.05$, MSE = 1549.8. In addition, there was a marginal three-way interaction between prime type, target frequency and L2 proficiency for response latencies, $F_s(1, 60) = 2.91$, $p = 0.09$, MSE = 1978.1; $F_i(1, 55) = 3.71$, $p = 0.06$, MSE = 1549.8. This interaction reflects the separate analyses reported earlier; namely, for the more-proficient bilinguals (Experiment 2A) the L2–L2 repetition priming effects were constant across target frequencies, whereas for the less-proficient bilinguals (Experiment 2B) the L2–L2 repetition priming effect was larger for low-frequency targets than for high-frequency targets.

For nonword targets, more-proficient bilinguals rejected L2 nonwords as real words significantly faster and more accurately (652 ms and 7.8%) than less-proficient bilinguals did (803 ms and 10.6%), $F_s(1, 60) = 18.46$, $p < 0.001$, MSE = 38235.5; $F_i(1, 59) = 574.94$, $p < 0.001$, MSE = 2447.5, for response latencies, and $F_s(1, 60) = 6.01$, $p < 0.05$, MSE = 40.4; $F_i(1, 59) = 7.25$, $p < 0.01$, MSE = 65.3, for errors. In addition, error rates were significantly higher when nonword targets were preceded by identity primes (10.5%) than when they were preceded by unrelated nonwords (7.8%), $F_s(1, 60) = 7.41$, $p < 0.01$, MSE = 31.1; $F_i(1, 59) = 10.74$, $p < 0.01$, MSE = 41.6.

Discussion

In Experiment 2, consistent with our prediction, there was a significant L2–L1 cognate translation priming effect, for both more- and less-proficient bilinguals. These results support the idea that cognate translation priming has a facilitative component due to the phonological similarity between primes and targets. The fact that in Experiment 2B the less-proficient bilinguals did not show an L2–L1 noncognate priming effect, which is consistent with many previous masked priming studies with unbalanced different-script bilinguals (e.g., Finkbeiner et al., 2004; Gollan et al., 1997; Hoshino et al., 2010; Jiang, 1999; Jiang & Forster, 2001), also reinforces the idea that the locus of the effect is phonological, as there was no priming effect based on the conceptual similarity between those primes and targets.

Note that one of our results was not consistent with our expectations; namely, that the L2–L1 cognate translation priming effect was larger for the more-proficient bilinguals (a 30-ms effect vs. a 15-ms effect for the less-proficient bilinguals). We expected that the L2–L1 cognate translation priming effect would be equivalent for more- and less-proficient bilinguals based on the results of previous phonological priming studies (Brysbaert & Van Wijnendaele, 2003; Dimitropoulou et al., 2011b; Van Wijnendaele & Brysbaert, 2002; Zhou et al., 2010) and the results of Nakayama et al. (2012), who found that phonological facilitation was not influenced by the processing fluency of L2 words. Note, however, that the pattern of this interaction was directly opposite from the interaction found in Experiment 1 (i.e., in Experiment 1 larger priming effects were found for less-proficient bilinguals), an interaction presumed to be based on conceptual similarity. Therefore, the interaction observed in this experiment, if it is real, likely has a different basis. We will return to this issue in the General Discussion section.

With respect to the L2–L2 repetition priming effect, significant priming effects were observed for both groups of bilinguals. Our bilinguals were thus of high enough proficiency to automatically process masked L2 (English) primes, even though the Roman alphabet is not used in the Japanese writing system. The two groups of bilinguals did produce slightly different patterns of repetition priming effects, however. For more-proficient bilinguals, the repetition priming effect was equal for high- and low-frequency targets (62 and 70 ms), an outcome often observed with native English speakers (e.g., Bodner & Masson, 2003; Forster & Davis, 1984, 1991; Forster, Davis, Schoknecht, & Carter, 1987). For the less-proficient bilinguals, in contrast, the repetition priming effect was numerically larger for low-frequency targets (60 ms) than for high-frequency targets (29 ms). The two groups of bilinguals also differed significantly in the speed and accuracy of their responses to English word and nonword targets, with the less-proficient bilinguals being substantially slower and less accurate than the more-proficient bilinguals. These results indicate that, as expected, the less-proficient bilinguals processed English stimuli less fluently than the more-proficient bilinguals did. As we discuss in the General Discussion section, this fact may be related to the unexpected finding that less-proficient bilinguals exhibited a smaller L2–L1 cognate translation priming effect.

GENERAL DISCUSSION

The purpose of the present experiments was to examine the phonological account of the cognate priming advantage (Voga & Grainger, 2007) and to test several new predictions derived from it. According to the phonological account, the cognate translation priming effect is an additive effect of phonological facilitation and conceptual facilitation, with the cognate priming advantage reflecting the impact of phonological facilitation. In Experiment 1, we examined the pattern of L1–L2 cognate and noncognate translation priming effects as a function of target frequency and L2 proficiency. In Experiment 2, we examined the L2–L1 cognate translation priming effect as a function of L2 proficiency. We next discuss each of our major findings in terms of their implications for the validity of the phonological account for different-script bilinguals.

L1–L2 cognate and noncognate translation priming and the effect of L2 processing fluency

One major issue examined in Experiment 1 was whether the cognate and noncognate translation priming effects would be modulated by L2 processing fluency factors. Nakayama et al. (2012) reported that L1–L2 cognate translation priming effects, but not phonological priming effects, were significantly larger for low- than for high-frequency targets, and for less- than for more-proficient bilinguals. We reasoned that if cognate translation priming effects consist of two facilitative components (phonological and conceptual), and one of the components (phonological facilitation) is insensitive to L2 processing fluency factors, then it must be the other component (conceptual facilitation) that is sensitive to these factors. If so, both the cognate and noncognate translation priming effects should be modulated by these fluency factors. The results confirmed this expectation. When averaged across L2 proficiency, the cognate translation priming effect was significantly larger for low-frequency targets than for high-frequency targets, as was the noncognate translation priming effect. Similarly, when averaged across target frequency, the cognate translation priming effect was significantly larger for less-proficient bilinguals than for more-proficient bilinguals, as was the noncognate translation priming effect. These results indicate that L2 processing fluency factors affect both cognate and noncognate translation priming effects, presumably by influencing a common, conceptually based process.

Although our results clearly show that translation priming effects are modulated by L2 processing fluency, as noted, our results for the noncognate priming effect do not appear to be consistent with Dimitropoulou et al.'s (2011c) finding of no difference among their three groups of bilinguals of varying levels of proficiency. Although it is not possible to know for certain what caused this discrepancy, the most likely possibility seems to be the differences in proficiency levels in the bilingual groups in the two studies. In an effort to match their three bilingual groups, Dimitropoulou et al. equated those groups on a number of factors including first exposure to English and first exposure to written English. On both measures, the averages were less than nine years of age. Based on demographic information we have for our two bilingual groups, this is also approximately when our more-proficient bilinguals began learning English. It is not surprising, therefore, that the noncognate translation priming effect shown by our more-proficient bilinguals in Experiment 1 (31 ms) was quite similar to the priming effects shown by Dimitropoulou et al.'s three groups (31, 28 and 28 ms). In contrast, most of our less-proficient bilinguals began learning English when they were 11 or 12 years of age. For these individuals, the noncognate translation priming effect was 54 ms, leading to the significant interaction we observed. As Dimitropoulou et al. argue, age of exposure to L2 may be a key variable determining proficiency. Therefore, it would seem reasonable to conclude that our less-proficient bilinguals would be the weakest bilinguals in either experiment and would, therefore, be helped more by a translation prime than all the other groups. Thus, the difference between our results and those of Dimitropoulou et al. seems to be more illusory than real.

The cognate priming advantage and the effect of L2 processing fluency

The second issue examined in Experiment 1 was whether the cognate priming advantage, which is claimed to be due to phonological similarity, would be stable across target frequency and/or L2 proficiency. We reasoned that if the cognate priming advantage reflects phonological facilitation, rather than conceptual facilitation, then the pattern observed for the cognate priming advantage would be similar to that observed for the phonological priming effect (Nakayama et al., 2012). That is, the size of the cognate priming advantage should be essentially constant across the L2 processing fluency factors.

Our results also confirmed this expectation. The size of the cognate priming advantage was statistically equivalent for low- and high-frequency targets and for more- and less-proficient bilinguals. This pattern of results nicely parallels the pattern of phonological priming effects observed with different-script bilinguals (Nakayama et al., 2012; Zhou et al., 2010, Experiment 3). These results support the hypothesis that the cognate priming advantage and the phonological priming effect have the same locus and, hence, that the cognate priming advantage is due to the phonological similarity between cognates.

As noted earlier, however, one aspect of our results that does not appear to be entirely consistent with this account is that, in the situation where L2 fluency was maximal (for the more-proficient bilinguals responding to high-frequency targets), the cognate priming advantage was substantially smaller than the cognate priming advantage in the other conditions. That is, although there was no four-way interaction in Experiment 1 (i.e., the cognate priming advantage was not modulated by the combined effects of target frequency and bilingual proficiency), nor was there a significant three-way interaction in a separate analysis of the data of the more-proficient bilinguals only, $F_s(1, 29) = 2.98$, $p = 0.09$; $F_i(1, 116) = 1.55$, $p > 0.20$, the overall pattern of priming effects suggests that the cognate priming advantage, like translation priming effects in general, can be affected by L2 fluency factors. Such a conclusion may appear to be problematic for the phonological account, an account based on the idea that cognate priming effects arise from independent phonological and conceptual components.

Two further considerations, however, seem to mitigate much of this concern. First, if L2 fluency factors do affect the cognate priming advantage, their impact is quite different from their effect on translation priming effects in general. That is, whereas the impact of both target frequency and L2 proficiency on overall translation priming effects was strong and easily detectable, the impact of these factors on the cognate priming advantage was weak and observed only in a very specific situation. Therefore, even if the impact of fluency can diminish phonological priming under certain circumstances, it still appears that phonological and conceptual factors do have separable effects in the priming process. What is perhaps a more important consideration is that Nakayama et al. (2012), in their examination of cross-script phonological priming, observed the identical (nonsignificant) pattern in their data. Thus, based on Nakayama et al.'s results, a data pattern of the sort observed here would be essentially what one might expect if the cognate priming advantage were being driven by phonology, as proposed by the phonological account.

L2–L1 cognate translation priming effects and the effect of L2 proficiency

Experiment 2 was an attempt to solidify these conclusions by examining whether significant L2–L1 cognate translation priming effects would be observed, effects that are presumed to be due to phonological similarity. Our reasoning was based on previous masked priming studies that showed significant L2–L1 phonological priming effects (e.g., Brysbaert et al., 1999; Brysbaert & Van Wijnendale, 2003; Dimitropoulou et al., 2011b; Duyck, 2005; Van Wijnendaele & Brysbaert, 2002; Zhou et al., 2010), but no significant L2–L1 noncognate translation priming effects (Dimitropoulou et al., 2011a; Finkbeiner et al., 2004; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Witzel & Forster, 2012). We also expected that if significant L2–L1 cognate translation priming effects were observed, such effects would be essentially equivalent for more- and less-proficient bilinguals because those effects would have been due to phonological rather than conceptual similarity.

Consistent with these expectations, we observed L2–L1 cognate translation priming effects for both more- and less-proficient bilinguals. Less consistent with these expectations, however, were two results: (1) the size of the cognate translation priming effect was significantly larger for more-proficient bilinguals, and (2) less-proficient bilinguals showed a seemingly odd interaction with frequency in the L2–L2 identity priming block, with high-frequency targets showing smaller priming effects than in any other identity priming situation. Given our assumptions, the first of these effects is the more surprising. Because the size of the phonological priming effect in the L2–L1 direction was not modulated by bilinguals' proficiency in the prime's language in previous masked phonological priming studies (Brysbaert & Van Wijnendaele, 2003; Van Wijnendaele & Brysbaert, 2002; Zhou et al., 2010), if the L2–L1 cognate translation priming effect was essentially a phonological priming effect then there should have been no interaction with L2 proficiency.

In our view, the most reasonable explanation for this outcome is simply that the less-proficient bilinguals were not able to process the masked L2 primes to the same extent as the more-proficient bilinguals. As it turns out, although our less-proficient bilinguals in Experiment 2 would be regarded as being reasonably proficient in English, they were not as proficient (average TOEIC score of 740) as our less-proficient bilinguals in Experiment 1 (average TOEIC score of 782). Their lower level of L2 proficiency likely meant that their processing of masked L2 primes, particularly, their phonological processing of those primes, which we suggest is what is driving the priming effects observed here, was not substantially far along when the target arrived. Therefore, although the less-proficient bilinguals did show a significant L2–L2 repetition priming effect, which suggests that they were able to process masked L2 primes to some degree, it is not surprising that L2 primes might not be quite as effective as for more-proficient bilinguals in the L2–L1 cognate priming condition, leading to a smaller priming effect. Further, by this same logic, it is also not surprising that the less-proficient bilinguals showed the interaction they did between identity priming and frequency. If phonological processing of the prime is still ongoing when the target arrives, more rapidly processed, high-frequency targets would benefit less from that processing. Hence, those targets might be expected to show smaller priming effects.

One final point to note is that our data do provide an additional, independent piece of evidence for the argument that the less-proficient bilinguals were having some difficulty processing masked L2 primes. Specifically, when one examines the overall response latencies in the L2–L1 cognate translation condition, one finds that the less-proficient bilinguals responded to L1 targets much more slowly than the more-proficient bilinguals in that situation. This result is consistent with the idea is that, for the less-proficient bilinguals, phonological processing of the L2 primes was still ongoing when the targets arrived, leading to a general delay in target processing even when the targets are words in their L1.

Evaluation of the phonological account for different-script bilinguals

With respect to our main findings, the implications for the phonological account are as follows. First, the fact that cognate and noncognate translation priming effects were affected by L2 processing factors (i.e., larger effects for low- than high-frequency targets and for less- than more-proficient bilinguals) implies that the co-occurrence of phonological and conceptual similarity (i.e., cognate translation equivalents) does not change the pattern of priming effects produced by conceptual similarity alone (i.e., noncognate translation equivalents). This pattern is quite consistent with the interpretation that the underlying conceptual structures of cognate and noncognate translation equivalents are not qualitatively different.

Second, the pattern of the cognate priming advantage being statistically constant across L2 processing fluency factors, with the pattern of the data being essentially the same as that observed in Nakayama et al.'s (2012) phonological priming experiments, suggests that the cognate priming advantage shares a source of facilitation with the phonological priming effect. This conclusion is also consistent with the phonological account.

Third, the fact that translation priming effects and the cognate priming advantage were modulated differently by L2 processing factors is most consistent with the interpretation that the cognate translation priming effect consists of two facilitative components, and that the two components have independent effects. This interpretation is also supported by our finding of significant L2–L1 cognate translation priming effects (regardless of L2 proficiency), a situation in which conceptual facilitation typically does not occur (Finkbeiner et al., 2004; Gollan et al., 1997; Hoshino et al., 2010; Jiang, 1999; Jiang & Forster, 2001). The fact that our less-proficient bilinguals showed a significant L2–L1 cognate priming effect, but not an L2–L1 noncognate priming effect, also reinforces this interpretation. Virtually all of our results are, therefore, consistent with the two central claims of the phonological account of the cognate priming advantage: that the cognate translation priming effect is composed of two additive facilitative effects (phonological and conceptual facilitation) and that the cognate priming advantage is due to the additional phonological facilitation that is not available for noncognates.

Priming mechanisms and lexical representations for different-script bilinguals

In addition to supporting the phonological account of the cognate priming advantage, at least for different-script bilinguals, our data offer some theoretical implications in terms of the representation of translation equivalents for those bilinguals. We propose that phonological facilitation occurs at the sub-lexical phonological level, with the cognate advantage being essentially equivalent to the phonological priming effect when the prime–target pairs do not share conceptual similarity. On the other hand, like most researchers, we assume that conceptual facilitation occurs at the lexical level. This would mean that for different-script bilinguals cognate translation equivalents are linked to each other at two different levels of representation.

The idea that phonological facilitation occurs at the sub-lexical level converges with the findings of cross-language phonological priming effects irrespective of prime lexicality (Brysbaert et al., 1999). Studies that have found that phonological facilitation is generally insensitive to the L2 proficiency of bilinguals when priming is examined in both the L1–L2 direction (Duyck et al., 2004; Nakayama et al., 2012; Zhou et al., 2010) and the L2–L1 direction (Brysbaert & Van Wijnendaele, 2003;

Van Wijnendaele & Brysbaert, 2002; Zhou et al., 2010) also support the idea that phonological facilitation occurs at the sub-lexical level.

The fact that less-proficient bilinguals exhibited a significant L2–L1 cognate translation priming effect but did not exhibit a significant L2–L1 noncognate translation priming effect is also consistent with the idea that the former effect reflects sub-lexical level processing, because the absence of an effect for noncognates must mean that conceptual priming is not available in this situation, especially when the task is lexical decision (Finkbeiner et al., 2004; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Witzel & Forster, 2012). Therefore, the significant cognate translation priming effect in the L2 to L1 direction for both more- and less-proficient bilinguals can be interpreted as being due to phonological facilitation. Such facilitation will arise as long as bilinguals are proficient enough to sub-lexically activate phonological representations corresponding to masked primes, even if the higher-level representations (including conceptual features) of such primes cannot be activated sufficiently to produce a priming effect.

Although the idea that conceptual facilitation occurs at the lexical level seems to be obvious, with regard to the nature of conceptual facilitation, there is still the question of what mechanism is responsible for the increased L1–L2 translation priming effects associated with lower processing fluency in L2. That is, what mechanism can explain why the translation priming effect in the L1–L2 direction (Experiment 1) was larger when L2 processing fluency was lower? One possibility is simply that low processing fluency is associated with overall slower responding, making it easier to observe priming effects. A post hoc analysis does not support this interpretation, however, because there was no significant correlation between bilinguals' overall speed of responding and the sizes of their translation priming effects (collapsed across cognate status and target frequency), $r(64) = 0.18$, $p > 0.10$. A similar outcome was reported by Gollan et al. (1997), who found that the L1–L2 cognate translation priming effect sizes were not modulated by the overall speed of responding. On the other hand, the overall priming effects were significantly correlated with bilinguals' TOEIC scores, $r(64) = -0.33$, $p < 0.01$. As such, what the larger effects do appear to indicate is simply that when L2 processing fluency is low, processing can benefit more by pre-activated lexical/conceptual features.

One theoretical framework that could provide an explanation for the interaction between L2 proficiency and the size of the translation priming effect is the lexical integrity hypothesis (Yap, Tse, & Balota, 2009). According to Yap et al., words that are high in "lexical integrity" can be retrieved in a more fluent manner than words that are lower in lexical integrity. Lexical integrity refers to the degree of stableness of lexical representations in the mental lexicon. In a semantic priming paradigm, facilitation from conceptually related primes should then be larger for words with lower lexical integrity (e.g., low-frequency words). That is, because the representations of these words are less stable and coherent, they would be more difficult to recognise. As a result, these words would benefit more from a conceptually related prime. According to this interpretation, the activation of conceptual information by an L1 prime facilitates the processing of an L2 word to a larger degree if its representation is weakly established and, hence, difficult to activate. The obvious implication for the present situation would be that larger translation priming effects for less-proficient bilinguals would be expected given that these individuals would have lower integrity lexical representations in their L2 and would therefore benefit more from translation (i.e., conceptually similar) primes.

CONCLUSIONS

The results of the present research provide support for the phonological account of the cognate priming advantage (Voga & Grainger, 2007) for different-script bilinguals. The lack of modulation of the cognate priming advantage as a function of target frequency and L2 processing fluency in the L1–L2 direction was quite similar to that observed for phonological priming effects (e.g., Nakayama et al., 2012), suggesting that the cognate priming advantage reflects phonological facilitation. In contrast, both cognate and noncognate translation priming effects were modulated by L2 processing fluency factors, which implies that a core component of translation priming itself is based on conceptual processing. We also observed a significant L2–L1 cognate translation priming effect regardless of L2 proficiency. This result supports the claim that phonological effects can be observed independent of conceptual effects. All of these results converge on the conclusion that, at least for different-script bilinguals, the cognate translation priming effect is an additive effect of phonological and conceptual facilitation and that the underlying representational structure of cognate and noncognate translation equivalents are not qualitatively different. Note, however, that our results do not indicate that the phonological account is necessarily a better account than the morphological account (Davis et al., 2010; García-Albeaet al., 1998; Sánchez-Casas & García-Albea, 2005) when considering the nature of representations for same-script bilinguals, individuals for whom cognate translation equivalents are also orthographically similar. An important question for future research is, therefore, whether it might be the case that cognate translation equivalents are represented differently for same- and different-script bilinguals.

Original manuscript received February 2013
Revised manuscript received August 2013
Revised manuscript accepted August 2013
First published online October 2013

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APPENDIX: TARGETS AND PRIMES USED IN EXPERIMENT 1

Cognate primes			
High-frequency targets		Low-frequency targets	
ベース	BASE	コーチ	COACH
コース	COURSE	エンジン	ENGINE
ホーム	HOME	フォーラム	FORUM
レベル	LEVEL	レジャー	LEISURE
ライン	LINE	メディア	MEDIA
ノート	NOTE	メロディー	MELODY
パターン	PATTERN	ムード	MOOD
プレー	PLAY	オペラ	OPERA
プロセス	PROCESS	パイプ	PIPE
レース	RACE	リズム	RHYTHM
ラジオ	RADIO	ラッシュ	RUSH
ラウンド	ROUND	サミット	SUMMIT
シーズン	SEASON	テープ	TAPE
シェア	SHARE	タクシー	TAXI
テーブル	TABLE	ツアー	TOUR
バランス	BALANCE	ブーム	BOOM
グラウンド	GROUND	ブランド	BRAND
ケース	CASE	リース	LEASE
コミュニティー	COMMUNITY	ローン	LOAN
カバー	COVER	ネットワーク	NETWORK

フィルム	FILM	パネル	PANEL
アイデア	IDEA	ピーク	PEAK
イメージ	IMAGE	ロケット	ROCKET
リスト	LIST	ルート	ROUTE
パート	PART	セミナー	SEMINAR
パワー	POWER	テント	TENT
レコード	RECORD	テーマ	THEME
リポート	REPORT	トラック	TRUCK
シーン	SCENE	トンネル	TUNNEL
ステージ	STAGE	ウイルス	VIRUS
	Noncognate primes		
High-frequency targets		Low-frequency targets	
芸術	ART	大人	ADULT
黒	BLACK	著者	AUTHOR
色彩	COLOR	鳥	BIRD
根拠	EVIDENCE	借金	DEBT
食品	FOOD	出口	EXIT
未来	FUTURE	農民	FARMER
少女	GIRL	指	FINGER
半分	HALF	人類	MANKIND
熱	HEAT	一致	MATCH
内側	INSIDE	牛乳	MILK

光	LIGHT	豚肉	PORK
外側	OUTSIDE	印刷	PRINT
苦痛	PAIN	約束	PROMISE
応援	SUPPORT	魂	SOUL
時計	WATCH	自殺	SUICIDE
答	ANSWER	牛肉	BEEF
値段	COST	砂漠	DESERT
顔面	FACE	離婚	DIVORCE
父親	FATHER	薬	DRUG
拳銃	GUN	運賃	FARE
頭髪	HAIR	特色	FEATURE
手紙	LETTER	休日	HOLIDAY
部屋	ROOM	趣味	HOBBY
秘密	SECRET	海軍	NAVY
船	SHIP	歌手	SINGER
空間	SPACE	汗	SWEAT
物語	STORY	涙	TEARS
表面	SURFACE	賃金	WAGE
苦労	TROUBLE	手首	WRIST
窓	WINDOW	区域	ZONE

Targets and primes used in Experiment 2

L2–L1 cognate translation prime–target pairs			
slim	スリム	wine	ワイン
diet	ダイエット	camp	キャンプ
gang	ギャング	rock	ロック
joke	ジョーク	gray	グレー
lift	リフト	file	ファイル
jump	ジャンプ	bank	バンク
rank	ランク	rose	ローズ
star	スター	king	キング
tube	チューブ	film	フィルム
gift	ギフト	jazz	ジャズ
tape	テープ	lobby	ロビー
host	ホスト	lucky	ラッキー
copy	コピー	panic	パニック
pink	ピンク	cycle	サイクル
milk	ミルク	entry	エントリー
hero	ヒーロー	fence	フェンス
risk	リスク	guide	ガイド
text	テキスト	magic	マジック

shop	ショップ	piano	ピアノ
desk	デスク	guest	ゲスト
focus	フォーカス	dress	ドレス
shift	シフト	frame	フレーム
pride	プライド	knife	ナイフ
trend	トレンド	model	モデル
humor	ユーモア	title	タイトル
guard	ガード	speed	スピード
count	カウント	check	チェック
wagon	ワゴン	cover	カバー
dream	ドリーム	dance	ダンス
block	ブロック	style	スタイル

L2–L2 repetition word targets and nonword targets			
Low-frequency targets	High-frequency targets	Nonword targets	
CHEEK	LAKE	GELB	MOOF
CLOCK	LADY	OHAL	WODE
PRINT	TALL	PLAB	JULL
TWIST	ROOF	TACY	FICE
SHAKE	NICE	BOLI	SOAN

LOGIC	JOIN	HOMB	MARN
ALARM	PICK	PEAF	YAIL
FANCY	VOTE	YEEP	ATTOW
TRICK	RULE	CUNE	FEMOD
ELBOW	TASK	THOT	DRUBA
GRIEF	UNCLE	BIME	SPLUM
SOLVE	FAVOR	HERL	TASIN
THIEF	SMILE	EALL	GELLE
BEAST	EXIST	BICEL	ROEMS
SHAVE	TASTE	SLESS	CAREP
NOISY	STORE	TABIN	NOSSY
NASTY	TWICE	HEING	RONCH
EAGLE	PROUD	TOUBT	FINGO
CRASH	PROVE	DELPE	VEGAL
DIARY	AGREE	GARAT	MITTY
BELL	SPEND	LANJO	GLABE
FUEL	ENTER	DOMUD	FLOSH
DEAF	LOOSE	VINGY	POINS
SILK	SHARP	HASER	SCOVE

FAKE	SLEEP	GLAST	GASTE
DOLL	QUICK	SAGEY	LORER
ENVY	GUESS	DANAL	SAKER
RUDE	METAL	APTLE	FUSHY
CHAT	EMPTY	SHEST	BLACE
CUTE	WORSE	DIMPY	FAUNT