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COGNATE STATUS AND CROSS-SCRIPT PRIMING WITH CHINESE-ENGLISH BILINGUALS AND ENGLISH-CHINESE BILINGUALS

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Table of Contents

Summary

This thesis examines the cognate representation in the bilinguals' minds with psycholinguistic experiments. Experimental studies that attempted to answer the question have shown that cognate processing is different from non-cognate. It is found that cognates are responded to faster than non-cognates in visual word recognition (e.g. De Groot & Nas, 1991), spoken language processing (Marian & Spivey, 2003) and in word production (Costa, Caramazza, & Sebastian-Galles, 2000), which is known as cognate facilitation (Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010). Several theoretical explanations have been put forward to explain cognate facilitation, represented by three positions--- morphological account, (Cristoffanini, Kirsner, & Milech, 1986; Kirsner, Lahor, & Hird, 1993; Sánchez-Casas & Garcia-Albea, 2005), the link view (Kroll & Stewart, 1994), and the form overlap account (French & Jacquet, 2004; Thomas, 1997; Dijkstra, Grainger, & van Heuven, 1999; Voga & Grainger, 2007). Morphological account argues that cognate facilitation is similar to morphological effect; the link view suggests the stronger link between cognates is the cause of larger cognate priming effect; and the form overlap account proposes that cognate facilitation is the result of the additional form overlap between cognates.

Up till now, most of the cognate studies were done with language pairs of the same scripts (De Groot & Nas, 1991; Lemhofer & Dijkstra, 2004). The problem is that when the scripts are the same in the two languages, it is hard to distinguish the roles of orthography and phonology. Results from cross-script language pairs can help eliminate possible influences from orthography and provide more evidence of cognate processing. Adopting masked priming paradigm, we examined cognate processing with Chinese and English materials. Chinese-English bilinguals and English-Chinese bilinguals were tested in two tasks, namely masked lexical decision task and masked word naming task. The relationships of prime (L1) and target (L2) were manipulated so that the prime was either translation equivalent of the target, phonologically similar to the target, or unrelated to the target. Both cognate and non-cognate produced robust translation priming in Chinese-English bilinguals in LDT (Experiment 1) and naming (Experiment 2), as well as in English-Chinese bilinguals in LDT (Experiment 3). Cognate phonological priming was found in English-Chinese naming task (Experiment 4). Non-cognate phonological priming was found in Chinese-English naming task (Experiment 2). Cognate translation priming was only significantly larger than non-cognate translation priming in tasks where there was phonological priming effect (Experiment 2 and 3). The finding indicates that cognate translation priming advantage is caused by the combination of semantic and phonological overlaps between the prime and target, which is in support of the form overlap account of the cognate facilitation effect. The results are discussed in terms of how translation equivalents are represented in bilingual memory, and how prime-target direction and task-decision system affect performance.

List of Tables

List of Figures

Chapter 1 Introduction

Despite the estimation that half of the world's population is bilingual (French & Jaquet, 2004), bilingual memory study was not started until 1950s. Since then, how the languages are represented and processed in bilinguals' minds remains a hot-debated topic in psycholinguistics. A primary issue is whether bilingual lexical processing is language-specific, or whether there are interactions between lexical processing in the two languages. Early research suggested that there is language-selective processing in bilingual lexical processing (Kirsner, Brown, Abrol, Chadha, & Sharma, 1980; Gerard & Scarborough, 1989; Ransdell & Fischler, 1987), but there is now compelling evidence that lexical information of both languages are activated even when only one language is used (Brysbaert, Van Dyck, & Van de Poel, 1999; Dijkstra & van Heuven, 1998; Marian & Spivey, 2003; Van Heuven, Dijkstra, & Grainger, 1998).

If language non-selectivity is a feature of bilingual lexical processing, interaction in bilingual lexical processing is expected. In fact, there could be different levels of overlaps (orthography, phonology, or semantics) of lexical representations across two languages, which can affect bilingual language performance. A key finding is that there is a translation priming effect across two languages, for example, the Spanish word *rico* can facilitate recognition of English translation equivalent *rich* in lexical decision task (LDT) (de Groot & Nas, 1991). Also, interlingual homographs, i.e., words that have identical or similar orthography but belong to different languages, and interlingual homophones (words with identical or similar pronunciation) are found to influence processing of each other, even in single language mode. For example, Dijkstra, van Jaarsveld, and ten Brinke (1998) found that orthographic similarity can facilitate word recognition in Dutch-English bilinguals; Brysbaert et al. (1999) found that the Dutch word *dier* (beast) can facilitate recognition of French homophone *dire* (to say) in masked LDT. These findings suggest that information from one language can influence lexical processing of another language in the bilinguals.

1.1 Cognate Facilitation Effect

Since lexical processing in one language may be influenced by the semantic and lexical information from another in the bilinguals, questions follow are how the two systems of lexical processing work and how they interact with each other. As discussed, cross-language interaction can happen at different levels. The interactions mentioned before are based on overlap at one level (semantic, orthography, or phonology). Semantic overlap can happen when the two lexical items in the two languages are translation equivalents, e.g., apple and 苹果 (ping2guo3). Overlap at orthographic level can result in interlingual homographs, e.g., *spot* is a word in both English and Dutch, but it means *mockery* in Dutch. Phonologically overlapped lexical items across languages are sometimes referred to as interlingual homophones, e.g., the English word *cow* is pronounced like the Dutch word kou (meaning *cold* in English), (see Lemhofer & Dijkstra, 2004 for more examples).

There are also cases of multiple levels of overlap, which needs to be investigated in order to understand the bilingual mental lexicon. One special type among such words is *cognates*, which traditionally refer to words that have a common etymology. For example, English-French cognates *cognition* have a common Latin origin. However, in psycholinguistic studies, the definition for cognates is broader (Voga & Grainger, 2007). It refers to translation equivalents that have identical or similar form overlaps. The question hence arises is that whether words that have multiple overlaps, like cognates, are represented and processed like words that have overlap at only semantic level, i.e., non-cognate translation equivalents.

A number of studies have demonstrated that cognates behave differently from non-cognates. It is found that cognates are responded to faster than non-cognates in visual word recognition (e.g. De Groot & Nas, 1991), spoken language processing (Marian & Spivey, 2003) and in word production (Costa, Caramazza, & Sebastian-Galles, 2000). Cognates are translated more quickly than non-cognates (de Groot, 1992). Cognates also generate stronger and more stable priming effect than non-cognates both in masked priming studies (de Groot & Nas, 1991; Gollan, Forster, & Frost, 1997; Sánchez-Casas, Davis, & García-Albea, 1992; Voga & Grainger, 2007) and long-lag priming studies (Lalor & Kirsner, 2001). The advantage of cognates in processing over non-cognates is known as *cognate facilitation effect* (Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010).

However, different results were also reported. For example, Kim and Davis (2003) did not find cognate priming advantage over non-cognates in masked priming lexical decision task (LDT) with proficient Korean-English bilinguals; Bowers, Mimouni, and Arguin (2000) only found long-lag priming with French-Arabic cognates of same scripts but not of different scripts. That is, only cognate homographs produced long-lag priming effect but not cognates in different scripts, suggesting the critical role of orthography for obtaining long-lag priming effect.

The role of shared orthography may not be indispensible in short-term priming studies, since cross-script cognate facilitation has been found in some masked priming studies (Gollan et al., 1997; Voga & Grainger, 2007). Regardless of whether shared orthography is critical in obtaining cognate facilitation, it should be noted that there can be different types of cognates depending on the script difference. When the two languages have the same script, there can be three types of cognates, translation equivalents that are similar in both orthography and phonology (S+O+P+), translation equivalents that are similar in orthography (S+O+P-), and translation equivalents that have overlaps in phonology (S+O-P+). It is difficult to distinguish the contribution of shared orthography and phonology in cognate processing, as is shown by the contradicting results of Dijkstra et al. (1999) and Lemofer & Dijkstra (2004). Both studies tested Dutch-English bilinguals with similar sets of materials in LDT but the reaction times to the S+O-P+ cognates were different. In Dijkstra et al. (1999), this type of cognates was found to be responded to slower than the control words. However, there was a null effect in Lemhofer & Dijkstra (2004). Depending on the contradicting results from the two studies, it is not easy to determine whether this type of cognates could be responded to faster than ordinary words or not. However, one thing that calls our attention is that the cognates they examined were not completely orthographically different. For example, for the pair of cognates *wiel-wheel*, there are three letters in common, which makes it difficult to classify them into pure S+O-P+ cognates. Therefore, the inconsistency of results might have been caused by the influence from the orthographic codes.

1.2 Cross-script cognate priming studies

Influence from orthography can be avoided if cross-script languages are used. Meanwhile, we are also able to concentrate on the possible interactions at the semantic and phonological levels. Three cross-script studies, all of which used masked priming paradigm in the L1-L2 direction, have probed the issue of cognate status and they are Gollan et al. (1997), Kim & Davis (2003), and Voga & Grainger (2007).

1.2.1 Gollan et al. (1997)

Gollan et al. (1997) was among the earliest studies that focused on cross-script translation priming in masked LDT. They examined translation priming of both cognates and non-cognates in Hebrew-English bilinguals and English-Hebrew bilinguals in both L1-L2 and L2-L1 direction. For each group of bilinguals in each direction, three types of priming were tested for both cognates and non-cognates, i.e., L1-L1 repetition priming, L2-L2 repetition priming, and translation priming. As far as translation priming is concerned, L2-L1 direction basically did not produce any priming effect in their experiments. However, in the L1-L2 direction, both cognate and non-cognate priming effects were found, and cognate priming was significantly larger than non-cognate priming, especially in the English-dominant bilinguals. Larger cognate priming was only significant in item analysis in their Hebrew-dominant bilingual participants, and the magnitudes of both cognate and non-cognate priming were smaller compared to the English-dominant bilinguals. Since the Hebrew-dominant bilinguals were more balanced than the English-dominant bilinguals, their results suggest that language dominance may affect the magnitude of priming as well as cognate facilitation.

In fact, it is critical that Gollan et al. (1997) found cross-script non-cognate priming, since early studies with languages of the same script only found cognate priming effect (de Groot & Nas, 1991; Sάnchez -Casas et al., 1992). After Gollan et al. (1997), cross-script non-cognate priming was also found in several studies with Chinese-English bilinguals (Jiang, 1999; Forster & Jiang, 2001; Wang & Forster, 2010). One explanation is that when prime and target are in two different scripts, the uniqueness of each script can provide a cue as to which lexicon should be accessed, which allows for rapid access of the relevant lexicon and increases the chance that the prime can be accessed rapidly enough to influence the processing of the target. This is known as orthographic cue hypothesis in Gollan et al.'s (1997) account. Another line of explanation is that there is orthographic competition between within-script prime and target, which inhibits the priming effect, as suggested in BIA+ model (Dijkstra & van Heuven, 2002; Kim & Davis, 2003; and Voga & Grainger, 2007), and this will be discussed in detail later.

Since Gollan et al. (1997) failed to find L2-L1 translation priming in their study, their result was consistent with a well-known phenomenon found in bilingual literature, i.e., *translation priming asymmetry*. Translation priming asymmetry refers to the finding that while L1 word has consistently been found to have an impact on L2 word recognition, it is hard to find L2-L1 priming in masked priming studies (e.g., Keatley et al., 1994; Gollan et al., 1997; Jiang, 1999). However, the fact that L2-L1 translation priming was found in semantic categorization task (Grainger & Frenck-Mestre, 1998; Finkbeiner et al., 2004; Wang & Forster, 2010) and that symmetric translation priming has been found with highly proficient simultaneous bilingual speakers (see Duñabeitia, Perea, & Carreiras, 2010 for an overview) suggests that translation priming effect is semantic in nature and that the magnitude of priming effect depends on the proficiency of the bilinguals, as well as the task.

1.2.2 Kim & Davis (2003)

It was found that lexical processing is influenced by the task nature (Kim & Davis, 2003; Dijkstra et al., 2010). Grainger and Frenck-Mestre (1998) examined translation priming with highly proficient English-French bilinguals in masked LDT. They found non-cognate translation priming effect in semantic categorization task but not in lexical decision task. They explained that translation priming is mediated by the common semantic representation, which can only be captured in tasks that require semantic information to make a response. Finkbeiner, Forster, Nicol, and Nakamura (2004) replicated the results with Japanese-English bilinguals.

Task effect in translation priming was closely examined in Kim & Davis (2003). They examined cross-script translation priming in three different tasks, namely masked LDT, masked word naming, and masked semantic categorization task. Three critical prime and target conditions were tested in each task, i.e., cognate condition, in which the prime and target were cognates in the two languages, non-cognate condition, in which the prime and target were translation equivalents with no form overlaps, and the homophone condition, in which the prime and target only shared similar phonology. They tested Korean-English bilinguals in the three tasks and found both translation priming for cognate and non-cognate in LDT and semantic categorization task but not in naming task. Homophone priming and cognate priming were found in naming task (Experiment 2) but there was no non-cognate translation priming. They did not find larger cognate priming than non-cognate priming in LDT (Experiment 1) either. Although their results did not show larger cognate priming effect, it provides more evidence that the nature of task could put different loads of burden on cognitive capacity and thus affect the priming effect we can observe. To make a response, participants may only rely on decoding one or more codes in the lexical representation, thus economizing the cognitive processing.

Kim and Davis (2003) tested homophone priming in their study but only found robust priming effect in naming task. In fact, the role of phonological coding in visual word recognition is important in both monolingual and bilingual literature. Grainger (1993) hypothesized that it should be possible to prime L2 word with L1 homophone, whether it is a word or nonword. This hypothesis has been confirmed by several studies. The within-language phonological priming effect is well established in monolingual studies (Perfetti, Bell, & Delaney, 1988; Perfetti & Bell, 1991; Ferrand & Grainger 1992, 1993; Grainger & Ferrand, 1996; Forster & Davis, 1991). Brysbaert et al. (1999) found that interlingual homophone in Dutch (L1) facilitated the recognition of target in French (L2) (Experiment 1), and so did the Dutch pseudohomophone prime (Experiment 2). With English-Spanish bilinguals, Schewarts, Kroll, and Diaz (2007) found that when cognates had overlap in orthography but difference in phonology, there was an inhibitory effect. They suggested that there was feed-forward activation from orthography to phonology, and that the competition in phonology interfered with word recognition. More recently, Dimitropoulou, Duñabeitia, and Carreiras (2011) found bidirectional masked phonological priming effect with even not very proficient Greek-Spanish bilinguals, so did Zhou, Chen, Yang, and Dunlap (2010) with unbalanced Chinese-English bilinguals. It should be noted that the two aforementioned studies used languages of different scripts. In fact, when there is orthographic overlap, phonological priming effect disappeared in Dimitropoulou et al. (2011). And while Dijkstra et al. (1999) found inhibitory phonological priming effect, Lehomfer & Dijkstra (2004) found facilitatory effect with the same set of items. It remains to be seen whether the lack of orthographic overlap has an impact on the result of cross-language phonological priming.

As can be seen, cross-language phonological effect can be found in visual word recognition but it can easily be influenced by the possible interaction at orthographic level. If cross-language phonological overlaps can influence the bilingual lexical processing, it is foreseeable that this effect might have an influence on the cognate facilitation effect, since cognates share phonological overlaps between each other while non-cognate translations do not.

1.2.3 Voga & Grainger (2007)

Voga and Grainger (2007) compared cognate and non-cognate priming effect with proficient Greek-Spanish bilingual speakers in masked LDT. In Experiment 3, they manipulated the semantic and phonological overlap between the prime and target so that there were three prime conditions and two target conditions (cognate and non-cognate). For each type of target, there were three types of primes: translation, which is the translation equivalent of the target word; phonologically related prime, which has a high degree of phonemic overlap with the target; and the control prime, which is unrelated to the target. They found that significant cognate priming advantage only exists when cognate priming was measured against the control condition. When the baseline was changed into matched phonological condition, the advantage of cognate priming disappeared. Therefore, they argued that cognate facilitation was caused by the additional form overlap, i.e., it was the phonemic overlap that led to the larger cognate priming than non-cognate priming.

The significance of Voga and Grainger’s (2007) study is that they for the first time examines whether the shared phonology across cross-script cognates can affect cognate facilitation effect. They not only compared masked translation priming between cognates and non-cognates but also compared priming effect when the form (phonological) priming effect was taken out (by measuring translation priming effect against phonological priming effect for both cognates and non-cognates). Their finding was very enlightening in that it suggests that the larger cognate priming effect was actually caused by the additional form (phonological) priming. This is a very important piece of finding that can provide an explanation for cognate facilitation, which will be explicated in 1.3.2.

To sum up, the three cross-script studies used masked priming technique to examine cognate and non-cognate representation and processing in different groups of bilinguals. Their studies involved detailed examination of translation priming effect (in all the three) and phonological priming effect (in Kim & Davis (2003) and Voga & Grainger (2007)). The focus of each study was not exactly the same but their findings were enlightening in the understanding of bilingual lexicon. Gollan et al. (1997) was among the first to find that the difference in scripts can strengthen the effect of translation priming, and it also found that priming direction (from L1 to L2 or from L2 to L1) and language dominance can influence the magnitude of the priming effect, as indicated by the finding of *translation priming asymmetry*. Kim and Davis' (2003) study did not find cognate facilitation effect but their study gave support to task effect, which was reflected in the robust translation priming effect in LDT and phonological priming in naming task. Voga and Grainger (2007) was the only study that tried to answer the question why cognates have certain advantages in processing than non-cognates. Their study was able to distinguish the difference between cognate and non-cognate priming effects when form (phonological) priming effect was taken out, and thus provide evidence that the form overlap between cognates was the cause of cognate facilitation.

1.3 Theoretical explanations of Cognate Facilitation Effect

Different theories have been proposed to explain the effect of cognate facilitation. There are two important positions that can be identified: the link view, which comes from a well-known model of bilingual mental lexicon, RHM (Revised Hierarchical Model) (Kroll & Stewart, 1994) and suggests the stronger link between cognates is the cause of larger cognate priming effect; the form overlap account (French & Jacquet, 2004; Thomas, 1997; Dijkstra et al., 1999; Voga & Grainger, 2007), which proposes that cognate facilitation is the result of the additional form overlap between cognates.

1.3.1 The link explanation of cognate facilitation

One line of theoretical explanation comes from a well-known model of bilingual mental lexicon, RHM. RHM assumes that there is an associative link between the translation equivalents at the lexical level and there is at the same time a common meaning/concept linking the two (see figure 1 for illustration).

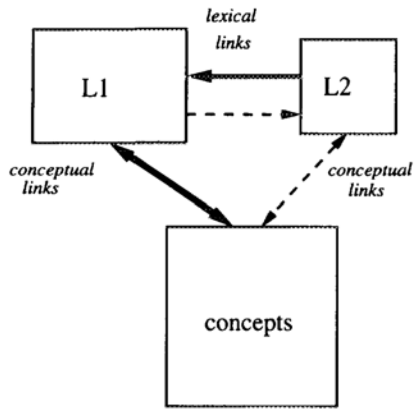

Figure 1: Revised Hierarchical Model of lexical and conceptual representation (from Kroll & Stewart, 1994)

In RHM, the connection between L2 word and the concept is less strong than that between L1 word and the concept but it grows stronger as the bilingual becomes more proficient with the L2 language. Cognate facilitation exists because the lexical link between cognates is stronger than non-cognates.

While RHM provides plausible explanation for the translation asymmetry (it is easy to get L1-L2 priming effect but not vice versa), it faces some challenges. For example, if there is a strong connection between L2 and L1 at form level, L2 words should easily prime the L1 translation equivalents, which is not the case apparently (e.g., Keatly, Spinks, & de Gelder, 1994; Gollan et al., 1997; Jiang, 1999). RHM explains this with the relatively slower processing speed of L2 word. However, given longer processing time, Jiang (1999) still failed to find L2-L1 priming effect. Moreover, L2-L1 priming effect was found when the task was changed to semantic categorization (Grainger & Frenck-Mestre, 1998; Finkbeiner et al., 2004), indicating the semantic priming nature of translation priming.

If cognate facilitation is caused by the stronger lexical connection between the cognates which have similar forms, is this connection strong enough to generate L2-L1 priming effect? Gollan et al.'s (1997) study apparently failed to get any L2-L1 priming effect, even with cognates. So if cognate connections are truly stronger, RHM should at least provide reasons for why they are stronger and how strong they can be to generate what kinds of effect. For example, is the lexical link strong enough to produce L2-L1 priming as just mentioned? In fact, in this model, the strength of the link between the L1 and L2 word is assumed to differ as a function of L2 proficiency and relative dominancy of L1 over L2. There is no straightforward explanation or statement that the strength of the link also depends on the relation between the L1 and L2 words. So it is not quite clear as for why cognate lexical link is stronger than non-cognate.

Although RHM did not address the issue of cognates directly, as a model on translations across languages, its theoretical positions on translations should apply to cognates too, which belong a type of translation equivalents. If RHM is to provide a proper explanation to the cognate facilitation with the difference of strength of links between the L1 and L2 words, some additional assumptions about the strength of link need to be implemented. For example, they should specify what variables could influence the strength of the links, other than just level of proficiency and relative dominance, because these two factors are mainly variables that relate to the bilinguals' acquisition process, with no reference to the possible influence that comes from the specific relation between L1 and L2 word. Furthermore, RHM predicts that cognate priming advantage should be observed in other tasks than lexical decision, because it is the lexical link that causes this advantage. If this prediction is true, we should expect cognate facilitation effect free from any possible influence of task demands, which is not consistent with the aforementioned result of robust L2-L1 priming in semantic categorization task but not in LDT.

To sum up, the stronger link explanation is able to predict cognate facilitation effect, but this explanation lacks specifications on what variables determine the strength of the link, except for proficiency levels and dominance. There are certain findings that can not be directly explained by RHM. For example, it was found that languages with different scripts can yield translation priming more easily than languages with the same script (Gollan et al., 1997). RHM simply did not address this issue in its framework. Its prediction that cognate facilitation should be observed in different tasks remains to be examined with experimental data.

1.3.2 The form overlap account

Another line of explanation comes from the connectionist models (French & Jacquet, 2004; Thomas, 1997; Dijkstra et al., 1999; Voga & Grainger, 2007). The basic assumption is that cognates are only different from non-cognates in that they share form overlaps with their translation equivalents. There are two camps in this broad model, namely distributed model and localist model.

The distributed model assumes that the overlaps in representation could become joint force of attractor for cognates and thus strengthen co-activation. Localist model, which is represented by BIA+ model (Bilingual Interactive Activation plus, see

Figure 2 for illustration) (Dijkstra & van Heuven, 1998, 2002), shares similar assumptions.

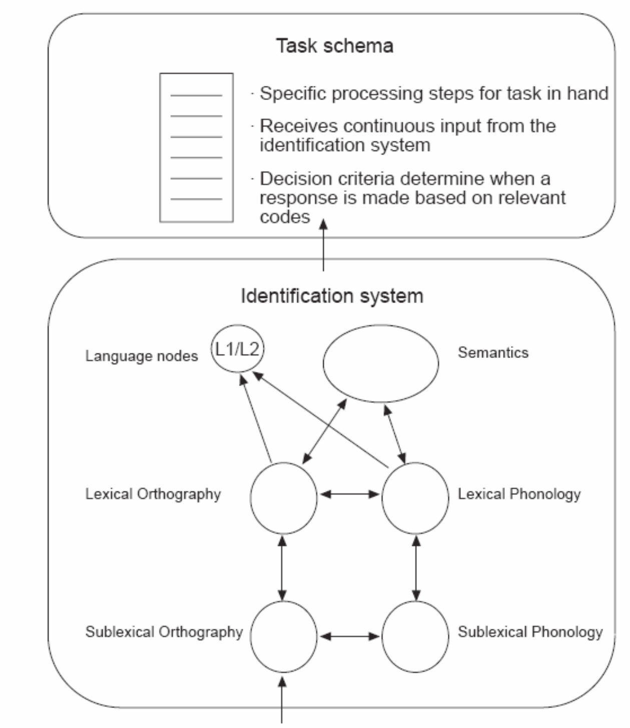

Figure 2: The BIA+ model for bilingual word recognition

(from Dijkstra & van Heuven, 2002)

As can be seen, in BIA+, interactions between languages can happen at different levels and it also implemented mechanism of lateral inhibition and task decision system to explain findings in bilingual literature. Lateral inhibition refers to the competition within and across languages at different levels. For example, when the two lexical items share a common script, there might be lateral inhibition at the orthographic level. This successfully explained the finding on interlingual homographs (e.g., Dijkstra, 1998) and can give a sound explanation to the finding that priming is easier to be found with languages of different script (e.g., Gollan et al., 1997). BIA+ model explains cognate advantage in a way slightly different from distributed model. In BIA+ model, the activation of orthography and phonology are language non-selective. For example, the English word *tomato* can activate its orthographic neighbors in English, as well as in Dutch, for a Dutch-English bilingual. Therefore, the word *tomaat* (tomato in Dutch) can be activated with the presentation of *tomato*. This orthographic activation can feed forward to the conceptual level of the words. In the case of cognate word *tomato*, the shared semantics of *tomato* and *tomaat* is co-activated and it sends feed-back to orthographic representation, thus strengthening both *tomato* and *tomaat* (see Dijkstra et al., 2010 for a detailed discussion).

The difference between the two camps in the form overlap account lies in that the localist model, which assumes non-selective activation of both languages, predicts lateral inhibition at each level of representation, while no such mechanism is clearly stated in distributed model. Thus localist model predicts that identical cognates and similar cognates are different in that identical cognates receive no lateral inhibition at the orthographic level while similar cognates do.

Except for the above differences, both models believe that form overlap is the cause of cognate advantage and the degree of overlaps influences the processing of cognates. With Dutch-English bilinguals, Dijkstra et al. (2010) have found that facilitatory cognate effect in L2 lexical decision increased linearly with the orthographic overlap with non-identical cognates, indicating the role of form overlap in processing. Voga and Grainger (2007) tested Greek-French bilinguals and also found that the degree of phonemic overlap affected the amount of priming

(Experiment 2). While the former study tested languages of the same script, the latter one was done with languages of different scripts.

To summarize, the two theoretical explanations on cognate facilitation effect have different ways of interpretation and predictions. The link account attributes the facilitation effect to stronger link at the lexical level and thus predicts cognate facilitation regardless of task; form overlap account from connectionist models argues that cognate facilitation arises because besides shared semantics, cognates have additional shared form overlaps. The predictions of connectionist models are more specific compared to the link account. If cognate facilitation arises out of form overlaps, cognate facilitation should disappear when the influence of form overlaps is taken out. Further, if form overlap does not affect processing, cognate facilitation will not exist either.

1.4 Rational and research questions

Although the aforementioned studies on cognate and non-cognate processing has revealed important characteristics about cognate and non-cognate representation in bilinguals' minds, there are still some unresolved issues that need more attention.

First, of the three studies that have been done with languages of different scripts, Gollan et al. (1997) and Voga & Grainger (2007) successfully found larger cognate priming effect, but Kim & Davis (2003) did not. It seems that cognate facilitation is not quite stable to be found in the cross-script languages, especially when there are not many empirical results that exist, and existing results are based on distinctly different language pairs. It might be interesting to do more empirical experiments that can include more language pairs to give a better picture on cognate representation and processing.

Second, although both RHM and BIA+ model give explanations on cognate facilitation effect, only one cross-script study (Voga & Grainger, 2007) was designed to test one explanation, i.e., the form overlap explanation from BIA+ model. We can not conclude from Gollan et al. (1997) or Kim & Davis (2003) why or why not cognate facilitation is found.

Third, while Gollan et al. (1997) and Kim & Davis (2003) did not address the deep reason of cognate facilitation, their results do have important implications. Gollan et al. (1997) examined two groups of bilinguals and found that language direction in priming had an impact on whether priming effect can be found or not, and language dominance influenced the magnitude of priming. Although Kim & Davis (2003) did not find cognate facilitation in LDT, they varied the task types and the result suggested that task demands could impact priming effect, as is seen from the finding that cognate priming in masked naming task was similar to that of homophone priming, indicating that cognate priming can be purely phonological in a task that put cognitive load on the phonological and vocal activation. The implications might be of great importance in understanding cognate and non-cognate representation and processing in the bilingual mind. However, there is a problem--- no single study has been done to systematically examine how priming direction, language dominance, and task type will potentially influence cognate and non-cognate priming.

Based on the above observations with existing empirical studies, the current thesis was designed in order to contribute to the understanding of cognate facilitation. There are three main research questions, which correspond to the observations given above:

First, since cross-script cognate facilitation effect was not consistently found in empirical studies, cross-script cognate studies are in need of more evidence to get a clearer picture of cognate representation and processing. Meanwhile, many studies that have involved Chinese-English bilingual populations have been concentrated on the non-cognate translation equivalents, but as we know, there is still no work that have been done to investigate cognate representation in this growing number of bilingual population. Therefore, it is not only interesting but also valuable for us to examine whether cognate facilitation can be found in the new language pair, i.e., Chinese and English. The first question therefore is can we find cognate facilitation effect with Chinese and English? Can we find cognate and non-cognate translation priming as well as significant different between the two? What will be different from the findings of the previous studies?

Second, both RHM and BIA+ model have given different explanations on cognate facilitation effect (respectively the link account and the form overlap account of cognate facilitation). Which line of explanation is more suitable in explaining the empirical data? If the link account is correct, we should be able to find cognate facilitation effect regardless of task type, since the strength of the lexical link should not be influenced by the task demand. If the form overlap account is correct, we should be able to find cognate facilitation effect when form priming is also found, since this account explains the cognate advantage as a combination of semantic and form effect. So can we observe cognate facilitation in different tasks? Or can we observe form (phonological) priming which influences cognate facilitation effect?

Third, what would be the group difference when we compared two groups of bilinguals, as indicated by Gollan et al. (1997)? Does the language dominance influence the magnitude of priming effect if there is one? And if L2-L1 priming is hard to find, does the order of the prime and target affect priming effect when only L1-L2 priming is considered? In other words, does the difference of language play a role in priming?

Chapter 2 The Current Study

The current study is focused at answering the three research questions listed in Chapter 1. Chinese-English cognate and non-cognate processing was examined with experimental methods. Before introducing the design of the experiments, we will give a summary of the languages involved in this study.

2.1 Linguistic features of Chinese and English

Chinese and English are two distinctly different languages. They belong to two different language families. While Chinese is a branch of Sino-Tibetan language family, English is a West-Germanic language which belongs to the Indo-European language family. Therefore, they are typologically quite different. The two languages use distinctively different scripts, phonological systems as well as word-formation rules.

English is an alphabetic language which uses letters to form words. Chinese has two systems of orthographies, with one using logographic characters and the other using alphabets (known as pinyin). English, as an alphabetic language, has the characteristic that allow for the use of grapheme-phoneme conversion (GPC), but the transformation of orthography to phonology is also constrained by the regularity mappings (e.g., Plaut, McCelland, Seidenberg, & Patterson, 1996). Compared with English, the correspondence between orthography and phonology in Chinese is more arbitrary (Zhou, Shu, Bi, & Shi, 1999), which means that the phonology of Chinese is activated on the basis of character representations in the orthographic lexicon. Since each character corresponds to a spoken syllable, “Chinese has often been viewed as a system that takes the reader directly to the meaning, with phonology not playing an important role” (Perfetti, Liu, Fiez, Nelson, Bolger, & Tan, 2007: 13). The difference lies in that although it requires prior knowledge to pronounce the irregular English words, there are always graphemes in them which follow GPC rules and give hints to pronunciation. Although almost 90% of single-character words in the Chinese consist of a lexical radical (LR) that contributes to the meaning element of the word, and a “non-radical component” (NR), which contributes to the syllabic pronunciation of the word in its entirety (Chen & Allport, 1995), the information the two radicals can provide is still unreliable because there are too many exceptions. One main exception is the numerous homophone characters and words, which only differ in tone.

Cognates in Chinese, also known as loan words, refer to words that come from English, the concepts of which did not exist in Chinese before their introduction into the Chinese language. There are two types of these words (Hall-Lew, 2002): senseloan, which only takes the meaning from the original words and do not have any phonological overlap with the original, like 拳击 [fist+ hit (quan2ji1)= boxing]; transliteration, which sounds like the original word in English and the combination of morphemes in Chinese does not make sense, i.e., opaque words, like 巴士 [one kind of surname+ one kind of men (ba1shi4)= bus). Since cognates typically refer to words that share both meaning and form-level overlap, we will concentrate on transliterations in this study. The same word borrowing process can happen from Chinese to English, resulting in cognates like *jiaozi* (饺子)and *wonton* (云吞).

2.2 Experimental Design

In order to answer the research questions outlined in Chapter 1, four masked priming experiments were designed, all of which used L1 as prime and L2 as target. The reason is that L2-L1 priming effect was rarely obtained (Jiang, 1999; Gollan et al., 1997). In order to maximize the evidence, we adopted the L1-L2 priming direction. Masked priming technique (Forster & Davis, 1984) was used in all the four experiments for its proven effectiveness in studying rapid and automatic underlying processing mechanism (de Groot & Nas, 1991; Sάnchez -Casas et al., 1992; Gollan et al., 1997; Jiang, 1999; Forster & Jiang, 2001).

In standard masked priming paradigm, a visual mask (e.g., ####) is followed by a prime word for a very brief period of time (normally 40-60ms), and then immediately by the target word itself. The presentation of the prime is so brief that the participants are not even aware of its presence. It is acknowledged that this technique can avoid the influence of strategy used by participants and can thus tap into more automatic and underlying working mechanisms in lexical processing.

Since this is cross-script study, only semantic overlap and phonological overlap were manipulated. Experiment 1 and 3 used masked lexical decision task and Experiment 2 and 4 used masked word naming task. The reason to use both LDT and naming task is to test the prediction of the link account. If cognate facilitation is caused by the stronger lexical link, the effect should be observed in both tasks. Another reason to include naming task is that both semantic and phonological codes are involved in the study. Based on previous studies on task effects, semantic effect is expected in LDT while phonological effect may only be found in naming task. Therefore, participants were tested in both tasks.

The difference between Experiment 1, 2 and Experiment 3, 4 is that the two sets of experiments tested different groups of bilinguals. There are two reasons to use two different groups of bilinguals. First, as discussed before, we would like to test if language direction (Chinese as prime and English as target vs. English as prime and Chinese as target) has an impact on priming. When L1-L2 priming was adopted, the only way to test language direction effect was to use two groups of bilinguals. The second reason is that we hoped to see if language dominance has an influence on priming effect. To do so, two groups of bilinguals should be tested.

Experiment 1 and 2 tested Chinese-dominant Chinese-English bilinguals who were late learners of English. Experiment 3 and 4 tested proficient and simultaneous English-dominant English-Chinese bilinguals. The Chinese-English bilinguals were students who started learning English through a classroom-instruction manner in China. Later, they came to study in Singapore and used English on a daily basis. The English-Chinese bilinguals were Singaporean Chinese. They were born and raised in an environment where both English and Chinese were used. The official language and the language used in school was English for them but the home language was Chinese. They acquired the two languages around the same time but English was more emphasized than Chinese.

Chapter 3 Cognate and Non-cognate Masked Priming with Chinese-English Bilinguals

3.1 Experiment 1: Chinese-English bilinguals in masked LDT

Experiment 1 was designed to test if cognate processing is different from non-cognates and if there is such an effect, whether it is caused by the overlaps in semantics and phonology.

Method

Participants

Twenty-one Chinese-dominant Chinese-English bilinguals were recruited from National University of Singapore (NUS). They had all passed the Qualifying English Test (QET) Band 3 or had passed the English module required when they passed Band 1 or Band 2 of QET. QET is an English test NUS holds for the students who are not from English-speaking countries. Passing QET means that the student has a good command of English and he/she needs not take any special English module to pursue degrees in NUS (see the QET notice on the NUS website at http://www.nus.edu.sg/celc/announcements/qet_notice.html for more information). All participants had normal or corrected-to-normal vision and they were paid for their participation. Each participant filled out a language questionnaire before experiment. They rated their proficiency levels in reading, writing, speaking, and listening respectively based on a 7-scale question (1 means very poor, 2 means poor, 3 means fair, 4 means functional, 5 means good, 6 means very good, and 7 means native-like). Both the mean and the standard deviation (SD) were listed, with SD in parentheses. The participants' language background information is presented in Table 1 below.

Table 1: Language background information of the Chinese-English bilingual participants

(a)

Age	Years of English Learning	Years of Staying in Singapore
22.1 (2.3)	10.7 (2.7)	4.2 (1.9)

(b)

Language	Self-rated Proficiency Levels			
	Reading	Writing	Speaking	Listening
English	5.5 (0.6)	4.9 (0.5)	5.3 (0.9)	5.4 (0.8)
Chinese	6.8 (0.7)	6.7 (1.1)	7.0 (0)	7.0 (0.2)

(c)

Language	Age of Acquisition		
	Speaking	Reading	Writing
English	11.0 (2.1)	11.0 (2.1)	11.4 (1.9)
Chinese	1.5 (1.9)	3.5 (2.1)	4.3 (2.5)

As can be seen, the Chinese-English bilinguals were native speakers of Chinese and late learners of English (age of acquisition around 11 years old). Their English proficiency levels in each skill were obviously lower than Chinese, showing that they were unbalanced Chinese-English bilinguals.

Materials and Design

One hundred and eight words and one hundred and eight non-words were used as targets. Targets were presented in English (L2) and primes in Chinese (L1). Of the 108 word targets, 54 were cognates and 54 were non-cognates. Among the Chinese word primes, there were 18 three-character Chinese words and 36 two-character Chinese words for both cognates and non-cognates. Each English target was primed by three types of Chinese primes: its translation equivalent (cognate or non-cognate prime), a phonologically related prime, and an unrelated prime (see Table 1 for example). The phonologically related primes of the cognate targets were pseudohomophones of the cognate translation primes (all the characters were substituted by the ones that have the same sounds and same tones), and phonologically related primes of the non-cognate targets are interlingual pseudohomophones of the English targets (illegal combinations of Chinese characters that sound like the English targets). The unrelated primes were matched to the other prime conditions for character length. The English targets were matched for letter-length for each condition. The English word targets and the corresponding Chinese prime stimuli are shown in Appendix A. The primes for nonword targets matched the primes for word targets in terms of length and phonological overlap and were constructed to mimic the cognate and phonological primes used for word targets.

The "cognate primes" of the nonword targets were created that they were phonologically similar. Three experimental lists were created by rotating the targets across the three prime conditions so that each target appeared only once for a given participant but was tested in all the priming conditions across participants. All the primes were Chinese Simsun words of size 10 presented in bold characters. All the targets were English Courier New words of size 13.5 presented in lowercase bold letters. The sample stimuli are listed in Table 2 as below.

Table 2: Sample Stimuli in Experiment 1

	Prime Condition		
Target	**Translation**	**Phonological**	**Unrelated**
Cognate			
clone	克隆 (ke4long2)	课龙 (ke4long2)	寻常 (xun2chang2)
Non-cognate			
cup	杯子 (bei1zi3)	卡破 (ka3po4)	手杖 (shou3zhang4)
Nonword			
yob	药卜 (yao4bo0)	药玻 (yao4bo1)	扩充 (kuo4chong1)
Nonword			
wuke	距戏 (ju4xi4)	午棵 (wu3ke1)	兵团 (bing1tuan2)

Procedure

The experiment was conducted on two PCs using DMDX software (Forster & Forster, 2003). Each trial consisted of the following sequence: the trial started with a 500ms forward mask (贔贔贔贔), followed by a Chinese prime for 50 ms, and then the English target word for 500 ms. No participant reported seeing the Chinese words preceding the English targets.

Participants were randomly assigned to one of the three lists. They were asked to read written instructions in English before they performed the task. The Chinese prime was not mentioned, nor was the fact that their knowledge of Chinese might be of use in the experiment. They were asked to decide whether the presented string of letters made a word or not by pressing either a "YES" button or a "NO" button as quickly as possible. There were 10 practice trials before the real trial.

Results and discussion

In analyzing the results of this experiment and all subsequent experiments, data from trials on which an error occurred were discarded and outliers were treated by setting them equal to cutoffs established at two standard deviations above or below the mean for each participant.

Table 3: Lexical decision latencies (in ms) and percentage error rates for English targets in masked LDT (Experiment 1)

	Translation (T)		Phonological (P)		Unrelated (U)		Net Priming Effects	
	RT	Error	RT	Error	RT	Error	T-U	P-U
Cog	658	11.3	720	15.0	732	16.2	74	12
Non-cog	668	14.1	709	13.4	715	14.1	47	6

Table 3 presents the mean lexical decision times and percentage error rates for each of the prime and target condition. In the following analysis, separate ANOVAs were conducted by both subject analysis (F1) and item analysis (F2). In our analysis, two factors were included in the initial analysis: Prime Type (translation, phonological, or unrelated), and Target Type (Cognate or Non-cognate). The Target Type factor was a repeated measures factor in the participant analysis but not in the item analysis and the Prime Type factor was a repeated measures factor in both analyses. For latencies, there was a main effect of prime type in the participant analysis, F1(2, 40)= 22.36, p<.05, F2(2, 212)= 15.67, p< .05; there was no main effect of target type, F1(1, 20)= .41, p>.05; F2(1, 106)= .097, p= .756. There was no interaction between prime type and target type, F1(2,40)= .42, p>.05, F2(2, 212)= 1.01, p= .37. For errors, there was no main effect of prime type, F1 (2, 40)= .72, p= .49, F(2, 212)= 1.12, p= .33; and there was no main effect of target type, F1(1, 20)= .02, p= .89, F2(1, 106)= .003, p= .95; the interaction between target type and prime type is not significant either, F1 (2, 40)= 1.26, p= .29, F2 (2, 212)= 1.17, p= .32.

Planned comparisons show that for cognates, there was a significant translation priming effect in the reaction time data, F1(1, 20)= 18.54, p= .000, F2(1, 53)= 20.68, p= .000; and for non-cognates, there was also a significant translation priming effect F1(1, 20)= 9.96, p= .005, F2(1, 53)= 7.24, p = .01. The cognate translation priming effect was larger (74ms vs 47ms) than non-cognate priming effect, but it was not significantly different from each other, F1(1, 20)= 1.26, p= .27, F2(1, 53)= 2.52,

$p = .12$. There was no phonological priming effect with either cognates or non-cognates, all Fs < 1.

For errors, there was a trend of significant cognate translation priming effect, $F1(1, 20) = 3.50$, $p = .076$, $F2(1, 53) = 3.89$, $p = .054$. There was no significant non-cognate translation priming effect, both Fs < 1. There was no significant phonological priming effect.

Discussion

In this experiment, we successfully found translation priming effect for both cognates and non-cognates, but there was no phonological priming effect for either type of target words. Both translation priming effects were very robust, providing evidence that cross-script translation priming is stable to be found. Unlike previous studies on cognates, we did not find significant cognate facilitation in masked LDT from Chinese to English. Although we found both robust cognate and non-cognate translation priming, the 27 ms difference did not reach significance level. Phonologically related condition clearly did not show any impact on recognition times. This is quite different from Voga and Grainger's (2007) study, which found both cognate and non-cognate translation priming effect, as well as phonological priming effect with Greek-French bilinguals. It is also different from Gollan et al.'s (1997) findings, which discovered robust cognate and non-cognate translation priming effect, and significantly larger cognate priming effect than non-cognate priming in masked LDT. Since Gollan et al.'s (1997) study did not test phonological priming effect, we can not compare phonological effect with their study.

However, our finding does have some similarity with the results from Experiment 1 in Kim and Davis (2003). In their study, only significant cognate and non-cognate translation priming effect was found but the two were not significantly different from each other. No homophone priming effect was found in their LDT experiment either. Kim and Davis (2003) suggested that if participants were familiar enough with the materials, phonological information was not necessarily used to make the lexical decision.

As far as phonological priming is concerned, our data does not conform to Zhou et al. (2010)'s results either. They found bidirectional phonological priming in masked LDT with not very proficient Chinese-English bilinguals but we did not. The lack of phonological priming effect in our study may have several reasons. First, in Zhou et al. (2010), the items were exclusively monosyllabic, but in our study, they were multisyllabic. The phonology of monosyllabic items may be activated quite quickly and exert influence in processing the target word, which is also monosyllabic. However, the processing of multisyllabic prime words may exert more loads on the cognitive processing and may not be able to influence target word processing in such short time. Second, Zhou et al. (2010) inserted a 35ms backward mask after the presentation of the prime word in their experiments. This extra 35ms was added to give more time to phonological decoding in Chinese character processing.

Brysbaert et al. (1999) argued that phonological priming effects may rely on the rapid and automatic activation of phonological code of both languages. It was found in many studies that the phonological code can be activated very early in English word recognition (see Rastle & Brysbaert, 2006 for an overview). But the situation is different for Chinese. The phonological representation of the Chinese characters can not be retrieved by GPC, but rather mapped to the distinctive characters. Previous research (Perfetti & Tan, 1998; Tan & Perfetti, 1997; Chen & Peng, 2001) found that the activation of phonology in Chinese reading might be only observed between 57ms and 200ms. It might be that the 50ms prime duration was not long enough for our participants to fully process the phonology of the prime words, especially when the primes were two or three characters. The relatively slower activation of phonology of the Chinese primes might be the reason why we did not find phonological priming effect. However, there are still other possible causes. A very obvious cause is that our participants simply did not recruit their knowledge of phonology in making the decision. It is possible that in LDT, participants can just rely on orthographic and semantic information to make a decision, as reviewed before in the task effect.

To find the cause of our failure to get phonological priming and to further examine cognate effect in other tasks, in the following experiment, we used another task which is considered to be the most efficient way to tap phonological representation, i.e., word naming task.

3.2 Experiment 2: Chinese-English bilinguals in masked word naming task

Experiment 2 was designed to examine the pattern of translation priming and phonological priming effect in the masked naming task. Like Experiment 1, the prime was in Chinese (L1) and target word is in English (L2). If phonological effect is more sensitive to naming task, then we should be able to find phonological effect with both target types. If naming task can only tap on the phonological processing and no semantic information is needed in making the response, then we should not be able to find non-cognate translation priming. However, if priming is not influenced by the task type, we should observe similar patterns like Experiment 1.

Method

Participants

The same participants except one from Experiment 1 participated in this experiment. Another participant was recruited to fill in. All the participants who participated in Experiment 1 took part in this experiment at least one week after Experiment 1 to minimize any influence from the last experiment.

Materials and Design

Experiment 2 used the word stimuli of Experiment 1. Another ten pairs of prime and target were selected to be practice items at the beginning of the experiment.

Procedure

Participants were tested individually on one PC in a booth using E-Prime software. The same procedure used in Experiment 1 was employed in the current experiment except that in this case the participants were instructed to say aloud the English target word as quickly and as accurately as possible. Response data were obtained using E-Prime software with the participant's vocal response triggering a voice-box. On the triggering of the voice-box, the next trial would automatically begin so that the experiment was continuously running. The whole testing process was recorded in a SONY recorder for later analysis. No participant reported seeing the Chinese words preceding the English targets.

Results and discussion

In analyzing the results, the author listened to the recordings of the experiments and discarded the data of trials when the participants failed to pronounce the correct word or when there was technical problems (mostly the microphone did not catch the participants' voice and they had to repeat). No participant was rejected because of high error rate. The lower cutoff was set at 200ms and the high cutoff at 2500ms. Table 4 listed the mean naming latencies and percentage error rates in each condition, as well as the net priming effect.

Table 4: Naming latencies and percentage error rates for English targets in masked naming (Experiment 2)

	Translation (T)		Phonological (P)		Unrelated (U)		Net Priming Effects	
	RT	Error	RT	Error	RT	Error	T-U	P-U
Cog	777	4.0	836	6.2	820	9.2	43	-16
Non-cog	781	5.6	780	6.3	817	6.2	26	27

For latencies, there was a main effect of prime type in the participant analysis, F1(2, 40)= 7.85, p= .001, F2(2, 212)= 8.83, p= .000; there was also a main effect of target type in the participant analysis, F1(1, 20)= 4.48, p= .047, but not in item analysis F2(1, 106)= .51, p= .475. Interaction between prime type and target type was also significant, F1(2,40)= 4.59, p= .016, F2(2, 212)= 4.70, p= .010. For errors, there was a main effect of prime type in participant analysis, F1(2, 40)= 4.99, p= .012, but not in item analysis, F2(2, 212)= 2.49, p= .086; there was no main effect of target type, both Fs< 1. The interaction effect between prime type and target type was not significant either, F1(2, 40)= 2.43, p= .101, F2(2, 212)= 2.00, p= .139.

Planned comparisons showed that for cognates, there was a significant translation priming effect in the reaction time data, F1(1, 20)= 10.31, p= .004, F2(1, 53)= 9.70, p= .003, but there was no significant phonological priming effect, F1(1, 20)= 1.43, p= .246, F2(1, 53)= 1.32, p= .257. For non-cognates, there was a significant translation priming effect F1(1, 20)= 12.80, p= .002, F2(1, 53)= 7.55, p = .008, as well as a significant phonological priming effect, F1(1, 20)= 5.07, p= .036, F2(1, 53)= 7.77, p= .007; the difference between cognate translation priming effect and non-cognate priming effect was significantly different from each other, F1(1, 20)= 6.50, p= .019, F2(1, 53)= 7.09, p= .010.

Error analysis showed a significant cognate translation priming effect, F1(1, 20)= 15.39, p= .001, F2(1, 53)= 6.86, p= .011, but no difference between cognate translation prime condition and phonological condition, F1(1, 20)= 2.47, p= .132, F2(1, 53)= both Fs< 1. The difference between cognate phonological condition and unrelated condition was not significantly different from each other, $F1(1, 20)= 3.35$, $p= .082$, $F2(1, 53)= 2.92$, $p= .093$. There was no significant effect for non-cognates, the difference between translation prime condition and unrelated condition was not significant, $F1(1, 20)= .152$, $p= .70$, $F2(1, 53)= .064$, $p= .801$; and the same was true with the difference between phonological condition and unrelated condition, $F1(1, 20)= .01$, $p= .916$, $F2(1, 53)= .001$, $p= .979$.

Discussion

The results showed that there was significant cognate and non-cognate translation priming effect as well as non-cognate phonological priming effect. The cognate translation priming effect was significantly larger than non-cognate priming effect in this experiment (43ms vs. 26ms). Non-cognate translation and phonological priming effect was of similar magnitude (26ms vs. 27ms), suggesting that both semantic information and phonological information facilitated response making in naming task. As discussed before, to make a response in naming task, participants only need enough phonological information to make an articulation. Clearly, our participants can directly access the phonological code through the interlingual psuedohomophones. Meanwhile, the concept can be activated by the Chinese translation prime and further activate the phonological representation of the English target word, i.e., the semantic-to-phonology feedback facilitated naming response among our participants.

Results from this experiment do not conform to those from the naming task

(Experiment 2) of Kim and Davis (2003). In their experiment, only cognate and homophone primes facilitated naming latencies and non-cognate translation primes did not; the magnitude of cognate priming and homophone priming was not significantly different from each other (28ms vs. 20ms). Kim and Davis (2003) argued that it was because naming task is more sensitive to phonological processing, and translation equivalents do not necessarily facilitate the naming response, even if they have provided some orthographic cue to the target word, as Gollan et al. (1997) suggested. Our finding of translation priming effect in naming task suggests that semantic information can facilitate articulation as well.

In this experiment, we have provided evidence that translation priming can be found in naming task. This, however, does not mean that response task effect is not true. What it suggests is that preparation of articulation can receive facilitation not only directly from the phonological code but also indirectly from the feedback of the semantic information of the word.

Curiously, we did not observe cognate phonological priming effect. The data even suggests an inhibitory effect (-16ms) although it did not reach significance. If non-cognate phonological prime can facilitate naming latency, why cannot cognate phonological prime? The only difference between these two conditions is that while most of the phonologically related primes for non-cognates do not sound like existing Chinese compounds, the phonologically related primes for cognates are also pseudohomophones to the translation condition, for example, the phonological prime for non-cognate *cup* 卡破(ka3po4) does not have similar phonology with any normal

Chinese compound, however, the phonological prime for cognate *bus* 八式(ba1shi4) have the same pronunciation as 巴士(ba1shi4), which is the translation prime for *bus*. If 八式 can activate 巴士, we should observe facilitation effect since we already found that 巴士 can facilitate the recognition of *bus*, i.e., cognate translation priming effect. In other words, 八式 can activate *bus* via 巴士. The seemingly counter-intuitive results suggest that maybe the cognate phonological prime activated the translation prime in Chinese, which interfered with the articulation, i.e., phonological codes of both Chinese and English were activated, which caused interference effect in articulating the English word. Unfortunately we can not be sure whether this is true based on our experiment and to test this hypothesis is out of the scope of this thesis.

3.3 General discussion of Experiment 1 and Experiment 2

To sum up, in lexical decision task, we only found translation priming for both cognates and non-cognates, without any cognate translation priming advantage. In word naming, however, both cognate and non-cognate translation priming were found, as well as non-cognate phonological priming. Unlike studies that have successfully found cognate priming advantage in masked LDT, as in Gollan et al. (1997) and Voga & Grainger (2007), we did not observe such an effect. Cognate translation priming advantage was however found in naming task. It seems that when phonological information was not needed to facilitate response making, like in LDT (Experiment 1), cognate translation priming advantage was missing. However, when phonological information was recruited to make a response, larger cognate translation priming was observed, like in naming (Experiment 2). If this is the case, then phonological priming is crucial in finding cognate facilitation in cross-language priming, suggesting the indispensible role of phonological priming in cognate facilitation, which is in support of the form overlap account of cognate facilitation effect.

Task effect was supported in the sense that our data clearly suggests that LDT only tapped the semantic processing in our participants but naming task involved both semantic processing and phonological processing. It proves that semantic activation through L1 to L2 is very fast and that to pronounce the L2 word in English, our participants did use the feedback from semantics. It is possible that the relatively difficult task required our participants to recruit any possible codes to perform the task. There is also another possibility. As we mentioned earlier, in English, there are quite a number of irregular words which do not follow GPC rules. Meanwhile, the correspondence between Chinese characters and their phonology is very arbitrary, somewhat like irregular English words. Second language learners like native Chinese speakers may have extended the processing strategy in Chinese into that in English, i.e., phonology in both languages can be easily activated by the concept itself, rather than only influenced by the GPC rules.

Chapter 4 Cognate and Non-cognate Masked Priming with English-Chinese Bilinguals

As has been seen, the data from our Chinese-English bilinguals was not the same as any single previous study on how cognate is represented and processed in the bilingual mental lexicon. The results were from experiments which used Chinese as primes and English as targets. As mentioned before, the two languages are different in several aspects. There is a possibility that the pattern may be different in another direction, i.e., from English to Chinese. In the following two experiments, we aimed to see if this is the case. There are two options for the experiment design. One is to test more participants from the same population as in the previous experiments with English (L2) as prime and Chinese (L1) as targets. The other is to adopt the L1-L2 direction but test another group of population, i.e., English-Chinese bilinguals. Here we restate the two reasons for the option of testing a different group of population. The latter is opted for several reasons. First, as discussed earlier, L2-L1 priming is very unstable and we may not be able to find any priming effect and a pilot study conducted with some participants from the same population group as Experiment 1 and 2 did not show any priming effect in the L2-L1 direction. Another reason is that the Chinese-English bilinguals we tested earlier were late learners but the Singaporean English-Chinese bilinguals were simultaneous bilinguals, some comparisons can be made to study the role of language dominance in cognate processing. Besides, Singapore provided us with options to test both priming directions (from Chinese to English and from English to Chinese) in L1-L2 scheme with both Chinese-English bilinguals and English-Chinese bilinguals. Previously, Chinese-English bilinguals showed robust translation priming effect but null phonological effect in masked LDT (Experiment 1). It remains to be seen whether English-Chinese bilinguals could produce similar or different patterns of result. If English phonology is activated more quickly and automatically than Chinese phonology, it is likely that phonological effect can be found with the English-Chinese bilinguals even in LDT. We hoped to test the English-Chinese bilinguals as well to see, first, if there is processing difference in Chinese as prime and English as prime and second, how cognates are represented and processed in the Singaporean Chinese population.

4.1 Experiment 3: English-Chinese bilinguals in masked lexical decision task

Experiment 3 examined the cognate and non-cognate representation and processing in the English-Chinese bilinguals. This experiment used masked LDT as Experiment 1. The aim is to see if English prime can facilitate the recognition of Chinese target in masked LDT and how the English-Chinese bilinguals process cognates and non-cognates.

Method

Participants

Twenty-one Singaporean undergraduate students from National University of

Singapore participated in the experiment. They all acquired both English and Chinese at roughly the same age and they use English on a daily basis. The participants reported speaking mandarin at home but they predominantly use English outside. All of them got at least A grade in AO level Chinese, which is a standard test Singapore government arranged to test language proficiency levels of the students. Having A grade in a language is regarded to be quite proficient. All the participants had normal or corrected-to-normal vision. They were paid for their participation. Each participant filled out a language questionnaire before experiment. They rated their proficiency levels in reading, writing, speaking, and listening respectively, based on a 7-scale question (1 means very poor, 2 means poor, 3 means fair, 4 means functional, 5 means good, 6 means very good, and 7 means native-like). Both the mean and the standard deviation (SD) were listed, with SD in parentheses. The mean age of the participants was 20.8. The participants' language background information is presented in Table 5 below.

Table 5: Language background information of the English-Chinese bilingual participants

(a)

Language	**Self-rated Proficiency Levels**			
	Reading	**Writing**	**Speaking**	**Listening**
Chinese	5.9 (0.7)	5.3 (0.8)	5.9 (0.8)	6.3 (0.8)
English	6.3 (0.7)	6.3 (0.6)	6.3 (0.7)	6.3 (0.8)

(b)

Language	**Age of Acquisition**		
	Speaking	**Reading**	**Writing**

Chinese	1.3 (1.4)	2.8 (1.5)	3.5 (1.6)
English	2.2 (2.1)	3.1 (1.6)	3.9 (1.7)

As can be seen, although participants acquired Chinese a bit earlier than English, the ages of acquisition of both languages were quite early and roughly similar, which made them more like simultaneous bilinguals. Participants were more dominant in English than Chinese, especially in reading, writing, and speaking, but the language proficiency levels in the two languages in each skill did not differ much from each other, which showed that they were more balanced than the Chinese-English bilinguals in Experiment 1 and 2.

Materials and Design

The one hundred and eight Chinese words in the translation prime condition and one hundred and eight nonwords in the translation prime condition in Experiment 1 were used as targets. Targets were presented in Chinese (L2) and primes in English (L1). Each Chinese target was primed by three types of English primes: its translation equivalent (cognate or non-cognate prime), phonologically related prime, or unrelated prime (see Table 4 for example). The phonologically related primes of the cognate targets were pseudohomophones of the cognate translation primes, and phonologically related primes of the non-cognate targets were the pinyin of the Chinese targets. The English pseudohomophones were selected based on the list of sound-spelling correspondences in Rastle, Harrington, and Coltheart (2002). The primes were matched for letter-length for translation and phonological condition.

The reason to choose pinyin as phonological prime to the non-cognate target word is because it is hard to create suitable letter combinations that sound like Chinese but look like English at the same time. On one hand, we need to make sure that the phonological prime does sound like the target; on the other, it is known that masked priming taps very early and automatic language processing, and thus we need to be sure that the phonological prime can be processed at very early stage of processing. The option is to use pinyin to meet the two requirements. Pinyin and the characters share the same pronunciation. It is in alphabetic form and our participants were familiar with it (they all studied pinyin for the whole period of their primary school years).

The Chinese word targets and the corresponding English prime stimuli are shown in Appendix B. The primes for nonword targets matched the primes for word targets in terms of length and phonological overlap and were constructed to mimic the cognate and phonological primes used for word targets. The "cognate primes" of the nonword targets were created that they were phonologically similar. Three experimental lists were created by rotating the targets across the three prime conditions so that each target appeared only once for a given participant but was tested in all the priming conditions across participants. All the primes were English Courier New words of size 12 presented in lowercase bold letters. All the targets were Chinese Simsun words of size 12 presented in bold characters. Sample stimuli are presented in Table 6 as below.

Table 6: Sample Stimuli in Experiment 3

	Prime Condition		
Target	**Translation**	**Phonological**	**Unrelated**
Cognate			
探戈	tango	tangow	slang
Non-cognate			
动词	verb	dongci	tidy
Nonword			
的斯	durrs	ders	study
Nonword			
啊抱	flosk	abao	shame

Procedure

The experiment was conducted on two PCs using DMDX software (Forster & Forster, 2003). Each trial consisted of the following sequence: the trial started with a 500ms forward mask (##########), followed by an English prime in lowercase letters for 50 ms, and then the Chinese target word for 500 ms. No participant reported seeing the English words preceding the Chinese targets.

As with the previous experiments, participants were randomly assigned to one of the three lists. They were asked to read written instructions in Chinese before they performed the task. The English prime was not mentioned, nor was the fact that their knowledge of English might be of use in the experiment. They were asked to decide whether the presented Chinese characters made a word or not by pressing either a

"YES" button or a "NO" button as quickly as possible.

Results and discussion

Table 7: Lexical decision latencies and percentage error rates for Chinese targets in masked LDT (Experiment 3)

	Translation (T)		Phonological (P)		Unrelated (U)		Net Priming Effects	
	RT	Error	RT	Error	RT	Error	T-U	P-U
Cog	607	10.3	641	16.5	683	18.6	76	42
Non-cog	609	6.2	627	8.3	633	10.7	24	6

The data treatment procedure was the same as in Experiment 1. In analyzing, one item was eliminated because of high error rates across subjects. For latencies, there was a main effect of prime type in the participant analysis, $F1(2, 40)= 16.79$, $p= .000$, $F2(2, 210)= 19.94$, $p= .000$; there was also a main effect of target type in the participant analysis, $F1(1, 20)= 19.35$, $p= .000$, and a trend of significance in the item analysis $F2(1, 105)= 1.90$, $p= .170$. Interaction between prime type and target type was also significant, $F1(2,40)= 4.51$, $p= .017$, $F2(2, 210)= 4.06$, $p= .019$. Error analysis showed that the Mauchly p value for prime type was .004. Greenhouse-Geisser correction was adopted when reporting. For errors, there was a main effect of prime type, $F1(1.38, 27.69)= 5.26$, $p= .02$, $F2(2, 210)= 7.40$, $p= .001$, and a main effect of target type, $F1(1, 20)= 22.22$, $p= .000$, $F2(1, 105)= 6.91$, $p= .01$. The interaction effect between prime type and target type was not significant, both $Fs<1$.

Planned comparisons showed that for cognates, there was a significant translation priming effect in the reaction time data, F1(1, 20)= 41.63, p= .000, F2(1, 52)= 37.21, p= .000, and a significant phonological priming effect, F1(1, 20)= 6.55, p= .019, F2(1, 52)= 6.06, p= .017. For non-cognates, there was a significant translation priming effect F1(1, 20)= 7.60, p= .012, F2(1, 53)= 7.59, p = .008; but there was no significant phonological priming effect, F1(1, 20)= .36, p= .558, F2(1, 53)= 1.98, p= .165.

When measured against unrelated condition, cognate translation priming was significantly larger than non-cognate translation priming, F1(1, 20)= 10.50, p= .004, F2(1, 52)= 9.44, p= .003. When cognate translation priming was measured against phonological condition, there was no significant difference between cognate translation priming and non-cognate translation priming, both Fs<1.

For errors, there was a significant cognate translation priming effect, F1(1, 20)= 6.69, p= .018, F2(1, 52)= 10.08, p= .003. Cognate phonological priming was not significant in both error analysis, both Fs<1. There was only a trend of significant non-cognate translation priming effect, F1(1, 20)= 3.36, p= .082, F2(1, 53)= 3.06, p= .086, but no non-cognate phonological priming effect, with both Fs<1.

Discussion

In this experiment, we found both cognate translation priming and non-cognate translation priming effect. Cognate phonological priming was also found in this masked LDT, but non-cognate phonological priming effect was not found. When measured against the unrelated condition, larger cognate translation priming effect was observed, showing evidence of the existence of cognate translation priming advantage in masked LDT in this English-Chinese direction, unlike in the Chinese-English direction as observed in Experiment 1. However, when both priming effect was measured against the form (phonological) condition, cognate and non-cognate translation priming was not significantly different from each other. This result was similar to what Voga and Grainger (2007) had found with their Greek-Spanish bilinguals. The result showed that cognate facilitation was caused by the additional form overlap, i.e., additional form priming. Thus, our result was another piece of evidence in support of the form overlap account of cognate advantage effect.

Unlike Experiment 1, Experiment 3 found phonological priming effect in masked LDT, but only for cognates. Along with the finding of cognate phonological priming effect, cognate translation priming advantage was also observed. This is another difference from Experiment 1, which found neither cognate phonological priming nor cognate translation priming advantage effect. This can be taken as evidence in support of the view that cognate facilitation only arises when phonological information can facilitate the response making. It is in line with the form overlap account, which predicts that cognate facilitation is caused by the facilitation from both semantic and form overlap and it is the additional form priming that caused larger cognate translation priming. If form overlap does not influence latency in making a response, then cognate translation priming is purely semantic in nature, and it is no better than non-cognate priming. Although Experiment 1 did not find larger cognate translation priming effect, we can still assume that form overlap account is supported because the absence of cognate facilitation was accompanied with the absence of phonological priming effect, i.e., when form priming is not observed, larger cognate translation priming is absent either.

However, non-cognate phonological priming was not found in this experiment. The reason is not clear yet. If phonological information can be used to help response making in LDT, as has been proven by cognate phonological priming effect found in this experiment, non-cognate phonological priming effect should have been observed as well. In an unreported experiment conducted previously, we tried to use pseudohomophones that sounded like the Chinese target words but looked like English words (e.g., *donts* as phonological prime for the Chinese target word *动词* (verb, dong4ci2)) as the phonological prime for non-cognates, but we still found null effect. It suggests that it is not the stimuli but something else that caused the null phonological effect for non-cognates. We conducted word naming task in the following experiment to see if it was because of the task. Besides, we have found that the English-Chinese bilinguals did produce different patterns from the English-Chinese bilinguals in LDT. We hope to find out whether in naming, the English-Chinese bilinguals can produce different pattern of results as well.

4.2 Experiment 4: English-Chinese bilinguals in masked naming task

Experiment 4 was to examine whether we could find both cognate and non-cognate phonological priming effects in masked naming task. As has been shown, the English-Chinese bilinguals did use different processing mechanisms from the

Chinese-English bilinguals in the masked LDT. We aimed to find out whether the pattern of results was different in the naming task. The most important question in this experiment is whether translation primes and phonological primes can generate facilitation effect and whether cognates behave differently from non-cognates.

Method

Participants

The same participants in Experiment 3 participated in this experiment after at least one week of Experiment 3 to minimize influence from the previous experiment.

Materials

The materials were the same as in Experiment 3, except that there were no nonwords in this experiment.

Procedure

The experiment was conducted one at a time in a booth using E-Prime software. The same procedure as Experiment 3 was employed in the current experiment except that in this case the participants were instructed to say aloud the Chinese target word as quickly and as accurately as possible. Response data were obtained using E-Prime software with the participant’s vocal response triggering a voice-box. On the triggering of the voice-box, the next trial would automatically begin so that the experiment was continuously running. The whole process was recorded in a SONY recorder for later analysis. No participant reported seeing the English words preceding the Chinese targets.

Results and discussion

Table 8: Naming latencies (in ms) and percentage error rates for Chinese targets in masked naming (Experiment 4)

	Translation (T)		Phonological (P)		Unrelated (U)		Net Priming Effects	
	RT	Error	RT	Error	RT	Error	T-U	P-U
Cog	824	4.1	831	7.6	897	6.6	73	66
Non-cog	765	3.8	757	1.9	781	5.1	16	24

Data treatment was similar to that of Experiment 2. For latencies, there was a main effect of prime type in the participant analysis, $F1(2, 40)= 8.82$, $p= .001$, $F2(2, 212)= 5.86$, $p= .003$; there was a main effect of target type in the participant analysis, $F1(1, 20)= 48.70$, $p= .000$, $F2(1, 106)= 10.20$, $p= .002$. Interaction between prime type and target type was not significant, $F1(2,40)= 1.93$, $p= .158$, $F2(2, 212)= 1.93$, $p= .147$. For errors, there was no main effect of prime type, both $ps> .20$, but there was a main effect of target type in the participant analysis, $F1(1, 20)= 7.16$, $p= .015$, and a trend in item analysis, $F2(1, 106)= 3.13$, $p= .08$. The interaction effect between prime type and target type was not significant, $F1(2, 40)= 2.37$, $p= .106$, $F2(2, 212)= 2.87$, $p= .059$.

Planned comparisons showed that for cognates, there was a significant translation priming effect in the reaction time data, $F1(1, 20)= 11.05$, $p= .003$, $F2(1, 53)= 5.58$, $p= .022$; there was a significant phonological priming effect, $F1(1, 20)= 9.91$, $p= .005$, $F2(1, 53)= 9.00$, $p= .004$. The translation condition and phonological condition did not differ significantly from each other, $p=1.00$. For non-cognates, there was no effect of either translation priming or phonological effect, with both $Fs<1$.

Error analysis showed no significant difference between conditions except for non-cognates, there was a significant phonological priming effect in the item analysis, $F2(1, 53)= 5.20$, $p= .027$, and a trend in participant analysis, $F1(1, 20)= 4.17$, $p= .054$.

Discussion

In this experiment, we only found cognate translation and phonological priming effect, which were not significantly different from each other. Non-cognates did not produce any priming, but participants did make fewer errors when the target word was preceded by a phonologically related prime. This pattern of results is different from that of the previous experiments.

In contrast to Experiment 2, which was also naming task, this experiment did not find translation priming effect for non-cognates. Actually, the fact that the cognate translation and phonological priming effects were of the similar magnitude suggests the possibility that the cognate translation priming effect was phonological in nature, since the cognate translation priming did not differ significantly from the cognate phonological priming, and there was no non-cognate translation priming. If this is the case, then our finding of the phonological effect is consistent with the results of Kim and Davis (2003), and we can further demonstrate the rapid phonological recoding of the masked primes and prove that the phonological overlap between the cognate or the cognate phonological primes and the target was sufficient to produce priming effect. However, if the effects were phonological in nature, we should have also observed non-cognate phonological priming effect as well. The absence of non-cognate phonological priming suggests another possibility—perhaps the translation and phonological priming effects for cognates are semantic. It is possible that the cognate phonological prime activated the translation, which is the pseudohomophone to the phonological condition, and it was the translation that primed the target word processing. But if this is true, then non-cognate translation priming should have been observed as well. We can not determine which explanation is more valid with our current data, but judging from the absence of non-cognate phonological priming in both LDT and naming task, it is likely that phonological primes (pinyin) for non-cognates were not sensitive enough for the participants, which resulted in the absence of non-cognate phonological effect.

4.3 General discussion of Experiment 3 and 4

To sum up, in English-Chinese LDT (Experiment 3), translation priming effect was found for both cognates and non-cognates, but phonological priming effect was only found for cognates; in English-Chinese naming task (Experiment 4), there was only translation priming and phonological priming for cognates. Larger cognate translation priming was discovered in LDT with English-Chinese bilingual participants. This cognate advantage only existed when cognate priming was measured against the unrelated condition. This pattern of results is similar to that of Experiment 2 and 3 in Voga & Grainger (2007), and it also provided evidence in support of the form overlap account.

In LDT, phonological priming was only found with cognates. In naming task, only cognate translation priming and cognate phonological priming was observed. The lack of non-cognate phonological priming in both tasks may suggest the insensitivity of the participants to the non-cognate phonological prime. The contrast between cognates and non-cognates in naming shows the cognate advantage in bilingual lexical processing.

It is still undetermined whether the cognate translation priming and cognate phonological priming observed in naming task is semantic or phonological in nature but we tend to regard it as phonological effect for three reasons: first, as reviewed previously, naming task normally taps on the phonological processing and normally researchers would consider the effect to be phonological in nature, like in Kim & Davis (2003); second, the fact that non-cognate phonological priming was not observed in both LDT (Experiment 3) and naming (Experiment 4) and that both psuedohomophone (from an unreported study) and pinyin (Experiment 3 & 4) prime failed to produce any effect suggests the insensitivity of the participants towards the non-cognate phonological prime; and third, if the effect is lexical (semantic) in nature, we should have observed non-cognate translation priming as well, which was clearly not the case and thus implies that it is actually phonological effect. Unfortunately we can not prove the validity of this explanation with the current data. More evidence is needed to solve this issue in further studies.

Chapter 5 General Discussion

This study was designed to examine cognate status with Chinese-English bilinguals and English-Chinese bilinguals in the masked priming paradigm. It has been shown in several studies (de Groot & Nas, 1991; Gollan et al., 1997; Sánchez - Casas et al., 1992; Voga & Grainger, 2007) that cognates can produce larger and more stable translation priming effect than non-cognates, known as cognate facilitation. Two theoretical explanations on cognate representation and processing, namely the link account from RHM and the form overlap account from BIA+ model, were tested with four experiments. The link account predicts that cognate facilitation can be observed regardless of task. However, the form overlap account predicts larger cognate translation priming effect only when the baseline is the unrelated condition and that when the baseline is the phonologically related condition, the cognate facilitation should disappear. In order to test these predictions with Chinese-English materials, four experiments were conducted in which the semantic and phonological overlaps between the prime and target were manipulated so that we can see if different degrees of form relatedness can influence the translation priming magnitude. Two tasks were used to see if cognate facilitation can be found regardless of task.

Experiments 1 and 2 tested Chinese-English bilinguals in masked LDT and word naming task. In masked LDT (Experiment 1), both cognate and non-cognate produced translation priming effect, but neither phonological priming effect nor cognate facilitation was observed. In naming task (Experiment 2), both larger cognate translation priming and non-cognate phonological priming were found.

Experiments 3 and 4 tested English-Chinese bilinguals in two tasks. In masked LDT (Experiment 3), we found translation priming for both cognates and non-cognates. Larger cognate translation priming and cognate phonological priming were also found. Cognate translation priming advantage disappeared when the baseline was changed to phonological condition. In naming task (Experiment 4), only cognate translation priming and cognate phonological priming were found, with no non-cognate effect observed.

Clearly, out study with Chinese-English bilinguals and English-Chinese bilinguals observed cognate facilitation effect, but the finding of this effect was dependent on some restraints, like task type and language direction in priming.

In order to get a better look at our results in comparison with the three cross-script cognate studies that are most relevant to ours, the results of each study are listed in the Table 9. Only the net priming effect was listed.

Table 9: Priming Effect in Gollan et al. (1997), Kim & Davis (2003), Voga & Grainger (2007), and the Current Study (Experiment 1-4)

Prime type	Gollan et al. (1997) Hebrew-English	Gollan et al (1997) English-Hebrew	Kim & Davis (2003) Korean-English	Voga & Grainger (2007) Greek-French	Exp. 1 & 2 Chinese-English	Exp. 3 & 4 English-Chinese
Masked LDT						
C-Unrel	53*	142*	34*	48**	74*	76**
C-Phon	NA	NA	NA	22*	12	42*
NC	36*	52*	40*	22*	47*	24*
NC-Phon	NA	NA	18	-5	6	6

Masked Naming						
C	NA	NA	28*	NA	43**	73*
C-Phon	NA	NA	NA	NA	-16	66*
NC	NA	NA	8	NA	26*	16
NC-Phon	NA	NA	20*	NA	27*	24

Note: C is for cognates; NC is for non-cognates; Phon is for phonological condition; Unrel is for unrelated condition; - is for comparison, e.g., C-Unrel means the priming effect of cognate against the unrelated condition; NA is for not applicable; and * is for significance.

Since translation and phonological priming were examined in almost every study we summarized above, our comparison of the studies will focus on these two priming effects in relation to two different visual word recognition tasks..

Translation priming

In all these cross-script studies, translation priming was observed in masked LDT, proving once again that translation priming can be found for both cognates and non-cognates when the scripts are different, consistent with the three previous studies. The finding could be interpreted by the Orthographic Cue Hypothesis put forward by Gollan et al. (1997) in that the change of orthography provided cue for the rapid activation of prime-target link. But as proposed in both Kim & Davis (2003) and Voga & Grainger (2007), this cross-script non-cognate translation priming can be explained by the lack of lateral inhibition too, as proposed in BIA+ model. In the framework of BIA+, when the languages have a common script, activation at the level of orthography is independent of language mode, and this would lead to lateral inhibition which will further diminish translation priming. Cross-script priming is not affected by lateral inhibition and thus it is easier to be found.

As far as the task effect is concerned, Kim & Davis (2003) gave evidence of task effect in the sense that they observed translation priming in LDT and phonological priming in naming task. Although they observed cognate priming in naming task, they suggest that it was phonological in nature, i.e., the shared phonological information between the cognate prime and target rather than the semantic information the cognate prime provided facilitated naming response. The same might be true with our English-Chinese bilinguals in naming task. However, in contrast to Kim & Davis (2003), there is translation priming effect in masked naming in our Chinese-English bilinguals, which suggests that when response making needs semantic information, translation priming can still be observed, even in naming task. In other words, the response making system can utilize lexical activity summed over a number of different lexical codes when the task is not easy (Ferrand & Grainger, 1996; Kim & Daivs, 2003). The Chinese-English bilinguals clearly used semantic information to help articulate the English words. A possible reason for this is that the participants were not familiar enough with the English target words and they needed to rely on whatever available lexical codes to make the response.

Phonological priming

Phonological priming was found in Voga & Grainger (2007) and in our Experiment 3 with English-Chinese bilinguals in masked LDT, as well as in Kim & Davis (2003) and in our Experiment 2 with Chinese-English bilinguals and

Experiment 4 with English-Chinese bilinguals in masked naming task.

It is easy to understand the finding of phonological priming effect in naming task, since naming taps on the phonological processing. However, in LDT, only Spanish-Greek (Voga & Grainger, 2007) and English-Chinese bilinguals (Experiment 3) produced priming. There was no phonological priming in LDT in Experiment 1 in Kim & Davis (2003) with Korean-English bilinguals and our Experiment 1 with Chinese-English bilinguals. It was found that Chinese phonology can be activated relatively later and phonological processing of Chinese is different from other alphabetic languages (Chen & Peng, 2001; Chen, Wang, & Peng, 2003; Perfetti & Tan, 1998; Tan & Perfetti, 1997). However, if the lack of phonological priming effect in our Experiment 1 was caused by the uniqueness of phonological processing in Chinese, Korean-English phonological priming should have been found in their LDT because Korean language also follows GPC rules, just like English and Spanish. The lack of phonological priming in these two LDTs suggests that the unique linguistic features in phonology might not be the reason. One promising way to interpret this is how the response making system adjust lexical activity at different levels in order to fulfill the task. In Kim and Davis (2003), it is possible that the relatively easier task (reflected by the relatively high frequency) demanded no phonological decoding to facilitate response making. We can not decide if this is true. The interpretation of the issue asks for more research findings.

Two findings regarding phonological priming effect are difficult to explain. First, we did not observe cognate phonological priming in naming with the Chinese-English bilinguals and we speculate that it was caused by the interference in production from the activated cognate translation. Second, our pinyin condition did not produce significant phonological priming effect for the English-Chinese bilinguals. It seems that the English-Chinese bilinguals were not sensitive enough to the phonological prime for non-cognate.

Cognate facilitation and theoretical explanations

As can be seen, larger cognate translation priming was observed in Gollan et al. (1997), Voga & Grainger (2007), and in our study with English-Chinese bilingual speakers in masked LDT and with Chinese-English bilingual speakers in masked naming. In both our study (Experiment 1) and Kim & Davis (2003, Experiment 1), cognate translation priming was not significantly different from non-cognate translation priming. The pattern here is that larger cognate translation priming was observed when phonological information was clearly used to make a response. When there was no cognate facilitation, phonological information was not a factor in response making. This pattern of results is evidence in support of the form overlap account of the cognate facilitation effect, which argues that the cognate facilitation is due to the additional form overlap. Therefore, the larger priming effect is caused by the additional form priming and when form priming is not observed, the facilitation will disappear.

The fact that larger cognate translation priming was only observed in English-Chinese bilinguals but not in Chinese-English bilinguals in LDT is evidence against the link account. If the lexical link between the cognates is stronger, both bilingual groups should produce cognate facilitation effect since they were all tested in the L1-L2 direction. Furthermore, the lack of cognate facilitation with Chinese-English bilinguals in LDT and its existence in naming indicates that the effect is task-dependent, which is another evidence against the link account.

Group Difference

Interestingly, our two groups of bilinguals produced different patterns of results regarding what lexical codes are needed in different response tasks. Cognate translation priming advantage was found in naming task with Chinese-English bilinguals and in LDT with English-Chinese bilinguals. Clearly, the Chinese-English participants recruited semantic information in making response in naming task, while the English-Chinese participants may have only relied on phonological information to make response in naming. In LDT, both groups of bilingual participants used semantic information in making decisions but it seems that phonological information did not help word recognition at all for Chinese-English participants, while the English-Chinese participants clearly benefitted from phonological information in the cognate condition. Such contrast of results with two groups of participants is easy to understand. As discussed before, English phonology can be activated early on a grapheme-phoneme correspondence but Chinese phonology may be activated later in visual word recognition. The English prime may have been processed more rapidly and automatically at the phonological level and thus resulted in the phonological priming effect in LDT.

As far as translation priming in LDT is concerned, the cognate translation priming effect between the two groups of participants did not differ much from each other (74ms vs. 76ms), but clearly the non-cognate translation priming effect was larger for our Chinese-English participants than for the English-Chinese participants (47ms vs. 24ms). This is actually consistent with the finding of Gollan et al. (1997) in that their English-Hebrew (less balanced) participants yielded larger priming effect than the Hebrew-English (more balanced) participants. What our results and Gollan et al.'s (2007) results have in common is that the less-balanced group of bilinguals produced larger priming effect than the more-balanced bilinguals, suggesting more reliance on the facilitation from the dominant language.

Conclusion

In our study, translation priming for both cognates and non-cognates were found with both Chinese-English bilinguals and English-Chinese bilinguals. Cross-language phonological priming effect was also observed in both groups of bilinguals (in naming task with Chinese-English bilinguals and in both LDT and naming task with English-Chinese bilinguals). The finding of cross-language phonological priming can be taken as evidence in support of the language non-selective view of bilingual language processing. However, as noted earlier, there are still some unresolved questions regarding the phonological priming effect. Although Zhou et al. (2010) successfully observed bidirectional phonological priming in both masked LDT and masked naming task with Chinese-English bilinguals, our data is a bit different, with the absence of cognate phonological priming in Chinese-English naming task, and the absence of non-cognate phonological priming in English-Chinese LDT and naming task. The controversial patterns of results on phonological priming between Chinese and English suggests that even when cross-language phonological priming can be found between Chinese and English, there might be some restrictions in finding the effect, especially when bi- or tri-syllabic Chinese compound processing is examined, as in our study.

As far as cognate facilitation is concerned, the result of our study, in which cognate translation priming advantage was found with the Chinese-English bilingual participants in naming task but not in LDT, challenge the link account. If cognates have stronger lexical link than non-cognates, we should have observed cognate translation priming advantage in both groups of bilingual participants in both tasks.

The view that cognate translation priming facilitation is caused by the combination of semantic and form overlap is able to provide a plausible explanation for our data. Cognate translation priming advantage was only observed when phonological information helped response making. Generally, translation priming is more sensitive to LDT and phonological priming is more sensitive to naming. However, task demands can put different levels of cognitive loads on participants, leading the participants to use sufficient lexical codes in order to make a response. For example, normally phonological information should be able to facilitate phonological task like naming, but if the participants' proficiency level is relatively lower (like our

Chinese-English bilinguals), they may use all possible lexical codes to help make a response, as the non-cognate translation priming effect we found in the naming task with our Chinese-English bilinguals. Furthermore, our data suggests that the proficiency level of participants can also influence the magnitude of both cognate and non-cognate priming effect, as indicated by the difference in the priming effect between the Chinese-English bilinguals (less-balanced and less proficient in English) and the English-Chinese bilinguals (more-balanced and more proficient in Chinese) in our experiment and the difference found in Gollan et al. (1997). The reason might be that the more proficient the bilinguals are (normally with the second language), the less help they would need in order to fulfill a task in the second language.

As far as phonological priming effect is concerned, our data indicates that it is relatively easier to observe such an effect with English as prime and Chinese as targets. The reason may be that English phonology is easier to be activated since it generally follows GPC rules. The weakened role of phonology in Chinese processing may have influenced the phonological priming effect, as suggested by the null effect of phonology in our Chinese-English LDT data.

To conclude, we found larger cognate translation priming in two groups of bilinguals, namely Chinese-English bilinguals and English-Chinese bilinguals, and this effect depends on the sort of lexical information participants need to make a response. We only observed robust cognate translation priming advantage when both semantic and phonological information were used to make a response in a given task, providing strong evidence that cognate translation priming advantage is caused by the form overlap between the prime and target. The fact that larger cognate translation priming was not found in both tasks for Chinese-English bilinguals provided evidence against the link account put forward by RHM. Cognate representation is not special. The cross-language effects were caused by the overlaps in the lexical systems.

The difference in the results of the two bilingual groups is in fact a difference of processing strategy, prime-target direction, as well as language dominance. The comparisons between the two language groups in our study and between our study and three relevant studies showed a clearer picture of how cognate is represented and processed in the bilingual's mind.

In general, the interpretations of our results, as well as the other three studies' results, can be all incorporated in the BIA+ model. In this model, cross-language interactions can happen at different levels and the task-decision system can assess the various task demands so that response making can be altered from different information sources. The fact that cognate facilitation depends on the overlaps in semantics and form, as well as the task demands, is just evidence for the basic assumptions of BIA+ model.

The present study has shortcomings and unresolved issues too. A very obvious issue to be solved is to find out why both pseudohomophone and pinyin prime did not produce non-cognate phonological priming in English-Chinese bilinguals. This is important for explaining the results we observed in English-Chinese naming task (Experiment 4). One possibility is that the phonological prime did not share enough phonological overlap with the Chinese target word, and another is that the pinyin prime was processed in a different way from English pseudohomophones, which caused the absence of phonological effects. Another finding that was not given a good explanation is the null priming effect of cognate phonological primes in the Chinese-English word naming task. Although we speculate that it is the articulation interference that caused the null effect, we can not be sure whether this is true or not. Further research needs to be done to resolve these issues.

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Appendix A: Experimental Items in Experiment 1 and 2

Target	Translation	Phonological	Unrelated
sudan	苏丹	酥单	哲理
nylon	尼龙	泥隆	结晶
hacker	黑客	嘿刻	奏效
guitar	吉他	及踏	填词
cola	可乐	渴勒	终究
logic	逻辑	萝既	明亮
clone	克隆	课龙	寻常
salad	沙拉	纱啦	慌张
salon	沙龙	杀隆	郊外
bus	巴士	八是	玩笑
koala	考拉	烤啦	排列
poker	扑克	蒲课	主帅
disco	迪斯科	敌思苛	恶作剧
vitamin	维他命	为它铭	会议室
italy	意大利	亿搭力	葡萄酒
sandwich	三明治	叁名至	电风扇
calorie	卡路里	咔陆李	高跟鞋
caffeine	咖啡因	卡非音	垃圾桶
blog	博客	伯克	救伤
india	印度	音渡	救命
pizza	披萨	批飒	操控
tango	探戈	谈个	兵器
soda	苏打	酥达	假想
cartoon	卡通	咔统	惯性
wonton	云吞	匀屯	唐代
sofa	沙发	杀罚	抗争
sauna	桑拿	丧哪	皇后
ballet	芭蕾	吧镭	听见
coffee	咖啡	卡飞	悬挂
radar	雷达	蕾答	推算
disney	迪斯尼	敌丝泥	差不多
cocaine	可卡因	咳咔音	工具箱
france	法兰西	伐蓝希	满天星
bikini	比基尼	笔机倪	木乃伊

heroin	海洛因	孩萝音	保温杯
singapore	新加坡	欣家泼	卸妆油
typhoon	台风	抬封	冲破
hamburger	汉堡	汗保	棉垫
yoga	瑜珈	鱼夹	肥皂
denmark	丹麦	单迈	忘记
champagne	香槟	箱斌	脱俗
mini	迷你	弥拟	共鸣
finland	芬兰	纷蓝	城墙
iran	伊朗	一郎	航空
curry	咖喱	喀李	耿直
pudding	布丁	部町	皮夹
modern	摩登	磨灯	鉴别
bowling	保龄	宝玲	夜里
golf	高尔夫	糕而肤	安乐窝
microphone	麦克风	卖刻峰	蛋白质
england	英格兰	应革蓝	笔记本
chocolate	巧克力	俏棵例	全日制
marathon	马拉松	码垃耸	因特网
whisky	威士忌	微市记	免疫力
nerve	神经	呢无	首页
robe	长袍	肉拨	漏气
clown	小丑	克朗	称呼
gamble	赌博	杆宝	词语
swan	天鹅	思万	传承
menu	菜单	麦牛	穿越
stair	楼梯	思带	塑像
hobby	嗜好	号被	脸色
peach	桃子	屁吃	讲课
veiling	面纱	味玲	扩充
camel	骆驼	恺毛	逗留
dolphin	海豚	倒纷	积雪
bakery	面包店	被壳瑞	神经病
dramatic	戏剧性	桌买提	办公室
committee	委员会	克枚体	天花板
coastline	海岸线	抠死蓝	人民币
plumber	水管工	普拉末	丈母娘
jeans	牛仔裤	真恩斯	银行卡

tiger	老虎	泰格	尖端
tempo	节奏	摊泡	神话
flour	面粉	副烙	离去
weave	编织	味无	春雨
movie	电影	木为	高雅
winter	冬天	温特	讲究
leather	皮革	来则	接洽
culture	文化	考扯	归纳
simple	简单	森跑	猴子
toilet	厕所	逃里	滚动
mall	商场	猫而	绚丽
cup	杯子	卡破	手杖
lullaby	催眠曲	拉乐百	女学生
jury	陪审团	住额锐	安乐窝
psychology	心理学	赛靠乐	双胞胎
parasite	寄生虫	拍弱塞	降落伞
pyramid	金字塔	陪若梅	幼儿园
camera	照相机	开模若	降落伞
coat	外套	抠特	缩影
layman	外行	泪曼	欢聚
lightning	闪电	来挺	月租
lunch	午餐	浪池	奢侈
butcher	屠夫	部车	骨灰
kite	风筝	开特	香蕉
comma	逗号	考末	浑身
muscle	肌肉	妈扫	情谊
mood	情绪	目德	顾问
fever	发烧	飞窝	后盾
servant	仆人	瑟文	收买
quotation	引用	口忒神	栏目
buffet	自助餐	补费	商务车
circus	马戏团	色科斯	大学生
storm	暴风雨	斯盗亩	羽毛球
violin	小提琴	哇哦临	石英钟
fireman	消防员	发而曼	高血压
triangle	三角形	揣按高	劳动力

Appendix B: Experimental Items in Experiment 3 and 4

Target	Translation	Phonological	Unrelated
苏丹	sudan	soodan	vapor
尼龙	nylon	nighlon	miner
黑客	hacker	haiker	barley
吉他	guitar	gitar	mutton
可乐	cola	koula	memo
逻辑	logic	lodgik	label
克隆	clone	klone	chunk
沙拉	salad	salade	chalk
沙龙	salon	sarlon	badge
巴士	bus	buss	fig
考拉	koala	coala	jewel
扑克	poker	pouka	vogue
迪斯科	disco	disko	canal
维他命	vitamin	vitemin	empathy
意大利	italy	etaly	olive
三明治	sandwich	sandweedge	resource
卡路里	calorie	kalorie	bicycle
咖啡因	caffeine	caphine	notation
博客	blog	blorg	wolf
印度	india	indea	slice
披萨	pizza	pizer	metro
探戈	tango	tangow	colon
苏打	soda	souda	flea
卡通	cartoon	kartoon	censure
云吞	wonton	wontun	cherry
沙发	sofa	soufa	visa
桑拿	sauna	sorner	eagle
芭蕾	ballet	baley	finger
咖啡	coffee	koffee	barber
雷达	radar	rader	penny
迪斯尼	disney	disny	bucket
可卡因	cocaine	kokaine	lottery
法兰西	france	franse	slogan
比基尼	bikini	bikyny	orange
海洛因	heroin	herowin	peanut

新加坡	singapore	singepore	carpenter
台风	typhoon	tighfoon	torture
汉堡	hamburger	hambergur	partition
瑜珈	yoga	youga	cozy
丹麦	denmark	danmark	fallacy
香槟	champagne	shampagne	highlight
迷你	mini	myny	soul
芬兰	finland	phinland	vintage
伊朗	iran	eeran	flaw
咖喱	curry	kurry	dummy
布丁	pudding	puding	chateau
摩登	modern	mauden	single
保龄	bowling	boaling	cuisine
高尔夫	golf	galf	pact
麦克风	microphone	mikrofone	fertilizer
英格兰	england	englend	magnate
巧克力	chocolate	chokolate	satellite
马拉松	marathon	marethone	dinosaur
威士忌	whisky	weesky	genius
神经	nerve	shenjing	shark
长袍	robe	changpao	yawn
毛巾	towel	maojin	hazel
赌博	gamble	dubo	profit
天鹅	swan	tiane	weed
菜单	menu	caidan	frog
楼梯	stair	louti	blush
嗜好	hobby	shihao	colon
桃子	peach	taozi	ruler
面纱	veiling	miansha	massage
骆驼	camel	luotuo	cadre
海豚	dolphin	haitun	receipt
面包店	bakery	mianbaodian	cosmos
戏剧性	dramatic	xijuxing	alphabet
委员会	committee	weiyuanhui	slaughter
海岸线	coastline	haianxian	badminton
水管工	plumber	shuiguangong	closure
牛仔裤	jeans	niuzaiku	torch
老虎	tiger	laohu	relay

节奏	tempo	jiezou	skirt
面粉	flour	mianfen	swipe
编织	weave	bianzhi	spoon
电影	movie	dianying	thank
冬天	winter	dongtian	cancel
皮革	leather	pige	shampoo
文化	culture	wenhua	payment
简单	simple	jiandan	letter
厕所	toilet	cesuo	madam
商场	mall	shangchang	pane
杯子	cup	beizi	lab
催眠曲	lullaby	cuimianqu	plateau
陪审团	jury	peishentuan	tidy
心理学	psychology	xinlixue	domination
寄生虫	parasite	jishengchong	calendar
金字塔	pyramid	jinzita	tornado
照相机	camera	zhaoxiangji	banana
外套	coat	waitao	bond
外行	layman	waihang	purple
闪电	lightning	shandian	hurricane
午餐	lunch	wucan	shade
屠夫	butcher	tufu	netting
风筝	kite	fengzheng	mute
逗号	comma	douhao	feint
肌肉	muscle	jirou	bureau
情绪	mood	qingxu	fade
发烧	fever	fashao	angel
仆人	servant	puren	orchard
引用	quotation	yinyong	gunpowder
自助餐	buffet	zizhucan	fathom
马戏团	circus	maxituan	violet
暴风雨	storm	baofengyu	puppy
小提琴	violin	xiaotiqin	coward
消防员	fireman	xiaofangyuan	oatmeal
三角形	triangle	sanjiaoxing	conquest