Asymmetric Cross-language Activation of Translations in Korean-English Bilinguals*

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This study tested the predictions of the Revised Hierarchical Model (RHM) and the Bilingual Interactive Activation Plus (BIA+) model through a translation recognition task in which low-intermediate Korean-English bilinguals decided whether the second word of a two-word sequence was the correct translation of the first. In the critical distractor conditions, the second word was not a correct translation of the first, but phonologically related to the first word (i.e., phonological neighbors), or phonologically related to the correct translation (i.e., translation neighbors). Results showed that the participants experienced interference for related distractors in both L2-L1 and L1-L2 translation directions. However, an interaction with distractor type was only found in the forward (L1 to L2) translation direction, with a larger interference effect for the translation neighbors. The results of the present study support and extend the predictions of the BIA+ model by showing nonselective phonological activation for different-script bilinguals, while also supporting the predictions of the RHM regarding translation asymmetry. We suggest previous assumptions regarding the mechanisms of the translation recognition task and interpretation of its data may be flawed, and propose a fundamental rethinking of these issues.

Keywords: *bilingual lexicon, Korean-English bilinguals, translation recognition, translation asymmetry, non-selectivity*

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1. Introduction

The Revised Hierarchical Model (RHM; Kroll & Stewart, 1994) is one of the most prominent developmental models proposed to account for the organization of the bilingual lexicon. The main claims of the RHM are based on an underlying asymmetry in the relative strength of the links connecting words and concepts in the first (L1) and second language (L2) of a bilingual speaker. In the RHM (shown in Figure 1), strong connections are depicted as solid lines while weaker connections are depicted as dotted lines. For beginning bilinguals with a low level of L2 proficiency, access to the meaning of L2 words must be accomplished through mediation of the L1 translation equivalent, as the link between the L2 lexicon and the conceptual store is weak. On the other hand, semantic access for L1 words may be accessed directly through the strong L1 conceptual link. In other words, the RHM predicts that backward translation (L2 to L1) is accomplished through lexical mediation, and does not necessarily require semantic access, while forward translation (L1 to L2) is semantically mediated via the strong link from the L1 lexicon to the conceptual store. The result is a predicted asymmetry in translation direction, with faster translation from L2 to L1, via the direct lexical route, compared to L1 to L2 translation.

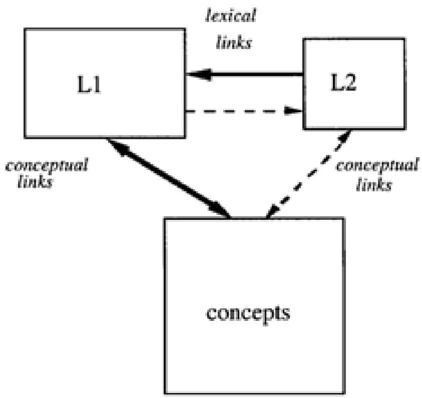

Figure 1. The Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994)

In a series of experiments with late bilinguals, Kroll and colleagues (Kroll & Stewart, 1994; Sholl, Sankaranarayanan & Kroll, 1995) obtained results confirming the predicted directional asymmetry in translation, with shorter translation latencies when translating from L2 to L1 (backward translation) compared to translation from L1 to L2 (forward translation). The shorter translation latencies were attributed to use of the direct lexical links from the L2 to L1 lexicon. Furthermore, the bilingual participants were more likely to access the semantic information of words during forward translation than during backward translation, supporting the predictions of the RHM.

The main claims of the RHM also include predictions regarding changes in the relative strength of the L2 conceptual links as L2 proficiency develops. As a bilingual speaker increases in the level of L2 proficiency, the connections from the L2 lexicon to the conceptual store are predicted to grow stronger, so that highly proficient bilinguals will be able to access the meaning of L2 words directly, and their reliance on L1 translations to access meaning for L2 words will gradually decrease.

The translation recognition task is the most common method that has been employed to support the predictions of the RHM (Sunderman & Kroll, 2006; Sunderman & Priya, 2012; Talamas, Kroll & Dufour, 1999). The translation recognition task is a bilingual task in which the participant is presented with a sequence of two words in different languages, and required to decide whether the second word is the correct translation of the first word by pressing a ‘yes’ or ‘no’ button. The critical trials in the translation recognition task are the ‘no’ trials, in which the second word is not a correct translation of the first word, but a distractor word, which is related in some way to the correct translation. For example, a distractor word may be related to the correct translation word in meaning, e.g., *cara-head*. In this Spanish-English word pair, the correct English translation for the Spanish word *cara* is *face*, which is semantically related to *head*. In other conditions, the distractor word may be related to the correct translation word in form, e.g., *cara-fact*, instead of the correct pair, *cara-face*. The degree of interference that a participant experiences from a distractor is measured by comparing response times (RTs) and accuracy of the distractor to a control condition.

According to the RHM, bilinguals with a low level of L2 proficiency performing the translation recognition task in the backward direction (L2 to L1) are predicted to rely on the direct lexical links from L2 to L1 words. Therefore, beginning bilinguals are expected to experience a greater degree of interference from form-related distractors compared to meaning-related distractors, which would be reflected as longer RTs and higher error rates. In contrast, highly proficient bilinguals are predicted to be more susceptible to interference from meaning-related distractors, as they access the L1 translation equivalent via the direct conceptual links. These predictions were supported by experimental results showing greater form interference for less proficient bilinguals and greater semantic interference for highly proficient bilinguals while performing a translation recognition task (Poarch, Van Hell & Kroll, 2015; Talamas et al., 1999).

In contrast to the RHM, whose primary focus lies in the predicted asymmetry in translation production, and the developmental changes of the bilingual lexicon as a consequence of increased L2 proficiency, the Bilingual Interactive Activation Plus (BIA+) model (Dijkstra, 2005; Dijkstra & Van Heuven, 2002; Thomas & Van Heuven, 2005) is a connectionist word recognition model which was proposed to account for experimental data showing non-selectivity in the lexical access of proficient bilinguals. The BIA+ model (see Figure 2) claims that word recognition occurs through bottom-up activation of lexical and sub-lexical features of the target word. According to the BIA+ model, when a proficient bilingual processes visual or auditory input, lexical candidates that share orthographic or phonological features with the target word are non-selectively activated in both languages. Support for the predictions of the BIA+ model was found in various studies showing results suggesting non-selective, cross-linguistic lexical activation (Blumenfeld & Marian, 2007; De Groot, Delmaar & Lupker, 2000; Brysbaert et al., 1999; Dimitropoulou, Duñabeitia & Carreiras, 2011; Grainger & Frenck-Mestre, 1998; Lagrou, Hartsuiker & Duyck, 2011; Schwartz & Kroll, 2006).

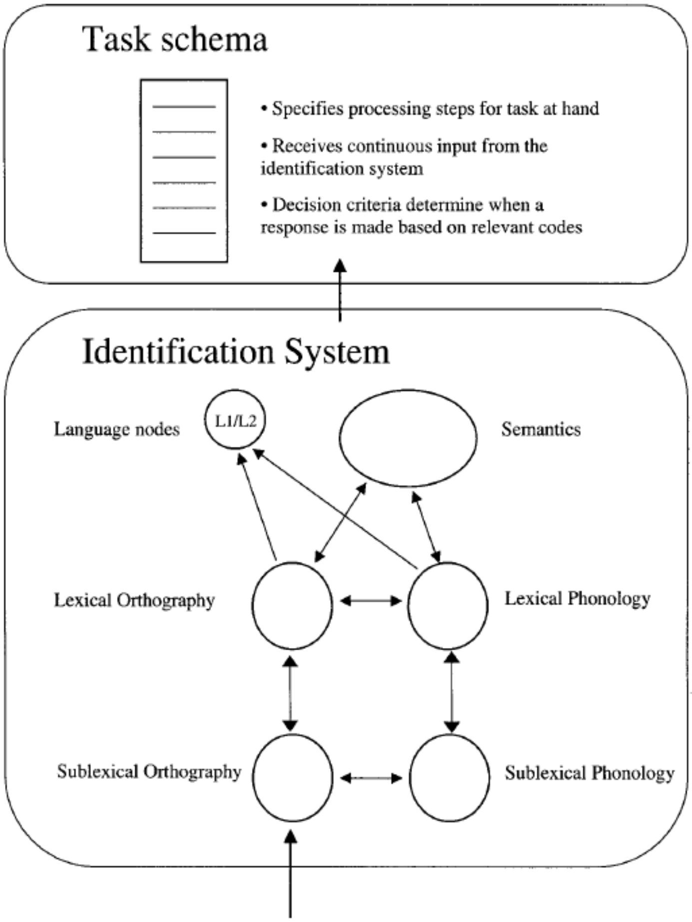

Figure 2. The Bilingual Interactive Activation Plus (BIA+) model (Dijkstra & Van Heuven, 2002)

For example, using an auditory lexical decision task, Lagrou et al. (2011) found that Dutch-English bilinguals took longer to make lexical decisions for interlingual homophones, e.g., *lief* (meaning 'sweet' in Dutch) – *leaf*, compared to non-homophone control words, supporting non-selective activation. In another study, Dijkstra, Timmermans and Schriefers (2000) used a 'go/no go task' in which Dutch-English bilingual participants were instructed to respond only when the target word belonged to a pre-specified language. Results showed that bilinguals experienced inhibition effects for interlingual homographs, e.g., *room* (meaning 'cream' in Dutch) relative to non-homograph control words. In both studies, interference from interlingual homographs or homophones was found even when the bilinguals were performing the task in Dutch, their native language, suggesting that non-selective lexical access occurs in both directions.

Although these studies have significant implications regarding the issue of non-selectivity in bilingual lexical access, a potential confound is inevitable when employing bilinguals whose languages share the same script. Languages which share writing systems, such as Spanish and English, also tend to share phonology (*cara-card*), so that cross-linguistic form interference effects could be due to orthography, phonology, or a combination of both. In an effort to tease apart the effects of shared orthography and phonology in bilingual lexical access, following studies employed bilinguals with different-script languages. Experimental studies with Japanese-English bilinguals (Ando, Jared, Nakayama & Hino, 2014; Hoshino & Kroll, 2008; Nakayama, Sears, Hino & Lupker, 2012), Chinese-English bilinguals (Zhou, Chen, Yang & Dunlap, 2012), Korean-English bilinguals (Moon & Jiang, 2012), Russian-English bilinguals (Spivey & Marian, 1999), and Hindi-English bilinguals (Mishra & Singh, 2016) all found evidence supporting simultaneous activation of the non-target language, supporting the BIA+ model's predictions for non-selective lexical access. In particular, these studies support the role of phonological information in non-selective bilingual access, as words in different script languages only share phonology, and not orthography.

To summarize, the RHM and BIA+ model are two distinct models of the bilingual lexicon, differing in focus and scope, and addressing different issues regarding the organization of the bilingual lexicon and nature of lexical access. The RHM is a developmental model of language production, designed to account for translation asymmetries and the consequences of L2 learning history (Kroll, Van Hell, Tokowicz & Green, 2010: 374). The BIA+ model is primarily a model of word recognition whose main predictions lie in the nonselectivity of bilingual lexical processing. Most previous studies on bilingual lexical processing, however, have been focused on testing the predictions of only one of these models.

In a seminal study, Sunderman and Priya (2012) conducted a translation recognition task with Hindi-English bilinguals. In contrast to previous studies using translation recognition, which have been focused solely on the predictions of the RHM (Altarriba & Mathis, 1997; Poarch et al., 2015; Talamas et al., 1999), Sunderman and Priya (2012) noted that the claims and predictions of the RHM and BIA+ model were not mutually exclusive, and attempted to investigate whether the predictions of both models could be supported simultaneously through a translation recognition task, using different-script bilinguals.

The experimental stimuli in Sunderman and Priya (2012) were designed so that the second word of the critical distractor word pair was either phonologically related to the correct translation of the first word, or phonologically related to the first word (see Table 1). The first distractor condition, i.e., the translation neighbor condition, tested the predictions of the RHM.[1] As the RHM predicts that L2 to L1 translation will be lexically mediated via the direct lexical links, a greater interference effect for translation neighbors was predicted in the L2 to L1 direction compared to L1 to L2 translation. The second distractor condition, i.e., the phonological neighbor condition, was designed to test the predictions of the BIA+ model. The BIA+ model predicts that if the distractor shares phonological information with the first word, interference effects will be observed when making a translation decision, due to nonselective access of lexical information.

1 The term used in the original study was ‘phonological translation neighbor’ (Sunderman & Priya, 2012: 1276). In this paper, we use the term ‘translation neighbor’ in order to prevent confusion with the term ‘phonological neighbor’.

Table 1. Sample stimuli for the correct translation pair, बिल्ली = “cat” (L1 to L2 translation)

Correct pair	Condition	Related	Unrelated
बिल्ली/billi:/ = “cat”	Translation neighbor	cap	Dan
	Phonological neighbor	Billy	entry

The results showed that the Hindi-English bilingual participants took longer to answer ‘no’ to distractor word pairs in the translation neighbor condition compared to word pairs in the control condition, suggesting that the bilinguals were experiencing interference due to activation of the translation equivalent. However, in contrast to the predictions of the RHM, a significant interaction with translation direction was found, in which the magnitude of interference was greater in the L1 to L2 direction, compared to the L2 to L1 direction. In their discussion of their results, Sunderman and Priya (2012) noted that the direction of the translation asymmetry runs counter to the predictions of the RHM, and suggest that the English dominance of the bilingual participants may be a potential reason underlying the unexpected results.

Evidence in support of nonselective phonological access predicted by the BIA+ model was also found, but in the form of facilitation, and not inhibition, for the distractor conditions in which the second word was phonologically related to the first word. The authors suggested that the practice of transliterating Hindi into English script had heightened the bilingual participants’ activation of phonological information during lexical access, and claimed that the phonological similarity between the second word and the first may have served as a cue that alerted the participants to a ‘no’ answer, resulting in shorter RTs.

Sunderman and Priya (2012) claim that the results of their study present a challenge for the predictions of the RHM regarding the direction of translation asymmetry in translation, and suggest that the nonselective phonological activation found in their study supports the BIA+ model and extends its predictions to languages with different scripts. The authors conclude that the BIA+ model is a more effective way in which to account for the cross-linguistic relations between orthography, phonology, and semantics in the bilingual lexicon.

Sunderman and Priya (2012) was the first study to simultaneously test the predictions of the RHM and BIA+ model with different-script bilinguals, and their results offer valuable insights into the translation asymmetry predicted by the RHM and the non-selective nature of lexical processing predicted by the BIA+ model. However, a closer examination of their experimental stimuli, in particular, the stimuli in the translation neighbor condition, reveals potential problems. The distractors in this condition were designed so that the second word was phonologically related to the correct translation of the first. For example, in Table 1, the distractor word *cap* is phonologically similar to the correct English translation equivalent of the Hindi word (बिल्ली), meaning *cat*. Although the distractor stimuli in the translation neighbor condition for the opposite direction (L2 to L1) should have been constructed in a similar fashion, the second word in this direction was a Hindi word (कुर्सी, pronounced /*kursi:*/) whose English translation *chair* was phonologically related to the first word *chain* (Sunderman & Priya, 2012: 1279). The correct distractor in this condition would have been a Hindi word whose pronunciation was similar to the Hindi translation equivalent of *chain*, and not the Hindi word for *chair*. This critical error in stimuli construction for the translation neighbor condition in the L2 to L1 direction raises concerns about the validity of the translation asymmetry reported in the results.

A second, more general point of discussion concerns the assumptions underlying the mechanisms of the translation recognition task and interpretation of the results. Compared to the relatively long history of previous studies using masked priming methodology (Ando et al., 2014; Gollan, Forster & Frost, 1997; Jin, 1990; Jiang, 1999; Kim & Davis, 2004; Zhou et al., 2010), the translation recognition task is a fairly recent experimental technique which has been employed in only a few studies to date (Sunderman, 2014; Sunderman & Kroll, 2006; Sunderman & Priya, 2012; Talamas et al., 1999).

The key assumptions underlying the mechanisms of the translation recognition task are in the nature of the distractors. When a distractor, i.e., incorrect translation, is related to the correct translation in form, bilingual participants who rely more on the direct lexical links between languages are predicted to suffer more interference, reflected as longer response times and lower accuracy. In contrast to masked priming, in which the main task is lexical decision and the participant is unaware of the cross-linguistic nature of the task, the translation recognition task is an overtly bilingual task. Furthermore, unlike the lexical decision task, the nature of the translation recognition task requires all participants to activate the translation equivalent of the first word, regardless of whether or not they are more reliant on the direct lexical links than the conceptual links. In this paper, we suggest that previous assumptions regarding the translation recognition task, i.e., that stronger reliance on the direct lexical links between languages will result in more interference for translation neighbors, may not be correct. Contrary to these assumptions, it may be that low proficiency bilinguals, who are more reliant on L1 translation equivalents for L2 lexical access, will suffer less interference from a form-related translation neighbor, due to their stronger L2-L1 connections. To elaborate, strong connections from the L2 lexicon to the L1 lexicon will result in strong activation of the translation equivalent, which in turn will make it less susceptible to competition from form-related neighbors. On the other hand, more proficient bilinguals, for whom direct semantic access is possible without activating L1 translation equivalents, may suffer more interference from a distractor related in form to the correct translation, due to weaker activation of the translation equivalent. The results of Talamas et al. (1999), showing form interference effects even for proficient bilinguals, support these predictions.

If our assumptions regarding the mechanisms of the translation recognition task are correct, our predictions for the pattern of results for translation neighbors are as follows. The degree of interference from translation neighbors in the translation recognition task is predicted to be greater in the L1 to L2 direction compared to the L2 to L1 direction, and not vice versa. According to the RHM, direct connections between the two lexicons are stronger from L2 to L1 than from L1 to L2. Therefore, when translating from the L2 to L1, L1 translation equivalents will have a higher level of activation compared to L2 translation equivalents for L1-L2 translation. The weaker activation for L2 translation equivalents due to the weaker L1-L2 lexical links will result in increased susceptibility to interference effects from form-related competitors, i.e., translation neighbors, which will be reflected as longer RTs and higher error rates.

The critical difference between our assumptions and those of previous studies employing the translation recognition task lie in the direction of the predicted effects of translation activation. Previous studies (Talamas et al., 1999; Sunderman & Kroll, 2006; Sunderman & Priya, 2012) assumed that greater reliance on the translation equivalent would result in greater interference from a form-related distractor. While we agree that strong lexical connections from the L2 to L1 lead to a greater degree of activation for the translation equivalent, we predict that this stronger activation will render the translation equivalent less susceptible to competition from form-related neighbors, which will be reflected as shorter reaction time and higher accuracy rates in the L2 to L1 direction.

2. The Present Study

In the present study, we aim to investigate the predictions of the two most prominent models of the bilingual lexicon, the RHM and the BIA+ model, through a translation recognition task with low-intermediate Korean-English bilinguals. To our knowledge, only one published study to date has examined the claims of the RHM and the BIA+ model in parallel with different-script bilinguals (Sunderman & Priya, 2012). However, the problematic issues regarding construction of the stimuli in the L2-L1 direction call for a re-examination of their research questions. In this study, we adopt the experimental design used in Sunderman and Priya (2012), and employ a translation recognition task with two types of distractors. The first condition is the translation neighbor condition, which was designed to test the predictions of the RHM, and the second condition is the phonological neighbor condition, designed to test the predictions of the BIA+ model.

A second goal of the present study is to rethink the assumptions underlying the mechanisms of the translation recognition task. Contrary to previous studies (Talamas et al., 1999; Sunderman & Kroll, 2006; Sunderman & Priya, 2012) which interpret translation neighbor interference effects as an indicator of strong lexical links, we predict that strong lexical connections from the L2 to L1 will result in less interference from translation neighbors, due to a stronger activation level of the L1 translation equivalent. The logic behind our predictions lies in the nature of the translation recognition task, in which all participants are required to retrieve the translation equivalent in order to make the translation decision, regardless of whether they are at the beginning or advanced stage of L2 proficiency.

The predictions for our present study are as follows. According to the RHM, low-intermediate Korean-English bilinguals are predicted to rely on the direct lexical links when translating from L2 to L1. Strong activation of the L1 translation equivalent will consequently be reflected as less interference in the translation neighbor distractor condition, compared to the L1 to L2 direction. The second prediction concerns the BIA+ model's claims for the non-selective activation of lexical neighbors sharing orthographic and phonological information. Korean, like Hindi, is an alphabetic language which employs a different script from English. Therefore, it is possible to investigate effects of non-selective activation of phonological information during lexical access without the confounding effects of shared orthography found for languages sharing the same script (Dijkstra et al., 2000; Grainger & Frenck-Mestre, 1998; Sunderman & Kroll, 2006; Van Hell & De Groot, 1998). If the Korean-English bilingual participants in the current study non-selectively activate cross-linguistic phonological neighbors, interference effects are predicted for the phonological neighbor distractor condition.

Another limitation of Sunderman and Priya's study was that the critical distractor items were matched for length and frequency with unrelated control words *within* conditions only, which did not enable them to compare interference effects *across* conditions. In the present study, the critical distractor items were controlled for length and frequency across conditions. Therefore, it is possible to compare the relative size of interference effects of the translation neighbor distractor condition to the phonological neighbor condition. We predict that stronger activation of the translation equivalent due to strong lexical connections will result in less interference from translation neighbors in the L2 to L1 direction compared to the L1 to L2 direction. Taking into account the claims of the BIA+ model that bilingual lexical access is nonselective in both directions, the stronger degree of interference from translation neighbors in the L1 to L2 direction is predicted to be reflected as an interaction, with a larger difference in the magnitude of interference between translation neighbors and phonological neighbors in the L1 to L2 direction.

Experiment 1 investigated the nature of translation activation for low-intermediate Korean-English bilinguals in the L2 to L1 (English-Korean) direction, and Experiment 2 examined translation recognition in the L1 to L2 (Korean-English) direction.

3. Experiment 1

3.1. Participants

Thirty-four undergraduate students from a large Korean university participated in the present study. All students in this university are required to take an English placement test at the beginning of freshman year and assigned a level of English proficiency from 1 to 5 (from highest to lowest). In order to ensure that the Korean-English bilingual participants were at a low-intermediate level of English proficiency, the participants were recruited from English classes for students assigned levels 4 and 5.[2] The participants' English proficiency was measured again at the time of testing, this time with a different version of the English proficiency test. The mean score was 14.06 (SD=2.90) out of a total of 25 points, and mean self-rated proficiency in English was 2.63 (SD=0.61) on a scale of 1 to 5, confirming that the English proficiency of these bilingual participants was at a low-to-intermediate level. None of the participants reported residing in an English-speaking country for more than four months. Detailed demographic information of the participants is presented below in Table 2.

2 Although the participants were recruited from the lowest two English classes, they cannot be classified as beginning English learners, as the students admitted into this university consisted of the upper ten percent of the high school population in Korea. Also, in order to ensure that the students had sufficient knowledge of the vocabulary used in the translation recognition task, a vocabulary test comprised of the experimental stimuli was administered to the participants after the main task.

Table 2. Participant information: Experiment 1 (n=34)

	Proficiency test	Self-rated proficiency scores	Length of residence (months)
Mean	14.06	2.63	0.13
SD	2.90	0.61	0.71
Range	9-19	2-4	0-4

3.2. Materials

The construction of the experimental stimuli was done in various stages. First, a preliminary set of 98 correct English-Korean translation pairs was chosen. In order to select English words at a low-intermediate level, the English words were selected from English textbooks used in elementary and middle schools in Korea. All English words were concrete nouns consisting of two syllables.[3] In order to ensure that the bilingual participants would retrieve the same Korean translation for each English word, a norming test was administered to a group of eighteen Korean participants at the same level of English proficiency as the bilingual participants in the present study. In the translation norming test, the participants were asked to write down the Korean translation for each of the 98 English words in the preliminary list. English-Korean translation pairs which had more than one corresponding translation were excluded, resulting in 53 translation pairs.

For the remaining correct translation pairs, two Korean distractors related to each English word were created. The distractors were either a) phonologically related to the correct translation of the English word (translation neighbor) or b) phonologically related to the English word (phonological neighbor). In controlling for phonological similarity for the translation neighbor condition, all distractors shared the first syllable with the correct translation, and the onset of the second syllable where possible (64% of all items). For the distractors in the phonological neighbor condition, a Korean word phonologically similar to the English word was

3 Van Hell and De Groot (1998) showed that conceptual representation in bilingual memory is affected by word-type and grammatical class.

selected. Another group of 20 Korean participants who did not participate in the main experiment rated the phonological similarity of each English word with its phonological neighbor distractor on a scale of 1 to 5. A final list of 48 English-Korean translation pairs, judged to share a high degree of phonological similarity were selected based on the results of the norming test. The ratings for phonological similarity for the final set of word pairs in the phonological neighbor distractor condition (mean rating: 2.88, SD=.65) were significantly higher than the word pairs in the unrelated distractor condition (mean rating: 1.05, SD=.09; t (47)=19.22, p<.001).

Each of the distractor items in the translation neighbor condition and the phonological neighbor condition were matched for frequency with an unrelated control item, and the four conditions did not differ in frequency (all *p*s >.37)[4]. In Table 3, the mean values for frequency for the four conditions are presented. The four conditions were also matched for length in number of syllables; all Korean items consisted of two-syllable words. A sample item showing a distractor pair for each of the four conditions is presented below in Table 4.

Table 3. Mean values for frequency for the four conditions (SD in parentheses)

	Translation neighbor		Phonological neighbor	
	Related	Unrelated	Related	Unrelated
Frequency	71.1 (64.5)	68.9 (59.6)	65.9 (44.7)	64.4 (44.4)

Table 4. Experiment 1: Sample stimuli for the correct translation pair “mirror – 거울”

Correct pair	Condition	Related	Unrelated
거울[gəul] mirror –	Translation neighbor	거인 [gəin], ‘giant’	봉투 [boŋtu], ‘envelope’
	Phonological neighbor	미로 [miro], ‘maze’	두부 [dubu], ‘tofu’

4 British National Corpus was employed to match for frequency for the English words. For the Korean items, a frequency measure provided by National Institute of Korean Language was used (Kim, 2005).

As all of the critical distractor pairs required a 'no' answer, an additional set of 48 noncritical filler pairs which were correct English-Korean translations requiring a 'yes' response were constructed. The noncritical 'yes' trials did not differ from the critical distractor trials in the frequency of Korean words (all *p*s >.25). The final set of stimuli in Experiment 1 included a total of 96 English-Korean translation pairs: 48 incorrect translation pairs (critical distractor items) and 48 correct translation pairs (non-critical filler items).

3.3. Design

The experimental stimuli were constructed in a 2 (type of distractor: translation neighbor vs. phonological neighbor) x 2 (relatedness: related vs. unrelated) design. Four lists were constructed in a Latin square design, fully crossing the two factors of distractor type and relatedness, so that each participant saw experimental items in all four conditions, but no participant saw the same item twice. Each participant was presented with a total of 96 translation pairs: 48 critical pairs (requiring 'no' answers) and 48 filler pairs (requiring 'yes' answers).

3.4. Procedure

Participants were tested individually in a quiet room, and given verbal instructions in Korean in addition to written instructions on the computer screen. In the translation recognition task, participants were required to decide whether the second word (Korean) in a sequence was a correct translation of the first word (English) by pressing 'yes' or 'no' on the keyboard. Prior to the presentation of the word pair, a fixation point was presented in the center of the screen for 500 ms. The first word was presented for 700 ms, followed by a brief blank screen for 100 ms. Then the second word was presented for a maximum of 5,000 ms, or until the participant made their decision. The translation recognition task was programmed using Paradigm software, and the presentation of the word pairs was randomized for each participant. The participants completed twelve practice trials prior to the main experiment.

After the participants completed the translation recognition task, they were given a language background questionnaire, an English proficiency test designed to assess English proficiency, and a vocabulary translation test in which they were asked to provide Korean translations for the English words used in the main experiment. The entire session took about thirty minutes, and the participants received monetary compensation for participation in the experiment.

3.5. Data Analysis

Two participants who scored below 85% accuracy on the vocabulary translation test were excluded from further analysis. Only correct responses on the critical trials were included in subsequent analyses of response times (RTs), resulting in the exclusion of 3.77% of the data. RTs that were more than 2.5 standard deviations from each participant's mean RT (2.64%), and RTs shorter than 300 ms and longer than 3,000 ms (0.69%) were treated as outliers and also excluded from further analysis.

3.6. Results

The mean RTs and accuracy rates for the four conditions are shown in Table 5. Interference was calculated for each distractor condition as the difference between related and unrelated (control) trials. The RT and accuracy data were submitted to a repeated measures ANOVA with distractor type (translation neighbor vs. phonological neighbor) and relatedness (related vs. unrelated) as within-group factors. The mean RT for the correct translation filler trials was 609.42 ms, and mean accuracy rate was 88.41%.

Table 5. Experiment 1: Mean RTs and percentage of accuracy (SD in parentheses)

	Translation Neighbors (mirror-거인 [gəin])		**Phonological Neighbors** (mirror-미로 [miro])	
	RT (ms)	**Accuracy (%)**	**RT (ms)**	**Accuracy (%)**
Related	656.49 (161.49)	93.49	625.91 (152.91)	96.09
Unrelated	587.27 (137.40)	97.40	608.20 (188.31)	97.92
Interference	69.22	3.91	17.71	1.83

Response times. The main effect of relatedness was significant in the RT data analysis across both participants and items (F_1 (1,31) =17.54, p<.0005; F_2 (1,47) =11.20, p<.05), with participants significantly slower to reject related distractors compared to the unrelated control items. The relatedness effect was not qualified by a significant interaction between relatedness and distractor type (F_1 (1,31) = 3.63, p=.07; F_2 (1,47)=1.91, p=.17), and there was no main effect of distractor type (*p*s >.52).

Accuracy. In the accuracy data, a main effect of relatedness was found in both the participant and item analysis (F_1 (1,31) =10.45, p<.0005; F_2 (1,47)=5.93, p<.05), with lower accuracy found for the related word pairs. There was no significant effect of distractor type (*p*s >.13), and no interaction between distractor type and relatedness in both the participant and item analyses (*p*s >.26).

3.7. Discussion

Experiment 1 examined the translation recognition of low-intermediate Korean-English bilinguals through a translation recognition task in the L2 to L1 direction. The results showed a significant effect of relatedness in both response latencies and accuracy, indicating that the participants experienced interference in their translation decision when the second word was phonologically related to the correct translation or when the second word was phonologically related to the first word. These results provide evidence in support of the predictions of the RHM and the BIA+ model, i.e., non-selective activation of phonological information in addition to activation of the translation equivalent. The absence of a significant interaction between distractor type and relatedness indicates that the magnitude of interference did not differ significantly between the translation neighbor condition and the phonological neighbor condition. We did find, however, a trend toward an interaction between the two factors in the by-subjects analysis, with a marginally larger interference effect for the translation neighbor condition compared to the phonological neighbor condition (p=.07). This trend toward an interaction between distractor type and relatedness suggests that for the low-intermediate Korean-English bilinguals in this study, non-selective phonological activation may not have been as strong as activation of the translation equivalent, although this difference was not large enough to be statistically significant.

In Experiment 2, we examine L1 to L2 translation recognition by Korean-English bilinguals at a same level of L2 (English) proficiency as the bilingual participants in Experiment 1. We predict due to the directional asymmetry in the RHM, the weaker lexical link from the L1 lexicon to the L2 lexicon (see Figure 1) will result in a lower level of activation of the L2 translation equivalent, compared to the activation of the L1 translation equivalent in the L2 to L1 direction (Experiment 1). This lower level of activation for the L1 translation equivalent is predicted to result in more susceptibility to interference from translation neighbor distractors, which in turn will be reflected as significantly larger differences in RTs compared to the control conditions. Following the predictions of the BIA+ model and the results of previous studies showing that non-selective phonological activation occurs whether processing in the L1 or L2 (Dijkstra et al., 2000; Lagrou et al., 2011), we predict that the magnitude of interference for the phonological neighbor condition will be relatively constant across both translation directions. Therefore, the greater magnitude of interference from translation neighbors predicted in the L1-L2 direction (Experiment 2), in conjunction with a relatively unchanged level of interference for phonological neighbors, is predicted to result in a significant effect of relatedness, qualified by a significant interaction with distractor type, which was not found in the L2-L1 direction (Experiment 1).

4. Experiment 2

4.1. Participants

Thirty-two undergraduate students who had not participated in Experiment 1 were recruited from the same English classes (levels 4 and 5) as the previous participants. In order to ensure that the participants' English proficiency was at the same level of the participants in Experiment 1, English proficiency was assessed again at the time of testing. The mean proficiency score was 13.19 (SD=3.12) out of a total of 25 points, and mean self-rated proficiency in English was 2.31 (SD=0.78) on a scale of 1 to 5, confirming that the English proficiency of these bilingual participants was at a low-to-intermediate level. When the English proficiency scores and self-ratings of the participants in Experiments 1 and 2 were submitted to a t-test, no significant difference between the two groups was found (English proficiency scores: t (62)=1.16, p=0.25, Self-rated proficiency scores: t (62)=1.79, p=0.08). None of the participants reported residing in an English-speaking country for more than twelve months. Detailed demographic information of the participants is presented in Table 6.

Table 6. Participants information: Experiment 2 (n=32)

	Proficiency test	Self-rated Proficiency scores	Length of residence (months)
Mean	13.19	2.31	0.66
SD	3.12	0.78	2.61
Range	7-19	1-4	0-12

4.2. Materials

While constructing the experimental stimuli, we attempted to preserve as many of the original correct English-Korean translation pairs used in Experiment 1 as the baseline for forming the two distractor conditions as possible. Due to difficulties in controlling for the length and frequency of the new phonological neighbors, 28 out of the 48 correct English-Korean translation pairs were used as a baseline for the critical distractor pairs in Experiment 2, although this time as a Korean-English sequence. 20 additional pairs of stimuli were constructed according to the following stages.

First, a preliminary set of 48 correct Korean-English translation pairs was chosen, following the same criteria as Experiment 1. 11 Korean-English bilinguals who did not participate in the main task completed a translation norming test on the 48 Korean words in this list, and translation pairs with four or more incongruent translations were excluded from the final set of stimuli, which resulted in the removal of twenty translation pairs.

For each of the 28 remaining translation pairs, a set of two English distractors were created: a) a translation neighbor phonologically related to the correct English translation of the Korean word, and b) a phonological neighbor, which was phonologically related to the Korean word. A separate group of 10 Korean participants, who did not participate in the main experiment rated the phonological similarity of each word with its distractor on a scale of 1 to 5. Based on the results, a final list of 24 translation pairs judged to have a high degree of phonological similarity (2.5 or higher) were selected. The 24 new translation pairs were added to the list of 28 pairs from Experiment 1, and a final set of 48 pairs of experimental stimuli (25 pairs adapted from Experiment 1 and 23 newly constructed pairs) were selected from this set to control for frequency and length across conditions.[5] Each of the distractors in the translation neighbor condition and the phonological neighbor condition were matched with an unrelated control item, and frequency and length were matched across all four conditions (all *p*s >.25). In Table 7, the mean values for frequency and length for the four conditions are presented. A sample item set is presented below in Table 8.

Table 7. Mean values for frequency and length for the four conditions (SD in parentheses)

	Translation neighbor		**Phonological neighbor**	
	Related	**Unrelated**	**Related**	**Unrelated**
Frequency	908.73 (1073.37)	916.52 (908.77)	940.17 (1141.11)	917.58 (899.78)
Length	6.42 (1.2)	6.69 (1.13)	6.31 (1.29)	6.44 (1.13)

Table 8. Experiment 2: Sample stimuli for the correct translation pair "거울-mirror"

Correct pair	**Condition**	**Related**	**Unrelated**
거울[gəul]-mirror	Translation neighbor	mirage	button
	Phonological neighbor	coward	kitten

Similar to Experiment 1, an additional set of 48 noncritical filler pairs which were correct English-Korean translations requiring a 'yes' response were constructed. The filler trials did not differ from the critical distractor trials in frequency (all *p*s >.21). The final set of stimuli in Experiment 2

5 In a post-hoc comparison of the set of 25 translation pairs adapted from Experiment 1 and the new set of translation pairs constructed in Experiment 2, the two sets of items did not differ in RTs or accuracy (all ps.>.32) in the translation recognition task.

included a total of 96 Korean-English translation pairs: 48 incorrect translation pairs (critical distractor items) and 48 correct translation pairs (non-critical filler items).

4.3. Design and Procedure

The design and procedure for Experiment 2 was identical to that of Experiment 1.

4.4. Data Analysis

All participants obtained over 85% accuracy on the vocabulary translation test, so that none of the participants were excluded from analysis of the data. Mean accuracy for the critical trials was 89.97%, and only correct responses on the critical trials were included in the RT analysis. The RT data was trimmed for outliers by removing RTs that were above or below 2.5 standard deviations from each participant's mean RT, which made up 1.23% of the data, and RTs shorter than 300 ms and longer than 3,000 ms, which resulted in the removal of 0.07% of the data.

4.5. Results

The mean RTs and accuracy rates for the four conditions in Experiment 2 are presented in Table 9. RT and accuracy data were submitted to a repeated measures ANOVA with distractor type (translation neighbor vs. phonological neighbor) and relatedness (related vs. unrelated) as within-group factors. The mean RT for the correct translation filler trials was 767.85 ms, and the mean accuracy rate was 90.10%.

Table 9. Experiment 2: Mean RTs and percentage of accuracy (SD in parentheses)

	Translation Neighbors (거울[gəul]-mirage)		**Phonological Neighbors** (거울[gəul]-coward)	
	RT (ms)	**Accuracy (%)**	**RT (ms)**	**Accuracy (%)**
Related	946.59 (272.17)	69.79	830.87 (240.82)	95.05
Unrelated	832.53 (279.24)	96.88	810.62 (252.29)	98.18
Interference	114.06	27.09	20.25	3.13

Response times. A significant main effect of relatedness was found across participants and items (F_1 (1,31) =6.65, p<.05; F_2 (1,47)=17.79, p<.0005), with participants taking longer to reject related distractors as incorrect translations, compared to the unrelated control items. There was also a main effect of distractor type, with significantly longer response times for the translation neighbors than the phonological neighbors.

A significant interaction between relatedness and distractor type (F_1 (1,31) = 9.71, p<.005; F_2 (1,47)=4.63, p<.05) was also found, which was caused by a larger interference effect for the translation neighbor distractor condition compared to the phonological neighbor distractor condition.

Accuracy. The accuracy data showed a pattern similar to the RT data. A main effect of relatedness was found in both the participant and item analysis (F_1 (1,31) =90.84, p<.0005; F_2 (1,47)=34.34, p<.0005), with lower accuracy found for the related distractor condition. The factor of distractor type was also significant, with lower accuracy for translation neighbors (F_1 (1,31) =92.79, p<.0005; F_2 (1,47)=40.55, p<.0005) compared to phonological neighbors. A significant interaction between distractor type and relatedness was obtained in both the participant and item analyses, driven by a larger interference effect in the translation neighbor condition (F_1 (1,31) =54.12, p<.0005; F_2 (1,47)=31.43, p<.0005).

4.6. Discussion

In Experiment 2, we examined the translation recognition of low-intermediate Korean-English bilinguals in the L1 to L2 direction. The results showed longer response latencies for distractors that were in the related conditions, indicating that the bilingual participants took longer to reject a related distractor as a correct translation, and made more decision errors, also. The main effect of distractor type, which was qualified by a significant interaction with relatedness, suggests that the participants were more susceptible to interference effects if the distractor was phonologically related to the correct translation, compared to a cross-linguistic phonological neighbor of the first word. The greater magnitude of interference experienced from the translation neighbor distractors was reflected as longer RTs and higher error rates in the related, translation neighbor condition. In other words, although the bilingual participants in this experiment took more time to decide whether the L2 translation neighbor was a correct translation of the L1 (Korean) word or not, the result was a higher rate of incorrect decisions, compared to the phonologically-related distractors.

According to the predictions of the RHM (see Figure 1), the direct lexical links between a word and its translation equivalent are asymmetrical in the strength of the connections. L2 to L1 lexical links are strong, whereas L1 to L2 lexical links are weaker. As a beginning bilingual increases in their level of L2 proficiency, the conceptual links between the L2 lexicon and the conceptual store are predicted to grow stronger, so that highly proficient bilinguals will have less need to rely on the L2 to L1 lexical links to retrieve meaning for L2 words. Consistent with the claims of the RHM, we assumed that bilinguals with a low to intermediate level of L2 (English) proficiency such as the Korean-English bilingual participants in our study, would have a strong lexical link connecting words in the L2 lexicon to the L1 lexicon, but weaker lexical connections from L1 words to their L2 translation equivalents. In contrast to previous studies employing the translation recognition task, we predicted that weak L1 to L2 lexical connections would result in a lower level of activation for the L2 translation equivalent and more difficulty in its retrieval compared to L2 to L1 translation. A translation equivalent with a relatively low level of activation was predicted to be more susceptible to competition from orthographic or phonologically related neighbors during translation. The results of Experiment 2, which show a greater magnitude of interference in both decision latencies and error rates for the translation neighbor distractor condition compared to the phonological neighbor condition are consistent with our predictions.

5. General Discussion

In this study, we investigated the predictions of two prominent models of the bilingual lexicon, the RHM and the BIA+ model, through a translation recognition task with low-intermediate level Korean-English bilinguals. To our knowledge, only one published study to date has attempted to examine and compare the predictions of these two models in parallel with different-script bilinguals (Sunderman & Priya, 2012). However, this study had critical issues concerning the construction of the experimental stimuli in the L2 to L1 direction. By conducting a translation recognition study with Korean-English bilinguals, we were able to examine the effects of shared phonological information predicted by the BIA+ model without the confounding effects of shared orthography. In addition to investigating the predictions of the RHM and BIA+ model with different-script bilinguals, a second goal of the present study was to rethink the logic and assumptions underlying the translation recognition task.

Previous studies assumed that in the translation recognition task, the size of interference effects reflected the degree of activation. In other words, if a critical distractor word which was related to the correct translation of the first word had longer RTs and higher error rates compared to an unrelated control, the observed difference in RTs and error rates was interpreted as an indicator of the degree to which the participant was activating the translation equivalent. However, we suggest that previous studies may have overlooked the nature of the translation recognition task itself in the interpretation of the results.

In another type of widely used experimental methodology, masked priming, for example, the participant is required to make a lexical decision on the target word, and the properties of the masked prime are manipulated so the experimenter can investigate various relations in the monolingual or bilingual lexicon. As the masked prime is presented for a very brief time (usually 50 ms or less), the participant is only aware of consciously processing the target word. Therefore, by briefly presenting masked primes which are phonologically/semantically related to the target word or translation equivalents of the target word, we can examine the type of information which is activated during lexical retrieval.

In contrast, the translation recognition task presents both the first and second word for a sufficiently long amount of time (700 ms or more) so that the participant can consciously process both words. In addition, as the nature of the task requires overt translation, even proficient bilinguals, who are predicted to access the meaning of L2 words directly during normal lexical processing (RHM; Kroll & Stewart, 1994), will be required to activate the L2-L1 lexical links and retrieve the translation equivalent. In this task, a participant will initiate the process of activation and retrieval of the translation equivalent upon presentation of the first word before the second word is presented. When activating a translation equivalent, stronger lexical links will result in faster retrieval and a higher level of activation for the receiving end of the arrow, i.e., L1 translations for the L2-L1 lexical link. In line with previous studies showing that words with high resting levels of activation, e.g., high frequency words, are easier to retrieve, reflected as shorter RTs and lower error rates in a lexical decision task (Embick, Hackl, Schaeffer, Kelepir & Marantz, 2001), we suggest that stronger activation of the translation equivalent would lead to less interference from related competitors. Therefore, in contrast to the assumptions of previous studies, we predicted *less* interference for translation neighbors in the L2-L1 direction compared to the L1-L2 direction.

The results of our present study, which found significant effects of relatedness in both forward (L1 to L2) and backward (L2 to L1) translation, but a significant interaction of relatedness and distractor type only in the L1 to L2 direction, are consistent with these predictions. Unlike the RHM, whose main claims lie in the asymmetry of translation direction, the BIA+ model does not posit a directional asymmetry in the non-selective activation of lexical information (Dijkstra, 2005; Dijkstra & Van Heuven, 2002; Thomas & Van Heuven, 2005). Previous studies reporting an absence of directional effects in the non-selective access of phonological and orthographic information during bilingual lexical retrieval (Dijkstra et al., 2000; Jiang, 1999; Lagrou et al., 2011; Mishra & Singh, 2016; Zhou et al., 2010) support these claims. Assuming that the degree of non-selective phonological activation does not differ across directions, the interaction between relatedness and distractor type found in the L1 to L2 direction, which was driven by the higher response latencies and higher error rates in the related translation neighbor condition (see Table 7), imply that the weaker lexical links from the L1 to L2 lexicon result in *more* interference from translation neighbors compared to L2 to L1 translation, and not vice versa.

Sunderman and Priya (2012) report data showing a similar pattern to the results obtained in the present study. Setting aside problematic issues in the construction of their experimental stimuli in the L2 to L1 direction, which were discussed previously, Sunderman and Priya (2012) also found a larger interference effect for translation neighbors in the L1 to L2 direction, which was the direct opposite of their predictions. In their discussion, the authors suggested that language dominance may have been a factor which affected their results, as their Hindi-English bilingual participants were slightly more dominant in L2, which was English. In the present study, we obtained the same pattern of translation asymmetry for Korean-English bilinguals who were at a low-intermediate level of English proficiency, had not resided in an English-speaking country for over twelve months, and were all dominant in their L1, Korean. The pattern of results we found in the present study suggest that the unpredicted direction of translation asymmetry found in Sunderman and Priya (2012) was not due to the L2 dominance of the bilingual participants. Furthermore, our results support the predictions of the RHM and the BIA+ model, suggesting that the claims of the two models of the bilingual lexicon are not mutually exclusive. we propose that a revised version of the RHM could account for a larger pool of the existing experimental data on bilingual lexical processing.

6. Conclusion

This study provided evidence supporting the predictions of the RHM and the BIA+ model through a translation recognition task with low-intermediate Korean-English bilinguals. By using different-script bilinguals, we were able to focus on non-selective activation of phonological information during bilingual lexical processing, unlike the previous studies examining the translation recognition of bilinguals with shared script languages. A revised connectionist approach to the architecture of the RHM in relation to the translation recognition task was also proposed, by accounting for differences in the size of interference effects through the relative activation level of a translation equivalent. The fundamental rethinking of the mechanisms and logic behind the translation recognition task provide insight for future research in the development and use of various psycholinguistic experimental methods. Future studies exploring the nature of different-script bilinguals at varying levels of proficiency are expected to shed more light on this issue.

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