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Allen, D., Conklin, K., & Van Heuven, W.J.B. (2015). Making sense of the Sense Model: Translation priming with Japanese-English bilinguals. *The Mental Lexicon*, 10(1), 32-55.

## **Making sense of the Sense Model: Translation priming with Japanese-English bilinguals**

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Many studies have reported that first language (L1) translation primes speed responses to second language (L2) targets, whereas L2 translation primes generally do not speed up responses to L1 targets in lexical decision. According to the Sense Model (Finkbeiner, Forster, Nicol & Nakamura, 2004) this asymmetry is due to the proportion of senses activated by the prime. Because L2 primes activate only a subset of the L1 translations senses, priming is not observed. In this study we test the predictions of the Sense Model by using Japanese-English cognates, which allow us to manipulate the number of senses that words have in each language. Contrary to the predictions of the Sense Model, our results replicated the typical asymmetrical priming effects, suggesting that it is not the total activation of senses that drives the priming effect. Rather the results are more in line with theories that postulate slower, and thus ineffective, activation of semantics by L2 primes.

**Keywords:** translation priming, Sense Model, Japanese-English, cognates, semantic representation, lexical processing

A central concern of bilingual research is how words are represented in the bilingual lexicon and how translations are co-activated during bilingual processing (Dijkstra, 2007). To investigate these issues researchers have utilized the masked priming paradigm (Kinoshita & Lupker, 2003). The masked priming technique utilizes a mask before and/or after the prime in order to conceal the prime from the participant; this leads to unconscious processing of the prime stimuli, which removes the concern of participants applying a conscious strategy to the task. For example, participants are presented with a prime (e.g., TOWN) preceded and/or followed by a mask (e.g., #####), then a target, which is the translation of the prime in the other language (e.g., 町/machi/). One key finding using this technique is that translation priming often occurs in only one direction i.e., L1 to L2 (L1 (first language) prime, L2 (second language) target), and not at all or is weaker

in the other i.e., L2 to L1 (L2 prime, L1 target). This finding has been reported for languages that share script (Duñabeitia, Perea & Carreiras, 2010; Duyck, 2005; Grainger & Frenck-Mestre, 1998) and for those that differ in script (Finkbeiner, Forster, Nicol & Nakamura, 2004; Gollan, Forster & Frost, 1997; Jiang, 1999; Jiang & Forster, 2001). This asymmetry appears to reveal a difference in the effectiveness of L2 primes compared to L1 primes, which may in turn reveal important information about how bilinguals process words in different languages or how the bilingual lexicon is organized.

One explanation of the translation priming asymmetry in lexical decision was formulated by Finkbeiner and colleagues, which states that it is the degree of semantic activation *per se* that determines the translation priming asymmetry. Their proposed model, the Sense Model (Finkbeiner et al., 2004; see also Wang & Forster, 2010), assumes bundles of conceptual features to be ‘senses’. Translations in two languages will share a number, but not necessarily all, of these senses, as shared meaning is the basis of translation equivalency. To achieve priming, complete activation of senses (or activation of a high ratio of senses) in the target language is required (Finkbeiner et al., 2004:8). Because fewer senses will typically be known in an L2 for unbalanced bilinguals, in L1 to L2 priming the proportion of the target’s senses that are primed should be very high, while for L1 targets this should be very low (*ibid.*:9–10).

To test whether asymmetries in sense activation underlie the priming patterns predicted by the Sense Model we used Japanese-English cognates. Cognates are words that share formal (i.e., orthographic and/or phonological) and semantic similarity across languages (Dijkstra, 2007). Japanese-English cognates share phonological and semantic but not orthographic similarity, and they are in fact loanwords, which are borrowed into Japanese. It is important to note that when cognates in Japanese are borrowed from English, they almost always derive their meaning from the English word. Thus, it is rare that a Japanese cognate takes on a different meaning that is not originally derived from English. Moreover, loanwords typically have fewer senses than that of the original language. This is due to a feature of language borrowing termed *semantic narrowing* (Shibatani, 1990), which describes the fact that a Japanese cognate often has only one of the senses of the English word. This is because a word is borrowed to fill a very specific lexical gap in Japanese.

Crucially, we can distinguish between two types of Japanese-English cognates depending on the number of senses that the Japanese words share with the English words. The first type of Japanese cognate has complete semantic overlap with its English equivalent; in other words the ratio of shared senses is very high (i.e., 1:1 ratio of shared senses; e.g., バナナ/banana/ – *banana*). This is because the English word itself has one sense (or very few senses) and this is borrowed

into Japanese. The second type of Japanese cognate has much less semantic overlap with its English equivalent, because the English word has many senses that are not borrowed into Japanese. For example, ブラシ /burashi/ refers to the meaning of a brush as a tool in Japanese, whereas in English *brush* has additional meanings such as the verbs *to brush one's teeth* and *to touch lightly*. In sum, the difference between these two types of cognates depends on the number of English senses (few vs. many) of the Japanese-English cognate. Henceforth, we refer to these categories of cognates as having 'English-few' or 'English-many' senses.

In their formulation of the Sense model, Finkbeiner et al. (2004) suggested that a representational asymmetry exists due to the reduced knowledge of L2 senses relative to L1 senses. For Japanese-English cognates, the representational asymmetry is actually often in the opposite direction than what is predicted by the Sense Model: many English cognates have a greater number of senses than their respective Japanese translations. According to the Sense Model, this leads to two predictions for lexical decisions with masked translation primes from L1 and L2 (see Table 1). Firstly, in the L1 to L2 priming, the L1 prime should differentially activate the L2 target according to the proportion of senses activated. Japanese cognates in the English-Few condition should fully prime English targets as the ratio of activated senses is 1:1, such that バナナ /banana/ would activate the entirety of the sense of English *banana*. Whereas Japanese cognates in the English-Many condition should prime targets to a lesser degree, as the full range of English senses should not be activated by the Japanese prime. More specifically, ブラシ /burashi/ 'brush' would only activate the sense 'an implement with bristles', leaving the English word *brush* only partially activated. Secondly, in L2 to L1 priming, English primes should activate the full range of senses associated with the Japanese translations. For example, *brush* would activate the sense 'an implement with bristles', which is shared with Japanese word ブラシ, as well as other senses that are known for the English word (e.g., 'to brush one's teeth', 'to brush past someone'), but which are not shared with Japanese. The sense of the Japanese word will therefore be fully activated by the English prime. Thus, according to the Sense Model, L2 English primes should speed responses to *all* targets in L1 Japanese. The present study used a masked translation priming with a lexical decision task in order to test these predictions.

Table 1. Predictions of the current study according to the Sense Model.

		Priming direction	
		L1 to L2 (L1 prime, L2 target)	L2 to L1 (L2 prime, L1 target)
Number of English senses	Few	Priming	Priming
	Many	No priming	Priming

## Method

### *Participants*

Thirty-eight Japanese-English bilinguals participated in the study and completed informed consent forms prior to the experiment. All participants were undergraduate students (34 males; mean age=19, SD=0.6) recruited from the University of Tokyo and received 500 yen for participating. All but four participants responded that they were born and have only lived in Japan, spoke Japanese at home and that their whole education (from elementary to university level) was conducted in Japanese. The four that did not fit completely with the above category rated themselves at native speaker level proficiency in Japanese in all four skills (listening, reading, writing, speaking; on a scale of 1–10 with 0=no proficiency and 10= native speaker-level proficiency,  $M=9.75$ ,  $SD=0.5$ ). Thus, all participants were considered native speakers of Japanese. Most participants began learning English between 11–15 years of age ( $n=24$ ) with some beginning earlier (6–10 years:  $n=11$ ; 1–5 years:  $n=3$ ). Mean L2 (English) proficiency was 5.1 ( $SD=1.3$ ), which was calculated by averaging individual ratings for each of the four skills.

### *Materials*

In order to test the predictions of the Sense Model and to determine if translation priming effects can be attributable to the overlap in the number of senses, we conducted a norming translation study involving Japanese-English cognates. Translation tasks with bilinguals have been used previously to assess the degree of semantic overlap of translations (e.g., Tokowicz, Kroll, de Groot, & van Hell, 2002). When words are consistently translated using the same translation, they are considered to overlap considerably in meaning; conversely, when words have multiple translations this suggests that such words have multiple meanings and hence have less semantic overlap across languages.

In the norming study, 21 Japanese-English bilinguals (Mean L2 proficiency=4.6 on a scale of 1–10;  $SD=1.2$ ) translated cognate words into English or Japanese. Participants were asked to report the first translation that comes to mind for each item and to enter that word in the space provided (see Allen & Conklin, 2013, for further details). In the direction of L1 to L2 (translating L1 cognates into L2), there was a single primary English translation that was elicited ( $M=1.0$ ,  $SD=0$ ) whereas in the L2 to L1 direction there was a wider range of responses ( $M=3.0$ ,  $SD=1.0$ ). Consequently, the items were separated into two groups based on the number of translations given in the L2 to L1 direction. Cognates that were translated with the same translation each time ( $M=1.0$ ,  $SD=0$ ) were classified as ‘English-Few’ (few translations in either direction, i.e., a ratio of 1:1). Cognates that were translated using more than one Japanese translation in the L2 to L1



direction ( $M=3.0$ ,  $SD=1.0$ ) but only one English translation in the L1 to L2 direction were classified as ‘English-Many’ (in other words, the ratio is 1:1+). The two groups form a categorical variable in the present study referred to as *Number of English Senses*.

Sixty items were selected for the lexical decision task. All items were cognates in English and Japanese and included 30 items classed as English-Few and 30 items classed as English-Many. The two groups (English Few/Many) were matched as closely as possible on lexical characteristics: log-transformed (base e) Japanese word frequency (Amano & Kondo, 2000); log-transformed English word frequency (British National Corpus including both the spoken and written components; BNC, 2007); Japanese word length; and English Orthographic Neighborhood Size (taken from the Elexicon Project, Balota, et al., 2007;  $p$ 's > 0.1). Items differed marginally in terms of English word length, such that English-Few items were slightly longer on average than English-Many items ( $p < .06$ ). However, since mixed effects modelling will be used to analyze the results, any differences attributable to length can be accounted for in the model.

While it was possible to match items on word frequency, it was not possible to completely disentangle word familiarity from the number of senses. It is likely that the number of senses a word has influences how familiar that word is perceived to be by language users. Indeed, earlier research found that polysemy effects were in fact not observed when word familiarity was controlled (Gernsbacher, 1984). Because the present research is dealing with more or less polysemous words (English-Many or English-Few, respectively), it is important to control for familiarity effects. To do this, we collected both English (L2) and Japanese (L1) word familiarity ratings from Japanese-English speakers from a similar population as the participants in the present study. The L2 English word familiarity ratings are described in Allen and Conklin (2013) and the L1 Japanese ratings were taken from 30 bilinguals (mean self-rated L2 proficiency = 5.1) following the same procedure. As expected, English-Few items were rated as significantly less familiar than English-Many items in the L2 ( $M=3.9$  vs.  $M=4.3$ ;  $df=58$ ,  $t=3.34$ ,  $p < .001$ ) but not so in the L1 ( $M=4.1$  vs.  $M=4.2$ ;  $df=58$ ,  $t=-0.74$ ,  $p=0.43$ ). This mirrors the fact that the English words differed more markedly in the number of senses between the conditions, whereas the Japanese items did not. In order to control for the difference in word familiarity between L2 items, we included English word familiarity in the L1 to L2 mixed effects model of the response data.

The difference in familiarity for L2 items could potentially influence the size of the priming effect in the L2 to L1 task. In terms of the predictions of the Sense Model, however, priming is expected for all items in the L2 to L1 direction, and thus the difference should not affect the primary predictions of the experiment. The difference in familiarity should, if anything, result in greater priming for

English-Many items as they have higher familiarity ratings than the English-Few items. However, as the results show, there was no evidence of priming in the L2 to L1 task.

In addition, 60 nonwords matched on word length were selected for each task. The nonwords for the English task were taken from the Elexicon project (Balota, et al., 2007) and the nonwords for the Japanese task were created by changing one mora within an existing katakana word. Each experimental item was preceded by a prime in the other language that was either a translation equivalent (e.g., ラジオ /rajio/ ‘radio’ – radio) or an unrelated word (e.g., coffee – タスク /tasuku/ ‘task’). Primes were matched on length and frequency in L1 and L2 across translation and unrelated pairs ( $p$ 's > .1). Nonwords, like words, were preceded by word primes in the other language. The full list of stimuli is presented in the Appendix.

### *Procedure*

The experiment consisted of two parts that were fixed in order: an English L1 to L2 lexical decision task, followed by a Japanese L2 to L1 lexical decision task. This order was chosen to potentially boost the global activation of L2 words (Elston-Güttler, Gunter, & Kotz, 2005) such that they become more effective primes in the second L1 Japanese task. English was used in the on-screen instructions and in oral communication prior in the English task; Japanese on-screen instructions preceded the Japanese task.

All 60 experimental items were presented in both the English and Japanese tasks. However, the target was seen in different conditions in the two tasks. For example, if *radio* was preceded by its translation in the L2 task, then ラジオ /rajio/ ‘radio’ was preceded by an unrelated prime (e.g., *coffee*) in the L1 task. Two counter-balanced lists were created such that an equal number of participants saw targets in the translation and unrelated conditions in each language. Ten practice items preceded each task and were followed by feedback (‘correct’ or ‘incorrect’) and the response latency; items in the main task were not followed by any feedback.

Stimuli were presented in lower case (Arial, size 14). The presentation of primes and stimuli was similar to Finkbeiner et al. (2004). A forward mask was presented for 500ms followed by the prime for 50ms, then a backward mask that differed in size and font to the forward mask was presented for 150ms, and finally the target item appeared on the screen until a response was made or after 3000ms. The forward and backward masks were similar to those used in Hoshino et al. (2010), that is, mosaics of roman letters and katakana letters were created by overlapping strings of characters from these scripts. This proved to be effective in masking the prime, as participants reported not being able to see a word when prompted at the end of the task.

Participants were tested seated in front of a computer (Dell, English OS) in a quiet room. Responses were made via a keyboard press. The experiment was run using DMDX (Forster & Forster, 2003). Subjects sat around 40–50 cm away from the screen with eyes level with the centre of the screen. Participants made lexical decisions for which the ‘Yes’ decision was always made with the index finger of the preferred hand (only two participants were left-handed) and they were instructed to respond as quickly and accurately as possible. Response times and accuracy were recorded automatically via keyboard presses. After the experiment, participants completed a language background questionnaire.

## Results

The overall error rate for nonwords was 9.8% (8.4% in the English (L1 to L2) task and 1.4% in the Japanese (L2 to L1) task). The overall mean RT for nonwords was 766 ms (SD=375 ms). The mean RT for nonwords in the English task was 991 ms (SD=376 ms) and that for the Japanese task was 578 ms (SD=251 ms). The nonwords data was not analyzed further.

Responses to words that were faster than 300ms, slower than 3000 ms, or  $\pm 2.5$  standard deviations from the mean were identified as outliers and removed (2.4% of total data) before the analyses. A number of items were identified as having high error rates (>20%) and were removed from both accuracy and latency analyses (7 items (6 English-Few, 1 English-Many) from L2 to L1 task; 2 items (both English-Many) from L1 to L2 task; 7.0% of total data). Removing a small number of items is not an issue for the present design as linear mixed effects models, unlike standard Analysis of Variance (ANOVA), are capable of accounting for missing cells/unbalanced designs (Baayen, Davidson & Bates, 2008). Additional incorrect responses were removed for the latency analysis (3.3%). Table 2 shows the mean latency and percentage of errors for each of the conditions.

Table 2. Mean lexical decision latencies (in ms) with percentage errors in L1 to L2 and L2 to L1 masked priming tasks.

<i>Number of English Senses</i>	L1 to L2 (English targets)			L2 to L1 (Japanese targets)		
	Translation Prime	Unrelated Prime	Priming effect	Translation Prime	Unrelated Prime	Priming effect
English-Few	740 (5.8%)	764 (10.3%)	24 ms*	524 (3.0%)	528 (0.7%)	4 ms
English-Many	691 (4.3%)	727 (2.3%)	36 ms*	551 (2.5%)	546 (3.4%)	–5 ms

Note. \* Indicates a significant priming effect in the RT regression analyses ( $p < .05$ ).



*Latencies*

Analyses were conducted with R version 2.11.1 (R Core Development Team, 2010). Response times and accuracy rates were analyzed using linear mixed effects modelling. Both analyses were conducted using the package lme4 (version 0.9-2; Bates, Maechler & Bolker, 2013) and *p*-values were calculated for latency models using the pvals.fnc in languageR package version 4.1 (Baayen, 2011). RTs were log-transformed (base e) for the analyses. Accuracy rates were analyzed using a generalized linear mixed effects model with a binomial distribution. Separate analyses were conducted for each priming direction (L1 to L2 and L2 to L1) because the targets differ across tasks (i.e., English or Japanese translations, respectively). Two independent predictors were considered for each analysis: *Prime Type* (Translation/Unrelated) and *Number of English Senses* (English-Few/English-Many). In addition, the interaction between these two factors was included in the models. In all analyses, we fitted maximal models, which include random intercepts and slopes for fixed effects and interactions (Barr, Levy, Scheepers & Tily, 2013).<sup>1</sup>

As control variables, English word familiarity and word length were added to the L1 to L2 model. Because word familiarity, the number of senses and word length are all highly correlated variables, we removed this collinearity through residualization. This involved fitting a series of three models in which each variable (e.g., *Number of Senses*) was the response variable and the other two correlated variables (i.e., *Word Familiarity* and *Word Length*) were the predictors. The residuals of these models were used as predictors in the analysis. The resulting residualized predictors correlated highly with the original predictors (*Number of Senses*  $r=0.94$ ; *Word Familiarity*  $r=0.95$ ; *Word Length*  $r=0.99$ ).

Models for RTs in both priming directions are shown in Tables 3a and 3b. The L1 to L2 analysis showed that responses to English targets preceded by Japanese cognate primes (M=713 ms, SD=148 ms) were significantly faster (29 ms) than those to targets preceded by unrelated Japanese primes (M=742 ms, SD=152 ms;  $t=4.22$ ,  $p<.001$ ). The *Number of English Senses* were significantly impacting the responses such that Japanese-English cognates that had many senses in English were responded to faster than cognates with few senses in English (English-Many; M=709 ms, SD=145 ms; English-Few; M=752 ms; SD=155 ms;  $t=-3.31$ ,  $p<.01$ ). Importantly, the interaction between *Prime Type* and *Number of English Senses* was not significant ( $p=0.80$ ), indicating that the priming effect did not depend on whether prime-target pairs were English-Few or English-Many. In other words, the number of English senses that a target word has in English is predictive of

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1. Accuracy models that included the interaction term in the random effects structure did not converge and therefore the interaction term was not included in the random effects structure.

response times and this is independent of prime type. Regarding the control variables, *Word Length* was significant such that longer words were responded to more slowly ( $t=3.04$ ,  $p<.01$ ). In addition, *Word Familiarity* was highly significant ( $t=-3.96$ ,  $p<.001$ ), such that more familiar words were responded to more quickly. Thus, even when word familiarity is statistically controlled, the main effect of *Number of Senses* remained highly significant, indicating an important role of polysemy in determining response latencies.

The response times in the L2 to L1 direction revealed no effect of *Prime Type* ( $t=0.55$ ,  $p=0.58$ ), with mean target responses following cognate primes and unrelated primes being identical (537 ms; SDs=107 ms and 98 ms, respectively). The *Number of English Senses* significantly impacted the target responses ( $t=2.50$ ,  $p<.05$ ), indicating that responses to English-Few Japanese-English cognates were speeded relative to English-Many cognates. Just as in the L1 to L2 direction the interaction between *Prime Type* and *Number of English Senses* was not significant ( $t=-0.55$ ,  $p=0.58$ ), demonstrating that the difference in the mean RTs for English-Few and English-Many cognates was independent of prime type and thus due to the semantic characteristics of the target cognates.<sup>2</sup>

**Table 3a. Results of the mixed-effects analysis of response latencies for L1 to L2 (L1 prime, L2 target).**

<i>Random effects</i>			
Groups	Name	Variance	SD
Item	<i>(Intercept)</i>	0.004	0.065
	<i>Prime Type</i>	0.003	0.055
Subject	<i>(Intercept)</i>	0.042	0.204
	<i>Prime Type</i>	0.008	0.087
	<i>Number of English senses</i>	0.002	0.049
	<i>English word familiarity</i>	0.000	0.007
	<i>Word length</i>	0.001	0.028
	<i>Prime Type*Number of English Senses</i>	0.003	0.054
	<i>Residual</i>		0.023

2. As suggested by a reviewer we conducted additional analyses to test whether there was a priming effect earlier in the L2 to L1 priming task. As an experiment progresses, RTs typically reduce as participants become familiar with the task. If L2 primes require more processing time than L1 primes, it is natural that any priming effect would be more noticeable in the earlier stage of the task as RTs are overall slightly longer. To test this idea, we added the predictor *TrialCount* to the L2 to L1 analysis and an interaction between this variable and *Prime Type*. However, while the effect of *TrialCount* was a trend ( $p=0.07$ ), the interaction was not significant ( $p=0.16$ ), suggesting that there was no reliable priming effect earlier, or later, in the task.

<i>Fixed effects</i>				
Name	Estimate	Std. error	<i>t</i> -value	Pr(>  <i>t</i>  )
(Intercept)	6.553	0.020	320.62	0.000
Prime Type	0.046	0.011	4.22	0.000
Number of English Senses	-0.076	0.024	-3.31	0.002
English word Familiarity	-0.084	0.021	-3.96	0.000
Word Length	0.031	0.010	3.04	0.003
Prime: Number of English Senses	0.005	0.024	0.25	0.802

Note. The reference level for Prime Type was Translation, and that for Number of English senses was English-Few

Table 3b. Results of the mixed-effects analysis of response latencies for L2 to L1 (L2 prime, L1 target).

<i>Random effects</i>			
Groups	Name	Variance	SD
Item	(Intercept)	0.004	0.062
	Prime Type	0.003	0.056
Subject	(Intercept)	0.010	0.101
	Prime Type	0.000	0.001
	Number of English senses	0.000	0.011
	Prime Type*Number of English Senses	0.000	0.012
	Residual		0.018

  

<i>Fixed effects</i>				
Name	Estimate	Std. error	<i>t</i> -value	Pr(>  <i>t</i>  )
(Intercept)	6.201	0.032	193.27	0.000
Prime Type	0.016	0.030	0.55	0.581
Number of English Senses	0.046	0.018	2.50	0.013
Prime: Number of English Senses	-0.010	0.019	-0.55	0.580

*Accuracy*

Models for error rates in both priming directions are shown in Tables 4a and 4b. In the L1 to L2 direction, there was a significant priming effect such that items preceded by related primes were responded to more accurately (4.9%) than those preceded by unrelated primes (5.8%;  $z=2.74, p<.01$ ). There was no effect of the *Number of English senses* or word length, and there was there no interaction between *Prime Type* and *Number of English Senses*. *Word Familiarity* was significant, such that more familiar words had fewer errors ( $z=-2.12, p<.05$ ). In the L2 to L1 direction, there was an overall significant effect of *Prime Type* with items preceded by translation primes having more errors (2.7%) than items preceded by unrelated primes (2.0%;  $z=-2.84, p<.01$ ). There was no

effect of *Number of English Senses* on accuracy, though the interaction between *Prime type* and *Number of English Senses* was significant: English-Few items were responded to less accurately when preceded by translation primes (3.0%) than when preceded by unrelated primes (0.7%;  $z=2.51, p<.05$ ). In contrast, there was no difference for English-many items preceded by translation (2.5%) or unrelated primes (3.4%).

Table 4a. Results of the mixed-effects analysis of accuracy data for L1 to L2 (L1 prime, L2 target).

<i>Random Effects</i>				
Groups	Name	Variance	SD	
Item	<i>(Intercept)</i>	5.680	2.383	
	<i>Prime Type</i>	4.139	2.034	
Subject	<i>(Intercept)</i>	0.014	0.120	
	<i>Prime Type</i>	1.016	1.008	
	<i>Number of English senses</i>	0.125	0.353	
	<i>English word familiarity</i>	0.185	0.430	
	<i>Length</i>	0.083	0.287	
<i>Fixed effects</i>				
Name	Estimate	Std. error	z-value	Pr(> z )
<i>(Intercept)</i>	-5.126	0.491	-10.45	0.000
<i>Prime Type</i>	1.396	0.51	2.74	0.006
<i>Number of English Senses</i>	-1.185	1.033	-1.15	0.251
<i>English word Familiarity</i>	-1.228	0.578	-2.12	0.034
<i>Word Length</i>	0.127	0.214	0.60	0.552
<i>Prime: Number of English Senses</i>	-0.908	1.018	-0.89	0.372

Note. The reference level for Prime Type was Translation, and that for Number of English senses was English-Few.

Table 4b. Results of the mixed-effects analysis of accuracy data for L2 to L1 (L2 prime, L1 target).

<i>Random Effects</i>			
Groups	Name	Variance	SD
Item	<i>(Intercept)</i>	0.269	0.518
	<i>Prime Type</i>	0.004	0.060
Subject	<i>(Intercept)</i>	0.168	0.409
	<i>Prime Type</i>	0.311	0.558
	<i>Number of English senses</i>	0.392	0.198



<i>Fixed effects</i>				
Name	Estimate	Std. error	z-value	Pr(> z )
(Intercept)	-3.680	0.284	-12.97	0.000
Prime Type	-1.779	0.626	-2.84	0.004
Number of English Senses	-0.183	0.414	-0.44	0.658
Prime: Number of English Senses	1.834	0.729	2.51	0.012

## Discussion

Significant masked translation priming effects were found in RTs only in the L1 to L2 direction. Translation priming effects were found for all items regardless of whether prime-target pairs had English-Few or English-Many senses. In contrast, in the L2 to L1 task, English translation primes, whether they have many or few senses, did not influence the processing of L1 Japanese targets (at least, in terms of response latencies). Overall, this asymmetric pattern of translation priming is consistent with the findings in the literature (Finkbeiner et al., 2004; Gollan et al., 1997; Nakayama et al., 2012) and provides further evidence that significant cross-linguistic priming occurs in the L1 to L2 direction for languages that differ in script. In contrast to latencies, response accuracy was significantly influenced by prime type in *both* directions, though the direction of the effect was different. In the L1 to L2 direction, items preceded by related primes were responded to more accurately, suggesting a facilitatory effect. On the other hand, in the L2 to L1 direction, items preceded by related primes were responded to less accurately than those preceded by unrelated primes. Additionally, in this direction prime type interacted with the number of English senses such that L2 English translation primes induced more errors for items that had few English senses. In terms of the predictions of the Sense Model this is the opposite to what would be predicted: L2 primes should activate the full range of senses for both English-Few and English-Many L1 targets, leading to priming (and hence improved accuracy) for all targets.

It is possible to argue that the L2 primes were sufficiently processed by participants and this lead to semantic interference in processing the L1 targets. However, if this was the case then the interference should have been greater for the English-Many items which have not only a greater number of senses that could potentially interfere, but also non-overlapping senses. In fact, the only evidence of possible interference was in the English-Few condition, in which primes had overlapping senses with the Japanese targets. Moreover, had the L2 primes been processed and interference was caused by semantic mismatch between primes and targets, then this should have been evidenced by the RTs showing a greater delay in processing



for targets proceeded by translation primes. The mean RTs for targets were not affected by prime type, which suggests that the primes were not processed sufficiently to influence processing of the targets. Nonetheless, it is surprising to observe increased accuracy in the unrelated-prime condition for English-Few items. It should be noted that the number of errors in the L2 to L1 task was low (2.4%) and thus the accuracy analyses should be treated with caution.

The primary aim of our research was to test the Sense Model's predictions using Japanese-English cognates. Our results demonstrate that the number of English senses did not modulate the translation priming effect. In the L2 to L1 task, cognate targets had few senses and all of these were shared with the L2 prime, which would predict complete activation of L1 targets by L2 primes. However, in the present experiment no priming effect was observed for either English-Many or English-Few items in the L2 to L1 direction. Thus, activating the total number of senses (complete translation) does not appear to underpin the priming asymmetry (i.e., lack of L2 priming of L1 targets), and therefore the Sense Model appears unable to account for the current findings.

While there may be problems with the Sense Model's account of semantic overlap in masked translation priming, it should be emphasized that overlapping conceptual features are still likely to be critical for most forms of priming to occur in the L2 to L1 direction. Schoonbaert et al. (2009) offer convincing evidence that this is the case. In their study, they observed significant priming effects for non-cognates in both L1 to L2 and L2 to L1 directions in two tasks, masked translation priming with lexical decision (we return specifically to this later) and masked semantic priming with lexical decision, with Dutch-English bilinguals. While priming was observed in both tasks, the priming effect was smaller in semantic priming than in translation priming. Schoonbaert et al. (2009) argued that the difference between tasks arose due to translation prime-targets sharing more conceptual features than semantically related prime-targets (also see de Groot & Nas, 1991; Perea, Duñabeitia & Carreiras, 2008). While these findings highlight the importance of overlapping semantic features, the argument that the degree of semantic overlap between L2 and L1 translations is the only requirement for L2 to L1 priming (i.e., Finkbeiner et al., 2004) does not account for the current pattern of results.

It should be noted that while the Sense Model has problems accounting for these results in lexical decision, it is more successful at explaining the results of semantic categorization. As Wang and Forster (2010) have observed, the Sense Model correctly predicts that L2 to L1 priming occurs for exemplars, but not non-exemplars, in this task. While this priming effect is proposed to be due to the restriction of senses denoted by the category, the restriction of senses cannot be the only explanation, as this should have yielded a priming effect in the L2 to

L1 task in the present experiment. Thus, there must be a fundamental difference between the semantic categorization and lexical decision tasks that leads to the differences observed in L2 to L1 priming. This could be due to the presentation of the category itself, which serves to create initial semantic priming prior to the onset of the prime. If future research uncovered the differences in these two tasks, this would allow for a better explanation in the observed differences.

Importantly, target items in the present study were all cognates. Formal and semantic overlap has been shown to be influential in bilingual processing, and the direction of the effect depends upon both the type of overlap and the task (Dijkstra, Gainger & van Heuven, 1999; Dijkstra, Miwa, Brummelhuis, Sappeli & Baayen, 2010). Research using cognates has repeatedly shown that overlap in both form and meaning leads to greater cross-linguistic activation than for noncognate translations, which share only meaning (see Dijkstra, 2007, for a review). This cognate facilitation effect has been found in multiple studies with languages that share script (e.g., Costa, Santesteban & Cano, 2005; Duñabeitia, Perea & Carreiras, 2010; Lemhofer et al., 2008; Van Assche, Duyck, Hartsuiker & Diependaele, 2009; Van Assche, Drieghe, Duyck, Welvaert & Hartsuiker, 2011) and those that do not (e.g., Gollan, Forster, & Frost, 1997; Kim & Davis, 2002; Hoshino & Kroll, 2008; Voga & Grainger, 2007).

Although cognate facilitation in L2 to L1 masked priming has been observed in same-script languages (de Groot & Nas, 1991; Sanchez-Casas, Davis, & Garcia-Albea, 1992), in the two studies with different-script language cognates (Japanese-English in the present study and Hebrew-English in Gollan et al., 1997), L2 to L1 priming was *not* observed. In other words, when languages share script, the formal overlap of cognates (+O+P) facilitates masked priming in the L2 to L1 direction but this is not the case when languages do not share script (-O+P). Theoretical models such as the BIA+ assume that when there is no shared orthography for different script bilinguals, there should be no cross-linguistic activation between orthographic codes (Dijkstra & van Heuven, 2002). Thus, L1 orthography cannot be activated through bottom-up processes via L2 orthography. This would lead to less overall activation of L1 semantic and phonological codes compared to the same task with same-script bilinguals. In other words, cross-linguistic activation is greatly reduced due to the absence of shared orthography (i.e., a shared-script).

A recent study (Nakayama et al., 2013) did reveal cognate priming in the L2 to L1 direction with a lexical decision task and with Japanese-English bilinguals. In their study, both high and low proficiency bilinguals demonstrated significant priming effects (30 ms and 15 ms, respectively). In Nakayama et al. (2013), an L2 proficiency measure derived from a formal language test (TOEIC test of English proficiency) was used while in the present study we used self-ratings, meaning the proficiency measures are not directly comparable. However,

judging from the mean RTs in the L1 to L2 task (regardless of priming condition), it appears that their bilinguals had higher L2 proficiency than those in the present study (Nakayama et al., mean RT for all participants=634ms; low proficiency=644ms; high proficiency=623ms; present study=736ms). The difference in L2 performance may be due to proficiency differences in participants across the two studies. When bilinguals have high L2 proficiency, this would be reflected in the BIA+ by higher subjective frequencies for L2 lexical representations, which would lead to faster processing of L2 primes and targets. Thus, when primes are processed more quickly, it follows that there is a greater chance of activation of cross-linguistic L1 lexical representations as demonstrated by the L2 to L1 priming effect in Nakayama et al.'s study. Another study that used high proficiency Dutch-French bilinguals and also obtained L2 to L1 priming in lexical decision was Duyck and Warlop (2009). Bilinguals in this study rated themselves as 5.7 for reading proficiency in L1 Dutch (on a 7-point scale, from very bad (1) to very good (7)) and 4.2 in L2 French, which demonstrates considerably higher L2 proficiency than in the present study. A study by Wang (2013) tested English-Chinese/Chinese-English bilinguals who had lived/were living in Singapore, where both languages were used daily, and found symmetrical priming. Again, these participants were all considerably higher in L2 proficiency than the present Japanese-English bilinguals.

Schoonbaert et al. (2009) reported L2 to L1 masked priming in lexical decision with Dutch-English bilinguals and Schoonbaert et al. (2011) reported a similar finding with English-French bilinguals. In these studies, noncognates were used to minimize the role of formal overlap between prime-target translations. While priming effects were stronger in the L1 to L2 direction, significant facilitation was reported in the L2 to L1 direction. Schoonbaert et al. (2009, 2011) argued that the significant priming effect in the L2 to L1 direction was due to the presentation of primes for 100ms, which allowed greater processing time of the L2 prime. They suggested that L2 to L1 priming requires more processing time at the prime presentation stage. If this explanation is correct, the asymmetry reported in previous research could be due to the short prime presentation duration.

Essentially, for L2 to L1 priming to occur, the question becomes whether it is the initial presentation that requires increased processing time or whether it is total processing time that needs to be extended. It has been emphasized that if a prime is presented for 50ms and followed immediately by the target, the processing of the prime must continue while the target is being processed (Forster, 2013). This explains how L1 to L2 priming can occur at around 50ms prime durations. In the present study, the 50ms prime was followed by a 150ms backward mask, effectively allowing participants 200ms to process the prime, which should have been sufficient to allow semantic processing to occur (*ibid.*), at least in the L1

to L2 direction. In the opposite direction, this 200ms is insufficient to allow for semantic processing of the L2 prime or, if Schoonbaert et al. are correct, it could be the initial processing of the prime that is the issue.

In terms of theoretical models such as the BIA+, L2 processing is delayed relative to L1 processing due to the relative differences in subjective frequency of use of the two languages in unbalanced bilinguals (Dijkstra & van Heuven, 2002). Thus, the explanation of needing increased processing time is appropriate if one assumes that this leads to greater overall activation between L2 lexical representations and conceptual information based on reciprocal activation between these elements of the bilingual processing system. Longer durations for L2 masked primes in lexical decision tasks with languages that share script, and more importantly with languages that do not share script, should be evaluated in terms of the resulting priming effects. In this case, a necessary additional question is whether participants are aware of the primes: the issue with increasing prime duration is that participants may become aware of the prime and adopt a translation strategy that would make it impossible to draw conclusions about the underlying architecture of the lexicon.

The account provided by the BIA+ is particularly interesting if we look at languages that differ in script. In most accounts of word recognition, phonological processing is thought to occur at a later stage in word recognition than orthographic processing. The time required to activate L1 phonology from an L2 prime in a different script should be longer than the processing time required to activate L1 orthography via an L2 prime that shares script. In line with the temporal delay hypothesis (Dijkstra & van Heuven, 2002), this would lead to slower spreading cross-linguistic activation from L2 phonology. Moreover, for cognates, while orthography can be shared completely (as in *metro-metro* in Dutch-English) in same script languages, phonology is rarely identical across languages (regardless of script). This may further reduce the cross-linguistic effects of phonological similarity relative to those of orthography in shared script languages.

An additional concern is that initial decoding of different script languages is slow relative to same script languages. As Schoonbaert et al. (2009) put it

An advantage of a shared script is that many of the early processes in word recognition (e.g., letter identification, phonological coding) can be shared between L2 and L1, so that L2 word recognition can profit from the already well-established and fast-operating L1 machinery [...] In contrast, the processing of words in a different script relies on other processes that are not as well practiced as the processes of L1, so they take more time to complete. (p. 582)

Thus, the lack of a L2 to L1 priming effect for different script bilinguals may be unsurprising.



It is currently an open question as to whether increasing prime duration can induce a priming effect in the L2 to L1 direction when languages differ in script. By increasing prime duration, not only will different script bilinguals have more time in which to decode the less familiar L2 script, but the additional time would also potentially allow for greater build up of cross-linguistic activation between L2 and L1 phonological and semantic codes, which is particularly important because phonological features are rarely identical across languages. As stated previously, it would be essential to test whether participants are aware of the primes as this may influence the strategies they employ during the task. These tentative hypotheses hold promise for future research investigating translation priming with different script bilinguals.

Interestingly, in the current study, the number of senses of the target words was shown to significantly influence response latencies in both the L1 and L2 and this effect was independent of prime type. The effect of number of senses also varied depending on the language of the task. In the English lexical decision task, words with more senses were speeded relative to those that had few senses. Importantly, this effect was highly significant even when word familiarity was statistically controlled for in the model. Thus, while English-Many items were more familiar to participants and thus responded to more quickly, it was also the greater number of senses that these words have which lead to speeded lexical decisions. This is in line with previous research that has shown that responses to words with multiple senses are speeded relative to those for single-sense words in monolingual lexical decision (e.g., Hino et al., 1996; Hino & Lupker, 2002).

In the Japanese task, words with few English senses were speeded relative to those with more English senses. This was true even though word familiarity was controlled. Thus, when Japanese targets had few senses in Japanese (and English) they were processed more quickly, in other words showing a polysemy disadvantage. However, there was little difference between the number of senses of targets in Japanese compared to that of the English targets. Thus, whereas polysemy effects were evidenced with English targets due to the greater variability of senses, this cannot be said to be the case for the Japanese targets. Instead, another factor may be important in addition to the number of senses. Previous research suggests that concreteness interacts with the effect of number of senses, such that when words have few senses then concreteness effects may emerge (Tokowicz & Kroll, 2007). Concreteness is naturally highly correlated with the number of shared senses because words that are more concrete, tend to have fewer senses and vice-versa. Tokowicz and Kroll's (2007) findings in monolingual lexical decision with items that varied in the number of senses and concreteness revealed a concrete advantage for items that had one sense, but a concrete disadvantage for items that had two or more senses. The present findings display a similar trend in



that responses to Japanese items, which all nouns had one or very few senses, displayed an advantage for items that were more concrete. In contrast, in the English task, where items differed more greatly in the number of senses, there was a significant polysemy advantage. While these findings warrant further research, crucially the influence of number of senses was independent of the priming effects observed in the present study.

## Conclusion

In the present research it was shown that the priming asymmetry is robust for Japanese-English cognates in lexical decision with L1 primes speeding responses but L2 primes having no effect. The manipulation of semantic overlap in the present experiment showed that there was no processing benefit when L1 primes activated all of the senses of L2 targets compared to when primes activated a smaller proportion of L2 senses of targets. More importantly for testing the Sense Model, when L2 primes activated the full range of the L1 targets' senses, no priming effect was observed. These findings are problematic for the Sense Model, which assumes activating the total number of senses is what drives priming in cross-linguistic language tasks such as lexical decision and semantic categorization. The findings are more compatible with a view that L2 to L1 priming is not observed in different scripts due to delayed activation of phonological and semantic codes, as opposed to the proportion of activated senses.

## References

- Allen, D., & Conklin, K. (2013). Cross-linguistic similarity norms for Japanese-English translation equivalents. *Behavior Research Methods*, 46(2), 540–563.  
DOI: 10.3758/s13428-013-0389-z
- Amano, S., & Kondo, T. (2000). *Nihongo-no goi-tokusei* [Lexical properties of Japanese] Vol. 7. [CD-ROM]. Tokyo: Sanseido.
- Barr, D.J., Levy, R., Scheepers, C., & Tily, H.J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, 68, 255–278.  
DOI: 10.1016/j.jml.2012.11.001
- Baayen, R.H., Davidson, D.J., & Bates, D.M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, 59, 390–412.  
DOI: 10.1016/j.jml.2007.12.005
- Baayen, R.H. (2011). LanguageR. Version 4.1. Available at: <http://cran.r-project.org/web/packages/languageR/index.html>
- Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B., & Treiman, R. (2007). The English Lexicon project. *Behavior Research Methods*, 39, 445–459. DOI: 10.3758/BF03193014

- Bates, D., Maechler, M., & Bolker, B. (2013). lme4: Linear mixed-effects models using Eigen and Eigenfaces [Software]. URL <https://github.com/jjallaire/lme4/> (R package version 0.9-2)
- BNC. (2007). The British National Corpus, version 3 (BNC XML Edition): Distributed by Oxford University Computing Services on behalf of the BNC Consortium. Available: <http://www.natcorp.ox.ac.uk/>.
- Costa, A., Santesteban, M., & Caño, A. (2005). On the facilitatory effects of cognate words in bilingual speech production. *Brain and language*, 94, 94–103.  
DOI: 10.1016/j.bandl.2004.12.002
- De Groot, A.M.B., & Nas, G.L.J. (1991). Lexical Representation of Cognates and Noncognates in Compound Bilinguals. *Journal of Memory and Language*, 30 (1), 90–123.
- Dijkstra, A. (2007). The multilingual lexicon. In M.G. Gaskell (Ed.), *Oxford Handbook of psycholinguistics* (pp. 251–265). Oxford, UK: Oxford University Press.
- Dijkstra, T., Grainger, J. & Van Heuven, W.J.B. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language*, 41, 496–518.
- Dijkstra, T., Miwa, K., Brummelhuis, B., Sappeli, M., & Baayen, R.H. (2010). How cross-linguistic similarity affects cognate recognition. *Journal of Memory and Language*, 62, 284–301. DOI: 10.1016/j.jml.2009.12.003
- Dijkstra, T., & van Heuven, W.J.B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, 5(3), 175–197.
- Dunabeitia, J.A., Perea, M., Carreiras, M. (2010). Masked translation priming effects with highly proficient simultaneous bilinguals. *Experimental Psychology*, 57(2), 98–107.  
DOI: 10.1027/1618-3169/a000013
- Duyck, W. (2005). Translation and associative priming with cross-lingual pseudohomophones: Evidence for nonselective phonological activation in bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 31, 1340–1359.  
DOI: 10.1037/0278-7393.31.6.1340
- Duyck, W., & Warlop, N. (2009). Translation Priming Between the Native Language and a Second Language: New Evidence From Dutch-French Bilinguals. *Journal of Experimental Psychology*, 56(3), pp. 173–179. DOI: 10.1027/1618-3169.56.3.173
- Elston-Güttler, K.E., Gunter, T.C., & Kotz, S.A. (2005). Zooming into L2: global language context and adjustment affect processing of interlingual homographs in sentences. *Brain research. Cognitive brain research*, 25(1), 57–70. DOI: 10.1016/j.cogbrainres.2005.04.007
- Finkbeiner, M., Forster, K.I., Nicol, J., & Nakamura, K. (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory & Language*, 51, 1–22.  
DOI: 10.1016/j.jml.2004.01.004
- Forster, K.I. (2013). How many words can we read at once? More intervenor effects in masked priming. *Journal of Memory and Language*, 69(4), 563–573. DOI: 10.1016/j.jml.2013.07.004
- Forster, K.I., & Forster, J.C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, 35, 116–124.  
DOI: 10.3758/BF03195503
- Gernsbacher, M.A. (1984). Resolving 20 Years of Inconsistent Interactions Between Lexical Familiarity and Orthography, Concreteness, and Polysemy. *Journal of Experimental Psychology: General*, 113(2), 256–281. DOI: 10.1037/0096-3445.113.2.256
- Gollan, T.H., Forster, K.I., & Frost, R. (1997). Translation priming with different scripts: masked priming with cognates and noncognates in Hebrew-English bilinguals. *Journal of experimental psychology. Learning, memory, and cognition*, 23(5), 1122–1139.  
DOI: 10.1037/0278-7393.23.5.1122

- Grainger, J., & Frencke-Mestre, C. (1998). Masked priming by translation equivalents in proficient bilinguals. *Language and cognitive processes*, 13(6), 601–623.  
DOI: 10.1080/016909698386393
- Hino, Y., & Lupker, S.J. (1996). Effects of polysemy in lexical decision and naming: An alternative to lexical access accounts. *Journal of Experimental Psychology: Human Perception and Performance*, 22(6), 1331–1356. DOI: 10.1037/0096-1523.22.6.1331
- Hino, Y., Lupker, S.J., & Pexman, P.M. (2002). Ambiguity and synonymy effects in lexical decision, naming and semantic categorization tasks: Interactions between orthography, phonology and semantics. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 28, 686–713. DOI: 10.1037/0278-7393.28.4.686
- Hoshino, N., & Kroll, J. (2008). Cognate effects in picture naming: Does cross-linguistic activation survive a change of script? *Cognition*, 106, 501–511.  
DOI: 10.1016/j.cognition.2007.02.001
- Hoshino, N., Midgley, K.J., Holcomb, P.J., & Grainger, J. (2010). An ERP investigation of masked cross-script translation priming. *Brain research*, 1344, 159–172.  
DOI: 10.1016/j.brainres.2010.05.005
- Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language & Cognition*, 2, 59–75. DOI: 10.1017/S1366728999000152
- Jiang, N., & Forster, K.I. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory & Language*, 44, 32–51.  
DOI: 10.1006/jmla.2000.2737
- Kim, J., & Davis, C. (2003). Task effects in masked cross-script translation and phonological priming. *Journal of Memory and Language*, 49, 484–499.  
DOI: 10.1016/S0749-596X(03)00093-7
- Kinoshita, S., & Lupker, S.J. (Eds.) (2003). *Masked priming: The state of the art*. New York: Psychology Press.
- Lemhofer, K., Dijkstra, K., Schriefers, H., Baayen, R.H., & Grainger, J. (2008). Native Language Influences on Word Recognition in a Second Language: A Megastudy. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 34 (1), 12–31.
- Nakayama, M., Sears, C.R., Hino, Y., & Lupker, S.J. (2012). Cross-script phonological priming for Japanese-English bilinguals: Evidence for integrated phonological representations. *Language and Cognitive Processes*, 27(10), 1563–1583. DOI: 10.1080/01690965.2011.606669
- Nakayama, M., Sears, C.R., Hino, Y., & Lupker, S.J. (2013). Masked translation priming with Japanese-English bilinguals: Interactions between cognate status, target frequency and L2 proficiency. *Journal of Cognitive Psychology*, 25(8), 949–981.  
DOI: 10.1080/20445911.2013.839560
- Perea, M., Duñabeitia, J.A., & Carreiras, M. (2008). Masked associative/semantic priming effects across languages with highly proficient bilinguals. *Journal of Memory & Language*, 58, 916–930. DOI: 10.1016/j.jml.2008.01.003
- Princeton University “About WordNet.” WordNet. Princeton University. 2010. <http://wordnet.princeton.edu>
- R Development Core Team. (2010). *R: A language and environment for statistical computing version 2.11.1*. <http://www.R-project.org>.
- Sánchez-Casas, R.M., Davis, C.W. & García-Albea, J.E. (1992). Bilingual lexical processing: Exploring the cognate/non-cognate distinction. *European Journal of Cognitive Psychology*, 4, 293–310. DOI: 10.1080/09541449208406189

- Schoonbaert, S., Duyck, W., Brysbaert, M., & Hartsuiker, R.J. (2009). Semantic and translation priming from a first language to a second and back: Making sense of the findings. *Memory & Cognition*, 37(5), 569–586. DOI: 10.3758/MC.37.5.569
- Schoonbaert, S., Holcomb, P.J., Grainger, J., & Hartsuiker, R.J. (2011). Testing asymmetries in noncognate translation priming: Evidence from RTs and ERPs. *Psychophysiology*, 48, 74–81. DOI: 10.1111/j.1469-8986.2010.01048.x
- Shibatani, M. (1990). *The Languages of Japan*. New York: Cambridge University Press.
- Tokowicz, N., & Kroll, J. . (2007). Number of meanings and concreteness: Consequences of ambiguity within and across languages. *Language & Cognitive Processes*, 22(5), 727–779. DOI: 10.1080/01690960601057068
- Tokowicz, N., Kroll, J.F., de Groot, A.M.B., & van Hell, J.G. (2002). Number-of-translation norms for Dutch-English translation pairs: A new tool for examining language production. *Behavior Research Methods*, 34(3), 435–451. DOI: 10.3758/BF03195472
- Van Assche, E., Duyck, W., Hartsuiker, R.J., & Diependaele, K. (2009). The influence of semantic constraints on bilingual word recognition during sentence reading. *Journal of Memory and Language*, 64(1), 88–107. DOI: 10.1016/j.jml.2010.08.006
- Van Assche, E., Drieghe, D., Duyck, W., Welvaert, M., & Hartsuiker, R.J. (2011). Does bilingualism change native-language reading? *Psychological Science*, 20(8), 923–927. DOI: 10.1111/j.1467-9280.2009.02389.x
- Voga, M., & Grainger, J. (2007). Cognate status and cross-script translation priming. *Memory & Cognition*, 35(5), 938–952. DOI: 10.3758/BF03193467
- Wang, X., & Forster, K.I. (2010). Masked translation priming with semantic categorization: Testing the Sense Model. *Bilingualism, Language and Cognition*, 13(3), 327–340. DOI: 10.1017/S1366728909990502
- Wang, X. (2013). Language dominance in translation priming: Evidence from balanced and unbalanced Chinese-English bilinguals. *Quarterly Journal of Experimental Psychology*, 66(4), 727–743. DOI: 10.1080/17470218.2012.716072