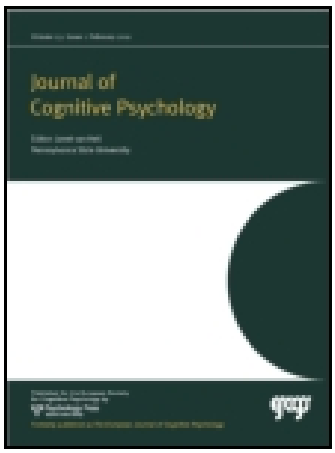

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Bidirectional transfer: The effect of sharing a translation

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This study investigated reciprocal influences between the first and second languages of bilingual speakers. Participants were monolingual English speakers and bilingual speakers of English and Hebrew who learned Hebrew either as a first language or as a second language. Participants rated the semantic similarity of English word pairs that either shared a Hebrew translation or did not, and that varied in their baseline relatedness in English. Shared-translation pairs (e.g., tool and dish are both translated as ''kli'' in Hebrew) were rated as more similar in meaning than different-translation pairs by both bilingual groups, but not by the monolinguals. Knowledge of Hebrew influenced the way bilinguals processed words in English not only when Hebrew was the native language but also when it was learned as a second language later in life. These findings provide evidence for bidirectional transfer, and emphasise the dynamic nature of the bilingual lexicon.

Keywords: Bilingualism; Translation ambiguity; Semantic transfer; Semantic similarity; Shared-translation effect.

The majority of individuals in the world are proficient in more than one language. This raises a number of important, yet unresolved, questions about the interplay between language and cognition that cannot be addressed in monolinguals. One such question is whether knowledge of the different ways in which languages assign words to meanings affects how word meanings are represented and processed in the different languages. Consider an ambiguous word with two meanings, such as the Hebrew word ''kli'', which refers to both ''tool'' and ''dish''. In contrast to English, Hebrew does not lexically distinguish these two meanings, and thus both meanings are likely to be activated, at least briefly, whenever the word ''kli'' is encountered (e.g., Elston-Güttler & Friederici, 2005); this fact may make the meanings seem more similar to Hebrew speakers than they would if they did not share a label. Here, we investigate the consequences of this phenomenon for bilinguals when they use the language that *does* make such a distinction, English. Thus, we examine whether knowing that two words share a label in another language makes them seem more related in meaning, and whether the first language (L1) is exclusively able to influence a second language (L2), or whether a later-learned L2 can similarly influence L1.

In previous research, Jiang (2002) examined the meaning similarity of semantically related English (L2) word pairs that did or did not share a label in Chinese (L1). For example, the words ''problem'' and ''question'' both translate into Chinese as ''wenti'', whereas the similarly related

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English words ''advice'' and ''suggestion'' translate into Chinese as ''quangao'' and ''jianyi'', respectively. Native Chinese speakers rated English pairs that shared a Chinese translation as more similar in meaning than pairs that did not share a translation. This pattern converged with participants' online yes/no semantic relatedness judgements (see also Jiang, 2004). Similarly, in an anomaly judgement study, Elston-Güttler and Williams (2008) observed that German-English bilinguals were slower and less accurate to indicate that an English sentence was anomalous when a target word was replaced by a semantically related word that shared a translation in German. For example, bilinguals had more difficulty than monolingual English speakers detecting an anomaly in the sentence ''His shoes were uncomfortable due to a bubble'' because ''bubble'' shares a German translation (''blase'') with ''blister''. However, the influence of L2 on L1 was not explored, nor was the generalisability of these findings to semantically unrelated words (but see Elston-Güttler, Paulmann, & Kotz, 2005, for a different investigation of unrelated pairs).

Here, we extend past research by addressing both of these issues. In particular, native Hebrew speakers with English as an L2 (proficient Hebrew-English bilinguals) and native English speakers with Hebrew as an L2 (proficient English-Hebrew bilinguals) rated the semantic similarity of English word pairs that either shared a Hebrew translation or did not and that varied markedly in their relatedness in English. Accordingly, across these two populations of proficient bilinguals, we examined not only the forward influence of L1 on L2, but also the backward influence of L2 on L1 (see also, e.g., Wolff & Ventura, 2009). Further, these bidirectional influences were examined for both related and unrelated pairs.

The account put forth to explain previous shared-translation effects (Jiang, 2002, 2004) predicts only a forward influence of L1 on L2, but not the reverse. Specifically, the L1 Lemma Mediation Hypothesis (L1-LMH; Jiang, 2000, 2004) suggests that most advanced learners access a copy of the L1 meaning whenever they encounter an L2 word, and thus meanings of words in L1 are likely to influence the meanings of most L2 words, but not the reverse. In contrast, models that assume that semantic representations are shared for both languages in the bilingual lexicon (e.g., Revised Hierarchical Model—Kroll & Stewart, 1994; Distributed Feature Model—de Groot, 1992) provide the foundation for bidirectional influences to emerge. These models assume that the words in the two languages are interconnected, and that they both access (albeit with different ease) a shared semantic level. Therefore, L1 processing is expected to be influenced by the mapping of words to meanings in L2 as well as the reverse (see also, e.g., Ameel, Malt, Storms, & van Assche, 2009, for bidirectional influences in naming patterns).

The current study is the first to examine a bidirectional manifestation of the shared-translation effect, which arises from the fact that many words have more than one translation equivalent. This one-to-many mapping is called *translation ambiguity*, and is relatively widespread (e.g., Prior, MacWhinney, & Kroll, 2007; Tokowicz, Kroll, de Groot, & van Hell, 2002). Here, we identified English word pairs that either shared a translation in Hebrew or did not, and asked whether bilinguals' perceived semantic similarity of such pairs was influenced by their translation status in Hebrew. We used a rating task in which participants indicated the semantic similarity of word pairs. These ratings correlate significantly with other measures of semantic similarity (e.g., feature generation; McRae, de Sa, & Seidenberg, 1997), and predict online task performance (e.g., semantic priming under certain conditions; McRae et al., 1997; semantic judgement, Jiang, 2002).

To examine *bidirectional* transfer, we tested Hebrew-English bilinguals who performed the rating task in their L2, and English-Hebrew bilinguals who performed the task in their L1. Therefore, the same English pairs were used to explore the influence of L1 on L2 and the reverse. Extending previous research, we manipulated the relatedness of the pairs based on English monolinguals' normative ratings, such that our sample included both related (e.g., ''clock'' and ''watch'') and unrelated (e.g., ''tool'' and ''dish'') pairs, that either shared a Hebrew translation or did not.

Shared-translation pairs could be perceived as *more* similar or as *less* similar than different-translation pairs, depending on whether strengthened or inhibitory connections link words that share a translation. A strengthened connection would be expected based on Hebbian principles of coactivation (Hebb, 1949). To illustrate, when a bilingual encounters the Hebrew word ''kli'', it activates its tool and dish meanings (e.g., Elston-Güttler & Friederici, 2005). At the same time, the English lexical representations for tool and dish will be active (e.g., Schwartz & Fontes, 2008),

leading to coactivation of the two meanings and the two English lexical representations. Based on Hebbian principles, this coactivation will likely lead to an associative connection between the two meanings and/or the two English translations.

Alternatively, words that share a translation may in fact develop reciprocal inhibitory connections, because one translation and not the other may be appropriate in a given context. Such inhibitory connections have been postulated to exist between the two alternative meanings of ambiguous words (e.g., Chwilla & Kolk, 2003), and between two unrelated words that share a translation (Elston-Güttler et al., 2005). In an ERP priming study with German-English bilinguals, Elston-Güttler et al. (2005) compared processing of unrelated English pairs that shared a German translation (e.g., pine-jaw for ''kiefer'') to completely unrelated pairs, in and out of sentence context. Less-proficient bilinguals' processing of targets (e.g., ''pine'') preceded by an unrelated shared-translation prime (e.g., ''jaw'') generated stronger negativities in the N200 component than processing of targets preceded by a completely unrelated prime (e.g., ''teeth''). The N200 component is thought to index (sub)lexical rather than semantic processing; thus, the findings were taken to suggest that inhibitory *lexical* links exist between unrelated words that share a translation. More-proficient bilinguals exhibited longer latencies to make a lexical decision to targets preceded by a shared-translation prime relative to an unrelated prime, but the effect was not observed in the ERP record or when the words were embedded in a sentence. The authors suggested that increased control allowed the more-proficient bilinguals to overcome the inhibitory lexical connections.

These inhibitory connections may thus imply that unrelated shared-translation pairs should be perceived as *less* similar than matched different-translation pairs, which presumably are not linked via inhibitory connections. It is not clear, however, whether this account can be extended to related pairs that share a translation. For instance, the related words ''watch'' and ''clock'', which share the Hebrew translation ''shaon'', in fact apply in many of the same contexts (e.g., checking the time). Under models of cascaded activation (e.g., Plaut, McClelland, Seidenberg, & Patterson, 1996), which assume that activation flows from the lexical to semantic level and the reverse, inhibition of the word ''watch'' would inhibit its semantic features (including those shared with the word ''clock''), thereby inhibiting activation of the intended word ''clock''. There is thus little advantage in developing inhibitory connections for related shared-translation pairs. Moreover, as described earlier, previous research has demonstrated increased perceived similarity for such related shared-translation pairs over related different-translation pairs (e.g., Elston-Güttler & Williams, 2008; Jiang, 2002, 2004).

To summarise, the present study examines the potential influences of both L1 and L2 on bilingual word meanings. Two groups of proficient bilinguals differing in the order in which they acquired English and Hebrew rated the meaning similarity of English word pairs that either shared a translation in Hebrew or did not. Based on models that posit connections between L1 and L2 at both the lexical and the semantic levels, we predict that both bilingual groups, but not monolinguals, will show a difference between shared- and different-translation pairs. Furthermore, the shared-translation effect is examined for both related and unrelated English word pairs. Based on previous research (e.g., Elston-Güttler & Williams, 2008; Jiang 2002, 2004), we expect related shared-translation pairs to be perceived as *more* similar in meaning than different translation pairs. Unrelated shared-translation pairs may be perceived as *less* similar than unrelated different-translation pairs if inhibitory links exist between them (Elston-Güttler et al., 2005). Alternatively, if coactivation leads to associative connections between the two meanings of words that share a translation, both related and unrelated shared-translation pairs are predicted to be rated as *more* similar in meaning than different-translation pairs.

METHOD

Participants

Twenty-six Hebrew-English bilinguals, 26 English-Hebrew bilinguals, and 26 English monolinguals participated. We recruited bilinguals through e-mail and monolinguals through the University of Pittsburgh's Psychology pool. Participants completed a Web-based semantic similarity task followed by a language history questionnaire, which revealed some differences between the groups on background characteristics (see Table 1). Note that all bilinguals were immersed in a Hebrew-speaking environment at the time of testing, but were not aware that

TABLE 1
Background characteristics for the final set of participants by group

	Linguistic background group		
Measure	*Hebrew-English bilinguals*	*English-Hebrew bilinguals*	*English monolinguals*
Number of participants	26 (12 males)	26 (6 males)	26 (10 males)
L1	Hebrew	English	English
Age (years)	32.27 (10.83)[a]	50.04 (15.72)[b]	18.54 (0.71)[c]
Age began L2 (years)	8.46 (2.23)[a]	15.58 (14.67)[b]	n/a
Time studied L2 (years)	12.58 (5.54)[a]	23.14 (17.66)[b]	n/a
L2 immersion (years)	1.19 (2.17)[a]	19.35 (13.24)[b]	n/a
L1 proficiency	9.96 (0.16)[a]	9.91 (0.23)[a]	9.45 (0.91)[b]
L2 proficiency	8.23 (0.89)[a]	7.38 (1.86)[a]	n/a
L1 current use	4.74 (0.51)[a]	4.45 (0.56)[b]	4.89 (0.16)[a]
L2 current use	3.80 (0.61)[a]	4.28 (0.88)[a]	n/a

Proficiency scores are the average of reading, writing, conversational, and speech comprehension ability ratings on a 10-point scale, on which 1 indicated the lowest level of ability. Current use scores are the average of speaking, writing, reading, listening to the radio, and watching TV ratings on a 5-point scale on which 1 indicated the lowest level of current use. Means in the same row that do not share superscripts differ at the $p < .05$ level in a *t*-test with the Bonferroni correction for multiple comparisons.

they were recruited due to their knowledge of Hebrew.[1] English monolinguals identified themselves as not being proficient in any language other than English, although some had studied a language other than Hebrew ($M = 3.8$ years, $SD = 0.91$).

Design

A 3 (linguistic-background group: Hebrew-English, English-Hebrew, English monolingual) $\times 2$ (translation type: shared translation, different translations) $\times 2$ (relatedness: related, unrelated) mixed design was used.

Stimuli

Initially, a separate group of 24 English monolinguals rated 320 English word pairs for semantic similarity. Each participant rated 240 pairs on a scale from 1 (''completely different'') to 7 (''exactly the same''); each pair was rated by at least 11 participants. From these, a set of 280 English word pairs, including candidates for the shared-translation condition (both English words had the same Hebrew translation) and the different-translation condition (each English word had a different Hebrew translation), was selected. To confirm translation status, six Hebrew-English bilinguals provided all known Hebrew translations for one word from each of the 280 pairs. Only pairs that were never given the same translation were considered for the different-translation condition. Those that received an identical Hebrew translation at least once for both words were considered for the shared-translation condition, under the assumption that the existence of a shared translation may influence the results, even if not all participants retrieved it during the translation task.

Twenty-eight critical pairs were then selected for each of the four experimental conditions (see Table 2). The 112 critical pairs (see Appendix) were chosen so that related pairs were rated as more similar than unrelated pairs by monolingual English speakers. Moreover, related pairs received higher LSA similarity values based on their cooccurrence compared to unrelated pairs. Importantly, the shared and different-translation conditions for each level of relatedness did not differ in their semantic similarity rating ($ps > .95$); and shared-translation pairs were *less* similar than different translation pairs based on LSA values ($p < .05$). Related and unrelated shared-translation pairs did not differ in the degree to which they elicited the same translation (translation overlap $p > .2$). Across the four conditions, the pairs were matched along several

[1]Data from nine additional bilinguals were replaced because they learned English and Hebrew simultaneously, or had an L1 other than Hebrew or English. To equate the number of participants in each version, we randomly excluded two Hebrew-English bilinguals. Data from two additional monolingual English speakers were replaced because they did not meet language background criteria.

TABLE 2
Properties and examples of stimuli in the experimental conditions

	Condition			
	Related		Unrelated	
	Shared translation	*Different translations*	*Shared translation*	*Different translations*
Example pairs in English Hebrew translation(s)	watch-clock shaon	chance-opportunity sikui-hizdamnut	tool-dish kli	marriage-moment nisuim-rega
Mean translation overlap	2.21 (0.79)	0	1.96 (0.88)	0
Mean baseline semantic similarity	5.29 (0.74)	5.30 (0.66)	1.93 (0.57)	1.94 (0.52)
Mean LSA similarity values	0.29 (0.15)	0.43 (0.18)	0.08 (0.07)	0.11 (0.10)
English length (number of letters)	6.00 (1.51)	6.00 (1.51)	5.82 (1.48)	6.07 (0.88)
English frequency (HAL)	57651.20 (51556.19)	76453.63 (110589.19)	43543.91 (56187.01)	35371.88 (10509.04)
Imageability rating	482.43 (83.66)	458.36 (98.05)	508.54 (76.42)	457.37 (56.21)
AOA rating	377.20 (89.95)	326.88 (95.16)	361.71 (125.34)	379.17 (75.61)

Standard deviations are shown in parentheses. Translation overlap is the number of times the shared translation was elicited in the normative data (range 0–3). Baseline semantic similarity ratings were given on a scale from 1 (“completely different”) to 7 (“exactly the same”). LSA similarity values were calculated using the term-to-term pairwise comparison available at http://lsa.colorado.edu. The pairs in the four conditions match on averaged length, frequency, AOA ($ps > .1$), and imageability ($p > .08$). Length and frequency were taken from Elexicon (Balota et al., 2002). Imageability and AOA were taken from the MRC database (Wilson, 1988).

lexical dimensions both individually and averaged across the first and second word (see Table 2).

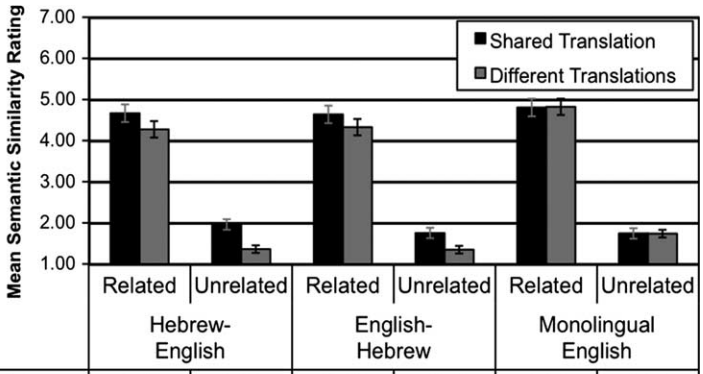
Two lists of 240 pairs were constructed; each was presented to half of the participants from each group in one of two randomised orders. These lists varied to some extent in their stimulus configuration, but importantly only 25% of the pairs in each list shared a translation (of these, 25 and 31 served as critical pairs), and less than 40% (90 and 95 pairs, respectively) were related (i.e., similarity rating more than 3.5). Filler pairs were matched to the critical pairs in length, frequency, imageability, and age of acquisition, $ps > .1$. Filler items were included to minimise the likelihood that participants would notice the experimental manipulation.

Procedure

Participants independently completed the Web-based rating questionnaire, and were encouraged to complete it in one sitting. They were instructed to rate the similarity of each word pair, in the order presented, in terms of meaning, ranging from 1 (“completely different”) to 7 (“exactly the same”), and were provided with two examples. They were then asked to complete the language history questionnaire.

RESULTS

Data were analysed by participants ($F1$) and by items ($F2$) using repeated-measures Analyses of Variance (ANOVAs). The main effect of linguistic-background group was significant only in the analysis by items, $F1(2, 75) = 1.08$, $MSE = 1.87$, $p > .34$; $F2(2, 216) = 10.06$, $MSE = 2.55$, $p < .001$, such that the ratings provided by the monolinguals were higher ($M_{\text{Items}} = 3.29$) than those provided by both bilingual groups ($M_{\text{Items}} = 3.06$ for Hebrew-English; $M_{\text{Items}} = 3.00$ for English-Hebrew). Because the groups were not matched on important characteristics (e.g., age) and because the group effect is qualified by the interaction with translation type (see later), it should be interpreted with caution. More importantly, as predicted, related pairs were rated as more similar in meaning ($M = 4.59$) than unrelated pairs ($M = 1.65$), $F1(1, 75) = 888.92$, $MSE = 0.76$, $p < .001$, $F2(1, 108) = 681.91$, $MSE = 1.07$, $p < .001$. Shared-translation pairs ($M = 3.26$) were rated as more similar in meaning than different-translation pairs



	Hebrew-English		English-Hebrew		Monolingual English	
	Related	Unrelated	Related	Unrelated	Related	Unrelated
Shared Translation	4.67	1.96	4.64	1.75	4.81	1.74
Different Translations	4.27	1.36	4.33	1.35	4.82	1.74

Figure 1. Mean semantic similarity ratings by linguistic background group, translation type, and relatedness. Words with shared translations were rated as more similar than words with different translations by both groups of bilinguals but not by monolinguals. Error bars reflect the 95% confidence intervals surrounding the mean, computed following the procedures recommended by Masson and Loftus (2003).

($M = 2.98$), $F1(1, 75) = 48.61$, $MSE = 1.13$, $p < .001$, $F2(1, 108) = 5.66$, $MSE = 1.07$, $p < .05$. Critically, the main effect of translation type was qualified by an interaction with linguistic-background group, $F1(2, 75) = 13.65$, $MSE = 0.13$, $p < .001$, $F2(2, 216) = 6.55$, $MSE = 2.55$, $p < .01$. Simple-effects tests used to probe the interaction revealed that although shared-translation pairs were rated significantly higher than different-translation pairs by both bilingual groups, $F(1, 75) = 25.98$, $p < .01$, for English-Hebrew, and $F(1, 75) = 49.92$, $p < .01$, for Hebrew-English, there was no corresponding difference for the English monolinguals ($F < 1$; see Figure 1). The remaining interactions with relatedness were not significant ($ps > .1$), indicating that the effect of translation type was similar across the two relatedness levels.

To summarise, consistent with models that allow bidirectional influences between the languages of bilingual speakers, both Hebrew-English and English-Hebrew bilinguals rated shared-translation pairs as more similar in meaning than different-translation pairs, in contrast to the monolingual English group. Further, for both bilingual groups, the increased similarity of shared-translation pairs applied for both related and unrelated English pairs.

GENERAL DISCUSSION

The present study investigated bidirectional influences between the two languages of bilingual speakers of Hebrew and English. The results demonstrated that sharing a translation in Hebrew increases the perceived semantic similarity of words in English, both for native Hebrew speakers and for native English speakers who learned Hebrew as an L2. This bidirectional pattern is in accordance with the assumptions of models that allow both languages to access shared meaning representations (e.g., Distributed Feature Model—de Groot, 1992; Revised Hierarchical Model—Kroll & Stewart, 1994).

Related pairs that shared a translation in Hebrew (e.g., watch-clock) were rated as significantly more similar than related different-translation pairs. These findings replicate Jiang (2002, 2004), and are compatible with the findings of Elston-Güttler and Williams (2008) from an anomaly judgement task. Because in the current study this pattern of results was obtained both for speakers of Hebrew as an L1 and as an L2, the findings are likely not the result of processing of L2 words via copies of the L1 meanings (as postulated by the L1-LMH; Jiang, 2000, 2004). Rather, the influence of L2 on L1 processing together with an influence of L1 on L2 is more compatible with a general account that allows connections between L1 and L2 at the lexical and semantic levels.

Interconnectivity between words in the two languages is a key assumption in bilingual interactive activation models, such as the BIA and BIA+ (Dijkstra & van Heuven, 1998, 2002). These models maintain that interlanguage and intralanguage connections are both present within an integrated lexicon. Thus, given the interlanguage links between ''kli'' and ''tool'' and between ''kli'' and ''dish'', activation flow is likely to

lead to an intralanguage association between ''tool'' and ''dish''. Although the semantic level has not been fully simulated using these models (but see Kerkhofs, Dijkstra, Chwilla, & de Bruijn, 2006, for a semantic extension), the interactive activation principle of these models would allow in theory for lexical as well as semantic associations to emerge between words that share a translation.

Although it is clear that both bilingual groups exhibit transfer from the nontarget language, it is difficult to directly compare the magnitude of the effects from L1–L2 and L2–L1 with the current data. This is because the groups varied on important background characteristics, such as age and years of exposure to an L2 (see Table 1). The English-Hebrew bilinguals, who exhibited L2–L1 transfer, had more experience using their L2, and therefore many more opportunities for an L2 shared-translation word to exert an influence. A direct comparison of the magnitude of forward and backward transfer awaits future investigation.

Interestingly, the pattern of results observed for related and unrelated pairs was the same. Thus, unrelated pairs that share a Hebrew translation (e.g., tool-dish) were also rated as *more* similar than matched different-translation pairs by both bilingual groups. This finding was not entirely predictable from previous results reported by Elston-Güttler et al. (2005), who had concluded that there was interference in processing of unrelated English word pairs that shared a German homonym translation, manifested in the N200 ERP component for less-proficient bilinguals. Because this component has been linked to lexical level processing (but see, e.g., Martin, Kaine, & Kirby, 2006, linking this component to sub-exical processing), the authors suggested that inhibitory lexical connections exist between unrelated words that share a translation. Based on these findings, if the semantic similarity rating task of the current study reflects lexical-level connections, one would predict reduced similarity between unrelated pairs that share a translation, because presumably an inhibitory connection exists between pairs like ''tool'' and ''dish'' for bilingual speakers who know the shared Hebrew translation ''kli''. In contrast to this prediction, we found that unrelated shared-translation pairs were perceived as *more* similar in meaning than different-translation pairs. It is possible that because the bilinguals in the current study are highly proficient, they relied less on lexical-level connections (in accordance with the Revised Hierarchical Model; Kroll & Stewart, 1994), and were thus less influenced by the inhibitory lexical connections. Note, however, that this would not explain why unrelated shared-translation pairs were rated as *more* similar than their matched different-translation pairs. Furthermore, it is possible that inhibitory lexical links exert their influence early in processing, but that the rating task employed in the current study taps into later, perhaps semantically driven, processes, such as those maintained by general coactivation accounts.

Specifically, we propose that by virtue of coactivation, pairs that share a translation become more strongly interconnected than pairs with different translations. When a word is encountered, its two meanings are activated, at least briefly (e.g., Elston-Güttler & Friederici, 2005), and its two translations are activated (e.g., Schwartz & Fontes, 2008). Based on Hebbian principles (Hebb, 1949), this coactivation leads to an association between the two meanings and/or lexical representations. Alternatively, one could consider these changes as occurring at an intermediate level that is neither purely semantic nor purely lexical. Moreover, assuming that activation flows across levels of representation, these associative connections are likely to exist at multiple levels of representation rather than being restricted to only one.

A change at the semantic level could be understood in the framework of models that emphasise the role of cooccurrence in the organisation of the lexicon (e.g., DevLex; Farkaš & Li, 2002). These allow for semantic changes to occur as a function of the mapping of words to meanings in the two languages. The coactivation of the two senses of a word like ''shaon'' (clock and watch) leads to an increase in the semantic association between them. In the case of unrelated words (e.g., tool and dish for ''kli''), coactivation will lead to the formation of a new association between the two semantic representations. This is not to say that unrelated words such as tool and dish become indistinguishable or extremely highly related, but rather that their coactivation leads to increased perceived similarity.

With this mechanism in mind, it is easier to understand why not only initially related words seem more similar due to the word-to-meaning mapping in the other language, but even the disparate meanings of unrelated words seem

slightly more similar. To illustrate, the pair invite-order received an average rating of 1.77 by English monolinguals, but an average rating of 3.20 by bilinguals. Thus, because a single word in Hebrew (''lehazmin'') corresponds to both meanings, bilinguals perceived these as more semantically similar. Note, however, that the bilinguals did not consider the pair to be *highly* related (the scale ranges from 1 to 7), but instead bilinguals perceived relatively more meaning similarity in this pair than did monolinguals.[2]

The mapping between words and meanings in one language appears to influence the relationship between meanings when bilinguals process the other language. The Sense Model (Finkbeiner, Forster, Nicol, & Nakamura, 2004) suggests that differences between languages in the mapping of words to meanings underlie translation processing. In particular, due to reduced proficiency, words in L2 encompass fewer senses than their L1 translations, and this difference can explain why masked translation priming is typically observed only from L1 to L2 (but see, e.g., Basnight-Brown & Altarriba, 2007; Duyck & Warlop, 2009; Duñabeitia, Perea, & Carreiras, 2010). Translation-ambiguous words of the type used in the current study (e.g., ''kli'' which means ''tool'' and ''dish'') provide a useful tool to examine the predictions of the model with cross-language priming. In particular, the word ''kli'' should prime the word ''tool'', but not the reverse because ''tool'' does not capture the ''dish'' meaning of the Hebrew word ''kli''. By testing bilinguals who differ in the order in which they acquired their languages, as was done in the current study, the same words can serve to test both directions of priming (L1–L2 and L2–L1). Similarly, groups of bilinguals who differ in their language dominance could also be examined because proficiency likely leads to increased knowledge of multiple senses. Testing these groups would allow one to determine whether one-to-many correspondence is sufficient to explain reduced L2–L1 priming, as postulated by the Sense Model.

The current study demonstrated the influence of L2 on L1 meaning within highly proficient bilinguals, who had been immersed in an L2 environment for 20 years on average. Despite these immersion circumstances, the English-Hebrew bilinguals still perceived their proficiency and use as higher in English (L1) than in Hebrew (L2). This is likely due to the availability of English in the general media in Israel, and to their continued contact with other native English speakers. Nonetheless, it is possible that the Hebrew environment in which they have been immersed had a significant role in the bidirectional manifestation of the effect, because frequent exposure to the shared Hebrew translation is required for the formation of the association between words that share a translation. Thus, the specific level of proficiency and the length of immersion that must be achieved before such bidirectional semantic influences become evident are yet to be determined (but see Brown & Gullberg, 2008, for bidirectional influences in the expression of manner in bilinguals living in an L1 environment).

Moreover, although we cannot fully rule out the influence of strategic processes, or that some of the participants may have become aware of the translation-type manipulation, there is reason to believe the current results reflect an actual change in the lexical/semantic associations between words. First, as mentioned previously, semantic similarity ratings correlate with online performance (Jiang, 2002; McRae et al., 1997). Second, because the English-Hebrew bilinguals performed the task in their native language, and were not aware that their knowledge of Hebrew was relevant to their participation, there is no reason to assume they translated the English words during the task. English shared-translation pairs were still rated by this group as more similar in meaning than different-translation pairs, presumably reflecting a change in the strength of the lexical/semantic association.

To conclude, the present study reinforces the notion that L1 semantics influence processing in L2. More importantly, our results provide compelling evidence demonstrating the impact of a later-learned L2 on processing of L1 words. Most notably, our results show that semantics are not solely determined by meaning learned through the L1, but rather are dynamic and may change as an individual acquires distinctions and shared translations in an L2. Thus, findings of semantic transfer from L1 to L2, rather than being taken as evidence of the pervasive and irrevocable influence of L1 on semantic representation, should be

[2]This finding is not due to overall higher similarity ratings in bilinguals, because the overall average rating of the bilinguals was lower than that of the monolinguals.

interpreted as one component of a bidirectional dynamic process of semantic influence.

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REFERENCES

Ameel, E., Malt, B. C., Storms, G., & van Assche, F. (2009). Semantic convergence in the bilingual lexicon. *Journal of Memory and Language*, *60*, 270–290.

Balota, D. A., Cortese, M. J., Hutchison, K. A., Neely, J. H., Nelson, D., Simpson, G. B., & Treiman, R. (2002). *The English Lexicon Project: A web-based repository of descriptive and behavioral measures for 40,481 English words and nonwords.* Washington University. Retrieved from http://elexicon.wustl.edu/

Basnight-Brown, D. M., & Altarriba, J. (2007). Differences in semantic and translation priming across languages: The role of language direction and language dominance. *Memory and Cognition*, *35*, 953–965.

Brown, A., & Gullberg, M. (2008). Bidirectional cross-linguistic influence in L1-L2 encoding of manner in speech and gesture: A study of Japanese speakers of English. *Studies in Second Language Acquisition*, *30*, 225–251.

Chwilla, D. J., & Kolk, H. H. J. (2003). Event-related potential and reaction time evidence for inhibition between alternative meanings of ambiguous words. *Brain and Language*, *86*, 167–192.

De Groot, A. M. B. (1992). Determinants of word translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 1001–1018.

Dijkstra, T., &van Heuven, W. J. B. (1998). The BIA model and bilingual word recognition. In J. Grainger & A. Jacobs (Eds.), *Localist connectionist approaches to human cognition* (pp. 189–225): Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

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*, 175–197.

Duyck, W., & Warlop, N. (2009). Translation priming between the native language and a second language. *Experimental Psychology*, *56*, 173–179.

Duñabeitia, J. A., Perea, M., & Carreiras, M. (2010). Masked translation priming effects with highly proficient simultaneous bilinguals. *Experimental Psychology*, *57*, 98–107.

Elston-Güttler, K. E., & Friederici, A. D. (2005). Native and L2 processing of homonyms in sentential context. *Journal of Memory and Language*, *52*, 256–283.

Elston-Güttler, K. E., Paulmann, S., & Kotz, S. A. (2005). Who's in control? Proficiency and L1 influence on L2 processing. *Journal of Cognitive Neuroscience*, *17*, 1593–1610.

Elston-Güttler, K. E., & Williams, J. N. (2008). First language polysemy affects second language meaning interpretation: Evidence for activation of first language concepts during second language reading. *Second Language Research*, *24*, 167–187.

Farkaš, I., &Li, P. (2002). *DevLex: A self-organizing neural network model of the development of lexicon*. Paper presented at the ninth international conference on Neural Information Processing.

Finkbeiner, M., Forster, K. I., Nicol, J., & Nakamura, K. (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory and Language*, *51*, 1–22.

Hebb, D. (1949). *The organization of behavior: A neuropsychological theory.* New York: Wiley.

Jiang, N. (2000). Lexical representation and development in a second language. *Applied Linguistics*, *21*, 47–77.

Jiang, N. (2002). Form-meaning mapping in vocabulary acquisition in a second language. *Studies in Second Language Acquisition*, *24*, 617–637.

Jiang, N. (2004). Semantic transfer and its implications for vocabulary teaching in a second language. *Modern Language Journal*, *88*, 416–432.

Kerkhofs, R., Dijkstra, T., Chwilla, D. J., & de Bruijn, E. R. A. (2006). Testing a model for bilingual semantic priming with interlingual homographs: RT and N400 effects. *Brain Research*, *1068*, 170–183.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*, 149–174.

Martin, F. H., Kaine, A., & Kirby, M. (2006). Event-related brain potentials elicited during word recognition by adult good and poor phonological decoders. *Brain and Language*, *96*, 1–13.

Masson, M. E. J., & Loftus, G. R. (2003). Using confidence intervals for graphically based data interpretation. *Canadian Journal of Experimental Psychology*, *57*, 203–220.

McRae, K., de Sa, V. R., & Seidenberg, M. S. (1997). On the nature and scope of featural representations of word meaning. *Journal of Experimental Psychology: General*, *126*, 99–130.

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review*, *103*, 56–115.

Prior, A., MacWhinney, B., & Kroll, J. F. (2007). Translation norms for English and Spanish: The role of lexical variables, word class, and L2 proficiency in negotiating translation ambiguity. *Behavior Research Methods*, *39*, 1029–1038.

Schwartz, A., & Fontes, A. B. (2008). Cross-language mediated priming: Effects of context and lexical relationship. *Bilingualism: Language and Cognition*, *11*, 95–110.

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 Instruments and Computers*, *34*, 435–451.

Wilson, M. D. (1988). The MRC psycholinguistic database: Machine readable dictionary, version 2. *Behavior Research Methods Instruments and Computers*, *20*, 6–11.

Wolff, P., & Ventura, T. (2009). When Russians learn English: How the semantics of causation may change. *Bilingualism: Language and Cognition*, *12*, 153–176.

APPENDIX: CRITICAL WORD PAIRS

Note that Hebrew translations were never shown during the experiment and are provided for information only.

Shared Translation Pairs–Related		*Shared Translation Pairs–Unrelated*	
English Word Pair	*Hebrew Translation*	*English Word Pair*	*Hebrew Translation*
arch - rainbow	קשת	acceptance-receipt	קבלה
audience-crowd	קהל	balanced-horizontal	מאוזן
benefit-advantage	יתרון	beak-source	מקור
cart-stroller	עגלה	bill-arithmetic	חשבון
clock-watch	שעון	brother-fireplace	אח
ghost-spirit	רוח	coin-drown	לטבוע
hero-protagonist	גיבור	criticize-visit	לבקר
home-house	בית	crop-tumor	גידול
knob-handle	ידית	fracture-fraction	שבר
learn-study	ללמוד	invite-order	להזמין
light-easy	קל	knot-relation	קשר
limestone-chalk	גיר	map † - tablecloth	מפה
meeting-date	פגישה	nail-carnation	ציפורן
moisture-humidity	לחות	nurse-sister	אחות
net-web^	רשת	overlap-shampoo^	לחפוף
objection-resistance	התנגדות	pillar-page	עמוד
obligation-duty	חובה	pill-ball	כדור
paint-color	לצבוע	race-trunk	גזע
perfect-complete	מושלם	ray-fund	קרן
performance-show	הופעה	read-call	לקרוא
period-point	נקודה	rule-general	כלל
price-cost	מחיר	signal^ - letter	אות
program-plan	תוכנית	society-company	חברה
reaction-response	תגובה	space-gain	רווח
stress-pressure	לחץ	stand-class	מעמד
tall-high	גבוה	tool-dish	כלי
thread-string	חוט	tune-direct	לכוון
trail-path	שביל	undress-expand	להתפשט

Different Translation Pairs–Related		*Different Translation Pairs–Unrelated*	
English Word Pair	*Hebrew Translations*	*English Word Pair*	*Hebrew Translations*
anger-frustration	תסכול-כעס	ability-diary	יומן-יכולת
angle-corner	פינה-זווית	accept-revenge	נקמה-לקבל
apology-regret	חרטה-התנצלות	accurate-attack	התקפה-מדוייק
artist-painter	צייר-אמן	addiction-hair	שיער-התמכרות
chance-opportunity	הזדמנות-סיכוי	apply-episode ^	מקרה-ליישם
clean-shiny	מבריק-נקי	art-publish	לפרסם-אומנות
coach-team	נבחרת-מאמן	bring-track	מסלול-להביא
comment-report	דוח-הערה	brown-nature	טבע-חום
dark-black	שחור-כהה	carrier-cable †	כבל-מוביל
decision-conclusion	מסקנה-החלטה	church-foreign	זר-כנסיה
doubt-suspicion	חשד-ספק	contract-engineer	מהנדס-חוזה
enjoy-like	לחבב-להנות	damage-stuck	תקוע-נזק
fork-spoon	כף-מזלג	deep-increase	
future-tomorrow	מחר-עתיד	dread-ring	טבעת-מפחד
give-provide	לספק-לתת	feature-ground	קרקע-מאפיין
hope-wish	משאלה-תקווה	graveyard-fair	הוגן-בית-קברות
laugh-smile	לחייך-לצחוק	install-curse	קללה-להתקין
machine-equipment	ציוד-מכונה	instruction-nerve	עצב-הוראה
move-turn	לסובב-להזיז	involve-ready	מוכן-מעורב
pencil-pen	עט-עפרון	length-drastic ^	קיצוני-אורך
pleasant-nice	נחמד-נעים	load-regular	־גיל-משא
problem-question	שאלה-בעיה	meet-military	צבאי-לפגוש
reality-truth	אמת-מציאות	mud-bottom	תחתון-בוץ
sleepy-tired	עייף-ישנוני	pick-starter	מתנע-לבחור
sun-star	כוכב-שמש	prefer-final	סופי-מעדיף
theory† - hypothesis	השערה-תיאוריה	six-collection ^	אוסף-שש
transmit-send	לשלוח-לשדר	statement-mother	אמא-הצהרה
vegetable-plant	צמח-ירק	van-congress^	בית-נבחרים-קרון

Note. † Word partially overlaps in form with the Hebrew translation, ^ a borrowed form can be used in Hebrew, but is not the translation that is shared in the shared-translation conditions.