EXAMINING ENGLISH-GERMAN TRANSLATION AMBIGUITY USING PRIMED TRANSLATION RECOGNITION

by

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Many words have more than one translation across languages. Such "translation ambiguous" words are generally translated more slowly and less accurately than their unambiguous counterparts. Additionally, there are multiple sources of translation ambiguity including within language semantic ambiguity and near-synonymy. The present study examines the extent to which word context and translation dominance reduce the difficulties associated with translation ambiguity, using a primed translation recognition task. We further examine how dominance and linguistic context influence translation ambiguity stemming from the two sources, specifically translation ambiguity derived from semantic ambiguity ("meaning translation ambiguity") and translation ambiguity derived from near-synonymy ("synonym translation ambiguity"). Participants were presented with English-German word pairs that were preceded by a related or unrelated prime and were asked to decide if the word pairs were translation equivalents or not. The speed and accuracy with which pairs were recognized as correct translations was examined with respect to translation ambiguity, source of ambiguity, prime relatedness, and translation dominance. Translation-unambiguous pairs were recognized more quickly and accurately than translation-ambiguous pairs. Further, target-translation pairs preceded by a related prime were responded to more quickly than pairs preceded by an unrelated prime. Dominant translations were responded to more quickly than subordinate translations, and source of ambiguity and translation dominance marginally interacted, such that meaning

translation-ambiguous words were more influenced by dominance than synonym translation-ambiguous words. We discuss the results in reference to models of bilingual memory and propose a new model that makes specific predictions about translation ambiguity, the Revised Hierarchical Model of Translation Ambiguity.

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1.0 INTRODUCTION

The process of translating a word often does not result in a simple one-to-one mapping between a word in the first language (L1) and a corresponding translation in the second language (L2). In fact, previous research considering English and Spanish, English and Dutch, and English and German has demonstrated that many words have a one-to-many mapping (Eddington, Degani, & Tokowicz, 2011; Prior, MacWhinney, & Kroll, 2007; Tokowicz, Kroll, de Groot, & van Hell, 2002). We refer to this one-to-many mapping between the source language and target language as "translation ambiguity."

One cause of translation ambiguity is near synonymy in the target language, as in the case of the word "fruit", which has two equivalents in German: "Frucht" and "Obst." Both correspond to the fruit meaning and can be used mostly interchangeably. Translation ambiguity is also sometimes due to semantic ambiguity within the source language. For example, the English word "odd" can mean an 'uneven number' or 'strange', and each of these meanings can be translated into a distinct German word ("ungerade" for the number sense and "merkwürdig" for the strange sense). We refer to the former as the "synonym" type of translation-ambiguous words and to the latter type as the "meaning" type of translation-ambiguous words.

Unlike translation-unambiguous words for which there is only one possible translation, a speaker translating a translation-ambiguous word could activate multiple translations. This parallels within-language semantic ambiguity in which a single word has multiple meanings. The

semantic ambiguity literature has debated whether all meanings of an ambiguous word are activated (context-independent models) or if only the contextually-relevant meaning is activated in a context (context-dependent models). Experimental research has supported context-dependent models (e.g., Simpson, 1981), which assume that context is sufficient to constrain activation to the relevant meaning. However, there is also support for the context-independent models (e.g., Onifer & Swinney, 198l) in which both meanings of an ambiguous word are activated briefly, despite a context biasing only one sense of the word. Although context is an important factor, other factors such as the dominance of the meanings also play a significant role in meaning activation (e.g., Duffy, Morris, & Rayner, 1988; Hogaboam & Perfetti, 1975). Previous research has further demonstrated that meaning frequency and context interact in lexical ambiguity resolution such that the more dominant meaning may be primed by either the dominant or subordinate context yet the subordinate meanings typically can be primed only by the subordinate biasing context (Duffy, et al., 1998; Hogaboam & Perfetti, 1975).

Additionally, the semantic similarity between the various meanings of an ambiguous word is influential in lexical ambiguity resolution and processing (Armstrong & Plaut, 2008, Azuma & Van Orden, 1997, Rodd, Gaskell, & Marslen-Wilson, 2002). For example, polysemous words, which have highly related senses (e.g., paper), are responded to more quickly in a lexical decision task than unambiguous words and homonymous words, which have fewer related senses (Armstrong & Plaut, 2008, Azuma & Van Orden, 1997, Rodd et al., 2002).

Because context, meaning frequency, and semantic similarity all play a role in processing ambiguous words within a language, these factors should also potentially influence processing translation-ambiguous words across two languages (Degani & Tokowicz, 2010a). Research to date has shown that translation-ambiguous words are translated more slowly and less accurately

than translation-unambiguous words (Tokowicz, Prior & Kroll, 2011; Tokowicz & Kroll, 2007; for a review, see Tokowicz & Degani, 2010). This research has provided important insights into the consequences these words have on processing by bilinguals and L2 learners. However, examining how other factors such as dominance and context influence the processing of these words is critical to gaining a more complete understanding of the lexical and semantic representations of these words in the bilingual mind. Yet, to date there are only a limited number of research studies that have directly examined these factors (Elston-Güttler, & Friederici, 2005; Elston-Güttler & Williams, 2008; Elston-Güttler, Paulmann, & Kotz, 2005; Frenck-Mestre & Prince, 1997; Laxén & Lavaur, 2010).

Laxén & Lavaur (2010, Experiment 3) used a translation recognition task to examine the effects of translation dominance and the semantic similarity between the translations of translation-ambiguous words. The translation-ambiguous words that had less semantically similar meaning translations were responded to more slowly overall compared to words with more semantically similar translations and to unambiguous words. Additionally, dominant translations were responded to more quickly than less dominant translations and the dominance effect was greater for words with less semantically similar translations than for words with more semantically similar translations. The authors suggested that this was due to greater shared representations at the semantic level of representation in memory for the more semantically similar translation-ambiguous words. Nevertheless, this study only examined bilinguals' decisions on translation-ambiguous words out of context where ambiguity effects may be exaggerated in comparison to within context effects.

A study by Elston-Güttler et al. (2005, Experiment 2) compared how less and more proficient German-English bilinguals processed homonyms in a sentence context. They also

manipulated dominance of the homonyms' meanings captured by the English translations (e.g., the German word 'keifer' both means 'jaw' and 'pine' in German). In the experiment a sentence biased one meaning of the homonymous word (e.g., *jaw*) which served as the prime. The prime appeared in the final position of the sentence. After a delay, the target word which corresponded to the other sense of the homonym (e.g., *pine*) was presented. Then, participants made a lexical decision to the target word. There were two conditions: (1) a sentence that biased the dominant meaning of the word (e.g., "The sticky candy stuck together his *jaw"*) and a target that represented the subordinate meaning (e.g., *pine*), and (2) a sentence that biased the subordinate sense (e.g., "The beautiful table was made of solid *pine*"), and a target that represented the dominant meaning (e.g., *jaw*). The dominant targets were responded to faster than the subordinate targets, but significant priming was observed only for the less-proficient bilinguals.

Another study by Elston-Güttler and Wilson (2008) examined how German learners of English processed translation-ambiguous words within a sentential context. They used polysemous words in German such as 'Blasen' which translates into both 'blister and 'bubble'. Participants in the study were asked to read a sentence and to decide if the final word in a sentence made sense or not. The German learners of English responded more slowly to the polysemous translations that biased the alternative sense (e.g., "His shoes were uncomfortable due to a *bubble*") than to the same words in a control sentence (e.g., "She was very hungry because of a *bubble*"). This study suggested that all meanings of the ambiguous word were activated, thereby leading to the interference effect. Because this interference effect appears even though only one translated sense was presented, it suggests that on viewing the English word form ('bubble') the bilinguals activated the German word form ('Blasen'), which in turn activated

both meanings and corresponding translations ('bubble' and 'blister') (but see Degani, Prior, & Tokowicz, 2010, for an alternative explanation).

Although Elston-Güttler and Wilson's (2008) study showed that both meanings of a polysemous word are activated in biasing context, they did not directly examine the effects of dominance directly, which may also influence these effects. Dominance is influential in processing ambiguous words (Elston-Güttler et al. 2005; Laxén & Lavaur, 2010) as is semantic similarity between the translations (Laxén & Lavaur, 2010) and these factors may interact with each other. The current study examines these three factors: context, semantic similarity/source of translation ambiguity, and translation dominance. Thus, this study provides a comprehensive investigation of how each of these elements affects processing of translation-ambiguous words and how these factors interact with one another.

Despite the fact that translation ambiguity consistently affects processing, the majority of bilingual models (e.g. Dijkstra & van Heuven, 2002; Jacquet & French, 2002; Kroll & Stewart, 1994; van Hell and de Groot, 1998) have not been adapted to take translation ambiguity effects into consideration. Laxén and Lavaur (2010) described a modified version of the distributed conceptual representation model (DCRM) (van Hell and de Groot, 1998) in explaining their findings. According to the original DCRM, semantic information from a word is distributed across nodes in a shared (L1/L2) semantic level of representation. The time and accuracy of translating a word will then be influenced by how many shared nodes there are between a word in the L1 and its corresponding translation in the L2. Concrete words and cognate translations are thought to share more nodes at the semantic level compared to abstract words and noncognate translations across two languages. The DCRM predicts that the greater the number of shared nodes between the L1 and L2 the faster processing will be. The model

therefore provides an explanation to why concrete words and cognates are translated more quickly than abstract words and noncognates (e.g. de Groot, 1992; van Hell & de Groot, 1998). Laxén and Lavaur's extension of the DCRM included translation-ambiguous words so that more than one translation could be selected at the lexical level of representation. The more semantically similar the possible translations are (as for synonym translation-ambiguous words) the greater number of shared nodes will be active, leading to faster processing (see *Figure 1*). When translations are less semantically similar (as for meaning translation-ambiguous words) there will less shared activation at the semantic level and therefore processing will be slower (see *Figure 2*).

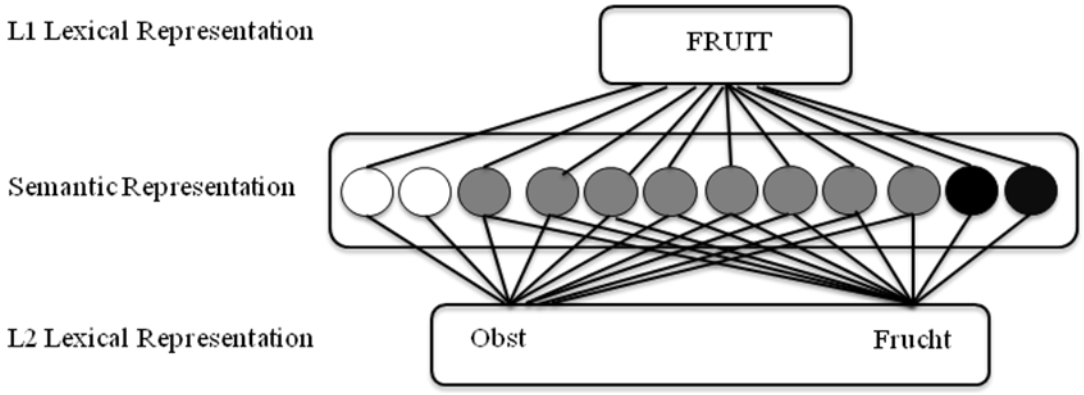

Figure 1. Hypothetical representation of Synonym Translation-Ambiguous words

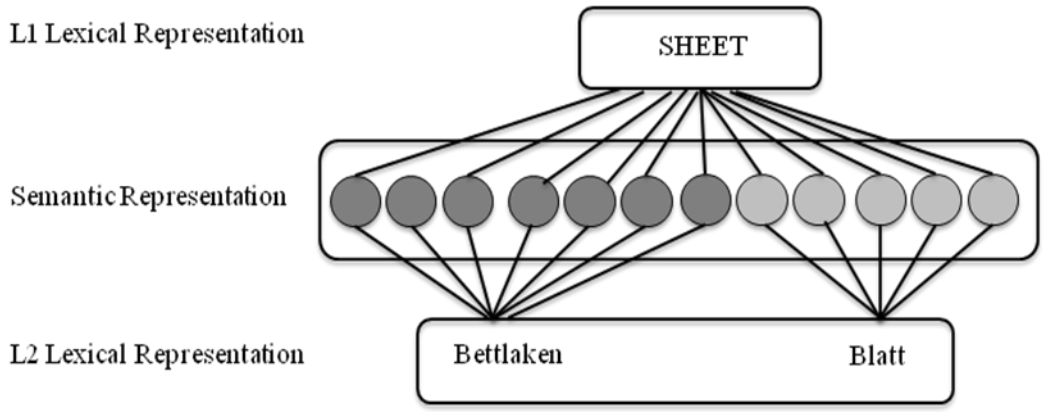

Figure 2. Hypothetical Representation of Meaning Translation-Ambiguous words

The Revised Hierarchal Model (RHM) (Kroll & Stewart, 1994) has also been extended to include translation ambiguity (Kroll & Tokowicz, 2001, see *Figure 3*). The RHM makes several assumptions. First, bilinguals have stronger lexical links from L2 words to their translations in L1 than vice versa. Second, there are stronger links between concepts and their corresponding words in L1. Third, that there are weaker links between L2 words and concepts. Translation from L2 to L1 is thought to be lexically mediated such that the individual accesses the translation by lexical associations. Translation from L1 to L2 is conceptually mediated, such that access to the translation is through concepts or meanings (from the L1 word, to the concept, to the L2 word).

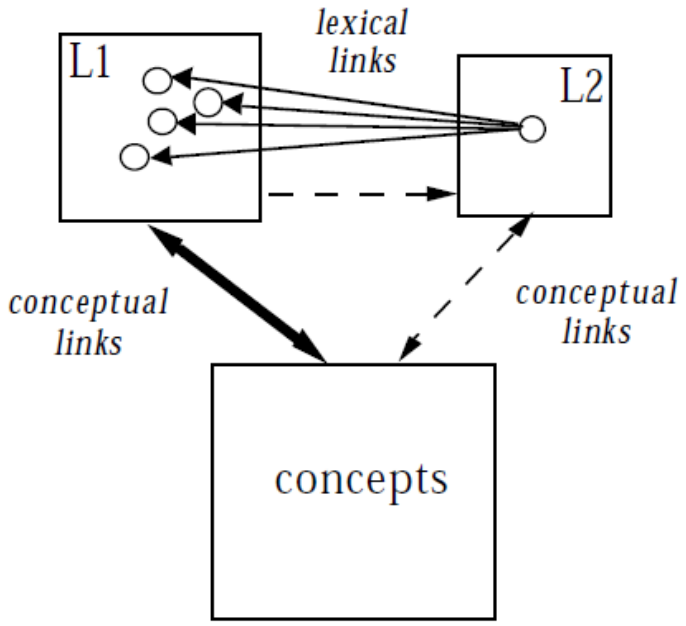

Figure 3. Revised Hierarchical Model adapted to account for translation-ambiguous words

Kroll and Tokowicz (2001) modified the RHM to include translation ambiguous words but synonym and meaning translation-ambiguous words were not distinguished. Here, we incorporate these two elements into the RHM and refer to the adapted model as "Revised Hierarchical Model of Translation Ambiguity" (RHM-TA). The RHM-TA predicts different outcomes for translation-ambiguous words derived from different sources (synonym vs. meaning). For synonym translation-ambiguous words there would only be one link from the L1 to the conceptual level and multiple links between concepts and the L2 (see *Figure 4*). For meaning type translations-ambiguous words there would be multiple connections from each meaning at the conceptual level to the L1 and L2 lexical levels (see *Figure 5*). Overall, the ambiguous word in the L1 would have strong conceptual links to all meanings and each meaning would have a unique connection to the L2 lexicon. Additionally, for meaning translation-ambiguous words with one highly dominant translation, there would be stronger connections to

concepts for the dominant meaning and to the L2 lexicon for the dominant translation; here, we make the simplifying assumption that the dominant translation corresponds to the dominant meaning, although this may not necessarily be the case because the meaning distribution experienced in L1 will not precisely mirror that in L2.

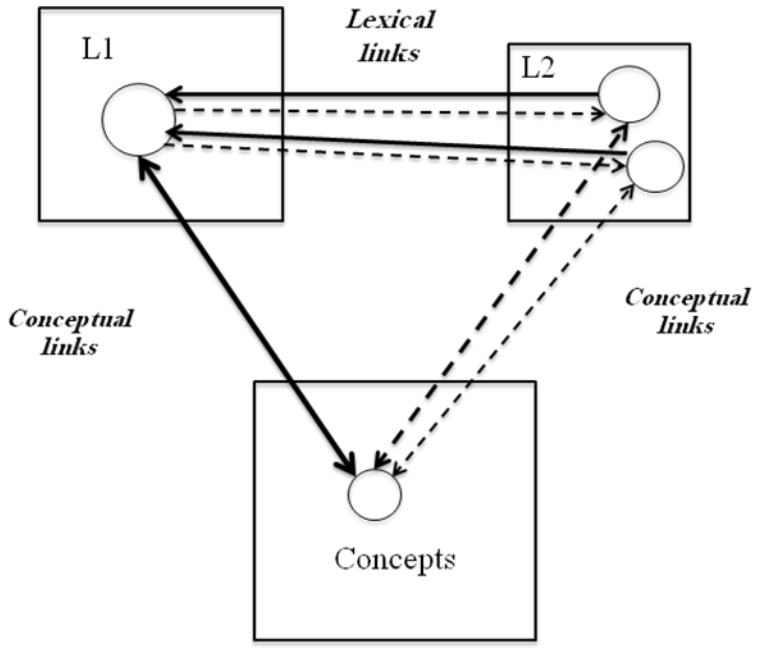

Figure 4. RHM-TA for synonym translation-ambiguous words

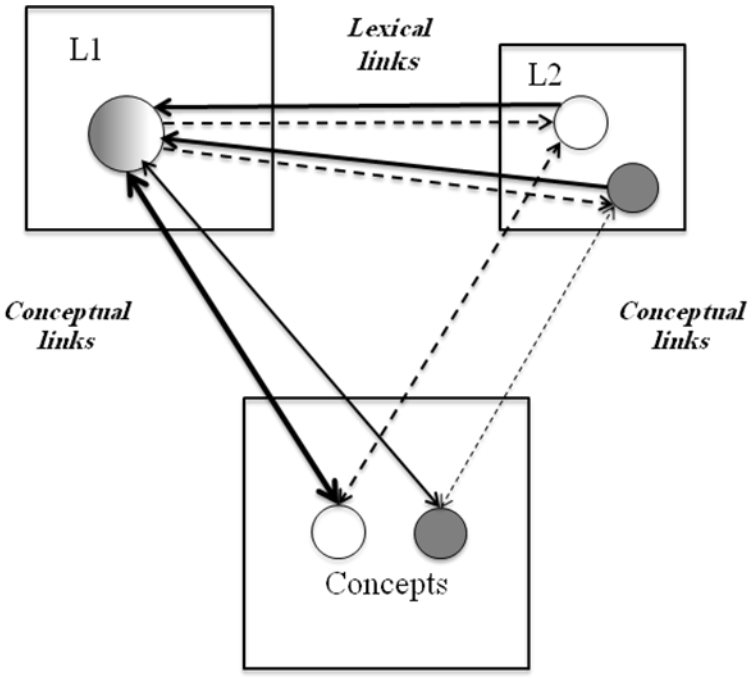

Figure 5. RHM-TA for meaning translation-ambiguous words

The RHM-TA predicts that dominant translations would be processed more quickly than subordinate translations. Furthermore, once the meaning is established for meaning translation-ambiguous words, there would be a more one-to-one connection from the L1 word to the L2 word via concepts. This is because the ambiguity for meaning translation-ambiguous words is from the multiple connections from the L1 lexical level to the conceptual level, but there is a more direct mapping from a single concept to a single word from the conceptual level to the L2 lexical level. For example, if the context biased the 'strange' sense of the word 'Odd' then the only possible translation would be 'merkwürdig.' In contrast, a context for the word 'Fruit' would not limit the possible translations available to a single translation in German; 'obst' and 'frucht' would both remain options. Therefore, meaning translation-ambiguous words may have an advantage over synonym translation-ambiguous words in tasks that establish a context because the latter will maintain a one-to-many mapping regardless of context. Degani and Tokowicz (2010b) in fact found that when training monolinguals on translation unambiguous and

ambiguous Dutch words, the meaning translation-ambiguous words were learned more easily than synonym translation-ambiguous words.

The goals of the current study are to better understand how L2 learners process words with translation ambiguity and understand how context, semantic relatedness, and dominance of the translations interact with processing of these words. Another goal was to examine whether a context could disambiguate translation-ambiguous words. We examined differences between the processing of synonym vs. meaning types of translation-ambiguous words compared to translation-unambiguous words (i.e., words with a single translation) and the differences in processing between the dominant and subordinate translations. Because the semantic similarity between different senses of ambiguous words influence processing within a language (Armstrong & Plaut, 2008, Azuma & Van Orden, 1997, Rodd et al., 2002) we also examined how the perceived semantic similarity between the multiple translations of the translation-ambiguous words correlate with processing speeds.

To examine these issues, we developed a modification of the "translation recognition task" (e.g. de Groot & Comijs, 1995), which we have termed the "primed translation recognition task". In this task, English-German bilinguals decide if pairs of words are correct translations. The pairs are preceded by an unrelated or related prime. Because we were interested in the processing of these various word types, we focused our analyses on the correct translation pairs (i.e., "yes" trials) preceded by unrelated vs. related primes; faster reaction times on related than unrelated trials was taken to indicate priming. Initially, we were additionally interested in whether the matching of the related prime to the meaning of the translation (i.e., a prime that matched the dominant translation paired with that dominant translation vs. paired with the subordinate translation) would affect processing but the manipulation of prime match (match RT:

1259 vs. mismatch RT: 1248) did not yield any effects, $F < 1$, *n.s.* Therefore, we only examine the effects of primes that matched the translation meaning and excluded data from trials on which mismatched primes were presented.

In line with previous studies (e.g. Tokowicz & Kroll, 2007) we predicted an overall ambiguity disadvantage such that translation-ambiguous words would be responded to more slowly and less accurately than unambiguous words. Based on previous semantic priming studies (see Neely, 1991, for an extensive review), we expected target-translation pairs preceded by related primes to result in faster response times than target-translation pairs preceded by unrelated primes. We also predicted that the semantic prime would disambiguate the meaning translation-ambiguous words and make them easier to process. Based on previous studies within a language (Duffy, et al., 1998; Hogaboam & Perfetti, 1975) and across languages (Laxén & Lavaur, 2010) we predicted further that dominant translations (both in synonym and meaning translation-ambiguous words) would result in faster response times than subordinate translations. Additionally, we predicted that the greater the semantic similarity between the multiple translations of the translation-ambiguous words the faster the translation-recognition speed would be. Also, we expected that synonym translation-ambiguous words would be responded to more quickly than meaning-translation ambiguous words based on previous research (Laxén & Lavaur, 2010) and based the predictions of the DCFM. Lastly, based on the RHM-TA we expected a translation ambiguity type by relatedness interaction such that a related prime should facilitate translation-recognition speed more for meaning translation-ambiguous words than synonym translation-ambiguous words. This is because a related prime could potentially disambiguate the meaning-translation ambiguous word by restricting the selection to one

translation but may not disambiguate a synonym-translation-ambiguous word because the prime could not restrict the selection to a single translation.

2.0 METHODS

2.1 PARTICIPANTS

Forty-three native English speaking students from the University of Pittsburgh and The Pennsylvania State University participated in the study. To be included in the final analysis participants had to be proficient in German and not have been exposed to languages other than English before the age of 10. Seventeen participants were excluded due to low accuracy on the primed translation recognition task and prior language exposure. In particular, a participant's data were excluded if they failed to reach 50% accuracy on all three word types in the translation recognition task (unambiguous, meaning translation ambiguous, and synonym translation ambiguous words). All but one of the participants was right handed. All participants completed a language history questionnaire that details their demographic information, previous language exposure, and self-reported ratings on their L1 and L2 proficiency levels (Tokowicz, Michael & Kroll, 2004; see Table 1).

Table 1. Language History Questionnaire Data

Measure	*M (SD)*	Median	Range
Number of Participants	26		
Age	23.00 (4.71)	22.00	18 - 40
Age began L2	13.65 (1.92)	13.50	11 - 18
Time Studied L2 (years)	8.00 (4.19)	8.00	1 - 22
Time Abroad in L2 country (months)	13.39 (39.42)	6.00	0 - 204
L1 Reading ability	9.77 (.043)	10.00	9 - 10
L1 Writing ability	9.69 (.62)	10.00	8 - 10
L1 Conversation ability	9.77 (.51)	10.00	8 - 10
L1 Speech comprehension ability	9.88 (.33)	10.00	9 - 10
L2 Reading ability	6.92 (1.47)	7.00	3 - 10
L2 Writing ability	6.38 (1.88)	7.00	3 - 10
L2 Conversation ability	6.38 (2.14)	7.00	2 - 10
L2 Speech comprehension ability	7.54 (1.53)	8.00	4 - 10

2.2 MATERIALS

2.2.1 Picture Naming

Thirty pictures from the International Picture Naming Project (Szekely, D'Amico, Devescovi, Federmeier, Herron, Iyer, Jacobsen, & Bates, 2003) were selected as stimuli. The mean German name-agreement for these pictures is .98 (*SD* = .06) and the mean log frequency for the labels of the pictures is 2.75 (*SD* = 1.29) (Baayen, Piepenbrock, & Gulikers, 1995).

2.2.2 Primed Translation Recognition Task

The critical word stimuli consisted of 448 prime-target-translation triplets. The target words consisted of 32 translation-unambiguous words, 32 meaning translation-ambiguous words, 32 synonym translation-ambiguous words, and 92 filler targets. For each target, there was a corresponding related and unrelated prime (see Table 2 for example stimuli). There were related and unrelated primes that corresponded to each meaning of a meaning ambiguous word. For synonym translation-ambiguous words there were two translations. Because the synonym translation-ambiguous targets essentially only have one meaning (although there may be slight differences in usage of the words) there was only one related and unrelated prime for each target. Translation-unambiguous targets were paired with a single translation and also had one related and unrelated prime. The conditions were counterbalanced across list versions such that each target word was presented only once per participant.

Prime and target pairs were previously normed for relatedness by a group of native English speakers (Eddington & Tokowicz, 2009). Related and unrelated primes were also matched on frequency (Wilson, 1988) and word length (see Table 3). The correct translations and dominance of the translations were obtained from English-German, German-English number-of-translations norms (Eddington, Degani, & Tokowicz, 2011). The incorrect translations were randomly assigned to the filler target words. The incorrect translations or "no" trials were used as fillers and therefore only "yes" trials were analyzed.

Table 2. Example Stimuli

Type		Related	Unrelated	Target	Translation
		Design	fiscal	ART	Kunst
Synonym	Dominant	Timid	Satin	SHY	Schüchtern
	Subordinate	Timid	Satin	SHY	Scheu
Meaning	Dominant	Bedding	Malaria	SHEET	Bettlaken
	Subordinate	Paper	Start	SHEET	Blatt

Table 3. Mean Log Frequencies and Word Lengths for Related and Unrelated Primes by Type

Type	Related Prime		Unrelated Prime	
	Log Freq.	Word Len	Log Freq.	Word Len
Unambiguous	3.25	5.71	3.3	5.78
Synonym	1.75	5.87	1.71	5.9
Meaning	3.5	5.84	3.54	5.89

2.3 DESIGN AND PROCEDURE

This study used a 3 word type (unambiguous, synonym translation-ambiguous, meaning translation-ambiguous) x 2 relatedness (related prime, unrelated prime) x 2 dominance (dominant, subordinate) within subjects design.

Participant first performed an operation-span task (Turner & Engle, 1989) that evaluated their working memory. We did not, however, evaluate their performance on this task due to missing data and therefore will not be reporting these results. Next, participants completed a picture-naming task to assess relative L2 proficiency, followed by the primed translation recognition task. Participants completed a language history questionnaire to gather detailed

information on language background. Additionally, a subset of participants completed form (spelling and sound) and meaning ratings for the German translations of the translation-ambiguous English words.

The picture-naming task was used to evaluate participants' German language skill level and included 30 pictures normed for name agreement in German (Szekely et al., 2003). After being familiarized with the microphone, participants saw pictures on the screen, one at a time, and were asked to quickly and accurately say the name of the picture in German. A digital recorder recorded their verbal responses and a microphone connected to a button box was used to capture their response times from the onset of the stimulus to the onset of vocalization.

In the primed translation recognition task, participants were asked to decide if English-German word pair translation equivalents were correct or incorrect. The English-German pair was preceded by a prime that was either related or unrelated to the meaning of the German translation. Timing parameters were determined using extensive pilot testing. Participants first saw a fixation cross for 1000 ms, then the prime for 250 ms, followed immediately by the target-translation pair. The participants had up to 3500 ms to decide if the target and translation were correct translation equivalents or not. The trials continued at a set pace. Participants had four breaks throughout the experiment to rest their eyes. The participants used a button box to make their responses (leftmost key for "no" and rightmost key for "yes"). The E-prime software package was used to present the stimuli and to record reaction time (RT) and accuracy measures.

3.0 RESULTS

3.1 PICTURE NAMING

The picture-naming task was used to assess relative proficiency. Participants included in the final analysis correctly labeled 48% (*SD* = .22) of the pictures. Three participants were not included in this analysis due to recording failures.

3.2 PRIMED TRANSLATION RECOGNITION

3.2.1 Data Trimming

One word was removed from the data analysis because it was mislabeled as being a synonym type rather than meaning type ambiguous word (*Triangle).* Following this, response latencies that were above 3000 ms or below 300 ms and all response latencies 2.5 standard deviations above or below each participant's mean were excluded from the analysis. These procedures led to the removal of 3.32% of the data.

3.2.2 Examining ambiguity and priming effect of all words.

Both meaning and synonym type translation-ambiguous words were collapsed in the following 2 word type (ambiguous vs. unambiguous) x 2 prime relatedness (related vs. unrelated) repeated measures ANOVAs, which analyzed mean RT and accuracy data by participants (F_1) and by items (F_2). All means and standard deviations are displayed in Table 4.

Overall, translation-ambiguous words were recognized more slowly (1284 ms vs. 1017 ms) [$F_1(1, 25) = 173.92$, $MSE = 10645.95$, $p < .001$; $F_2(1, 92) = 55.81$, $MSE = 50978.69$, $p < .001$] and less accurately (77% vs. 94%) [$F_1(1, 25) = 156.21$, $MSE = 0.004$, $p < .001$; $F_2(1, 93) = 9.76$, $MSE = 0.025$, $p < .001$] than translation-unambiguous words (see *Figure 6*). Target-translation pairs that were preceded by a related prime were responded to more quickly (1119 ms) than target-translation pairs preceded by an unrelated prime (1182 ms) [$F_1(1, 25) = 11.88$, $MSE = 8714.67$, $p = .002$; $F_2(1, 92) = 12.55$, $MSE = 17100.32$, $p = .001$]. No main effects of relatedness were found in the accuracy analysis, [$F_1(1, 25) = 2.01$, $MSE = 0.009$, $p = .169$; $F_2(1, 93) = .95$, $MSE = 0.007$, $p = .33$]. The ambiguity by relatedness interaction was not significant for the analyses of RT ($Fs < 1$) or accuracy [$F_1(1, 25) = 2.88$, $MSE = 0.008$, $p = .102$; $F_2(1, 93) = 1.59$, $MSE = 0.007$, $p = .21$].

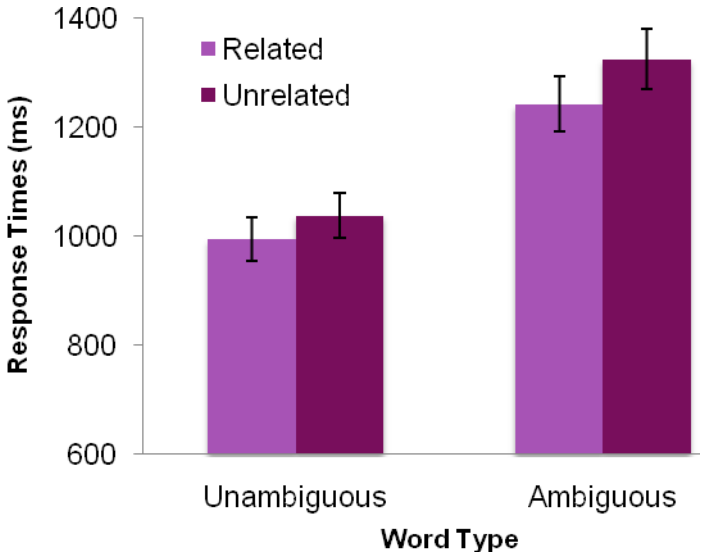

Figure 6. Mean translation recognition RTs (ms) for word type as a function of prime relatedness

We further analyzed the three word types in a 3 word type (synonym, meaning, unambiguous) by 2 prime relatedness (related vs. unrelated) repeated measures ANOVA on RT and accuracy. See table 4 for means and standard deviations. Again, we observe that translation-ambiguous words were recognized more slowly (Synonym: 1284, Meaning: 1268, Unambiguous: 1017) [F_1 (2, 25) = 54.45, *MSE* = 21902.58, $p < .001$; F_2 (2, 91) = 27.96, *MSE* = 51287.58, $p < .001$] and less accurately (Synonym: 79%, Meaning: 75%, Unambiguous: 94%) [F_1 (2, 25) = 41.21, *MSE* = 0.011, $p < .001$; F_2 (2, 92) = 22.31, *MSE* = 0.028, $p < .001$] than translation-unambiguous words. Also, processing was faster following related (1151 ms) than unrelated primes (1228 ms) in the RT analysis [F_1 (1, 25) = 12.23, *MSE* = 16162.06, $p = .002$; F_2 (1, 92) = 17.64, *MSE* = 17216.35, $p < .001$], however such priming was not significant in the accuracy analysis [F_1 (1, 25) = 1.83, *MSE* = 0.024, $p = .189$; F_2 (1, 92) = 3.19, *MSE* = 0.017, $p = .07$]. Word type and relatedness did not interact in either analysis [for RT: F_1 (1, 25) = 1.18, *MSE*

= 16162.06, p =. 316; F_2 (2, 91) = 1.10, *MSE* = 17216.35, p =.34; for accuracy: F_1 (1, 25) = .77, *MSE* = 0.027, p = *.47*; F_2 (2, 92) = 1.04, *MSE* = .017, p = .36].

Table 4. Means and SDs for RT and accuracy by participant for overall ambiguity effects

	Prime				
	Related		Unrelated		
Word Type	RT(SD)	% Correct (SD)	RT (SD)	% Correct (SD)	Priming
Unambiguous	994 (205)	.94 (.09)	1038 (206)	.94 (.00)	-44
Ambiguous	1243 (257)	.80 (.10)	1325 (279)	.75 (.14)	-82*
Synonym	1250 (282)	.82 (.12)	1318 (280)	.75 (.15)	-68
Meaning	1208 (274)	.77 (.19)	1327 (323)	.73 (.18)	-119*

3.2.3 Examining the role of dominance and priming for ambiguous words.

In the following analyses we tested only the translation-ambiguous words, and used a 2 ambiguity type (synonym vs. meaning) x 2 translation dominance (dominant vs. subordinate) x 2 prime relatedness (related vs. unrelated) repeated measures ANOVA on the RT and accuracy data (see Table 5 for means and standard deviations). No RT differences were found between the meaning translation-ambiguous words (1258 ms) and the synonym translation-ambiguous words (1258 ms), all *Fs* < 1). However, synonym translation-ambiguous words were responded to marginally more accurately (.79%) than the meaning translation-ambiguous words (.74%) only in the analysis by participants [F_1 (1, 25) = 3.21, *MSE* = 0.035, p = .085; F_2 (1, 60) = 1.31, *MSE* = 0.093, p = *.26*]. Dominant translations were responded to more quickly (1219.96 ms vs. 1291.04 ms) [F_1 (1,25) = 8.87, *MSE* = 26743.92, p = .007, F_2 (1, 50) = 20.51, *MSE* = 34646.08, p <.001] and more accurately (83% vs. 70%) [F_1 (1, 25) = 34.56, *MSE* = 0.024, p < .001; F_2 (1, 61) = 12.84, *MSE* = 0.094, p = .001] than subordinate translations. An analysis by participants

suggested that target-translation pairs preceded by a related prime were responded to more quickly (1204.51 ms) than target-translation pairs preceded by unrelated primes (1306.49 ms) [F_1 (1, 25) = 8.01, *MSE* = 59729.07, p =.01; F_2 (1, 50) = 1.93, *MSE* = 60426.44, p =.17]. Target-translation pairs preceded by related primes were also responded to more accurately (.79%) than target-translation pairs preceded by unrelated primes (.74%) according to the analysis by items [F_1 (1, 25) = 1.7, p = .20; *MSE* = 0.072, F_2 (1, 61) = 5.71, *MSE* = 0.04, p = .02]. A marginally significant ambiguity type by dominance interaction was observed in the RT analysis [F_1 (1, 25) = 3.26, *MSE* = 55908.77, p = .085; F_2 (1, 50) = .69, *MSE* = 34646.08, p = .417], and this interaction by participants was fully significant in the accuracy analysis [F_1 (1, 25) = 6.23, *MSE* = 0.033, p = .02; F_2(1,61)= 2.45, *MSE* = 0.094, p = .122] (see *Figure 7*). Post hoc analyses on the interaction revealed that the effect of dominance was observed for meaning translation-ambiguous words, t (25) = 2.09, p < .05, but not for synonym translation-ambiguous words, t (25) = 1.08, p = .29.

Table 5. Means and standard deviations for RT and error analysis by participant for ambiguous words

		Prime			
		Related		Unrelated	
Ambiguity Type	Dominance	RT (SD)	% Correct (SD)	RT (SD)	% Correct (SD)
Synonym	Dominant	1190 (263)	.86 (.13)	1307 (279)	.78 (.20)
	Subordinate	1228 (310)	.76 (.19)	1284 (306)	.73 (.26)
Meaning	Dominant	1157 (322)	.84 (.28)	1224 (334)	.84 (.26)
	Subordinate	1241 (320)	.70 (.35)	1409 (370)	.57 (.35)

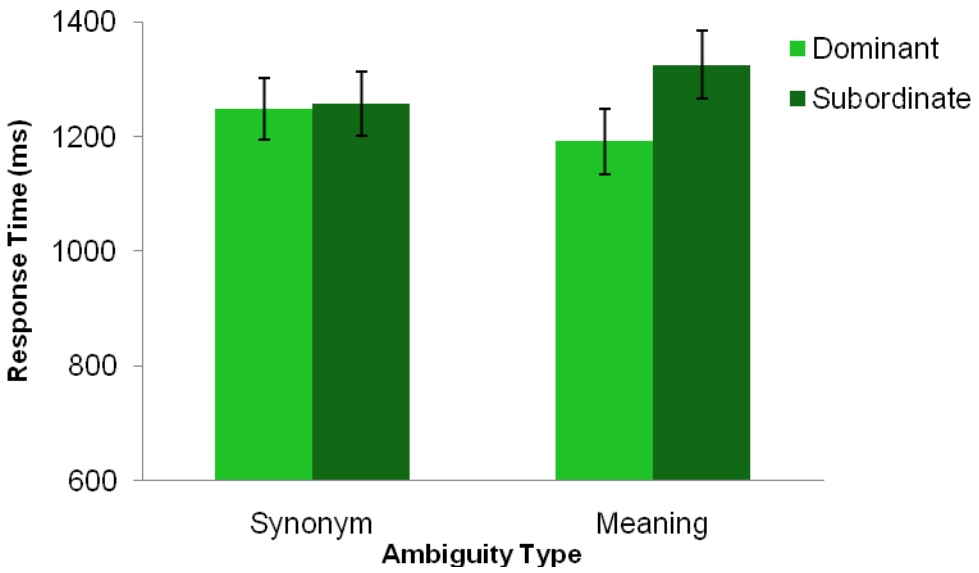

Figure 7. Dominance effect as a function of Ambiguity type

No ambiguity type by relatedness interaction was observed in the RT and accuracy analysis, all *F*s >1. However, a planned *t*-test comparing the RT priming effects for synonym vs. meaning translation-ambiguous words revealed that significant priming was observed for meaning translation-ambiguous words, t (25) = 2.67, p = .013, whereas only a marginal priming effect was observed for synonym translation-ambiguous words, t (25) = 1.95 p = .062 (see *Figure 8*). Furthermore, the priming effect for meaning translation-ambiguous words was almost double in magnitude (119 ms) that of the synonym translation-ambiguous words (68 ms). No dominance by relatedness interaction or three way interactions were observed.

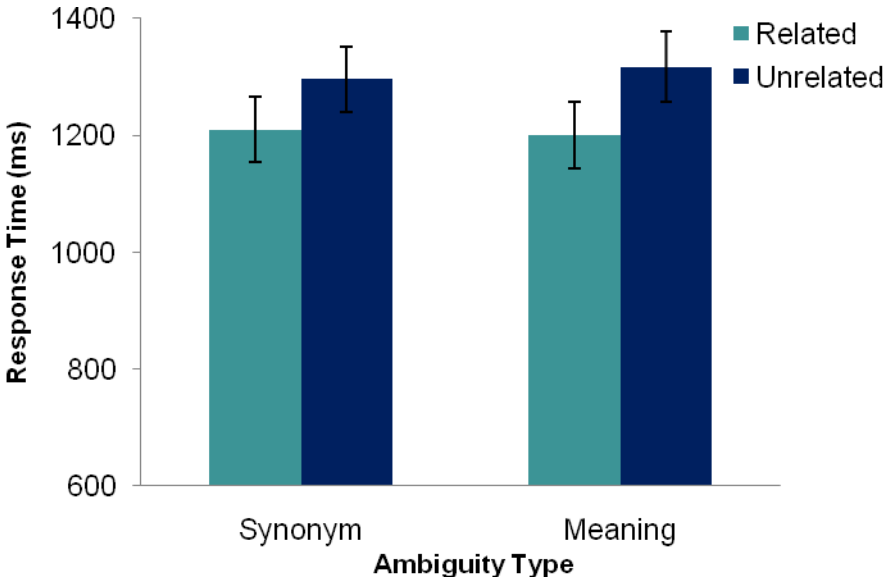

Figure 8. Relatedness effect as a function of ambiguity type

3.2.4 Semantic similarity between translations.

After the translation recognitions task a subset of the participants (n = 12) completed form (spelling and sound) and semantic similarity ratings of the German translations that corresponded to the English translation-ambiguous words. The participants rated how semantically similar two German words were to each other and how similar in spelling and sound the German words were to each other on a scale from 1 through 7. Although only the semantic similarity ratings were of interest, both form and meaning ratings were obtained to focus the participants' attention on each unique aspect between the two words (Tokowicz et al., 2002). The semantic similarity ratings between the translations provided a more continuous measure of semantic ambiguity of the target words than the dichotomy between synonym versus meaning translation-ambiguous words made in previous studies. On average, the words classified as being meaning translation ambiguous were rated a being less semantically similar

(*M* = 3.07, *SD* = 1.21) than the words classified as being synonym translation ambiguous (*M* = 4.19 , *SD* = .94), *t*(61) = 4.10, *p* < .001. There were no significant differences between the form ratings of meaning translation-ambiguous words (*M* = 1.89, *SD* = 1.17) and synonym translation-ambiguous words (*M* = 2.35, *SD* = 1.17), *t*(61) = 1.55, *p* < .13. This range in perceived semantic similarity may play a role in how bilinguals process these words in a translation recognition task. Therefore, we correlated the semantic similarity ratings with the average related prime RTs and the unrelated prime RTs on the ambiguous target words. We found a significant negative correlation between semantic similarity and related RTs (r^2= -.255, *p* = .046), such that the higher the semantic similarity ratings the faster the response times. We also found an even stronger significant negative correlation between semantic similarity and the unrelated RTs (r^2 = -.356, *p* < .004). It is possible that the weaker correlation found for the related RTs is because facilitation from the related prime made semantic similarity less influential for primed target-translation pairs.

4.0 DISCUSSION

The focus of this experiment was to explore how the processing of translation-ambiguous words is influenced by context, translation dominance, and translation ambiguity type in a translation recognition task. Consistent with our hypothesis and previous research (e.g., Tokowicz & Kroll, 2005) we found an overall ambiguity disadvantage. Participants were slower and less accurate in responding to words that had more than one translation compared to unambiguous words with a single translation. Additionally, our hypothesis that dominant translations would be recognized faster than subordinate translations was also upheld. We did not, however, observe any overall differences between the synonym and meaning translation-ambiguous words. Consistent with previous research (Laxén & Lavaur, 2010), we did find a marginally significant interaction between ambiguity type and dominance such that there was greater facilitation for the dominant translation for meaning translation-ambiguous words compared to the synonym translation-ambiguous words.

Furthermore, to our knowledge this is the first study to employ the primed translation recognition methodology. We demonstrated that a related prime can facilitate translation recognition speed compared to an unrelated prime, thus validating the primed translation recognition task. In the following sections we first will discuss the theoretical implications of the overall ambiguity effects, and then how bilingual models could account for the influence of context, dominance, and semantic similarity on processing of translation-ambiguous words.

4.1 TRANSLATION AMBIGUITY EFFECTS

The source of translation ambiguity effects has yet to be determined, although there are theoretical accounts that may provide some insights. The *Fan Effect* (Anderson, 1974) is the notion that the more things associated with a concept, the greater the processing time on the concept. For example a word with many associates would have smaller association strengths between the concept and each association but a word with or only one associate would have strong association strength between the concept and the associates. Applying this account to translation ambiguity generally, as the number of translations increases, the associative strength between a source word and each of its translations would decrease (Degani & Tokowicz, 2010b). Translation-unambiguous word pairs would therefore have the strongest associative strength, leading to facilitation in processing, whereas translation ambiguous words would have weaker associations between a source word and each translation, resulting in longer more difficult processing (e.g. Tokowicz et al., 2002).

The difficulty found with translation ambiguous words can also be explained by Interactive Activation (IA) models (e.g. Jacquet & French, 2002; McClelland & Rumelhart, 1981) in which the effects would be due to competition between the translations that correspond to one word (Degani & Tokowicz, 2010b). Because more than one alternative translation is available for selection for translation-ambiguous words, this may lead to active competition between the possible translations. Selecting one translation over another would require the inhibition of the unselected translation alternatives, thus leading to slower and less accurate responses, particularly in translation production tasks. Additionally, IA models could explain dominance effects by adjusting inhibitory connections such that there would be greater inhibition on the subordinate translation than the dominant translation. Although both theories can explain

translation ambiguity effects, the underlying mechanisms driving the effects are different. Moreover, it is not clear how other factors such as concreteness, cognate status, and source of ambiguity would be incorporated in these two accounts.

4.2 CONTEXT

One goal of the present study was to examine if context could reduce the translation ambiguity disadvantage in processing. We observed an overall priming effect suggesting that translation recognition can indeed be facilitated with a simple context for the translation-ambiguous words. However, priming was not present across all word types. Significant priming was observed for meaning translation-ambiguous words whereas only marginally significant priming was observed for the unambiguous and synonym translation-ambiguous words. Despite an overall priming effect for translation-ambiguous words, this effect was not strong enough to completely eliminate the translation ambiguity disadvantage. This is made evident by the fact that the mean RTs for primed translation-ambiguous words were still slower than those for translation-unambiguous words. The theoretical implications of these effects are discussed in the following sections.

4.3 DOMINANCE

The dominance effect we observed is consistent with several within-language (e.g. Duffy, Morris, & Rayner, 1988; Hogaboam & Perfetti, 1975) and cross-language studies (e.g. Elston-

Güttler et al., 2005; Frenck-Mestre & Prince, 1997; Laxén & Lavaur, 2010). These results are also in line with the modified DCFM (Laxén & Lavaur, 2010) in which dominant translations share more semantic nodes between the L1 and L2 compared to the subordinate translations, thus facilitating translation recognition. In this model framework, the number of shared nodes is taken to indicate the relative amount of semantic similarity. This dominance effect may also be explained by the RHM-TA. Stronger links may be formed between the L1 and L2 lexical representations for the dominant form, which would also lead to facilitation for dominant translations over subordinate translations.

4.4 TRANSLATION AMBIGUITY TYPE

We did not observe any differences between ambiguity types on mean latency, but did observe differences in accuracy such that meaning translation-ambiguous words were responded to less accurately than synonym translation-ambiguous words. We also found a marginally significant interaction between dominance and ambiguity type suggesting that translation dominance affected meaning translation-ambiguous words to a greater extent than synonym translation-ambiguous words. The interaction of ambiguity type by dominance is predicted by the modified DCFM (Laxén & Lavaur, 2010). For synonym translation-ambiguous words, the subordinate translation is semantically similar to the dominant translation. Thus, there will be more shared semantic features or representations between the multiple translations. Therefore, when either the dominant or subordinate translation is presented, there will be similar number of features active, which would reduce the effects of dominance. For the meaning translation-ambiguous words, the translations are less semantically similar, so fewer shared semantic

features would be active, and different features would be active for dominant vs. subordinate translations. The dominant translation would have a greater number of representations shared between the L1 and L2 and thus dominant translations would be responded to more quickly than subordinate translations. Based on the same logic, the DCFM would predict faster response times for synonym than meaning translation-ambiguous words because there is more shared semantic features for the former. However, we found no differences between the two types. The lack of a modulation by type of ambiguity in the presence of an overall translation ambiguity effect suggests that translation ambiguity slows down processing regardless of the source of ambiguity. It is also possible that we did not observe any differences between synonym and meaning translation-ambiguous words because of the variable proficiency levels of the participants or low power.

However, the significant negative correlation between RTs and semantic similarity would support the DCFM. One reason why the correlation data show a different pattern than the ANOVA is because the semantic similarity scores are based on the perceived similarity of the multiple translations. Within each category of words there is likely to be a range of similarity, and the correlation analysis takes advantage of this finer-grained measure of similarity. It is also possible that some words that were initially categorized as meaning or synonym translation-ambiguous words may be perceived as more or less semantically similar than we expected. The dichotomous categorization of meaning vs. synonym translation ambiguous may not best capture the full range of semantic similarity between the multiple translations (see Eddington et al., 2011, for the related Translation Semantic Variability measure). This result should be taken cautiously, however, because these ratings were obtained by participants who had just completed the translation recognition task, and therefore their ratings may have been biased. Additionally,

the perceived semantic similarity between the two words in one language may change as a function of them sharing a translation in another language (Degani et al., 2010). It is also important to note the distinction between the semantic similarity between the shared translations and the type of translation ambiguity. The semantic similarity ratings capture only the similarity between the multiple translations but not whether or not the word is translation ambiguous because of within language synonymy in the target language (synonym type) or due to within language semantic ambiguity (meaning type). Therefore, perceived semantic similarity in addition to the source of ambiguity may influence processing uniquely, but this has yet to be determined. Nonetheless, future researchers should consider a more continuous measure when examining the effects of ambiguity in processing (Eddington et al., 2011).

Examining the type of ambiguity allowed us to disentangle within-language semantic ambiguity effects from translation ambiguity effects. We predicted that there would be differential priming effects on the varying word types such that priming would facilitate translation recognition more for the meaning translation-ambiguous words than the synonym translation-ambiguous words. We expected this effect because a related prime for a meaning translation-ambiguous word could restrict the selection to one possible translation but would not restrict selection to one possible translation for the synonym translation-ambiguous words. We did not observe this interaction, but a planned *t*-test revealed that priming was significant only for the meaning translation-ambiguous words. Furthermore, the size of the priming effect for the meaning translation-ambiguous words was nearly double that of the synonym translation-ambiguous words. The slowing in processing for the meaning translation-ambiguous words in part could be due to the competition or decreased associations (fan effect) between the multiple translations, and/or it could be due to competing meanings of the word. For example, the word

'Trunk' in English is semantically ambiguous and translation ambiguous from English to German. An English-German bilingual may have difficulty processing this word because there are multiple meanings (tree sense, car sense) being activated and they may be activating the corresponding translation for those meanings ('Baumstamm' and 'Kofferraum'). The slowing in processing for synonym translation-ambiguous words would be influenced in part by the potential competition of the multiple translations, but not by semantic ambiguity because the words essentially capture only one sense. In a production task, both translations could compete for selection, but it appears that even in a recognition task such as ours in which only one possible translation is presented to the bilinguals the alternative translation is still active, which may be the source of the reduced priming for the synonym translation-ambiguous words. Thus, as the bilinguals made decisions on the target-translation pairs, the prime related to the meaning of the word could not restrict the activation and selection of one translation over the other. However, significant priming for the meaning translation-ambiguous words suggests that the prime narrowed the selection of the potential translation.

These effects are consistent with the RHM-TA, which predicts that a cue to one sense of a meaning translation-ambiguous word would disambiguate the word. The corresponding connection from the conceptual level to the L2 lexical representation would then be more direct. A semantic cue for synonym translation-ambiguous words would still result in multiple connections from the conceptual level to the L2 lexical level. Yet, because there are often meaning nuances between near-synonyms, a cue provided for one use of the word may in fact also disambiguate a synonym translation-ambiguous word. Additionally, the associative strength of a prime could modulate ambiguity effects (Nievas, Justicia, Cañas, & Bajo, 2005). Consequently, translation ambiguity due to multiple sources (near-synonymous vs. within

language semantic ambiguity) are represented and processed differently. Future research on translation ambiguity would benefit by examining not only the semantic similarity between the shared translations but also the underlying source of the translation ambiguity.

5.0 CONCLUSION

Translation-ambiguity is an influential phenomenon in bilingual and L2 learning and processing. Exactly how translation-ambiguity effects are resolved has yet to be elucidated. However, the current study provides a few pieces to the puzzle. Dominance, context, and source of ambiguity affect processing of translation-ambiguous words. Future research on translation ambiguity would also benefit from examining how other factors such as proficiency, direction of ambiguity, and semantic similarity influence processing. We also provide a new methodology in examining bilingual processing, the "primed translation recognition task" and provide a modified account of the RHM, the RHM-TA, which includes translation ambiguity. In addition to observing the consequences translation ambiguity has on bilingual performance, examining translation ambiguity may inform bilingual models and enhance our understanding of the bilingual mind.

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