Translation Ambiguity Affects Language Processing, Learning, and Representation

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1. Introduction

Adult second language (L2) learners are faced with a particular challenge relative to child L2 learners—adults arrive at the language learning situation with a fully-formed and ingrained first language (L1) system in place. As a result, adult learners are particularly influenced by the transfer of information from L1 to L2 (e.g., MacWhinney, 2005). Although transfer assists learning in some domains, mismatches between L1 and L2 pose particular challenges. Such difficulties can arise at any level of language. The present review focuses on mismatches at the lexical level, with a specific emphasis on research that has explored *translation ambiguity*, which occurs when a word in one language can be translated into another language in more than one way (see Tokowicz & Degani, 2010).

In this review, I first describe the sources, measurement, and prevalence of translation ambiguity. Then, studies conducted on the impact of translation ambiguity on language processing, learning, and representation are described. To date, translation ambiguity has been incorporated into only two models of bilingual language representation: the Distributed Feature Model and the Revised Hierarchical Model. The relevant adaptations of these models are discussed in the section on the impact of translation ambiguity on language processing, where they are most relevant. I conclude with a discussion of the implications of the research on translation ambiguity for models of bilingual language representation and for language instruction, and make suggestions for future research in this area.

2. Sources of Translation Ambiguity

There are many examples of translation ambiguity, and some of the most salient examples are instances in which a word has multiple possible translations because it does not transfer well to the other language conceptually (e.g., Moore, 2004). As an example, the word "gezellig" in Dutch can be translated as "cozy", "friendly", "comfortable", or "homey", yet none of these precisely captures the full meaning of the word. There are also words that are translation ambiguous because one language has a conceptual distinction that is not present in the other (e.g., Spanish has two verbs that indicate "to be": "ser" and "estar"). Another source of translation ambiguity is lexical ambiguity, which occurs when words have more than one meaning, and therefore more than one translation across languages. For example, the English word "bark" refers to both the outer layer of a tree and to the sound a dog makes; these two meanings are unlikely to be captured by the same translation in another language. A similar situation arises for polysemous words, which have multiple related senses. Although the senses of these words may be covered by a single translation, in some cases, they are not (e.g., "cita" in Spanish refers to the dinner date meaning of date, whereas "fecha" refers to the particular day meaning of date). Another common form of translation ambiguity is part-of-speech ambiguity (e.g., the Spanish

word "cocina" means both kitchen and he/she cooks). Finally, some words are translation ambiguous due to near-synonymy in one of the languages. For example, the English near-synonyms "story" and "tale" share the Dutch translation "verhaal".

3. Prevalence and Measurement of Translation Ambiguity

The prevalence of translation ambiguity in several language pairs has been established in normative studies. The first study of this type was conducted by Schönpflug (1997) who found that concrete words (words that refer to perceptible entities) had fewer translations across languages than abstract words (words that refer to imperceptible entities). Following on this work, Tokowicz, Kroll, de Groot, and van Hell (2002) obtained number-of-translations norms to select materials for use in language processing studies. They used the "first-translation" method in which each participant provided the first translation they thought of for each word. This method was preferred to a more objective, dictionary-based method because it was deemed important to base the norms on what participants know, rather than the maximum number of possible translations one could know. Once the norms were obtained, the number of translations across participants was computed; words assigned more than one correct translation were considered "translation ambiguous", and words assigned only one correct translation were considered "translation unambiguous".

Tokowicz et al. further collected semantic similarity ratings on all translation pairs (i.e., how similar in meaning are these two words?). Because all of the items were correct translation pairs, the average similarity rating was quite high (6.4 on a 1-7 scale on which 1 indicated low similarity and 7 indicated high similarity). However, there was a range (2.5-7.0), allowing the examination of variance in this dimension. Specifically, Tokowicz et al. tested a prediction of the Distributed Feature Model (de Groot, 1992), which posits that concrete words and cognate translations[1] are more similar in meaning across languages than abstract words and noncognate translations, respectively. In that sample, concreteness ratings and semantic similarity ratings did correlate positively, confirming the Distributed Feature Model prediction for these words. However, there was no correlation between form similarity (cognate) ratings and semantic similarity ratings, failing to confirm the prediction of the Distributed Feature Model that cognates are more similar in meaning to their translations than noncognates.

Since the Tokowicz et al. norms were collected, some additional norms have been made available to researchers who can use them to select stimuli for future studies (Boada, Sánchez-Casas, Gavilán, García-Albea, & Tokowicz, 2013; Eddington, Degani, & Tokowicz, 2012; Prior, MacWhinney, & Kroll, 2007; Smith, Walters, & Prior, 2012; Tokowicz & Kroll, 2007; Tseng, Chang, & Tokowicz, in press). Each of these normative samples has unique characteristics. Smith et al. includes Hebrew/English norms for more than 1000 English words. Prior et al. focused on part-of-speech ambiguity in Spanish/English and examined the relationships between word class, frequency, imageability, participant proficiency, and translation ambiguity. Eddington et al. collected English/German norms and focused on how proficiency relates to translation ambiguity. Finally, Tseng et al. collected Mandarin/English norms that allow an examination of the types of errors made as a function of translation ambiguity and bilingual proficiency.

Although the prevalence of translation ambiguity in experimental samples of words may not reflect the actual prevalence of ambiguity in the language in general, it gives us some sense of the extent to which such ambiguity may have affected previous research. For example, the Tokowicz et al. (2002) norms were collected on a sample of 550 words that had been used in several influential language processing experiments (De Groot, 1992; De Groot, Dannenburg, & van Hell, 1994; Dijkstra, Grainger, & van Heuven, 1999). Forty-five percent of words in that sample were translation ambiguous in one or both directions of translation. This is especially interesting because the majority of the words had been used by De Groot (1992) and De Groot et al. (1994), and were intentionally selected to be unambiguous. This demonstrates the importance of obtaining norms. In that set, most

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[1] The term cognate is used here in the psycholinguistic sense to indicate translations that share orthography and/or phonology as well as semantics, regardless of whether they share origin.

words with more than one translation had only two translations. Further, of the multiple translation words, most were translation ambiguous due to near-synonymy.

Across the available normative samples, the percentage of words that are translation ambiguous in one or both directions of translation ranges from 24% (Tokowicz & Kroll, 2007) to 55% (Prior et al., 2007). This suggests that if one wishes to use an unambiguous sample of words, norming may be the best way to identify a suitable sample. It also suggests that there are ample items available to examine translation ambiguity in a variety of language pairs.

Some of the previous normative studies have used the same or an overlapping sample of English words, allowing for cross-linguistic comparisons. Degani, Prior, Eddington, Arêas da Luz Fontes, and Tokowicz (2013) found significant positive correlations in the number of translations across languages (see Table 1) for the following language pairs: English-Dutch (Tokowicz et al., 2002), English-German (Eddington et al., 2012), English-Spanish (Prior et al., 2007), and English-Hebrew (Smith et al., 2012). These correlations suggest that there are properties of the source words (English words, in this case) that affect translation ambiguity. At the same time, these correlations are weak to moderate, likely because some of the factors that create translation ambiguity, such as near-synonymy, are likely to be idiosyncratic across languages. Furthermore, for a set of homonyms, Degani, Prior, et al. (2013) found that the relative meaning dominance in English was correlated with the relative dominance of translations into Hebrew and Spanish, rs > .64, demonstrating the tight coupling of ambiguity within and across languages.

Table 1
Correlations Between Number of Translations in Four Language Pairs

Language Pair	English-Spanish	English-Hebrew	English-German	English-Dutch
English-Spanish	1	--	--	--
English-Hebrew	.329[**]	1	--	--
English-German	.283[**]	.334[**]	1	--
English-Dutch	.391[**]	.305[**]	.312[**]	1

Note: ** $p < .01$.

4. Translation Ambiguity Affects Language Processing

Having established the prevalence of translation ambiguity, researchers have demonstrated that translation ambiguity impacts language processing. In the initial published study demonstrating this, Tokowicz and Kroll (2007) examined the influence of translation ambiguity on translation production, a task in which an individual is visually presented with a word in one language and is asked to translate that word aloud into another language. In this task, both accuracy of responding and the time to make correct responses (in ms) are taken to indicate processing difficulty. Tokowicz and Kroll found that translation-ambiguous words were processed more slowly and less accurately than translation-unambiguous words by a group of moderately proficient English-Spanish bilinguals.

The effect of translation ambiguity on translation production may be somewhat unsurprising, however, because of the need to select only one option for production. That is, when multiple alternatives are available and the individual has to choose one among several to produce, there could be competition between the alternatives, thereby slowing production and making it less accurate. Several more recent studies have examined the role of translation ambiguity in translation recognition, a task in which an individual is asked if a pair of words are correct translations. In this task, there is no competition for selection. Thus, this task allows us to ask whether translation ambiguity impacts processing separate from selection for production.

Laxén and Lavaur (2010) examined the role of translation ambiguity in translation recognition in a series of three experiments with French-English bilinguals. They demonstrated that translation-ambiguous words were responded to more slowly than translation-unambiguous words, that this effect was stronger for subordinate than dominant translations, and that it held across both directions of translation. These findings suggest that the translation-ambiguity disadvantage found in translation

production by Tokowicz and Kroll (2007) is not limited to production tasks. Furthermore, the results of Laxén and Lavaur's third experiment demonstrated that translation-ambiguous words that had near-synonymous translations (e.g., "husband" translates to both "mari" and "époux" in French) were responded to more quickly than translation-ambiguous words that had homonymous translations (e.g., "nail" translates to "ongle" for the part of the finger and "clou" for a metal nail). This finding was stronger for non-dominant translations (e.g., was stronger for "époux", which is the dominant translation of "husband").

Laxén and Lavaur (2010) used the Distributed Feature Model (De Groot, 1992) framework to explain this pattern of results. The original model represents word meanings as sets of distributed features, and emphasizes that different types of words are likely to vary in the extent to which they share features across languages, as discussed above for concrete/abstract words and cognate/noncognate translations. Laxén and Lavaur modified the model to accommodate words with multiple translations, and specifically represented translation similarity as the degree of overlap in semantic features across the translations. They concluded that synonymous non-dominant translations benefited from having semantic overlap with the (non-presented) dominant translations. That is, when the translation pair was presented, the first word of the pair cued the dominant translation. When the subordinate translation was then presented, it was primed by the meaning activation of the dominant translation, thereby facilitating translation recognition.

Similarly, Boada et al. (2013) also examined the role of translation ambiguity using the translation recognition task. They extended their study to the role of cognate status and language dominance of the bilinguals tested, who were highly-proficient Spanish-Catalan and Catalan-Spanish bilinguals. They found that the translation-ambiguity disadvantage occurred for these bilinguals regardless of whether the comparison was between unambiguous words and dominant or subordinate translations. This finding held even for dominant cognate translations (e.g., "sed" in Spanish and "set" in Catalan, which mean "thirst"). Further, the reaction time results held across the two directions of translation and for both Spanish and Catalan dominant bilinguals, demonstrating the ubiquity of this effect.

Taken together, the results from these studies show that in the translation recognition task, there is a disadvantage for translation-ambiguous words. This disadvantage holds across multiple types of words (cognates, noncognates, concrete and abstract words), dominant and subordinate translations, different groups of bilinguals, and in both translation directions. However, the magnitude of the effect is moderated by cognate status and translation dominance, suggesting that although translation ambiguity affects processing, in many cases, this is largely separate from other established word type effects.

In a follow-up to these studies, Eddington and Tokowicz (2013) examined whether a single-word context in the form of a prime word would be sufficient to reduce the translation-ambiguity disadvantage in translation recognition with moderately-proficient English-German bilinguals. They used a task called the primed translation-recognition task (see also Sánchez-Casas, Buratti, & Igoa, 1992). Eddington and Tokowicz focused on the role of context in the processing of two different types of translation-ambiguous words: *form translation-ambiguous words* (that have multiple translations due to near-synonymy; e.g., "fruit" translates into the German synonyms "Obst" and "Frucht") and *meaning translation-ambiguous words* (that have multiple translations due to multiple meanings; e.g., "sheet" translates into German as both "Bettlaken" for the bedding meaning and "Blatt" for the paper meaning). They proposed the Revised Hierarchical Model of Translation Ambiguity (RHM-TA) to make specific predictions about the relative magnitude of priming expected for the two types of ambiguous words (see Figure 1). The model uses the basic framework of the Revised Hierarchical Model (Kroll & Stewart, 1994) and modifies it to account for translation-ambiguous words (see also Kroll & Tokowicz, 2001). The RHM-TA predicts that meaning translation-ambiguous words have multiple conceptual representations and that these are each connected to a single translation; therefore, a semantically-related prime could selectively activate a single translation, thus reducing or eliminating the translation ambiguity disadvantage. In contrast, the RHM-TA predicts that form translation-ambiguous words have a single conceptual representation but multiple forms connected to that conceptual representation; therefore, a semantically-related prime would not selectively prime one of the two labels for this type of ambiguous word.
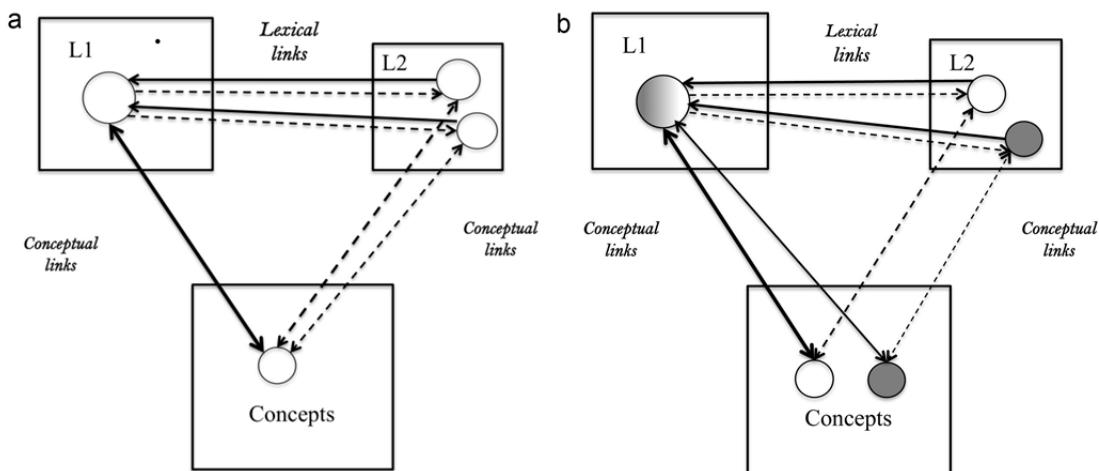
Figure 1. The Revised Hierarchical Model of Translation Ambiguity (RHM-TA; Eddington, C. M., & Tokowicz, N., Examining English-German translation ambiguity using primed translation recognition, *Bilingualism: Language and Cognition, 16, 02*, 442-457, reproduced with permission). Panel a depicts form-ambiguous translations and panel b depicts meaning-ambiguous translations. Dark shading in panel b denotes the subordinate meaning ambiguous translation.

Eddington and Tokowicz (2013) found that related primes (e.g., prime: design*;* target–translation: art–Kunst) reduced the processing speed of translation-ambiguous word pairs overall, but that this did not completely eliminate the translation-ambiguity disadvantage. Further, in a contrast specifically designed to test whether priming was greater for form or meaning translation-ambiguous words, they found priming only for meaning translation-ambiguous words, consistent with the predictions of the RHM-TA. This suggests that some of the translation-ambiguity disadvantage for meaning-ambiguous words can be attenuated by a prime that helps to restrict activation to a particular translation, in a recognition task.

In related research, Michael, Tokowicz, Degani, and Smith (2011) examined the influence of translation ambiguity on individuals who were more or less susceptible to interference from task-irrelevant information. Michael et al. investigated this using a group of moderately-proficient English-Spanish bilinguals who completed the translation production task. Overall, translation-ambiguous words were translated less accurately than translation-unambiguous words. Interestingly, although there were differences among individuals in their general performance on the task, the magnitude of the translation ambiguity disadvantage per se did not vary as a function of the bilinguals' individual difference characteristics. This suggests that these individual differences may instead influence how people process words in general rather than for specific types of words (see also Tokowicz, Michael, & Kroll, 2004).

The studies discussed up to this point have examined the role of translation ambiguity in translation performance. Although this is important in its own right, it is perhaps not surprising that translation ambiguity would have an impact in such a task. Degani, Prior, et al. (2013) asked whether translation ambiguity would influence performance in a single-language lexical decision task. This study follows research showing that bilingual language activation is largely non-selective in nature; that is, bilinguals activate word candidates in both languages, even when only one language is needed for a particular task (e.g., van Hell & Dijkstra, 2002; see Kroll, Bobb, & Wodnieka, 2006, for a review). Degani et al. had Spanish/English bilinguals perform an English lexical decision task (i.e., participants indicated whether letter strings were real words). Unbeknownst to the participants, some of the words had only a single translation from English to Spanish, whereas others had more than one. They found that bilinguals were less accurate in responding "yes" to real English words that were translation ambiguous into Spanish than to real English words that were translation unambiguous, even though the task required no activation of Spanish. This research extends previous work on non-selective access in bilinguals by testing words that do not share form across languages; much of the previous work in this area has used cognates and interlingual homographs to examine cross-language activation (but see, e.g., van Heuven, Dijkstra, & Grainger, 1998).

In summary, translation ambiguity affects translation recognition, as well as translation production. The translation-ambiguity disadvantage persists for dominant translations (even for cognates), in both directions of translation, and for bilinguals of varied language dominance. The disadvantage applies for bilinguals of varied individual difference abilities, and in a single-language lexical decision task. Finally, the use of a single-word prime context was not sufficient to eliminate this disadvantage.

On this latter point, it is important to consider whether a more elaborated context may be sufficient to eliminate the translation-ambiguity disadvantage. Previous research on the processing of words that are ambiguous within a language suggests that context is insufficient to eliminate activation of the dominant meaning, even when it is contextually inappropriate (e.g., Simpson, 1994). By extension, even a sentence context may not be sufficient to eliminate this disadvantage by priming a specific translation of a translation-ambiguous word. Ongoing research is examining this very issue (Tokowicz, Tuninetti, Degani, & Tolentino, 2012).

5. Translation Ambiguity Affects Language Learning

The research described in the previous section established that translation ambiguity influences language processing at least for moderately-proficient bilinguals. Additional research has examined the extent to which translation ambiguity may influence the initial stages of language learning.

In the first study of its kind, Degani and Tokowicz (2010) taught a set of Dutch vocabulary words (from Tokowicz et al., 2002) to native English speakers with no prior exposure to Dutch or similar languages. Some of the words were translation ambiguous in that a single English word had two Dutch translations. Of these translation-ambiguous items, half were form translation ambiguous (trained using identical definitions). For example, the English word "boot" translates into "laars" and "schoen", which represent the same meaning. The other half were meaning translation ambiguous (trained using definitions instantiating different meanings). For example, the English word "change" translates into "verandering" when indicating alteration and "wisselgeld" when indicating coins of small denomination. Overall, translation-ambiguous words were translated less accurately than translation-unambiguous words. This disadvantage went beyond a simple frequency disadvantage that might be expected for translation-ambiguous words because Degani and Tokowicz equated the number of presentations of the Dutch words in the ambiguous and unambiguous conditions. Furthermore, the translation-ambiguity disadvantage was larger for form-ambiguous than meaning-ambiguous words. Degani and Tokowicz concluded that when learning a meaning-ambiguous word, it is possible to map each meaning onto a single Dutch word, but when learning a form-ambiguous word, such a one-to-one mapping is not possible. If one-to-many mappings are the most problematic part of learning ambiguous words, the larger disadvantage for form-ambiguous words is to be expected.

In a follow-up study, Degani et al. (in press) examined whether the manner of training could help alleviate some of the translation-ambiguity disadvantage. This manipulation was inspired by the observation that in some foreign language texts, the multiple translations of translation-ambiguous words are sometimes not taught together, but are instead introduced at different times. Degani et al. therefore examined two training conditions: *together training*, in which the training of one translation of an ambiguous word was followed immediately by the training of the other translation of that word, and *separate training*, in which one translation of an ambiguous word was trained in the first training session, and the other translation was trained in the second training session two days later.

Degani et al. (in press) again found an overall translation-ambiguity disadvantage in accuracy and a larger decrement for form translation-ambiguous words. They also observed better accuracy in the together training condition than the separate training condition, for both form and meaning-ambiguous words. In fact, on some tests, ambiguous words trained in the together training condition did not show any disadvantage relative to translation-unambiguous words. Furthermore, within the separate training condition, there was an advantage for the translation that was trained first. They concluded that the together training may help alleviate some of the translation-ambiguity disadvantage because it allows the learner to establish appropriate one-to-many mappings during training that do not need to be revised later (see also Medina, Snedeker, Trueswell, & Gleitman, 2011). Thus, the practice of training multiple translations of translation-ambiguous words together benefits

learning and should be considered one way to reduce the disadvantage typically associated with learning translation-ambiguous words.

In the previous training studies, the type of ambiguity was manipulated as a dichotomy of form versus meaning-ambiguous words. Having established an overall translation-ambiguity disadvantage in early vocabulary learning, Bracken, Degani, Eddington, and Tokowicz (2013) examined the role of the similarity between the two translations of an ambiguous word in learning. Specifically, they devised a measure called the Translation Semantic Variability (TSV) score, to measure the similarity of a word's translations continuously (e.g., Laxén & Lavaur, 2010). Words with a high TSV rating would encompass form translation-ambiguous words and words with a low TSV rating would encompass meaning translation-ambiguous words. The advantage of this method is that it acknowledges that the similarity between translations is not a dichotomy, but rather a continuum with polysemous words falling between the two ends of homonymous and synonymous words.

Bracken et al. (2013) trained native English speakers on a set of German vocabulary words using English-German translation pairs (from Eddington et al., 2012). The items represented a wide range of TSV ratings. In this study, unlike Degani and Tokowicz (2010) and Degani et al. (in press), the direction of the ambiguity was from German into English (one German word had one or two English translations). For example, the German word "Kiefer" means "jaw" and "pine" in English (low TSV), and the German word "Tüte" means "bag" and "sack" in English (high TSV). Bracken et al. found that the accuracy to respond "yes" to translation ambiguous pairs in a translation recognition task was positively correlated with TSV ratings (higher TSV ratings associated with higher accuracy), and that the response time to accurately respond "yes" to ambiguous pairs was negatively correlated with TSV ratings (higher TSV associated with faster responses).

This pattern of findings is especially interesting in light of the Degani and Tokowicz (2010) results. Specifically, in that earlier study, form ambiguous words were at a learning disadvantage, whereas Bracken et al. found that high TSV (i.e., form ambiguous) words were at an advantage. However, these two studies differed in the direction of ambiguity that they tested. Degani and Tokowicz examined English words with multiple Dutch translations. In that case, learning form-ambiguous words required a one-to-many mapping from a single concept (boot) to multiple translations (schoen, laars). Bracken et al. examined German words with multiple English translations. In that case, learning form-ambiguous words means learning to associate a single German word (Tüte) with a single concept (bag, sack); because they were native English speakers, the learners were already familiar with the association between the two English synonyms. By contrast, learning meaning-ambiguous words means learning to associate a single German word (Kiefer) with two unrelated concepts (jaw, pine). Thus, the results of the two studies are consistent when considered in terms of the mappings that must be learned, and suggest that creating a one-to-many or many-to-one mapping per se drives the observed learning disadvantage.

Taken together, these three studies on the learning of translation-ambiguous words have implications for instruction of such words, although the results need to be generalized to more naturalistic learning contexts. Specifically, the difficulty associated with a particular type of word can be estimated based on the required mapping between L1 and L2 words and meanings. Furthermore, this difficulty can be alleviated somewhat by training multiple translations together rather than separately.

6. Translation Ambiguity Affects Language Representation

The research discussed in the previous sections addressed the consequences of words having multiple translations across languages. Related research has examined the consequences of words *sharing* a translation across languages for language representation. Although this research area is less well-developed than the research on language processing and learning, early results suggest that the way that words map across languages influences both L1 and L2 meaning representation.

For example, the English words "problem" and "question" both translate into Chinese as "wenti". In previous research on this topic, Jiang (2002, 2004) demonstrated that two related L2 words that share an L1 translation are considered more similar in meaning than two related L2 words that do not share an L1 translation (the *shared translation effect*). More recent research has extended this research

to unrelated word pairs, and to the influence of L2 on L1 representation. Degani et al. (2011) examined this issue in Hebrew-English and English-Hebrew bilinguals. They tested both related pairs such as the English words "house" and "home", which translate into Hebrew as "bait", and unrelated pairs such as the English words "tool" and "dish", which translate into Hebrew as "kli". They found that the shared-translation effect extends to unrelated word pairs. Further, Degani et al. found a similar effect for native Hebrew speakers and for native English speakers, all of whom performed the task on English word pairs. These findings show that the one-to-many mapping between words across languages influences language representation, and that even L1 representation is subject to dynamic shifts as a new language is learned.

In a related study, Degani and Tokowicz (2013) investigated whether bilinguals differ from monolinguals in how they process ambiguous words. Specifically, they tested ambiguous English words that either shared a translation or did not in Spanish. English-Spanish and Spanish-English bilinguals judged whether expressions representing the multiple meanings of the ambiguous English words (e.g., dinner date—expiration date) were related or not. Some of the critical (overlapping) words in these pairs shared a translation in Spanish ("joint-translation pairs"; e.g., flea market—housing market, which both translate to "mercado") and some did not ("split-translation pairs"; e.g., dinner date—expiration date, which translate to "cita" and "fecha", respectively). Spanish-English bilinguals (but not English-Spanish bilinguals or monolingual English controls) were more likely to judge split-translation pairs as related than joint-translation pairs. Further analyses indicated that this effect was limited to less-proficient Spanish-English bilinguals. Thus, for these individuals, meanings that share a translation are considered <u>less</u> related than meanings that do not.

Degani and Tokowicz (2013) concluded that their findings are consistent with three possible mechanisms. First, it is possible that words that share a translation develop inhibitory connections between them because they cannot be used in the same contexts (e.g., Chwilla & Kolk, 2003; Elston-Güttler, Paulmann, & Kotz, 2005; Klein & Murphy, 2001). However, Degani and Tokowicz's stimuli ranged in how related their multiple meanings/senses were, and they noted that inhibition may be less likely for words with more highly related meanings (but see Klepousnitou, Titone, & Romero, 2008). Second, it is possible that in early stages of learning, learners show an "exaggerated shared-translation effect", such that meanings that do not share a label in L1 but do in L2 are considered very highly related. This relatedness overshoots the relatedness of joint-translation items, which already share a label in L1, and therefore do not become more related due to the shared L2 label. This would lead to a lower relatedness for joint-translation items at lower levels of proficiency. Finally, learners may approach L2 learning with "exaggerated caution" (e.g., Kellerman, 1982), such that they do not assume that the L2 word captures the same senses as the L1 word. Again, this would reduce relatedness for the joint-translation items initially, but this would disappear with increased L2 proficiency, consistent with Degani and Tokowicz's findings.

7. Summary, Implications, and Next Steps

This paper reviewed the existing research on translation ambiguity. Translation ambiguity norms are now available for several pairs of languages, allowing researchers to examine this issue directly, or to control for it in experimental studies. Furthermore, cross-language comparisons show that some aspect of the source word leads to translation ambiguity because the number of translations from English into four other languages is correlated, as is the dominance of homonym meanings and translation probability. In numerous studies, translation ambiguity has been shown to affect language processing, in translation production and recognition tasks, with a variety of language pairs. Furthermore, translation ambiguity affected performance in a single-language lexical decision task, demonstrating that its effects are not simply a by-product of the translation task per se. Several studies have also demonstrated that translation ambiguity leads to poorer L2 word learning, and that the mapping of words to meaning seems to be the source of this finding. Interestingly, the only instance in which the translation-ambiguity disadvantage disappeared across numerous studies was when the two translations of translation-ambiguous words were trained one right after the other, suggesting a possible method of instruction specifically aimed at avoiding the difficulties associated with learning ambiguous words. Finally, it was demonstrated that two words sharing a translation in another

language changes the way these words are represented, even in a native language, making them seem more similar in meaning. At the same time, when two meanings represented by an ambiguous L1 word also share a translation in L2, these words are considered less similar than "split-translation" words, which do not share a translation in L1, at lower levels of proficiency. All of these findings demonstrate the importance of taking translation ambiguity into account in future research, and show the dynamic and changing nature of the bilingual lexicon.

The findings reviewed here also demonstrate the importance of considering translation ambiguity when modeling the bilingual lexicon, so that a more complete account of the language processing system can be developed. Currently, only two models specifically describe how translation ambiguity may be represented. First, the Revised Hierarchical Model was adapted to account for translation ambiguity (Eddington & Tokowicz, 2013; Kroll & Tokowicz, 2001). This model focuses on the difference between synonym and meaning translation-ambiguous words. Second, the Distributed Feature Model was adapted by Laxén and Lavaur (2010) to demonstrate the role of translation similarity and dominance in the processing of translation-ambiguous words. This model emphasizes the similarity of translations in meaning in a more continuous way (as the number of shared features). Additional models also may be amenable to adaptation for including such ambiguity.

In addition to the implications for models of the bilingual lexicon, these findings have implications for L2 instruction. Specifically, the findings regarding the instruction of translation-ambiguous words suggest that the difficulties with these words are present from the very earliest stages of language learning, and that they relate to the mappings that need to be created between words in the learners' two languages. Critically, the Degani et al. (in press) study indicates that the difficulty associated with learning translation-ambiguous words can be alleviated somewhat by training such words together from the outset. Although this is sometimes already done in the classroom and in textbooks, this varies. Future research should aim to extend this existing laboratory-based work to more authentic learning situations and to further develop possible remediation strategies based on this preliminary research.

To conclude, there are several next steps in the research on translation ambiguity. First, it appears that the types of processing difficulties that are present early in learning persist through advanced proficiency, but these cross-sectional comparisons give us little insight into the trajectory of these effects across the full proficiency continuum (see also Tokowicz & Degani, 2010). Future research that tracks the development of these effects over time will be useful in informing models and possible instructional methods. Second, although translation-ambiguity norms are available for an increasing number of language pairs, all but one of these language pairs includes English (Boada et al., 2013). It will be important to expand this work to other language pairs that have not yet been tested. Third, the research on the consequences of translation ambiguity for language representation is still in its infancy. We know relatively little about how learning an L2, even late in life, may change the way an individual represents L1. Expanding this research area, and including a variety of methodological approaches, will enable this area to advance our understanding of this issue.

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Selected Proceedings of the 2012 Second Language Research Forum: Building Bridges between Disciplines

edited by
Ryan T. Miller, Katherine I. Martin, Chelsea M. Eddington, Ashlie Henery, Nausica Marcos Miguel, Alison M. Tseng, Alba Tuninetti, and Daniel Walter

Cascadilla Proceedings Project   Somerville, MA   2014

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This paper can be cited as:

Tokowicz, Natasha. 2014. Translation Ambiguity Affects Language Processing, Learning, and Representation. In *Selected Proceedings of the 2012 Second Language Research Forum*, ed. Ryan T. Miller et al., 170-180. Somerville, MA: Cascadilla Proceedings Project. www.lingref.com, document #3095.