Psycholinguistic explorations of lexical translation equivalents

Thirty years of research and their implications for cognitive translatology

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This paper reviews psycholinguistic research on lexical translation equivalents to show how accumulating evidence constrained successive models of interlingual processing. Three stages are identified in the development of the field. First, in the foundational era, three initial models of interlinguistic associations were postulated. Second, during the take-off era, pioneering experiments assessed the involvement of conceptual representations in forward translation. Third, the ongoing expansion era witnessed the rise of the revised hierarchical model, which inspired research showing that word translation is modulated by directionality, L2 competence, and the stimuli's concreteness level and cognate status. Two additional issues that surfaced in this third era are of particular importance to cognitive translatology: the impact of translation expertise on word translation and the exploration of the neural basis of translation. Finally, the main findings are summarized and their methodological implications for empirical research within cognitive translatology are highlighted.

Keywords: lexical equivalence, word translation, directionality, L2 competence, translation expertise, psycholinguistics, neurolinguistics

Translation Spaces 4:1 (2015), **9–28**. DOI 10.1075/ts.4.1.01gar
ISSN 2211–3711 / E-ISSN 2211-372X

Introduction

Interlinguistic translation, in any of its modalities, involves myriad cognitive processes. A critical one is the establishment of connections between native-language (L1) and non-native-language (L2) words. For decades, this has been a main research topic for psycholinguists exploring bilingual memory organization. The rich literature thus produced, however, has been largely ignored within cognitive translatology. General introductions to both translation (e.g., Hurtado Albir 2001) and interpreting (Pöchhacker 2004) studies include sections on cognition, but fail to consider the evidence in question. Moreover, in volumes devoted to cognitive research on translation (e.g., Shreve and Angelone 2010) and interpreting (e.g., Tirkkonen-Condit and Jääskeläinen 2000), the assessment of interlinguistic lexical equivalents is either absent or exemplified in only one study.

Cognitive translatology has prioritized other issues, such as the distribution of cognitive effort between source- and target-text processing, the allocation of attentional resources during those tasks, and the development of translation expertise. The exclusion of interlinguistic lexical equivalents from this research agenda may be explained by two factors. On the one hand, it may reflect a jurisdictional criterion: the study of the bilingual lexicon pertains to psycholinguistics and informs bilingualism in general, but translation scholars must focus on distinctive aspects of the translator's mind. On the other hand, it may stem from the belief that studying isolated-word processing is irrelevant for understanding translation as a context-based activity. The latter view, in particular, has been emphasized by pioneering scholars in the field (e.g., Lederer 1978/2002).

Both arguments can be objected to. First, translation studies has thrived by adopting notions and methodologies from other fields, such as sociology and anthropology. Indeed, critical insights have been borrowed from experimental psychology. If, as is widely accepted, translation studies constitutes an interdisciplinary field (Snell-Hornby 2006), the study of interlinguistic lexical associations should not be disregarded on disciplinary grounds.

Second, although controlled single-word processing tasks fail to capture all the complexities of text-based translation, they offer valuable evidence to understand *critical aspects* of the activity. Lexical retrieval is a necessary step in processing all types of translation unit, ranging from phrases to sentences and any fragment in between. In fact, source texts in professional translation may involve several units coinciding with single words, such as list items and titles. Word-for-word translation has also been claimed to play a role in professional interpreting (Christoffels et al. 2003), especially during periods of fatigue or stress (Darò and Fabbro 1994). At the very least, single-word translation experiments tap process-

ing through the form-based route, which has been widely acknowledged in the translation literature.

More generally, interlinguistic translation requires activating, inhibiting, and otherwise controlling information represented in a bilingual lexicon. For roughly thirty years, psycholinguistic research has yielded relevant data. Much of the evidence has come from translation experiments, in which participants must produce target-language equivalents of source-language words. These studies may involve backward translation (BT, from L2 to L1), forward translation (FT, from L1 to L2), or both. However, knowledge about how L1 and L2 words are interconnected has also been boosted through other paradigms, such as lexical and semantic decision, together with careful manipulations of the stimuli. More recently, insights have been gained into the neural basis of this important dimension of translation.

This paper seeks to survey such data and their underlying methodological principles. The aim is to further our understanding of the translation process while promoting more valid and reliable experimental designs within cognitive translatology. Relevant studies are reviewed in three separate sections, each dealing with a different stage in the development of the field. First, in the foundational era (from the 1950s to the 70s), three initial models of interlinguistic associations were postulated. Second, during the take-off era (from the 80s to the early 90s), the first experiments on word translation assessed the involvement of conceptual representations in forward translation. Third, the ongoing expansion era (from the mid-90s onward) witnessed the rise of the revised hierarchical model, which inspired research showing that word translation is modulated by directionality, L2 competence, and the stimuli's concreteness level and cognate status. Two additional issues that surfaced in this era are of particular importance to cognitive translatology: the impact of translation expertise on word translation and the exploration of the neural basis of translation. Finally, the main conclusions of the field are summarized and their methodological implications for empirical research within cognitive translatology are highlighted.

The development of psycholinguistic research on translation equivalents

The foundational era (from the 50s to the 70s)

The first insights into how translation equivalents may be interconnected date from the early 50s. Weinreich (1953) postulated the three models depicted in Figure 1.

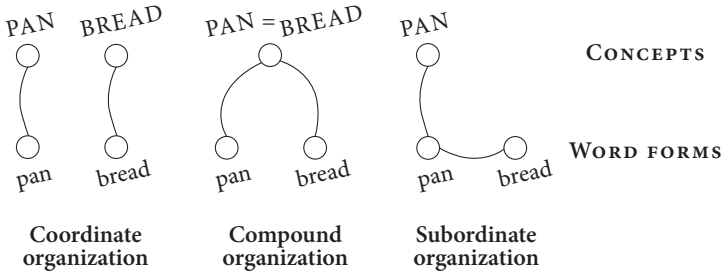

Figure 1. Three pioneering models of the organization of lexical equivalents (Weinreich 1953)

The coordinate model posits that an L1 word and its L2 counterpart are linked to separate conceptual representations. Instead, in the compound model, both words are connected to the same concept. Lastly, the subordinate model proposes that the L2 word accesses the conceptual level only through a form-level link to its L1 equivalent. Weinreich (1953) surmised that subordinate patterns would be dominant in beginner L2 learners and that increasing proficiency would promote a transition to coordinate structures.

This proposal implied that translation equivalents can be interconnected in more than one way and that links between L1 and L2 words may be restructured due to subject variables, such as proficiency or language history. For many years, the models and studies addressing both implications assumed that translation equivalents share full, self-contained concepts. While this simplification did not prevent significant breakthroughs during the 80s and 90s, more recent proposals have fostered progress by acknowledging language-specific patterns of semantic information (e.g., Dong et al. 2005; van Hell and de Groot 1998a).

The take-off era (from the 80s to the early 90s)

Experimental research on interlinguistic lexical connections began in the 80s, when Potter et al. (1984) generalized two of Weinreich's models to the L1 and L2 lexicons as a whole (Figure 2).

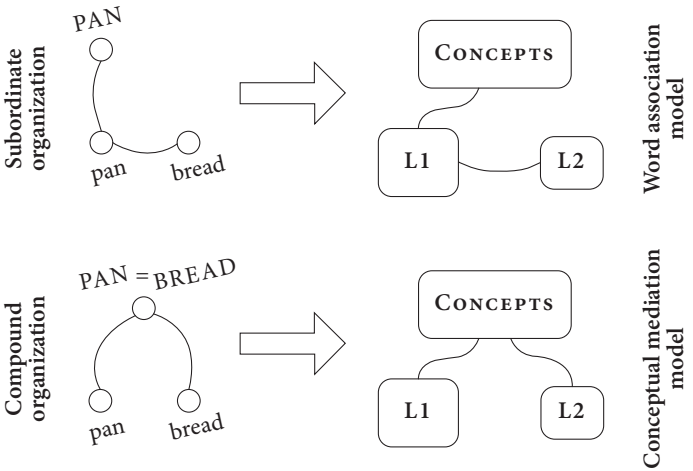

Figure 2. Generalizing subordinate and compound organizations to the word association and the conceptual mediation models, respectively (Potter et al. 1984)

The word association model (WAM) and the conceptual mediation model (CMM) share several features. First, they characterize the L1 and L2 lexicons as separate systems. Second, they assume a wider vocabulary in the former, as reflected by the different sizes of the lower boxes in Figure 2. Third, they include separate levels for lexical and conceptual information.

The models also present important differences. The WAM posits that all L2 words are connected to their L1 counterparts via subordinate structures, whereas the CMM proposes compound structures for all translation pairs. Following Weinreich, Potter et al. (1984) included a developmental hypothesis in their framework. They claimed that unbalanced bilinguals would first construct interlinguistic associations following the WAM, but that increasing levels of proficiency would result in a reconfiguration to the CMM.

To test this hypothesis, the authors relied on previous research showing that, in a native language, word reading is faster than picture naming (e.g., Smith and Magee 1980). The delay in the latter task would imply that, prior to a verbal response, only picture processing requires conceptual access. Thus, each model gave rise to distinct predictions. In the WAM, FT involves no conceptual activation. Thus, it should be faster than picture naming in L2, which would require accessing the conceptual system and then the L1 lexicon. No such differences should emerge if the CMM applies. As both tasks were performed similarly by high- and low-proficiency bilinguals, the authors concluded that the CMM characterized the organization of interlexical associations across all proficiency levels.

Nevertheless, other studies supported the developmental hypothesis. Kroll and Curley (1988) speculated that the second group assessed by Potter and

colleagues may have surpassed the proficiency threshold separating the WAM from the CMM. They replicated the experiment with a larger sample and found that bilinguals who had studied their L2 for less than two years performed as predicted by the WAM–FT faster than picture naming in L2. Above that cut-off point, participants performed as predicted by the CMM. This pattern was replicated by Chen and Leung (1989).

Kroll and Curley (1988) also examined whether semantic manipulations of the stimuli equally affected high- and low-proficiency bilinguals. They asked participants to name images and to read and translate words in two conditions. In the first, stimuli were blocked by semantic category (e.g., lists of stimuli belonging to the category FRUIT). In the second, the lists contained items from mixed categories. As predicted, the former condition caused delays only for the more proficient subjects, corroborating that conceptual mediation may be absent at low proficiency levels.

Other studies explored the role of lexical variables in FT. In several experiments, de Groot (1992; 1993) observed that high-frequency, cognate, and concrete words were translated faster than low-frequency, noncognate, and abstract words, respectively. Since the cognate effect involves form-level interactions, while the concreteness effect implies semantic processing, de Groot (1992; 1993) set forth an integrative mixed model in which L1 and L2 words are connected through both direct form-level links and indirect conceptually-mediated links (Figure 3).

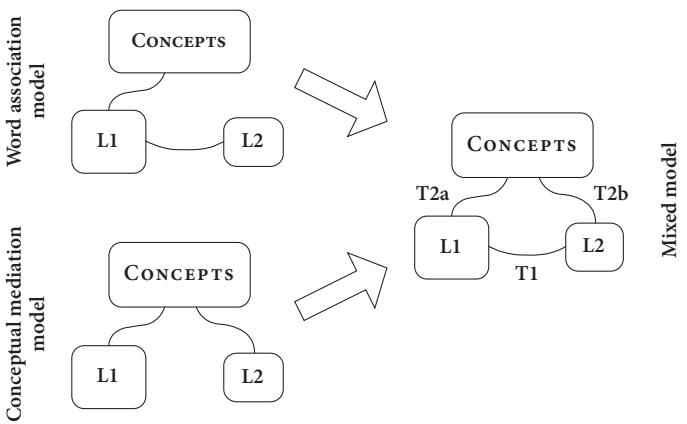

Figure 3. Merging the word association and the conceptual mediation models into the mixed model (de Groot 1992, 1993)

This model explains psycholinguistic effects in terms of connection strengths and interactions between processing routes. Frequency effects in both languages result from the strengthening of T2a and T2b links through repeated use. As these routes become more entrenched, conceptually mediated translation also improves.

Moreover, each time a word is translated, the underlying connections (T1 or T2a + T2b) will be reinforced. The cognate effect would emerge because lexical representations with overlapping sublexical (orthographic or phonological) units are coactivated during source-word processing, so that cross-language equivalents are already partially activated before production, resulting in faster access. The concreteness effect would imply that concrete equivalents share more conceptual representations than abstract equivalents; the latter would have fuzzier meanings and more language-specific connotations. According to de Groot (1992; 1993), concrete words would be translated through the joint action of the lexical (T1) and the conceptual (T2a + T2b) routes, whereas abstract words would rely solely on the former.

Furthermore, de Groot (1992) observed that the role of the lexical and conceptual routes varied as a function of L2 proficiency. Using a translation recognition paradigm, they showed that low-proficiency bilinguals are more affected by form-level manipulations than by semantic manipulations, whereas more proficient bilinguals show an opposite pattern. These data suggest that L2 proficiency modulates the relative importance of the lexical and the conceptual routes during interlinguistic processing.

The expansion era (from the mid 90s onward)

So far, studies on word translation had focused on FT. However, Kroll and Stewart (1990) had shown that FT is slower than BT. This asymmetry effect emerged across various levels of proficiency, although it was reduced in high-proficiency participants. A similar finding was reported by Sánchez-Casas et al. (1992), but only for noncognates. These data suggested that the asymmetry effect depended on word type.

Shortly afterwards, Kroll and Stewart (1994) reported groundbreaking results. Participants translated words in both directions. Depending on the condition, source words were blocked by semantic category (e.g., WEAPONS) or randomly presented. BT was significantly faster than FT, as expected. Moreover, in FT, translation was slower when items were blocked by semantic category. This categorical interference effect did not emerge in BT. Hence, the authors posited that semantic connections played a more important role in FT than BT.

Since the mixed model could not account for these findings, Kroll and Stewart (1994) proposed the revised hierarchical model (RHM), as illustrated in Figure 4.

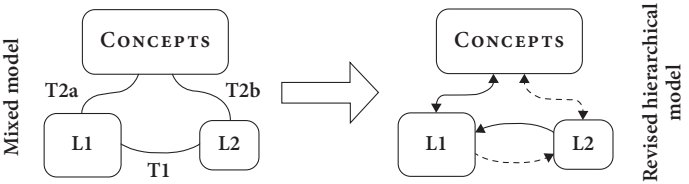

Figure 4. From the mixed model to the revised hierarchical model (Kroll and Stewart 1994)

Unlike the mixed model, the RHM includes two unidirectional routes between the L1 and the L2 word-form systems and it incorporates strength-based distinctions among routes. Crucially, the direct lexical route would be stronger from L2 to L1 than in the opposite direction. However, the model posits that increasing L2 proficiency strengthens the connections between the L2 lexicon and the semantic system, leading to more symmetrical performance across languages. Hence, the RHM, as depicted in Figure 4, refers to low-proficiency, L1-dominant bilinguals.

In the RHM, the translation asymmetry effect is explained by two factors. First, direct word-form connections are stronger for BT than FT. Second, only FT would necessarily involve conceptual mediation, via longer and slower connections. Categorical interference for FT but not BT would reflect increased semantic competition in the former direction. Finally, the increase of L2 proficiency would strengthen the links between the conceptual system and L2 words, so that these would have direct access to semantic representations.

In the last fifteen years, the RHM has been expanded or challenged by several alternative models of bilingual memory organization (e.g., Brysbaert and Duyck 2010; Dong et al. 2005; Pavlenko 2009; van Hell and de Groot 1998a). However, it remains as the most influential and successful model of word-translation production. In particular, the RHM laid the ground for four lines of research addressing crucial aspects of lexical equivalent processing, namely: (i) differences in performance between BT and FT, (ii) the impact of L2 proficiency, (iii) the role of translation expertise, and (iv) the neural basis of translation routes. These issues are next treated separately.

Processing differences between BT and FT. The translation asymmetry effect was replicated in several studies, although the advantage of BT over FT attenuates as L2 proficiency increases (e.g., Christoffels et al. 2006; McElree et al. 2000). Kroll and Stewart (1994) documented the effect using only concrete nouns, as did Sholl et al. (1995) and Choi (2005). Nonetheless, the words' concreteness level modulates the asymmetry effect. In her third experiment, de Groot (1992) had demonstrated that, in FT, concrete nouns are translated faster than abstract nouns. In another study, de Groot et al. (1994) found that the concreteness effect occurred in both directions. Still, van Hell and de Groot (1998b) reported that the concreteness effect was larger for FT than for BT. These data show that the concreteness

effect may affect each translation direction differently, although the exact nature of that interaction remains unknown.

Another variable influencing the asymmetry effect is cognate status. Sánchez-Casas et al. (1992) and de Groot et al. (1994) observed that the advantage of BT over FT emerged only for noncognates. In their first experiment, García et al. (2014) found the same pattern, but only for low-proficiency bilinguals. This suggests that the words' cognate status may affect each direction differently. However, in general, cognates are processed faster than noncognates in interlinguistic paradigms, including not only word translation (Christoffels et al. 2003; de Groot et al. 1994) but also translation priming (de Groot and Nas 1991) tasks. Additional evidence for the cognate effect comes from the cross-language word association studies conducted by de Groot (1992) and van Hell and de Groot (1998a), who showed that the frequency of equivalent responses is significantly higher for cognates than for non-cognates.

Progress has also been made regarding the hypothesis that only FT is conceptually mediated. Sholl et al. (1995) compared the impact of conceptual activation prior to translation, and found that only FT was affected by semantic factors. However, de Groot et al. (1994) had shown that the manipulation of semantic variables could affect both directions in translation tasks. A similar finding was reported by La Heij et al. (1996) in Stroop-type experiments. Moreover, Duyck and Brysbaert (2004) found that the semantic magnitude of number words also affected translation in both directions. Taken together, these results refute the hypothesis that BT bypasses conceptual mediation. However, the conceptual route may still be more crucially involved in FT than BT at low proficiency levels.

The role of the direct lexical routes has been explored through the masked cross-language priming paradigm, with lexical or semantic decision tasks. This paradigm yields clear asymmetrical effects. While L1 primes consistently facilitate decision on L2 words, the opposite direction leads to null or inconsistent results (Kiran and Lebel 2007).

In sum, the asymmetry effect is sensitive to several variables, and it may actually disappear as L2 proficiency increases. Also, while concreteness and cognate effects during translation are quite robust in themselves, it is still unclear how they vary as a function of translation direction. Finally, the evidence suggests that the conceptual level plays a role in both directions, while the lexical routes do appear to operate in an asymmetrical fashion.

The impact of L2 proficiency. Talamas et al. (1999) examined the role of the lexical route with low- and intermediate-proficiency English-Spanish bilinguals. They employed a translation recognition paradigm similar to that of de Groot (1992). The distractors (wrong translations) could operate at either the seman-

tic (*man-mujer*) or the word-form (*man-hambre*) level.[1] The higher proficiency group made more errors in pairs of the former type, whereas the low-proficiency group performed more poorly with pairs of the latter type. These results suggest that the lexical and conceptual routes play more critical roles in low- and intermediate/high-proficiency bilinguals, respectively.[2] A similar finding was reported by Ferré et al. (2006), but only for very strong semantic associates. In a related study, Guasch et al. (2008) showed that word-form manipulations modulate performance across all proficiency levels, whereas semantic relations do so only at intermediate and higher levels, and only when semantic associations are very strong. Taken together, these data confirm the hypothesis that the conceptual route plays a critical role only above very low levels of proficiency.

More recently, Menenti (2006) tested high-proficiency bilinguals with a lexical decision task involving word pairs. Crucially, lexical decision was significantly facilitated by covert rhymes in bilinguals (response times were shorter if the tacit equivalent of the first word rhymed with the second word). Yet, additional analyses revealed that the more competent a person is in L2, the lesser his/her reliance on the lexical route.

All in all, the evidence shows that L2 proficiency influences cognitive processing during word translation. As predicted by the RHM, the lexical route is crucial at low proficiency levels. However, once a critical proficiency threshold is surpassed, the conceptual route takes on a dominant role.

The role of translation expertise. The studies reviewed above were conducted with bilinguals possessing no translation-specific training. Since translation abilities are (at least partly) independent from language proficiency (PACTE 2000), word translation skills may be differentially affected by translation expertise. Also, since both student and professional translators will likely have high (or, at least, intermediate) levels of L2 proficiency, the distinctive effects observed in low-proficiency bilinguals may be presumed absent.

Multiple studies have revealed that translation expertise affects cognitive processing in several domains. Key-logging and eye-tracking studies comparing translation performance between professional and non-professional or student translators have revealed differences in the allocation of cognitive resources during source-text processing and target-text production (e.g., Hvelplund 2011). Similarly, data from online and offline cognitive tests show that professional

1. The word *hambre* has significant orthographic/phonological overlap with the translation equivalent of *man,* namely, *hombre*.

2. A limitation of this study is that the results collapse both L1–L2 and L2–L1 pairs. However, separate analyses of each direction reveal more semantic errors in BT and more word-form errors in FT, which contradicts the RHM but lends further support to the asymmetry effect.

interpreters outperform non-interpreters and/or interpreting students on various executive and linguistic tasks (for a review, see García 2014).

Surprisingly, only two studies have assessed the impact of translation expertise on word translation. Christoffels et al.'s (2006) study included two lexical retrieval tasks, namely, picture naming and word translation. The performance of professional interpreters was compared to that of bilingual university students and highly proficient L2 teachers. The interpreters were faster than the students in both BT and FT, but that their performance was similar to that of the teachers. Whereas only the students showed a directionality effect (FT faster than BT), all three groups responded faster to cognates than noncognates in both directions.

More recently, García et al. (2014) assessed word reading and word translation in three groups: beginner translation students, advanced translation students, and professional translators. Crucially, all groups differed in their translation expertise ratings, but successive groups were matched for L2 proficiency. Response-time recordings showed that, in word reading, concreteness and cognate status effects were absent in all groups. On the contrary, concrete and cognate words were translated faster than abstract and noncognate words. This was the case in both translation directions. Main effect and double-interaction analyses revealed no overall speed differences between BT and FT for any of the groups. Finally, response times for advanced students were significantly shorter than for beginners but similar to those of professionals.

While preliminary, this evidence suggests that cognate and concreteness effects during translation are present across all levels of translation expertise, indicating that the latter variable does not modify the relative contribution of lexical and conceptual routes to this task. Also, directionality effects seem to be absent at all levels of translation expertise, although this finding may also be related to high levels of L2 proficiency. However, translation expertise itself does seem to significantly increase word translation speed during the early stages of field-specific training. More research is needed to corroborate these findings.

The neural basis of word translation. All the results reviewed so far have been obtained through behavioral methods. Though less well known, there is also neurological evidence on word translation. First of all, note that all models and studies presented above assume that the L1 and L2 vocabularies constitute separate systems. While the behavioral evidence proposed to support such a claim has received strong criticism (French and Jacquet 2004), there is abundant confirmatory data coming from aphasiological (e.g., Paradis 2004), cortical electrostimulation (e.g., Lucas et al. 2004), and neuroimaging (e.g., Chee et al. 2003) studies.

Still, all bilinguals represent those functionally independent lexical systems within the same macroanatomical area, namely, the left temporal lobe (Paradis 2004; 2009). This region is also crucially involved in word translation as opposed

to sentence translation, which differentially engages frontobasal structures (García 2013; 2015). Also, recent studies have shed light on the neurofunctional organization of translation-specific routes — i.e., the routes connecting the L1 and the L2 lexicons. The architecture of the RHM implies three relevant hypotheses: (i) the routes are independent from those subserving monolingual processing in L1 or L2; (ii) the routes subserving BT and FT are independent from each other; and (iii) word translation can be performed through the lexical route in the absence of conceptual mediation.

García (2015) tested these hypotheses through a review of over twenty cases of translation disorders in bilingual aphasics. Some patients exhibit an *inability to translate*: they find it difficult or impossible to translate in either one or both directions, even when their processing skills in single-language tasks are spared. Others manifest *paradoxical translation behavior*: they are capable of translating into a language that is not available for spontaneous production but unable to translate into a language which remains available for spontaneous communication. Also, there are reports of *translation without comprehension*: these patients can translate words and phrases correctly and unhesitatingly but are unaware of the meaning of the words in question.

According to García (2015), hypothesis (i) is confirmed by the cases of inability to translate and paradoxical translation. These show that the routes supporting BT can remain functional even when those subserving L1 production are impaired, or vice versa. The same pattern has been observed between FT and L2 production. In the same vein, Borius et al. (2012) demonstrated that inhibition of specific cortical sites can impair L1 or L2 production without compromising translation processes. The same pathologies support hypothesis (ii), as they reveal that the neural circuits in charge of FT can remain functional when those subserving FT are inhibited or destroyed, and vice versa. This claim is corroborated by the finding that during word translation, certain brain structures (e.g., left putamen) are involved in FT but not in BT (Klein et al. 1995). Hypothesis (iii) is consistent with the pattern observed in translation without comprehension. Patients with this disorder are capable of activating translation equivalents of source-language words even when their brain lesion precludes access to conceptual information — for electrophysiological evidence that L1 equivalents are unconsciously activated during L2 word processing, see Thierry and Wu (2007). In sum, the overall architecture of the RHM, despite its simplicity and arguable underspecification, seems plausible in neurological terms.

These conclusions are mainly derived from the study of bilinguals possessing no translation experience or training. However, they may be presumed valid even for professional translators. In fact, some of them have been corroborated in studies with expert translators/interpreters. For example, the notions that translation

routes are left-lateralized and that there are neural networks which participate in only one translation direction have been independently confirmed in neuroimaging studies with non-translators (Klein et al. 1995) and professional interpreters (Rinne et al. 2000).

Still, translation expertise does modify neurocognitive processing in other respects. For instance, several reports suggest that brain activity during verbal processing is more bilateral in professional translators than in non-translators (e.g., Proverbio and Adorni 2011). Also, in an evoked response potentials (ERPs) study, Elmer et al. (2010) explored how interpreting expertise may bring about distinctive neuronal adaptations. To this end, they administered a semantic decision task to professional interpreters (specialized in L2–L1 direction only) and bilinguals lacking translation or interpreting experience. The stimuli were presented in all possible language combinations, namely, L1–L1, L2–L2, L1–L2, and L2–L1. ERP data revealed enlarged N400 responses for interpreters in all conditions but one, namely, the one corresponding to the direction professionally practiced (L2–L1). Since the N400 component is systematically modulated by semantic-level activity, the authors suggest that translation-specific training induces changes in sensitivity to lexico-semantic processing within and across languages. Additional statistical analyses showed that these differences between the groups reflected the impact of interpreting training, irrespective of the years of professional practice.

While research on the neural basis of translation is still scant, it represents a promising line of inquiry to foster progress within cognitive translatology. In particular, the integration of neuroscientific evidence and behavioral data may help fine-tune current cognitive models of translation and suggest new avenues of inquiry.

Findings and implications for research within cognitive translatology

Investigations on single-word translation and lexical equivalence may seem irrelevant to cognitive translatology due to lack of ecological validity. However, it is not the goal of any line of research (nor a possibility of any theoretical model) to account for a phenomenon as complex as real-life translation *in its entirety*. Accessing lexical equivalents of source-text words is just one of multiple mental activities during translation, and a most basic one at that. However, the basic nature of this skill does not render it trivial. On the contrary, it underscores the importance of studying lexical equivalence to understand more complex translation processes, since they will necessarily imply such a skill. The findings summarized in this paper motivate a number of conclusions about the processing of lexical equivalents, as listed in Table 1.

Table 1. Main findings about the processing of lexical equivalents

<table>
<tr><th rowspan="2">Aspect</th><th colspan="2">L2 proficiency</th><th colspan="2">Translation expertise</th></tr>
<tr><th>Low proficiency</th><th>High proficiency</th><th>Translation students</th><th>Professional translators</th></tr>
<tr><td>Lexical variables</td><td colspan="4">Cognate and concrete words are translated faster than non-cognate and abstract words, respectively.</td></tr>
<tr><td rowspan="4">Translation direction</td><td colspan="2">BT faster than FT.</td><td colspan="2">No differences in speed between BT and FT.</td></tr>
<tr><td colspan="2">The impact of directionality on cognate and concreteness effects remains unclear.</td><td colspan="2">Cognate and concreteness effects not modulated by directionality.</td></tr>
<tr><td>Conceptual active in both directions. Lexical route more crucial for BT than FT.</td><td colspan="3">The conceptual route seems to dominate in both directions.</td></tr>
<tr><td colspan="2">Lexical processing, including word translation, faster for high- than low-proficiency bilinguals.</td><td colspan="2">Lexical processing, including word translation, faster for professionals and advanced students than for beginner students.</td></tr>
<tr><td rowspan="3">Neural basis</td><td colspan="4">Word translation routes are critically subserved by left temporal brain regions. There are independent routes for translation, as opposed to monolingual speech production; BT, as opposed to FT; and form-based, as opposed to conceptually mediated, translation.</td></tr>
<tr><td colspan="2" rowspan="2">----------</td><td colspan="2">Translation expertise leads to more bilateral brain activity during verbal processing.</td></tr>
<tr><td colspan="2">Translation-specific training results in specific neurophysiological adaptations for lexico-semantic processing in the most practiced translation direction.</td></tr>
</table>

These findings, in turn, have methodological and theoretical implications for empirical research within cognitive translatology. First, as regards stimuli, source texts should be controlled for the ratio of concrete-to-abstract and cognate-to-noncognate words. If overall task length or other measures (e.g., gaze time or average fixation duration in eye-tracking studies) are found to differ across texts, part of the effects may be attributable to discrepancies in those variables. Most studies using key-logging and/or eye-tracking data to explore translation processes fail to consider such variables in their construction of source texts — for a review, see Hvelplund (2011). It would be interesting to test whether the effects documented in such studies remain unaltered after experimental texts are matched for concreteness and cognate status.

Second, when selecting participants for an experiment, both L2 proficiency and translation expertise should be controlled in all samples, as these variables may independently modulate cognitive performance. Conducting separate analyses of the participants' ratings or scores along each variable is particularly important in forming translation student groups, since only a few months of translation training may be enough to induce significant differences in cognitive processing (Bajo et al. 2000; Elmer et al. 2010; García et al. 2014).

Third, as seen in some of the above studies, important aspects of translation can be tapped through tasks other than translation proper. For instance, semantic decision paradigms offer crucial data through analysis of performance on non-equivalent words. The manipulation of hidden variables in the stimuli (e.g., rhyming patterns in the tacit equivalents of words) is also useful to obtain relevant data. Furthermore, critical aspects of translation processes can be inferred by considering translation errors, as seen in the analysis of bilingual aphasics (García 2015). Data that are usually discarded because of inaccuracy could be separately analyzed in search for systematic patterns.

Fourth, a lesson can be drawn regarding data interpretation. Specifically, researchers should be cautious not to extrapolate conclusions from studies on either BT or FT to both translation directions. Some cognitive models of translation, in fact, have been proposed by analyzing think-aloud protocols of a reduced sample of translation students engaging in FT only (e.g., Kiraly 1995). While certain effects in certain groups seem to hold irrespective of directionality, this cannot be assumed as the default situation in all cases. Thus, empirical reports and theoretical models should limit their conclusions to the direction they actually have concrete data about, especially when relying on non-expert participants.

Looking ahead, cognitive translatology may benefit from further research on several under-explored issues. First, more psycholinguistic studies are needed to gain deeper insights into how translation expertise modulates lexical processing — and, ultimately, how differences in this domain impact broader processes during translation. Second, additional neuroscientific experiments are needed to expand and test extant models of the translator's cognitive system. In this sense, the establishment of interdisciplinary bonds with neuroscience may be greatly beneficial for the development of translation studies at large (García 2013; in press).

In the pursuit of greater ecological validity, it would also be crucial to explore processing of translation equivalents within supra-lexical units. Some of the effects discussed above seem to be modulated by sentence context. For instance, the cognate effect occurs in both directions when words are presented in sentence context, although it is reduced as semantic and grammatical constraints increase (van Hell and de Groot 2008; Starreveld et al. 2014). Given this finding, it would

be useful to assess whether other lexical effects, such as the concreteness effect, are similarly attenuated by sentence-level restrictions.

Also, Ruiz et al. (2007) showed that lexical properties (e.g., frequency) of words within sentences have a differential impact on reading for translation as opposed to reading for repetition. Future studies should examine whether other lexical variables have a different impact on sentence translation relative to sentence reading, and whether such effects are mere reflections of word-level effects. For instance, the results reported by Ruiz et al. (2007) align with the finding that cognate and concreteness effects emerge during word translation but not during word reading, independently of L2 proficiency and translation expertise (García et al. 2014). This suggests the existence of translation-specific mechanisms that retain their cognitive distinctiveness irrespective of the translation unit.

Finally, additional studies could explore the impact of translation expertise on word access during sentence processing. A first step in this direction has been taken by Ibáñez et al. (2010), who showed that translation expertise modifies cognate effects (hence, language access mechanisms) during self-paced reading. Experience in translation may also change the way in which inhibitory mechanisms support language control during bilingual processing (García 2014). This possibility could be addressed, for example, through language switching tasks.

Concluding remarks

The history of psycholinguistic research on cross-language lexical equivalents illustrates how disciplinary progress can be fostered by three key activities: critical assessment of previous studies, experimental testing of controversial hypotheses, and formulation of successive theoretical models satisfying available empirical constraints. After thirty years' worth of experiments, basic yet non-trivial aspects of the translation process have been revealed. Specifically, the establishment of interlinguistic equivalence is sensitive to lexical variables (such as concreteness and cognate status) as well as directionality, L2 proficiency, and translation expertise. Moreover, neuroscientific evidence suggests that there are word-translation-specific routes at brain level. A prospective integrative model within cognitive translatology should not overlook such findings. While these do not tell the whole story of cognitive processes during translation, they do contribute an important, well-crafted chapter in that evolving narrative. By failing to consider them, we may be missing out on crucial information to understand the tale told by the translator's mind.

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