Published in final edited form as:
Lang Cogn Process. 2014 January 1; 29(3): 278–288. doi:10.1080/01690965.2012.762457.

Translation-priming effects on tip-of-the-tongue states

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Abstract

Bilinguals experience more tip-of-the-tongue (TOT) states than monolinguals, but it is not known if this is caused in part by access of representations from both of bilinguals' languages, or *dual-language activation*. In two translation priming experiments, bilinguals were given three Spanish primes and produced either semantically (Experiment 1) or phonologically related Spanish words (Experiment 2) to each. They then named a picture in English. On critical trials, one of the primes was the Spanish translation of the English picture name. Translation primes significantly increased TOTs regardless of task, and also speeded correct retrievals but only with the semantic task. In both experiments translation-primed TOTs were significantly more likely to resolve spontaneously. These results illustrate an effect of non-dominant language activation on dominant-language retrieval, as well as imply that TOTs can arise during (not after) lexical retrieval, at a level of processing where translation equivalent lexical representations normally interact (possibly competing for selection, or mutually activating each other, or both depending on the locus of retrieval failure).

When speakers get stuck retrieving a word they are sure they know, this is called a tip-of-the-tongue or TOT state. The frustrating and sometimes embarrassing experience associated with TOTs makes them of broad interest. TOTs have also received considerable attention within the psycholinguistic literature as a special case of halted retrieval, which can provide unique insights into the mechanisms of lexical access.

Of central interest here, speakers of more than one language – bilinguals – are especially familiar with TOTs, as they report them with greater frequency than speakers of just one language. The greater prevalence of TOTs in bilinguals is quite robust, as it has been reported for bilinguals of multiple language combinations, including Hebrew-English bilinguals (Gollan & Silverberg, 2001), Spanish-English bilinguals, Tagalog-English bilinguals (Gollan & Acenas, 2004), and more recently American Sign Language-English bilinguals (Pyers, Gollan, & Emmorey, 2009).

In general, two main explanations have been proposed for a range of processing differences seen between bilingual and monolingual speakers, including the greater rates of TOTs in bilinguals. One explanation reflects an emergent property of bilingual language use, which is that by virtue of speaking each language only some of the time, bilinguals are likely to use each language less frequently than monolingual speakers use their one language. We have called this explanation the *frequency-lag* hypothesis (Gollan, Slattery, Van Assche, Duyck, & Rayner, 2011; also known as the *weaker links* hypothesis; Gollan, Montoya, Cera, & Sandoval, 2008). Supporting the notion of a frequency lag, bilinguals exhibit larger frequency effects than monolinguals when naming pictures in and out of context (Gollan et

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al., 2008, 2011; Ivanova & Costa, 2008). More specifically, bilinguals named pictures more slowly than monolinguals, but had particular difficulty producing low-frequency names relative to monolinguals.

Because TOTs are more likely to occur for low-frequency target words (e.g., speakers seldom get stuck trying to retrieve high frequency words like *table*), the frequency-lag hypothesis fits very well with the finding of increased TOT reports for bilinguals. Indeed, current TOT evidence supports frequency lag as an explanation for bilinguals' greater TOT rates. First, according to the frequency lag hypothesis, words that are very low frequency for monolinguals are likely to be so low frequency for bilinguals that they will be unable to retrieve them at all. In agreement with this, Gollan and Brown (2006) found that bilinguals have fewer TOTs for very low-frequency words than monolinguals. Also, note that proper names are not subject to a frequency lag effect, because bilinguals may be effectively monolingual for proper names given that these are often identical in all of a bilingual speaker's languages (e.g., *Barack Obama* has the same name regardless of which language is spoken). Thus, according to the frequency lag hypothesis, proper name TOTs should be experienced about equally in bilinguals and monolinguals, which they are: Gollan, Bonanni, and Montoya (2005) reported the counterintuitive result that bilinguals and monolinguals experience about equal rates of TOTs for proper names – a class of words for which monolinguals are especially TOT prone.

The second explanation given for the various processing differences seen between bilingual and monolingual speakers, and one that reflects a more obviously possible consequence of knowing two languages, appeals to the notion of *dual-language activation*. A unique property of the bilingual lexicon is that it is full of translation equivalent word pairs – words that overlap almost exactly in meaning. Furthermore, by now, overwhelming evidence suggests that when bilinguals aim to produce a word in one of their languages, information about that word in the bilinguals' other language is also accessed or 'activated' (see review in Kroll, Bobb, Misra, & Guo, 2008). Thus, the greater rate of TOTs experienced by bilinguals might arise because activation of the unintended language can sometimes elicit a TOT response in the target language.

There are two ways that dual-language activation might lead bilinguals to have more TOTs than monolinguals. First, some evidence suggests that translations compete with one another across bilinguals' languages (Hermans, Bongaerts, De Bot, & Schreuder, 1998; for review see Kroll, Bobb, Misra, & Guo, 2008). This suggests that dual-language activation may increase TOT rates because a bilingual speaker who otherwise may have fully retrieved an intended response may encounter interference from the activated translation of that response, and that interference may (at least momentarily) cause a TOT for that retrieval attempt. Second, other evidence suggests that translations can actually mutually facilitate one another (Costa, Miozzo, & Caramazza, 1999; Gollan & Acenas, 2004; Gollan & Silverberg, 2001). This suggests that dual-language activation may increase TOT rates because a bilingual speaker who may otherwise completely fail to retrieve a target will have that retrieval facilitated by the activated translation, pulling the speaker out of a "don't know" response (or other unsuccessful response) into a partially successful retrieval – a TOT. We defer further discussion of these two specific mechanisms until the General Discussion, focusing in the main on the larger question of whether dual-language activation increases TOT rates in bilingual speakers at all.

It is worth noting that the explanations for the greater incidence of TOTs in bilinguals in terms of frequency lag or dual-language activation are not mutually exclusive. Reduced frequency of use could increase TOT rates for bilinguals at the same time that dual-language activation does so as well. Indeed, Gollan and Acenas (2004) showed that bilinguals have

more TOTs for words they know in just one of their languages. This, along with the evidence described above showing that bilinguals have fewer TOTs than monolinguals for very low frequency words (Gollan & Brown, 2006) – observations for which the dual-language activation account has no explanation – suggests that frequency lag very likely contributes to the greater incidence of TOTs in bilinguals. What remains uncertain is whether dual-language activation *also* contributes to the greater incidence of TOTs in bilinguals. Indeed, if both frequency lag and dual-language activation act to cause more TOTs in bilinguals in monolinguals, it could explain why the bilingual effect on TOT rates appears to be so robust.

In the current study, we investigated if activation of translation equivalents could be a possible source of bilinguals' increased rate of TOTs in their dominant-language (relative to monolinguals) using translation primed TOTs. Surprisingly few studies have addressed this question directly. These have yielded mixed results, and a number of limitations with the studies do not allow definitive conclusions. Ecke (2004) included a clever contrast by eliciting TOTs with definitions versus with English translation equivalents in a group of Spanish-English bilinguals (n = 34, similar to participants tested here). If activation of translation equivalents can affect TOT rates, then these rates should differ for definition versus translation prompts. However, there was no effect of stimulus type on TOTs, although translation prompts did lead to significantly more correct responses than definitions. Two methodological problems in the study by Ecke leave the question under investigation here unanswered. First, the number of items in each condition was very small, particularly considering that TOTs were the variable of interest and these only occur on a small minority of trials (i.e., there were only 23 targets and these were divided between the translation versus definition conditions; moreover, 6 of the 23 targets were Spanish-English cognates which elicit fewer TOT responses in bilinguals; Gollan & Acenas, 2004). Also, comparing definition with translation prompts is not straightforward, because it is much easier to identify an experimentally intended target when provided with a single word (the translation equivalent) than when needing to follow the description in a wordy definition (a better contrast might have been to compare pictures and translations).

A second study, by Askari (1999), tested a small number of Farsi-English bilinguals (n = 16) on a cross-language priming paradigm eliciting TOTs with definitions. In this study, translation-primes were never presented; the design crossed definition language, prime language, and prime-type (primes were semantically related, phonologically related, or unrelated to the targets). Speakers were instructed to retrieve targets in whichever language the definition was written. Askari found some evidence to suggest an influence of dual-language activation on retrieval. However, several methodological limitations in this study challenge any attempt to draw definitive conclusions from these data. First, there were only 12 items in each condition, and so power was again limited. Furthermore, targets were not counterbalanced across conditions, opening up the possibility that any apparent differences were driven by item specific effects rather than by the experimental manipulations (e.g., see Jones, 1989; Jones & Langford, 1987; and relevant discussion thereof in Meyer & Bock, 1992; Perfect & Hanley, 1992). Also, Askari did not report raw numbers of TOTs (only TOTs as a proportion of other failed retrievals), thereby making it difficult to evaluate the theoretical implications of any TOT effects (see Gollan & Brown, 2006). Of greatest relevance for the current study, Askari did not look for effects of translation-equivalent primes on TOT rates even though these should provide the strongest evidence for or against between-language effects on TOTs.

Translation equivalents are semantically related (indeed, nearly synonymous) but are usually phonologically unrelated to one another, and as such the question we asked also has potential implications for identifying the locus of retrieval failure during TOTs. If primed

translation equivalents elicit more TOTs, this implies that TOTs must arise at a locus of processing that can be affected by activation of semantically related words. But little is known about the effects of semantically related words on TOTs, even though a broader view of TOTs couched within models of language production provides some compelling reasons for considering the possible effects of semantically related words on TOTs. Most notably, models that include competition for selection as an integral part of lexical selection in production propose such competition specifically between semantically related lexical candidates (e.g., La Heij, 1988; Levelt, Roelofs, & Meyer, 1999). A close look at the literature on priming effects on TOT rates in monolinguals reveals some effects that likely arise at a processing locus where mutually active translation equivalents might also influence retrieval.

Meyer and Bock (1992) examined if semantically related primes have any effect on TOT rates. They elicited TOTs by presenting word definitions followed by phonologically or semantically related cue words either immediately after the definition (in Experiment 1), or after an initial retrieval attempt (Experiment 2). In both experiments, phonologically related words significantly reduced TOT reports and increased correct retrieval rates. By contrast, semantically related words seemed to produce more mixed results. Specifically, semantic primes slightly increased TOT reports in Experiment 1, and significantly increased TOTs in Experiment 2. However, semantically related primes also significantly increased correct retrieval rates in both experiments (though to a much smaller extent than the facilitation produced by phonologically related words). For this reason Meyer and Bock concluded that semantically related words can facilitate correct retrieval, and sometimes also facilitate speakers into a TOT out of a “don’t know” state.

Meyer and Bock’s (1992) finding that phonologically related cue words facilitated retrieval initiated a now substantial literature that reveals that experimental provision of phonologically related words increases correct retrievals, reduces TOT rates, and cues resolution of TOTs once they occur (e.g., retrieval of the target *malevolence* is facilitated by presentation of *molecular*; Meyer & Bock, 1992). Phonological facilitation effects also arise with presentation of multiple words with segments that are phonologically related to the TOT target (e.g., in a TOT for *velcro* the primes *venerable, pellet, decreed, overthrow*, and *mistletoe* facilitate correct retrievals and TOT resolutions; e.g., James & Burke, 2000; White & Abrams, 2002). However, it is relevant to note that recent work has demonstrated that phonological cuing effects may be offset by competition at a syntactic level. Phonologically related primes that share the same-part-of-speech as a TOT target fail to facilitate retrieval in young speakers, and may even block retrieval in older speakers by significantly decreasing TOT resolution rates (e.g., for a target noun *rosary*, an adjective prime like *robust* will facilitate retrieval but a noun such as *robot* will not; Abrams & Rodriguez, 2005; Abrams, Trunk, & Merrill, 2007). Thus, phonologically related but same part-of-speech primes have two effects that cancel each other out (the same part of speech cancels phonological cueing effects). In sum, a number of observations are consistent with the possibility that interactions at non-phonological representational levels may influence TOT rates.

Here, we present two experiments that assess whether producing the translation of a target in Spanish-English bilinguals increases TOT rates for that target, while avoiding the shortcomings of previous studies that have addressed this question. Each trial of each experiment included four events. First, participants were presented with three consecutive Spanish words; participants were asked to generate associates (semantically related in Experiment 1, phonologically related in Experiment 2) to each of these. Then, participants were presented with a line drawing of an object, which they were to name in English. To address our question of primary interest, we measured TOTs during this picture-naming attempt. To obtain additional insights into the possible locus of any effects observed we also

measured naming times for correct responses, and considered possible priming effects on other response outcomes (e.g., correct retrievals, "don't know" responses). On half of critical trials, counterbalanced across participants and items, the Spanish translation of the picture name was included in the list of primes; on the other half, the translation was replaced with an unrelated Spanish word. If dual-language activation increases TOT rates, participants should report more TOTs when the Spanish translation was included among the primes compared to when the translation was omitted in favor of an unrelated word. The separate associate tasks used in the two experiments were introduced to provide leverage for identifying the mechanism underlying any observed effects, as further explained below. Finally, we also measured reaction times for correct responses, to reveal if translation facilitation versus competition effects arise at different processing loci (e.g., facilitation effects could affect RTs but not TOTs, and competition effects could affect TOTs but not RTs).

Experiment 1: Semantic Association to Translation Primes

Early evidence for dual-language activation effects came from studies of late bilinguals speaking in a second language using the picture-word interference paradigm, showing that distractors in a non-target language, or related to words in a non-target language, can interfere with production of a different target language (Hermans et al., 1998). Under such conditions, influences from the more dominant language can be quite robust. Subsequent studies revealed similar effects in highly proficient early bilinguals (Costa et al., 2003; but see Costa, Albareda, & Santesteban, 2008). A question asked less often, but one that is critical for determining if dual-language activation can explain why bilinguals have more TOTs than monolinguals, is whether a nondominant language can influence a dominant language (see van Assche, Duyck, Hartsuiker, & Diependaele, 2009; van Hell & Dijkstra, 2002 for some evidence along these lines). For these reasons we focused our investigation on production of English target words, the language dominant in the environment at the University of California, San Diego (UCSD) and the dominant language for the majority of bilinguals at UCSD.

To increase the possibility of priming between translation equivalents (which are related only in meaning), in addition to having speakers read the primes aloud, we instructed speakers to focus on meaning (the aspect of representation most likely to be shared between translation equivalents) using a semantic association task. With presentation of each prime, participants read the prime aloud, and then were asked to think of and produce another Spanish word that is related in meaning. Thus, on related trials, both the experimentally presented translation-prime and the speaker initiated related Spanish associate could potentially influence retrieval of the English target word. For example, the primes for the target picture of an *octopus* might include *pulpo* (which is Spanish for *octopus*), *dinero* (Spanish for *money*) and *clase* (Spanish for *class*). Thus, both *pulpo* and whatever semantically related Spanish name speakers produce (e.g., *calamar*, Spanish for *squid*) could influence the subsequent ability to retrieve the English name *octopus*.

Method

Participants—Thirty Spanish-English bilinguals who were undergraduates at UCSD participated for course credit. Participants completed a language history questionnaire. Nine participants rated their ability to speak Spanish slightly better than English. With one small exception (reported below), the pattern of results does not change when excluding these Spanish-dominant bilinguals. The participants' characteristics are shown in Table 1.

Materials—One hundred pictures designed to elicit English target names were chosen from previous TOT experiments and other sources. An attempt was made to select targets that

speakers would know in both languages but that were also sufficiently low frequency that they might elicit a TOT in the dominant language. Each English target was then paired with 4 Spanish primes (for a total of 400 primes). Each target had one Spanish translation-equivalent prime (for related trials), an unrelated control prime (for unrelated trials), and two additional unrelated filler primes (for all trials). The English target names and their corresponding Spanish primes are shown in the Appendix. On each trial three primes were presented followed by one picture. The position of the related primes and their controls was also equally divided between first, second, and third prime position. Targets were always presented in the same order (these are listed in the order in which they were presented in the Appendix), but relatedness and critical prime position for each target was counterbalanced between subjects. To achieve this counterbalancing, six experimental lists were created rotating relatedness and prime position such that across lists each target appeared in related and unrelated conditions with critical primes in each of the three possible positions. Related and unrelated trials were distributed throughout the list (with no more than 6 trials of the same type in succession). Each participant was tested on just one of the 6 lists, each of which had 50 trials with one translation-related prime and two unrelated primes (related trials), and 50 trials with three unrelated primes (unrelated trials).

Procedure—Participants were told that a TOT is “when you are sure you know a name but can’t remember it” and were encouraged to report TOTs whenever they occurred. If participants could not retrieve the target name, and did not spontaneously say something like “I’m having a TOT” or “I know what this is, but I don’t know the name” the experimenter waited about five seconds before asking a series of questions to determine if the participant was in a TOT state or not (e.g., “Do you know the name? Are you sure you know it?”). If the participant retrieved an incorrect name the experimenter asked “Can you think of another name?” or “Can you think of a more specific name?” If the participant was in a TOT, the experimenter waited 5 to 10 seconds and then provided the target name, and asked if this was the name the participant was trying to retrieve (for TOTs), and if she or he knew the word before proceeding to the next trial.

Participants were tested individually with an experimenter present throughout the testing session. Stimuli were presented on a 17-inch color monitor connected to a Macintosh computer running PsyScope 1.2.5 (Cohen, MacWhinney, Flatt, & Provost, 1993). On each trial, three Spanish prime words were presented one at a time followed by the picture to elicit the English target name. Participants controlled the transition from each prime to the next prime or the target with a space-bar press. Participants were instructed to read each Spanish prime aloud, and then to produce a Spanish word that was related in meaning. For example, if the participant saw the word *perro* (*dog*) they might say *gato* (*cat*). After each set of three primes a picture was presented and participants were told to try to name the picture in English as quickly as possible. The use of three prime words (instead of just a single related or unrelated prime) was included to discourage speakers from translating the Spanish primes in anticipation of possibly related upcoming English target words. At the conclusion of all the trials participants were asked what they thought the experiment was about, if they noticed any relationship between the primes and targets, what the relationship was, and how soon in the experiment they noticed.

Classification of Responses into Types—Responses were classified into one of three major types: (a) GOTs (as in “got it”; Koriat & Lieblich, 1974) when the participant retrieved the correct target name, (b) TOTs if a participant reported a TOT, or if she or he reported being sure that she or he knew the target word but couldn’t retrieve it at the moment, and after being provided with the target name confirmed that this was the intended target, or (c) Other – this category collapses a number of responses we classify as “less successful” than a TOT including cases when a participant reported that she or he would

probably know the target word if it was provided but recall was not imminent (and after being provided with the target name confirmed that this was the intended target), cases when a participant reported that she or he would probably not know the target word but then reported knowing or recognizing the target after it was provided, and cases when the participant reported not recognizing the target name after it was presented. Cases when participants reported that the experimentally intended targets were not the ones they had in mind were also included in this "less successful other" category (prime relatedness did not significantly affect any of these individual response outcomes in either Experiment 1 or Experiment 2; hence we collapsed them).

Results

Related and unrelated trials were compared using both response outcomes and RTs. On each picture naming trial, an experimenter pressed one button if a correct naming response triggered the voice-key producing a valid RT, and a different button (to indicate that the RT was invalid) if the voice-key was triggered in a different way (e.g., the participant said "TOT!" or asked a question about the picture).

Figure 1 shows the number of positive TOTs (our variable of primary interest) on translation primed versus control trials, Table 2 shows the percent of responses classified into each of the three types outlined above, and Figure 2 shows naming times for correct retrievals.

Response Outcomes—Speakers reported almost one (0.93) more TOT per subject when primed with translations (4.13 TOTs per subject) than when primed with only unrelated words (3.20 TOTs per subject), a significant difference by subjects, $F1(1,29) = 4.93$, $MSE = .001$, $\eta_p^2 = .15$, $p = .03$; and marginally significant by items, $F2(1,99) = 3.59$, $MSE = .004$, $\eta_p^2 = .04$, $p = .06$[1].

To the extent that translation primes induced more TOTs, this effect was at least somewhat temporary, as speakers spontaneously resolved nearly one (0.90) more TOT per subject when primed with the translation (2.87 resolutions per subject) than when primed with only unrelated words (1.97 resolutions per subject), a significant difference, $F1(1,21) = 6.26$, $MSE = 0.16$, $\eta_p^2 = .23$, $p = .02$; $F2(1,99) = 5.09$, $MSE = 0.72$, $\eta_p^2 = .05$, $p = .03$. This result was only marginally significant after ($p = .09$) after excluding 9 Spanish-dominant participants (who may have had more difficulty retrieving English target names).

Analysis of GOTs and Other response rates did not show any consistent effects of prime relatedness. Related primes tended to decrease correct retrieval rates (GOTs), but this effect was not significant, $F1(1,29) = 1.12$, $MSE = .001$, $\eta_p^2 = .04$, $p = .29$; $F2<1$. Similarly, related primes tended to reduce other (less successful than TOT outcomes) but this effect was not significant, $F1<1$; $F2(1,99) = 1.53$, $MSE = .002$, $\eta_p^2 = .02$, $p = .22$.

Naming times—Naming times revealed significant and substantial translation facilitation effects, as bilinguals produced English names 121 ms faster when primed with a Spanish translation equivalent (1297 ms) than when primed only with unrelated words (1418 ms), a significant difference, $F1(1,29) = 16.95$, $MSE = 13{,}023$, $\eta_p^2 = .37$, $p < .01$; $F2(1,97) = 16.65$ $MSE = 64{,}001$, $\eta_p^2 = .15$, $p < .01$ (the degrees of freedom for the items analysis were 97 instead of 99 because the items *cradle* and *feather* did not produce any valid RTs in the related and unrelated cells respectively)[2].

[1]Translation priming effects on TOTs trended in the same direction in all prime positions but were significant on their own only in third position (i.e., when appearing just before the English target; 1.89 TOTs vs. 1.37 TOTs, $p = .03$), and not in first position (1.19 TOTs vs. 1.09 TOTs; $p = .50$), or second position (1.35 TOTs vs. 1.14 TOTs; $p = .37$); however, the relatedness by prime position interaction did not approach significance ($F<1$).

Discussion

Experiment 1 showed that bilinguals were more likely to report a TOT for an English target word when first primed with Spanish translation equivalent words than with unrelated words, an effect that was significant by subjects and marginally significant by items. This suggests that dual-language activation can increase TOT reports in bilinguals, and therefore that dual-language activation could be a contributing factor explaining why bilinguals get stuck in TOTs more often than monolinguals.

Experiment 1 also showed that when the prime set included the target picture's translation, target picture naming was faster. Of course, naming times are assessed only when speakers name the pictures correctly, so at least in principle, the facilitation observed on these correct retrievals may be separate from any effects seen with TOTs. One possibility is that the prime task used in Experiment 1 whereby subjects generated semantic associates of the translations (and other Spanish words) may have caused speakers to think of more of the conceptual features of the named entity. For example, asking for a semantic associate of "pulpo" may have led subjects to think that octopuses live in the sea, have multiple legs, and so forth. The fact that these features belong also to the target concept may have led to faster conceptual processing, causing faster picture naming times irrespective of any effects on TOTs.

To further explore the effect of translation equivalent primes on dominant-language TOT rates, we asked whether the effects we observed for RTs and TOT incidence might arise at different processing loci. To test this, in Experiment 2 we replaced the semantic association task with a phonological association task, such that speakers were asked to generate words that were similar in sound to the prime words. If translation facilitation effects (for either RTs and TOTs) are enhanced by the semantic association task, then the switch from semantic association to phonological association should reduce the extent to which translation facilitation occurs. In the first place, we can look to see if this eliminates the faster naming times observed for correct retrieval times when speakers were primed by translations compared to when they were primed by only unrelated words. Of further interest, however, will be whether the switch to the phonological association task has any effect on priming of TOTs observed in Experiment 1. For example, if the change in task also affects TOT rates this would place priming effects at a relatively early processing stage (i.e., where semantic elaboration occurs). Conversely, if the change in task does not affect TOT rates this would suggest that priming effects do not arise at a purely semantic locus, and perhaps instead arise at a lexical locus (we assume that the change in task leads speaker to perform less elaborate semantic processing – or perhaps even no semantic processing – of the non-dominant language translation primes). Also of interest was to consider if priming effects might have been caused by semantically related associates that bilinguals generated; to the extent that these might have increased TOT rates the effects should disappear in Experiment 2 in which speakers generated phonological rather than semantic associates to the translation primes.

Experiment 2: Phonological Association to Translation Primes

To examine the locus of translation-priming effects in Experiment 1, the procedure in Experiment 2 was the same as in Experiment 1 except that speakers were instructed to produce phonologically related words (instead of semantically related words) when presented with each Spanish prime. Note that although the phonological association task encouraged speakers to focus on the form of the Spanish prime words, the association

[2]Translation facilitation priming effects on naming times were significant with primes in first (1309 ms vs. 1463 ms; $p < .01$) and third position (1253 ms vs. 1411 ms; $p = .01$), but not with primes in second position (1301 ms vs. 1352 ms, $p = .24$); however, the relatedness by prime position interaction did not approach significance ($F < 1$).

responses they produced are not phonologically or semantically related to the target names. That is, in both Experiments 1 and 2, the translation primes were related to the targets only through meaning, whereas in Experiment 1 both the translation primes and (likely) the semantic associates that speakers produced were related in meaning to the English target names. Additionally, although the task was phonological association in Experiment 2, it is unlikely that the phonological associates would be related in meaning or form to the English targets. For example, consider again the related trial for the target *octopus* with the primes *pulpo* (Spanish for *octopus*), *dinero* (Spanish for *money*) and *clase* (Spanish for *class*). Phonological associates for these primes might include *papel* (Spanish for *paper*), *delgado* (Spanish for *thin*), and *clavo* (Spanish for *nail*), none of which are related in meaning or form to the target *octopus*[3]. In this respect the manipulation in Experiment 2 is rather different from phonological priming studies of TOTs in monolinguals (e.g., James & Burke, 2000), and also differs from other studies which demonstrated priming through automatic translation in bilinguals (e.g., Knupsky & Amrhein, 2007, found that bilinguals named a picture of a *leg* in English more quickly when *milk* [*leche* in Spanish] was a distractor relative to an unrelated control). Here the focus is exclusively on the possible influence of translation equivalent word forms for inducing TOTs.

Method

Participants—Thirty Spanish-English bilinguals who were undergraduates at UCSD and did not participate in Experiment 1 participated for course credit. The participants' characteristics are shown in Table 1. Five participants rated their ability to speak Spanish slightly better than English, and overall bilinguals in Experiment 2 rated their Spanish proficiency as slightly lower than that of bilinguals in Experiment 1 ($p = .04$). However, these differences were no longer significant after excluding Spanish-dominant participants, and the pattern of results reported below is not different when excluding Spanish-dominant participants from the analyses.

Materials—The materials were the same as in Experiment 1.

Procedure—The procedure was the same as in Experiment 1 except that after reading the Spanish prime aloud, participants were instructed to produce a word that is related in sound to the prime. For example, if the participant saw the word *perro* (which means *dog*) they might say papel (paper).

Results

As in Experiment 1 (see Table 2), the majority of responses were either GOTs or positive TOTs.

Retrieval Outcomes—Despite the change in task, as in Experiment 1, translation primes significantly increased TOT reports: Bilinguals reported 1.23 more TOTs per subject when primed with a translation (4.50 TOTs per subject) than when primed only with unrelated words (3.27 TOTs per subject), a significant difference; $F1(1,29) = 10.55$, $MSE = .001$, $\eta_p^2 = .27$, $p < .01$; $F2(1,99) = 7.63$, $MSE = 0.004$, $\eta_p^2 = .07$, $p = .01$[4].

[3]Note that on a minority of trials speakers did not complete the association task as instructed (e.g., they generated an incorrect associate, reported not knowing the prime, or produced an associate related to a homophonic meaning of the prime that was unrelated to the target). On average this occurred on 4% (SD=5%) of trials in Experiment 1, and on 1% (SD=3%) of trials in Experiment 2. To consider if such trials influenced the results we repeated the analyses of retrieval outcomes excluding these trials and found that this did not change the pattern or significance of results.

Also as in Experiment 1, TOTs were significantly more likely to be spontaneously resolved (by 0.97 resolutions per subject) when primed by a translation equivalent Spanish name (3.13 resolutions per subject) than when primed only by unrelated words (2.17 resolutions per subject), $F1(1,29) = 10.84$, $MSE = 1.29$, $\eta_p^2 < .27$, $p = .01$; $F2(1,99) = 6.48$, $MSE = 0.65$, $\eta_p^2 < .06$, $p = .01$.

As in Experiment 1, related primes tended to decrease the rate of correct retrievals (GOTs), but this effect was not significant, $F1(1,29) = 2.08$, $MSE = .001$, $\eta_p^2 = .07$, $p = .16$; $F2(1,99) = 1.95$, $MSE = .005$, $\eta_p^2 = .02$, $p = .17$. Similarly, related primes tended to reduce Other less successful responses, but this effect was not significant, $F1(1,29) = 3.01$, $MSE = .001$, $\eta_p^2 = .09$, $p = .09$; $F2(1,99) = 2.83$, $MSE = .002$, $\eta_p^2 = .03$, $p = .10$.

Naming Times—Mean naming times are shown in Figure 2. Unlike in Experiment 1, in Experiment 2, naming times were not facilitated by translations primes; instead bilinguals produced English names about equally quickly when primed with the translation (1439 ms) as when primed with only unrelated words (1433 ms), both Fs < 1. Thus, the change in task from semantic to phonological association seemed to have eliminated translation facilitation effects on RTs entirely.

Comparison of Experiments 1 and 2—Comparing the main findings in Experiments 1 and 2, the results suggest a robust effect of change in task on correct response times, but little effect on the TOT data. To assess these conclusions statistically, we compared the data across experiments with 2 × 2 ANOVAs contrasting task (semantic, phonological) and relatedness (translation, control). There was no evidence that the change in task had any effect on TOT incidence (see Figure 1; both Fs < 1), and instead there was a highly robust main effect of relatedness such that translation-primed targets were significantly more likely to result in a TOT response than unrelated control primed targets, $F1(1,58) = 14.62$, $MSE = .001$, $\eta_p^2 = .20$, $p < .01$; $F2(1,99) = 8.57$, $MSE = .005$, $\eta_p^2 = .08$, $p < .01$. In contrast, the change in task had a robust effect on the RT data (see Figure 2); these analyses revealed a significant interaction between task (experiment) and priming such that significant translation facilitation effects were obtained only when speakers produced semantic associates to the translation primes but not when they produced phonological associates, $F1(1,58) = 5.43$, $MSE = 22{,}428$, $\eta_p^2 = .09$, $p = .02$; $F2(1,97) = 7.48$, $MSE = 74{,}982$, $\eta_p^2 = .07$, $p = .01$. The contrast between experiments suggests that translation facilitation effects influenced naming times by speeding access to the target-relevant concepts in Experiment 1, and the similarity between experiments on TOT effects implies that the facilitatory effect of semantic elaboration affects only the speed of correct retrieval and is separate from any TOT effects.

General Discussion

The primary goal in the current study was to determine if bilingual speakers are more likely to get stuck in a TOT state because of prior production of (or activation of) a translation equivalent word. The results reveal that the answer to this question is “yes”: In two

[4]Translation priming effects on TOTs trended in the same direction in all prime positions, but whereas in Experiment 1 priming seemed to be most robust with primes in third position (though that interaction did not approach significance), in Experiment 2 priming effects on TOTs were significant on their own only in second position (1.79 TOTs vs. 1.07 TOTs; $p = .03$), and not in first (1.38 TOTs vs. 1.17 TOTs; $p = .55$), or third position (1.48 TOTs vs. 1.14 TOTs; $p = .22$). However, as in Experiment 1, the relatedness by prime position interaction did not approach significance ($F < 1$). Previous studies using similar priming paradigms (but with monolinguals) have sometimes shown that priming effects varied with prime position (e.g., competition effects were stronger when primes were not presented immediately before targets; e.g., Wheeldon & Monsell, 1994; Vitkovitch, Rutter, & Read, 2001). The results in the current study therefore seem to differ from those results; however, we refrain from interpreting these null effects any further because of the reduction in power when dividing the materials by prime position.

experiments, prior processing of a translation equivalent significantly increased the probability of a TOT response even though primes were in a nondominant language (Spanish) and bilinguals attempted to retrieve targets in their more dominant language (English). These data suggest that dual-language activation contributes to why bilinguals have more TOTs than monolinguals. Importantly, this conclusion does not require that dual-language activation increases TOTs via interference between languages (a possibility we discuss in detail below). It is also compatible with the hypothesis that reduced frequency of use of each language also leads bilinguals to have more TOTs than monolinguals (i.e., the frequency-lag hypothesis; Gollan et al., 2001; 2004; 2005; 2008; 2011). The current data merely demonstrate that the increased TOT rate may occur for more than one reason, a proposal that fits well with the robustness of the phenomenon.

Although these data demonstrate that recent processing of a translation equivalent word increases the chances of a TOT it remains to be determined to what extent translations must be processed to influence TOT rates, and how often bilingual speakers actually face such dual-language activation when they speak. In these experiments, the translation was explicitly presented, creating potentially greater other-language competition than bilinguals experience in everyday life. Priming of TOTs might occur only if translations are externally presented and overtly processed as they were in the current study, or it is possible that more implicit processing could have the same effect. Note however that the type of processing appeared to have no influence on TOT rates. That is, in Experiment 1 speakers generated semantic associates to the primes (enhancing semantic processing of the prime), whereas in Experiment 2 speakers generated phonological associates (enhancing phonological processing of the prime). Presumably, these tasks enhanced different aspects of prime processing, and indeed the change in task had a robust effect on correct naming times, but no effect on TOT rates. This suggests that differences in the extent or manner to which translations are activated do not change the extent to which dual-language activation increases TOT rates. In addition, the current study demonstrated an effect of the nondominant language on the dominant language; dual-language activation is likely to have much stronger effects when bilinguals speak in their non-dominant language. Finally, each bilingual produced just 100 target words in the current study – the number of words a speaker says in less than a minute or two. Though other-language activation may be relatively reduced in natural language use, the far greater number of opportunities for TOTs to occur in natural language production suggests that the current observations may indeed be relevant to everyday language use.

How do translation equivalents increase TOTs?

Another open question remains about the mechanism underlying the robust increase in TOTs reported here. In the introduction, we briefly described two mechanisms that might allow dual-language activation to increase TOT rates in bilingual speakers. First, competition between translations may have caused a response that would have been fully retrieved to be (at least temporarily) interfered with, effectively turning a GOT into a TOT. Second, facilitation between translations may have caused a response that would not have been retrieved at all to be partially retrieved, effectively turning a “don’t know” response into a TOT. These mechanisms make different predictions regarding the effect of the relatedness manipulation on GOT and Other less successful response rates. By the first explanation, including the translation in the prime set should decrease GOT rates (along with increasing TOT rates). By the second explanation, including the translation in the prime set should decrease “don’t know” rates. Analyses of GOTs and Other (less successful than TOT) responses in Experiments 1 and 2 did not provide conclusive evidence favoring either of these explanations – perhaps implying that both mechanisms are at play.

To further increase our power for testing these predictions, we combined the data from Experiments 1 and 2, and used a form of analysis of derived TOT rates based on logic developed by Gollan and Brown (2006). In addition, we used logistic mixed-effects regression which combines subjects and items into a single analysis (and also addresses a number of possible shortcomings associated with the use of traditional ANOVA in repeated measures designs with categorical outcomes; Dixon, 2008; Jaeger, 2008). Fixed effects were prime relatedness, and the models included both random intercepts, and correlated random slopes for relatedness for both subjects and items. For these analyses it was not possible to calculate proportions as Gollan and Brown (2006) recommend because with logistic regression each trial for each participant is coded individually. Thus, in the analysis of GOTs, correct responses were coded as 1s and all other trials were coded as 0s. For the analysis of Other response outcomes we used the logic of Gollan and Brown (see below) by coding GOTs and positive TOTs (both self-resolved and not) as 1s and all other trials as 0s. To confirm that this approach to data analysis replicates the above reported TOT findings, we also conducted an analysis of TOTs, in which we contrasted successful (GOTs) with partially successful retrievals (TOTs), by coding GOTs as 1s, and all positive TOTs (both self-resolved and not) as 0s, and excluding all other trials.

These codings roughly correspond to the logic outlined by Gollan and Brown in the following way: From the perspective of a TOT analysis, to fully produce a name, speakers must proceed through two processing steps: First, they must retrieve the conceptual features that correspond to the meaning of the name. Second, they must retrieve the lexical representation and phonological features of the name. A failure at the first of these steps, such that speakers do not retrieve the correct conceptual features of a to-be-produced name (either because they retrieve nothing, or because they retrieve the wrong conceptual features) is what Gollan and Brown termed a *Step 1 failure* –both TOTs and GOTs reflect successful completion of this stage which justifies collapsing these together when analyzing Other response outcomes in the logistic regression. Note that if Step 1 fails, the speaker never has an opportunity to have a TOT – this justifies the exclusion of all responses that are not TOTs or GOTs when evaluating TOT rates with logistic regression (as explained above)[5]. A failure at the second of these steps, such that speakers do not fully retrieve the lexical or phonological features of a to-be-produced name *given* that they have retrieved the correct conceptual features is what Gollan and Brown term a *Step 2 failure*. If neither Step 1 nor Step 2 fails – that is, if both steps succeed – then the speaker has fully retrieved the name – a GOT.

Confirming the above-reported findings, TOT responses were higher on related (M = 9.0, SD = 8.7) than on unrelated prime trials (M = 6.9, SD = 7.5), a significant increase [coefficient = 0.41, SE = 0.12, Wald Z =3.41, $p < .001$]. However, of greatest importance given the goals of these analyses were GOTs, which should decrease with prime relatedness if translation equivalents interfere with retrieval, and Other responses which should decrease with prime relatedness if translation equivalents facilitated speakers out of profound retrieval failures into partially successful retrievals (i.e., TOTs). Of interest, correct retrieval rates were significantly lower on related (M = 86.9, SD = 10.4) than on unrelated prime trials (M = 88.0, SD = 10.3), a significant reduction in correct retrievals (GOTs; coefficient =0.25, SE = 0.09, Wald Z =−2.72, p = .01]. In contrast, related primes did not facilitate speakers out of a pre-TOT failure; although Step 1 failure rates were lower on related (M =

[5]Note that ANOVAs on the Step 1 and Step 2 proportions (calculated as recommended by Gollan & Brown, 2006, and combining data from Experiments 1 and 2, but without applying the more powerful logistic regression approach) did not reveal conclusive results. Specifically, this analysis confirmed the results already reported above, i.e., related primes significantly increased Step2 failures, (both ps < .01), but the reduction in Step 1 failures was just marginally significant, $F1(1,59) = 3.42$, MSE = .001, η_p^2 = .06, p = .07; $F2(1,99) = 4.52$, MSE = .001, η_p^2 = .04, p = .04.

4.5, *SD* = 7.0) than on unrelated prime trials (*M* = 5.5, *SD* = 7.8), this difference did not approach significance (Wald Z < 1). Thus, the results of these analyses suggest that related primes increase TOTs primarily via interference between languages (indeed this seems also more plausible given that we used pictures to elicit TOTs; failure to access the target concept seems more likely with definition stimuli, which are inherently more ambiguous, than pictures).

TOT Resolution Rates

Having concluded that translation equivalents sometimes interfere with correct retrieval, it is necessary to clarify how related primes significantly increased TOT resolution rates in both experiments (see Table 2). If translations exerted a facilitatory effect, cueing speakers into a TOT out of a less successful retrieval outcome, then such facilitation could continue to eventually resolve the TOT. If translations exerted an interfering effect, blocking a correct retrieval enough to yield a TOT, subsequent resolution could be triggered by a reduced ability for the translation to compete with continued attempts to retrieve the target. Additionally, it is important to realize that mechanisms underlying TOT incidence and TOT resolution need not – indeed probably do not – overlap completely. For example, once speakers are in a TOT state, prior access to the translation equivalent could allow the strategy of re-accessing translations as a means for elaborating conceptual activation to increase activation in the lexical representation and resolve the TOT. This “re-access” account of why translations cue TOT resolution also provides a ready explanation for why spontaneous resolutions were equivalent across experiments; once the translation can be recalled the strategy can be implemented regardless of prior processing task.

The Locus of TOT Failure and Implications for Processing Models

Models of language production generally agree that lexical access can be divided into stages or steps in which lexical-semantic, syntactic (sometimes called *lemmas* analogous to Step 1 above), and phonological representations (or *lexemes* analogous to Step 2 above) are accessed separately (Kempen & Huijbers, 1983; for reviews see Biedermann, Ruh, Nickels, & Coltheart, 2008; Levelt, et al., 1999). As discussed above, once retrieval is divided into stages in this way there is the possibility of access failure at each of these different points. The first proposed locus for TOT states in a well-articulated model of language production was that TOTs reflect failed lexeme, but successful lemma, access (Levelt, 1989; Levelt et al., 1999). However, this account leads to the prediction that activation of semantically related words should have no effect on TOT rates because TOTs occur after semantic processing is complete (Gollan & Acenas, 2004). Thus, the finding of significant translation priming effects on TOT rates seems more compatible with a view proposed by Caramazza and colleagues in which TOTs arise during lexical selection and reflect partial activation of lexical representations (Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997). The earlier locus for TOT failure is also consistent with recent reports that syntactic class modulates phonological cueing effects in TOT resolution paradigms (Abrams & Rodriguez, 2005; Abrams et al., 2007).

The proposal that priming translation equivalent lexical representations increases TOT rates may be more broadly relevant to the extent that it also applies to semantically related words within a single language, and if so the current interpretation also provides some explanation for why phonological cues are superior to semantic cues for facilitating TOT resolution (e.g., Meyer & Bock, 1992). That is, initially, the contrast between phonological and semantic effects on TOTs seemed more consistent with the previously proposed later-locus for TOT failures, and with the idea of TOTs as a failure in phonological encoding. On this view, phonological cues are effective because they activate needed representations precisely at the point of failure. By moving TOTs back to an earlier processing locus, a different

explanation is required. Semantic cues may be less effective than phonological cues because to the extent that they cue retrieval they may also block it. Phonological cues by contrast activate the desired lexical representations without increasing activation of semantically related competitors. An avenue to consider for future investigations of the TOT phenomenon is the possibility that there may be more than one type of TOT. Some TOTs may reflect failure of lexical selection while others reflect failure of phonological encoding. This too would reduce the effectiveness of semantically related primes (which would only affect the early-locus failure type TOT) giving the impression that there are little or no semantic blocking effects (note that both types of TOTs would be facilitated by phonological cues).

Conclusions

Overall, the results of these experiments suggest that in addition to a frequency lag (Gollan & Silverberg, 2001), the heightened rate of TOTs observed in bilingual speakers is also caused by dual-language activation. Further work is needed to confirm the proposal that competition between lexical representations leads to increased TOT rates in bilinguals, and to further explore the locus (or possibly loci) of processing for TOT failures. In addition to helping us to understand bilingual language processing better, this helps to identify that TOTs in general arise not only because of failed phonological access (Levelt, 1989), but also at a level of representation where lexical candidates compete for selection. (Abdel Rahman & Melinger, 2009a, 2009b; Bloem & La Heij, 2003; Levelt et al., 1999; but see Costa, Alario, & Caramazza, 2005; Costa, La Heij, & Navarrete, 2006; Janssen, Schirm, Mahon, & Caramazza, 2008; Kuipers, La Heij, & Costa, 2006; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007; Navarrete, Mahon, & Caramazza, 2010). As frustrating as TOTs are, their causes and nature help to illuminate the functioning of the cognitive mechanisms responsible for fluent (and nonfluent) language production more broadly.

Acknowledgments

This research was supported by R01s from NICHD (HD050287 and HD051030) and by a Career Development Award from NIDCD (DC00191). The authors thank Niels Janssen and F. Xavier Alario for their comments on an earlier version of this manuscript.

Appendix

Materials used in Experiments 1 and 2. English translations of Spanish prime words are provided in parentheses but were not presented during the actual task

Critical Prime translation equivalent	Critical Prime control unrelated	Unrelated Prime	Unrelated Prime	Target
tiburón (shark)	oso (bear)	río (river)	maíz (corn)	shark
anillo (ring)	iguana (iguana)	látigo (whip)	vela (candle)	ring
apio (celery)	goma (glue)	piel (skin)	rueda (wheel)	celery
ballena (whale)	nopal (cactus)	cuchara (spoon)	ciruela (plum)	whale
aspiradora (vacuum)	golpe (a hit)	estado (state)	diente (tooth)	vacuum
embudo (funnel)	policía (police)	lago (lake)	pino (pine tree)	funnel
cuello (neck)	huevo (egg)	docena (dozen)	costa (coast)	neck
abanico (fan)	fierro (piece of metal)	cuerda (rope)	cigarro (cigar)	fan
escalera (ladder)	candado (lock)	sapo (toad)	lazo (lasso)	ladder
vaquero (cowboy)	alarma (alarm)	manteca (lard)	tijeras (scissors)	cowboy
pato (duck)	caja (box)	limón (lemon)	regla (ruler)	duck

Critical Prime translation equivalent	Critical Prime control unrelated	Unrelated Prime	Unrelated Prime	Target
pavo (turkey)	dormir (sleep)	rama (branch)	tabla (plank)	turkey
martillo (hammer)	pie (foot)	pelota (ball)	llanta (tire)	hammer
papalote (kite)	gusano (worm)	pesa (weight)	boca (mouth)	kite
granada (pomegranate)	canción (song)	invierno (winter)	nervio (nerve)	pomegranate
parrilla (grill)	cinto (belt)	trapo (rag)	topo (mole)	grill
frijol (bean)	plata (gold)	silla (chair)	mesa (table)	bean
recogedor (dustpan)	palacio (palace)	tomate (tomato)	edificio (building)	dustpan
cacahuate (peanut)	hielo (ice)	babero (bib)	sillón (couch)	peanut
corona (crown)	suelo (ground)	bote (can)	repollo (cabbage)	crown
cadena (chain)	león (lion)	salón (hall)	paquete (package)	chain
sobre (envelope)	durazno (peach)	brazo (arm)	leche (milk)	envelope
lobo (wolf)	arete (earring)	uña (nail)	planeta (planet)	wolf
mariposa (butterfly)	plátano (banana)	símbolo (symbol)	pastel (cake)	butterfly
calabaza (pumpkin)	botón (button)	rastro (trail)	puerta (door)	pumpkin
pepino (cucumber)	árbol (tree)	botella (bottle)	ratón (rat)	cucumber
telaraña (spiderweb)	biblioteca (library)	costura (sewing)	secadora (blowdryer)	spiderweb
girasol (sunflower)	taza (cup)	canasta (basket)	sangre (blood)	sunflower
piña (pineapple)	número (number)	respeto (respect)	tocino (bacon)	pineapple
rábano (radish)	lluvia (rain)	gente (people)	pasta (pasta)	radish
peluca (wig)	clavo (nail)	mosca (fly)	cereza (cherry)	wig
zorrillo (skunk)	tina (bathtub)	mandil (apron)	horno (oven)	skunk
tobillo (ankle)	playa (beach)	sábana (sheet)	sombra (shadow)	ankle
campana (bell)	peine (comb)	perro (dog)	plato (plate)	bell
jarra (pitcher)	vena (vein)	boda[a] (wedding)	cutis (skin)	pitcher
tortuga (turtle)	llave (key)	cama (bed)	canal (channel)	turtle
rey (king)	teléfono (telephone)	cárcel (prison)	piedra (rock)	king
corbata (tie)	paraguas (umbrella)	abeja (bee)	animal (animal)	tie
cuchillo (knife)	manguera (hose)	naranja (orange)	plancha (iron)	knife
gallo (rooster)	nota (note)	palma (palm tree)	cuadra (block)	rooster
ombligo (bellybutton)	pan (bread)	madera (wood)	pasa (raisin)	bellybutton
murciélago (bat)	tamal (tamale)	chamarra (jacket)	donación (donation)	bat
caballo (horse)	trono (throne)	grito (shout)	pistola (gun)	horse
grillo (cricket)	letra (letter)	prima (cousin, f)	sopa (soup)	cricket
pestaña (eyelash)	mundo (world)	comadre (close friend, *f*)	corazón (heart)	eyelash
ardilla (squirrel)	doctor (doctor)	pulmón (lung)	cuadro (frame)	squirrel
pico (beak)	ceniza (ashes)	arena (sand)	carne (meat)	beak
alberca (swimming pool)	gancho (hanger)	menudo (a kind of soup)	vaso (cup)	swimming pool
columpio (swing)	pera (pear)	luna (moon)	fuente (fountain)	swing
bombero (firefighter)	chancla (slipper)	alcancía (piggybank)	maestra (teacher)	firefighter
trigo (wheat)	cerebro (brain)	pierna (leg)	calcetín (sock)	wheat

Critical Prime translation equivalent	Critical Prime control unrelated	Unrelated Prime	Unrelated Prime	Target
garra (claw)	algodón (cotton)	manzana (apple)	fruta (fruit)	claw
pala (shovel)	ejotes (green beans)	nuez (nut)	ruido (noise)	shovel
zanahoria (carrot)	tenedor (fork)	mano (hand)	dedo (finger)	carrot
reloj (watch)	labios (lips)	calle (street)	estrella (star)	watch
cebolla (onion)	peso (weight)	premio (prize)	piso (floor)	onion
almohada (pillow)	tren (train)	queso (cheese)	tienda (store)	pillow
saltamontes (grasshopper)	pueblo (town)	padre (father)	dueño (owner)	grasshopper
cuna (crib)	venado (deer)	payaso (clown)	patín (rollerskate	cradle
cerco (fence)	gota (drop)	tarjeta (card)	manga (sleeve)	fence
rana (frog)	guitarra (guitar)	coliflor (cauliflower)	galleta (cookie)	frog
abrelatas (canopener)	enfermera (nurse)	fantasía (fantasy)	dragón (dragon)	canopener
mantequilla (butter)	oro (gold)	carro (car)	volante (steering wheel)	butter
uva (grape)	pájaro (bird)	pescado (fish)	barco (boat)	grape
espina (thorn)	saco (coat)	olla (pot)	pichón (pigeon)	thorn
muleta (crutch)	polvo (dust)	licuadora (blender)	frío (cold)	crutch
cola (tail)	verano (summer)	deseo (wish)	jardín (garden)	tail
flecha (arrow)	sol (sun)	bebé (baby)	maceta (flower pot)	arrow
codo (elbow)	peca (freckle)	música (music)	risa (laughter)	elbow
hueso (bone)	lápiz (pencil)	dulce (candy)	agua (water)	bone
aguja (needle)	baño (bathroom)	precio (price)	negocio (business)	needle
nido (nest)	bolsa (purse)	perfume (perfume)	raíz (root)	nest
rompecabeza (puzzle)	timbre (doorbell)	zapato (shoe)	criminal (criminal)	puzzle
ventana (window)	lechuga (lettuce)	estatua (statue)	lente (lens)	window
sandía (watermelon)	nariz (nose)	estufa (stove)	pared (wall)	watermelon
pluma (feather)	borrador (eraser)	toro (bull)	espárrago (asparagus)	feather
puente (bridge)	comida (food)	rodilla (knee)	golfo (gulf)	bridge
tornillo (screw)	jirafa (giraffe)	falda (skirt)	concha (shell)	screw
langosta (lobster)	examen (exam)	testigo (witness)	tiempo (time)	lobster
fantasma (ghost)	brazalete (bracelet)	gobierno (government)	cabaña (cabin)	ghost
ola (wave)	frente (forehead)	nudo (knot)	país (country)	wave
buzón (mailbox)	pantalla (screen)	ropa (clothing)	viento (wind)	mailbox
ala (wing)	colchón (mattress)	miel (honey)	familia (family)	wing
pañal (diaper)	chile (chili pepper)	espejo (mirror)	fama (fame)	diaper
banco (bench or bank)	lengua (tongue)	gorra (hat)	pez (fish)	bench
relámpago (lightning)	novela (novel)	alfombra (carpet)	salsa (sauce)	lightning
camarón (shrimp)	bufanda (scarf)	foto (photo)	frasco (jar)	shrimp
serrucho (saw)	tía (aunt)	fiesta (party)	artista (artist)	saw
conejo (rabbit)	tocador (dresser)	nube (cloud)	ley (law)	rabbit
pinzas (tweezers)	escoba (broom)	casa (house)	ojo (eye)	tweezers
trapeador (mop)	freno (brake)	cocina (kitchen)	llama (flame)	mop
foca (seal)	palo (stick)	mujer (woman)	cuarto (room)	seal
cangrejo (crab)	revista (magazine)	espalda (back)	madre (mother)	crab

Critical Prime translation equivalent	Critical Prime control unrelated	Unrelated Prime	Unrelated Prime	Target
hormiga (ant)	fresa (strawberry)	papel (paper)	libro (book)	ant
chivo (goat)	jabón (soap)	fútbol (soccer)	rincón (corner)	goat
tambor (drum)	ajo (garlic)	flor (flower)	hoja (leaf)	drum
trenza (braid)	avión (airplane)	sabor (taste)	mar (sea)	braid
jaula (cage)	techo (roof)	boda[a] (wedding)	luz (light)	cage
pulpo (octopus)	globo (balloon)	dinero (money)	clase (class)	octopus
vino (wine)	placa (badge)	espuma (foam)	autobús (bus)	wine

[a]The prime *boda* was accidentally used twice; once as an unrelated prime for *cage* and once as an unrelated prime for pitcher.

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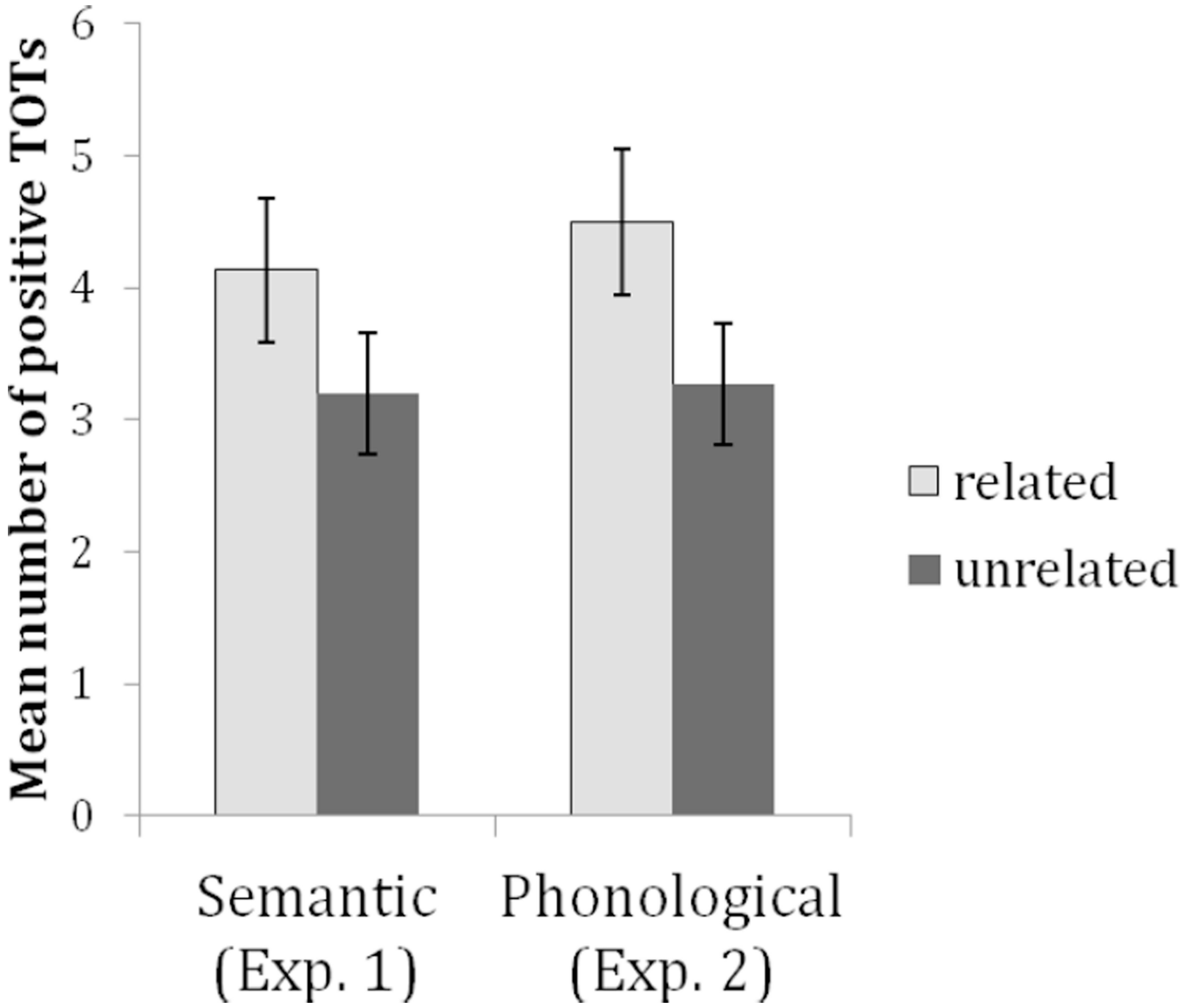

Figure 1.
Mean number of positive TOT states in related and unrelated conditions in Experiments 1 and 2. Error bars show standard errors.

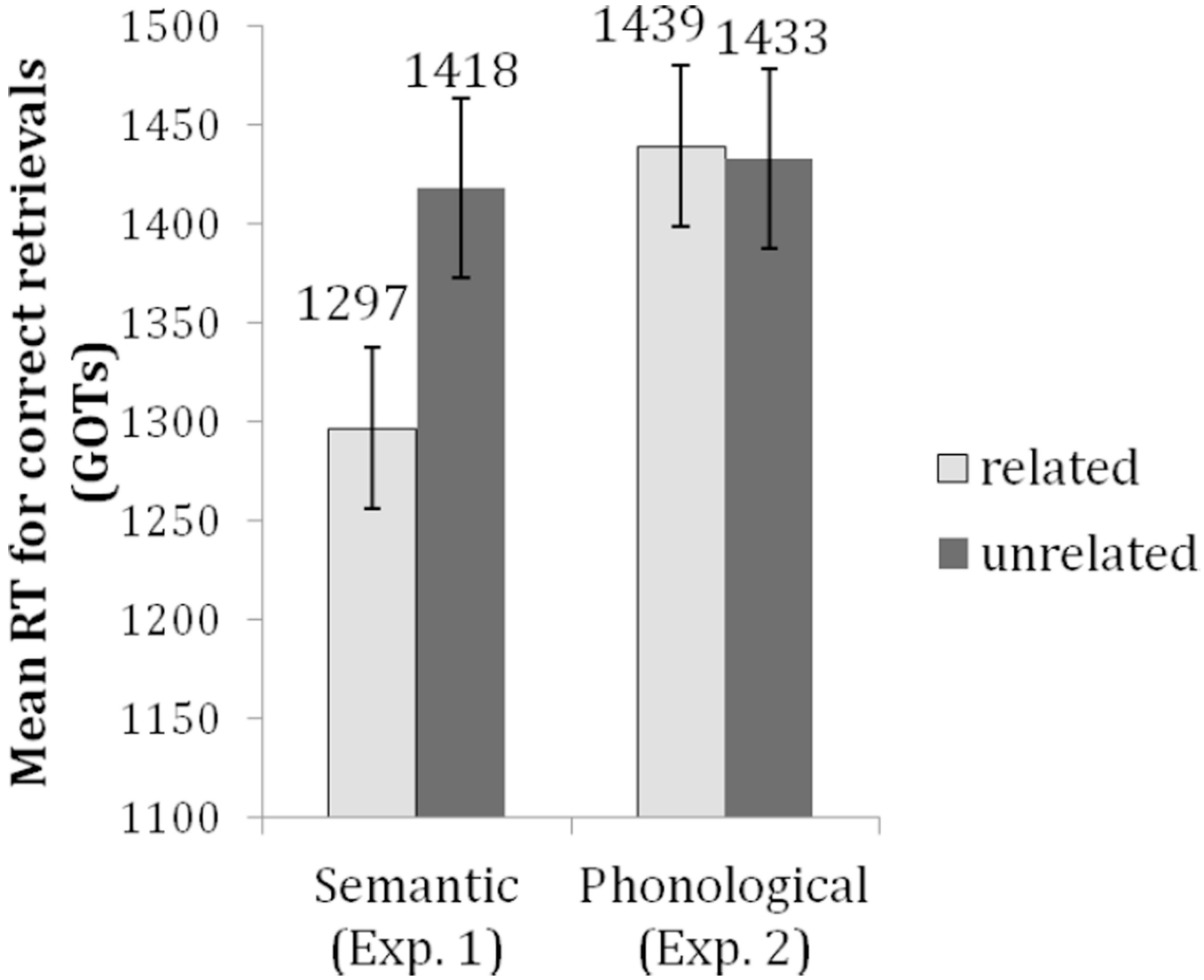

Figure 2.
Mean naming times (RTs) for correct responses in related and unrelated conditions Experiments 1 and 2. Error bars show standard errors.

Table 1

Participant characteristics in Experiments 1 and 2 and t-tests for the difference between experiments.

	Experiment 1 - Semantic Association		Experiment 2 - Phonological Association			
	Mean	SD	Mean	SD	*t*[a]	*p*
age	19.8	1.8	19.8	1.3	< 1	0.94
age of acquisition of English	4.6	3.7	3.8	2.9	< 1	0.32
age of acquisition of Spanish	0.2	0.5	0.1	0.3	< 1	0.54
English speaking[b]	6.3	0.9	6.7	0.6	2.01	0.05[c]
Spanish speaking[b]	6.5	0.7	6.0	1.0	2.14	0.04[c]

[a] degrees of freedom = 58

[b] Self-rated proficiency level based on self-ratings using a scale of 1–7 with 1 being “little to no knowledge” and 7 being “like a native speaker.”

[c] There were 4 more Spanish-dominant bilinguals in Experiment 1 than in Experiment 2. The small differences between experiments in language proficiency are not significant when removing Spanish-dominant bilinguals (all *t*s≤1.72); and reported results do not change when these same bilinguals are excluded from analyses.

Lang Cogn Process. Author manuscript; available in PMC 2015 January 01.

Table 2

Mean (and SD) percent of responses classified as GOTs, TOTs, or other "less successful than TOT" responses in Experiments 1 and 2 (Note: the column means sum to 100%).

	Experiment 1 Semantic Association to Translation Primes					
	GOTs: correct retrievals		TOTs		Other Responses	
	M	*SD*	*M*	*SD*	*M*	*SD*
related	86.0	12.4	8.3	8.9	5.7	9.3
unrelated	87.0	12.8	6.4	7.7	6.6	10.4
	Experiment 2 Phonological Association to Translation Primes					
	GOTs: correct retrievals		TOTs		Other Responses	
	M	*SD*	*M*	*SD*	*M*	*SD*
related	87.7	8.1	9.0	7.9	3.3	2.9
unrelated	89.1	7.1	6.5	6.5	4.4	3.4