]Bilingual lexical disambiguation: the nature of cross-language activation effects

letrônica

Ana B. Arêas da Luz Fontes[1]
Li-Hao Yeh[2]
Ana I. Schwartz[3]

1 Introduction

The cognition of reading continues to be a topic of fascination to researchers. The ambiguity aspect of reading is of particular interest to language researchers because it allows us to explore how the mind first activates multiple representations and then selects or settles on a particular one. While it is true that there is plenty of ambiguity within a single language, an entirely new layer is introduced when there is an additional language within the same cognitive system, as is the case for bilinguals. The study of bilingualism allows researchers to examine ambiguity from the letter level all the way up to the language level in ways not possible with monolinguals.

In the present study we focused on the processing of cross-language ambiguity in sentence context. Currently there is general agreement across models that the relative time-course of meaning selection is influenced by meaning frequency and by semantic information from context (Binder & Rayner, 1998; Binder & Morris, 1995; Dopkins, Morris, & Rayner, 1992; Duffy, Morris, & Rayner, 1988; Rayner, Pacht, & Duffy, 1994; Sereno, Pacht, & Rayner, 1992). For example, the Reordered Access Model (RAM) (Duffy et al., 1988) assumes that access of homonym meanings is exhaustive and not directly constrained by

[1] Ana B. Arêas da Luz Fontes is a doctoral student at the University of Texas at El Paso; Arêas da Luz Fontes, A.B., and Schwartz, A.I. (2010) On a different *plane*: Cross-language effects on the conceptual representations of within-language homonyms. *Language and Cognitive Processes* 25(4), 508-532.
[2] Li-Hao Yeh is a doctoral student at the University of Texas at El Paso; Yeh, L., Schwartz, A. I. & Baule A. (in press). The impact of text-structure strategy instruction on the text recall and eye-movement patterns of second language English readers. Submitted to *Reading Psychology*.
[3] Dr. Ana I. Schwartz is an Assistant Professor at the University of Texas at El Paso; Schwartz, A.I., & Arêas da Luz Fontes, A.B. (2008). Cross-language mediated priming: Effects of context and lexical relationship. *Bilingualism: Language and Cognition*, 11, 1-16.

context. It postulates that the proper role of contextual information is in modulating the relative time-course with which competing meanings become activated. Although models such as the RAM can explain a variety of evidence related to ambiguity resolution, they still cannot completely explain data pertinent to bilingualism. That is, their assumptions do not address psycholinguistic dynamics that are specific to bilingualism, such as the role of cross-language lexical activation.

We hypothesized that the dynamics of cross-language activation is a critical influence on the magnitude with which a meaning is activated for bilingual readers. It is therefore of paramount importance that these dynamics be incorporated into current models of lexical disambiguation. In the present paper we present evidence that cross-language activation boosts activation of both dominant meanings and subordinate meanings in a language-pure sentence processing task. We further propose a way that these findings extend the RAM to bilinguals (B-RAM). We next turn to a review of the relevant literature on ambiguity processing before describing the present study in more detail.

2 Bilingual lexical access

Overall, research has demonstrated that bilingual lexical access is non-selective in nature. When bilinguals encounter words, lexical candidates from both languages are simultaneously activated. Most of the evidence demonstrating this non-selectivity has come from studies that have incorporated word stimuli that have some type of cross-language lexical ambiguity. For example, many studies have looked at the processing of cognates. Cognates are words that share a high degree of lexical form and have meanings that overlap across languages (e.g., piano/piano in English and Spanish). Therefore, identical cognates are ambiguous in terms of language membership. In general, these studies have found facilitative effects of cognate status (Costa, Caramazza, & Sebastian-Galles, 2000; de Groot & Poot, 1997; de Groot & Keijzer, 2000; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Dijkstra, Grainger, & Van Heuven, 1999; Dijkstra & Van Hell, 2003; Gollan, Forster, & Frost, 1997; Lemhöfer, Dijkstra, & Michel, 2004; Van Hell & de Groot, 1998; Van Hell & Dijkstra, 2002). This facilitative effect has largely been interpreted as reflecting the converging activation of the cognate's lexical representations across languages. Since cognates often have identical lexical form it is possible that they might even have a single lexical representation shared across languages. This would imply that their facilitated identification is the result of a higher pooled frequency across languages. However, in two recent trilingual studies (Lemhöfer et al., 2004; Van Hell & Dijkstra, 2002) strong facilitation effects were observed for non-identical

cognates, for which a single representation would not be possible. Although cognate facilitation has been observed across many different studies, languages and tasks, there is evidence that when the lexical overlap is not complete, these effects go away or even turn into inhibition (Dijkstra et al., 1999; Schwartz, Kroll, & Diaz, 2007).

Bilingual studies have also examined processing of interlingual homographs. Like cognates, interlingual homographs have a high degree of lexical form overlap across languages but they do not share meaning (e.g., "fin" in Spanish means "end"). Therefore, identical interlingual homographs are ambiguous not only in terms of language membership, but also meaning. Findings regarding interlingual homographs have been mixed. Some studies have demonstrated inhibitory effects associated with homograph status (Dijkstra et al., 1998; Jared & Szucs, 2002; Von Studnitz & Green, 2002) while others have failed to find any effects at all (Gerard & Scarborough, 1989). Furthermore, the specific nature of homograph effects, whether they are inhibitory or facilitative in nature, has varied as a consequence of differences in task demands, the salience of the non-target language, and the relative frequency of the homographs' lexical representations across languages (Dijkstra, De Bruijn, Schriefers, & Brinke, 2000; Dijkstra, Timmermans, & Schriefers, 2000).

The fact that cognate effects have been much more consistently observed in the literature than interlingual homograph effects suggests that shared semantics boosts activation of the alternative representation from the non-target language. In the present study we capitalized on the existence of ambiguous cognates that have multiple meanings (e.g., novel/novela in English and Spanish). These items can be considered the ideal blend of cognates and homographs: Like unambiguous cognates, there is some semantic overlap, bolstering the degree of cross-language activation. Like homographs, they are also semantically ambiguous (e.g., "novel" in English can mean "a story" or "something new"). This combination allowed us to explore the dynamics of bilingual lexical disambiguation while maximizing the likelihood that any cross-language activation of the irrelevant language lexicon would be observed experimentally, thanks to the shared semantic links.

3 Lexical ambiguity in sentence context: Monolingual and bilingual studies

It is quite clear from existing research that bilingual lexical access is non-selective in nature. Not only have effects of non-selectivity been found consistently across different paradigms and laboratories, they have also been found to occur irrespective of participants' language expectations, or language mode (Dijkstra & Van Hell, 2003; Van Hell & Dijkstra, 2002). This leaves us with an important problem, because, clearly, bilinguals are capable of

selecting a language at some point in order to communicate effectively. Nevertheless, how is this selection executed? Recently, bilingual researchers have started to examine whether the existence of a linguistic context facilitates language selection. Before reviewing this body of work, we will first consider existing monolingual theories on the influence of context on lexical disambiguation. Since most of the research on the effects of sentence context on lexical disambiguation has been based on monolinguals, it provides an important framework for interpreting the more recent bilingual investigations.

4 Monolingual investigations

There is general agreement across theories that a sentence context plays an important role in the activation and selection of meanings of ambiguous words. Theoretical differences lie primarily in the assumption regarding how exhaustively all meanings are first accessed. Context-dependent theories assume that selective access of just the target meaning is possible when the context provides adequate information. Context-independent theories assume that all meanings are accessed exhaustively, irrespective of the influences of context. This is a difficult debate to settle since the observation of selective-like patterns of performance does not necessarily rule out the possibility of initial non-selective activation.

Most theories agree that the degree of contextual support for a given meaning as well as its frequency relative to the other meanings are key factors in how early and strongly it will be activated (Binder & Morris, 1995; Duffy, et al., 1988; Duffy, et al., 2001; Tabossi, 1988; Tabossi & Zardon, 1993). The Reordered Access Model (RAM) (Duffy et al., 1988) makes specific predictions regarding how contextual support and meaning frequency interact. According to the RAM, the extent to which the multiple meanings of an ambiguous word compete is dependent on the relative time-course of their activation. The time-course of activation, in turn, depends on the relative frequency of the alternative meanings and the contextual support provided by the sentence. In the absence of a biasing context, the relative frequency of the alternative meanings determines the order (or relative speed) of their activation. However, a strong biasing context can reorder this activation.

Thus, according to this model, initial word access is affected by both lexical and contextual factors. This model does an excellent job of accounting for patterns of performance observed across various studies (Dopkins, et al., 1992; Duffy et al., 1988; Duffy, Henderson, & Morris, 1989; Duffy et al., 2001; Rayner et al., 1994; Sereno, O'Donnell, & Rayner, 2006). For this reason, we sought to extend this model to bilingual reading by examining whether the interactions between context and meaning frequency would be further modulated by cross-

language activation. Since our predictions rested on the assumption that there is continued cross-language activation in sentence context, we next turn to a review of bilingual sentence processing and what it suggests about continued non-selectivity in context.

5 Bilingual investigations

Recent research on bilingual lexical access in sentence context demonstrates that a sentence context can constrain cross-language activation. However, the mere presentation of a sentence does not allow for complete language-selective activation (Altarriba, Kroll, Sholl, & Rayner, 1996; Duyck, Assche, Drieghe, & Hartsuiker, 2007; Elston-Güttler, Gunter, & Kotz, 2005; Schwartz & Kroll, 2006; Libben & Titone, 2009; Van Hell & de Groot, 2008). For example, more language-selective patterns of performance have been observed when the sentence contexts are highly biasing (Schwartz & Kroll, 2006; Van Hell, 1998; Van Hell & De Groot, 2008; Libben and Titone, 2009).

Conversely, more language *non*-selective patterns of performance are typically observed when the target word stimuli have a high degree of lexical overlap, particularly semantic overlap (Duyck et al., 2007; Elston-Güttler, 2000; Schwartz & Kroll, 2006; Van Hell & De Groot, 2008). For example, Schwartz and Kroll (2006) found more consistent effects of cross-language activation in low-constraint sentences for cognates then they did for interlingual homographs. Using eye-tracking methodology, Duyck et al. (2007) observed shorter reading times for identical cognates in sentence context, but not for non-identical cognates (e.g., *banaan-banana* in Dutch and English). Elston-Güttler (2000) found no cross-language priming in sentence context between an interlingual homograph and its non-target L1 translation (e.g., *gift-poiso*n; gift means "poison" in German). However, in the same study significant priming was observed when the primes and targets were translations of homonyms from the non-target L1 (e.g., *pine-jaw*; both are translations of "kiefer" in German). This suggests that the cross-language, semantically-based, translational links were more resilient to the constraints of a sentence context than simple form-based links. Therefore it seems that the extent to which a sentence context actually limits cross-language activation depends on whether the critical words share semantic links across languages. However, Van Hell and De Groot (2008) observed that the influence of sentence context was similar when differences in the semantic overlap of the critical items was more subtle (comparing abstract and concrete cognates) rather than absolute (e.g., comparing homographs to cognates).

In summary, the bilingual research demonstrates that a sentence context has a general constraining or attenuating effect on cross-language activation. Given the large body of

monolingual literature examining the effects of context on meaning activation of ambiguous words, in the present study we investigated whether a sentence context has a more specific effect on processes of the activation and selection of meanings of L2 words.

It has recently been demonstrated that how bilinguals process homonyms in context is further influenced by cross-language lexical activation (Schwartz, Yeh & Shaw, 2008). In that study, highly proficient Spanish-English bilingual read English sentences that biased the subordinate meaning of the final-word homonym, which was either a cognate (e.g., novel/novela) or noncognate (e.g., fast/rápido) with Spanish. Participants showed a cost in processing when rejecting follow-up target words that were related to the contextually-irrelevant dominant meaning (e.g., BOOK for "novel"). More critically, this cost was significantly greater when the homonym was a cognate and the dominant meaning was shared with Spanish. This finding demonstrates that bilinguals activate the semantic representations of homonyms from the non-target language even in a single-language task. The critical implication for current models like the RAM is that such cross-language activation influences the strength with which a meaning competes for selection.

In the interest of extending the RAM to bilingualism one goal of the present study was to replicate the major finding from Schwartz et al (2008) and to more thoroughly examine the role that cross-language lexical activation plays in bilingual homonym processing. Specifically, the RAM assumes that the dominant meanings of homonyms are always activated and context operates by sometimes allowing other, more subordinate meanings to be activated early enough to compete with the dominant meaning.

Thus, we hypothesized that, if cross-language lexical representations are activated during reading, competition from dominant meanings homonyms would be even greater if they are shared across a bilingual's languages. For example, "fast" and "novel" are both English homonyms. However, "novel" is also a cognate with "novela" in Spanish and the dominant meaning is shared across the two languages (e.g., the meaning of a fiction story). Therefore, we predicted that we would observe greater competition from the dominant meaning of "novel" than that of "fast". Using the same logic, we predicted that when a subordinate meaning of a cognate homonym (e.g., the weapon meaning of *arm/arma*) is shared across languages, its activation would be boosted, allowing access of that meaning to be facilitated relative to that of a subordinate meaning of a noncognate homonym (e.g., the "not eating" meaning of *fast*).

6 Methods

6.1 Participants

142 highly proficient Spanish-English bilingual undergraduate students from the University of Texas at El Paso participated in the study. All participants earned course credit for their participation. Data from 34 participants were excluded from the analyses due to high error rates (greater than 30% on the control conditions and/or greater than 60% on the critical conditions) and 36 participants were excluded because they did not meet the criteria for bilingualism to be included in the study (See complete criteria in the Results section). These exclusions produced a final sample size of 62 participants. Participants were randomly assigned to one of the two experimental conditions (dominant meaning shared with Spanish, n=39; subordinate meaning shared with Spanish, n=23).

6.2 Materials and Design

Dominant meaning shared

Prime words. The critical stimulus list included 80 English prime words. Half of these words (40) were semantically ambiguous, polarized homonyms in English that had one highly-frequent meaning. Half of these ambiguous primes (20) were English-Spanish cognates [e.g., novel (novela)] and half were noncognates [e.g., fast (rápido)]. The dominant meaning of the cognate homonyms was always shared with Spanish. Since most ambiguous words have more than two alternative meanings our selection of critical prime words was guided principally by the existence of one, clearly dominant meaning and many of the ambiguous primes had third meanings and/or senses in both English and Spanish and this was not confounded by cognate status. To minimize effects of other meanings and/or senses we made sure the dominant meaning had a published probability of at least 75% (Twilley, Dixon, Taylor, & Clark, 1994). Five Spanish-English bilingual research assistants reviewed all the selected ambiguous words and confirmed that the first two primary meanings were meanings commonly used in the surrounding bilingual community.

The remaining 40 unambiguous prime words were similarly divided into cognates [e.g., piano (piano)] and non-cognates [e.g., pencil (lápiz)]. Since homonymy is confounded with lexical frequency, cognate and non-cognate prime words were matched on lexical frequency and word length within each ambiguous condition (see Table 1).

Target words. Each prime word was paired with a target word. For each critical, ambiguous prime word the target word was related to its dominant meaning [e.g., novel (BOOK), fast (SPEED)] while for each critical, unambiguous prime word the target word was completely unrelated to its meaning [e.g., piano (GRASS), pencil (HAPPY)]. It was not

possible to obtain a sufficient number of target words that were all noncognates while maintaining a match in lexical characteristics and avoiding associative relationships with primes. The existence of cognate target words was not confounded by condition. In other words, we had similar number of cognate target words across conditions. An additional 80 prime-target word pairs were included for filler, "yes" trials. To ensure that the presence of a cognate or ambiguous word would not cue the participant to a "no" response, the filler primes included 30 cognates and 30 ambiguous words. Target words for these filler, "yes" primes were selected so that they were highly related to the prime word (e.g., theater-STAGE).

All prime words were preceded by a sentence frame which strongly biased its meaning (subordinate meaning for ambiguous words). This sentence frame consisted of the complete sentence minus the last word. The frames were written to be as concise as possible (15 words or less) with simple syntactic structure (we avoided using embedded clauses) (see Table 2).

Table 1. Lexical characteristics of prime-target stimuli used in the experiment.

	Dominant meaning shared condition			
	Ambiguous primes		Unambiguous primes	
	Cognate	Noncognate	Cognate	Noncognate
Example pair	novel- BOOK	drag- PULL	poet- BUILD	happy- BEAUTY
Mean prime frequency[1]	113.8	95.9	70.2	101.1
Mean prime length[2]	5.1	5.0	5.9	6.0
Mean target frequency[1]	98.0	115.5	97.1	115.1
Mean target length[2]	5.5	5.0	5.0	5.1
	Subordinate meaning shared condition			
	Ambiguous primes		Unambiguous primes	
	Cognate	Noncognate	Cognate	Noncognate
Example pair	plane- FLAT	ruler- KING	guitar- BASS	carrot- CELERY
Mean prime frequency[1]	69.1	76.2	58.0	71.8

Mean prime length[2]	5.6	5.2	6.0	6.4
Mean target frequency[1]	119.2	79.3	63.2	150.5
Mean target length[2]	6.3	5.8	6.2	5.8

[1.] Celex; [2.] Number of letters

Subordinate meaning shared

Prime words. The critical stimulus list included 152 English prime words. Seventy-six of these were semantically ambiguous, polarized homonyms in English that had one highly-frequent meaning. Half of these ambiguous primes (38) were English-Spanish cognates [e.g., arm (arma)] and half were noncognates [e.g., ball (pelota)]. As with dominant meaning shared conditions, our selection of critical prime words was guided principally by the existence of one, clearly dominant meaning. We made sure the dominant meaning had a published probability of at least 70%. Thus, the subordinate meaning had a published probability of 30% or less (Twilley et al., 1994). For the ambiguous cognate condition we selected those for which the subordinate meaning was shared with Spanish and the dominant meaning was not. Once again bilingual research assistants from the surrounding community verified that both the dominant and subordinate meanings were commonly known and used in the region. The remaining 76 prime words were unambiguous words and were similarly divided into cognates (n = 38) [e.g., piano (piano)] and non-cognates (n =38) [e.g., pencil (lápiz)]. As in dominant meaning shared conditions, cognate and non-cognate prime words were matched on lexical frequency and word length within each ambiguous condition (see Table 1).

Target words. Each prime word was paired with a target word. For each critical, ambiguous prime word the target word was related to its subordinate meaning (e.g., plane-FLAT; ruler- KING) and each critical, unambiguous prime word was paired with a target word related to its meaning (e.g., guitar- BASS; carrot- CELERY].

The entire set of critical prime-target word pairs were randomly split into two experimental running lists (n = 76). Additional filler, "no" pairs (n = 76) were included in each running list. To ensure that the presence of a cognate or ambiguous word would not cue the participant to a "yes" response, the primes of these filler pairs included 30 cognates and 30 ambiguous words. Target words for these filler, "no" trials were unrelated to the prime words (e.g., word-TIGHT).

All prime words were preceded by a sentence frame which strongly biased its meaning (dominant meaning for ambiguous words). This sentence frame consisted of the complete sentence minus the last word. The frames were written to be as concise as possible (15 words or less) with simple syntactic structure (we avoided using embedded clauses) (see Table 2).

Table 2. Example materials of sentences, prime and target words by conditions

Dominant meaning shared condition			
Prime condition	Sentences	Prime	Target
Ambiguous cognate	He is an original thinker and all of his ideas are	novel	BOOK
Ambiguous non-cognate	Before tossing the cigarette she took one more	drag	PULL
Unambiguous cognate	Though he sometimes wrote prose, he was also a	poet	BUILD
Unambiguous non-cognate	She was tired of feeling depressed and made an effort to feel	happy	WOOD
Subordinate meaning shared condition			
Prime condition	Sentences	Prime	Target
Ambiguous cognate	He trained for months before entering the	race	ETHNICITY
Ambiguous non-cognate	Drawing a straight line is easier with a	ruler	KING
Unambiguous cognate	The drummer of the band could also sing and play the	guitar	BASS
Unambiguous non-cognate	When she wanted to give her rabbit a treat she would offer a	carrot	CELERY

The experiment was based on a 2 X 2 X 2 mixed design. The between-subject independent variable was the status of the meaning shared with Spanish (dominant or subordinate meaning shared). The two within-subject independent variables were cognate status (cognate versus non-cognate) and ambiguity (ambiguous versus unambiguous) of the

critical prime words. The dependent variables were reaction time in milliseconds measures and percent error rates on the semantic verification task.

6.3 Procedure

All interactions with participants were carried out in English (L2). After informed consent procedures, participants were randomly assigned to one of the conditions and tested in individual rooms where they were seated in front of a computer. They were instructed that they would be reading sentence frames presented on the computer screen. When they had read each frame they were to press a key on a button-box and the last word of the sentence would appear. Finally, a target word would be presented in all capital letters. In the dominant meaning shared condition, participants were asked to decide, as quickly and accurately as possible, whether the target word was related in meaning to the last word of the sentence, as the last word was used in the sentence. In the subordinate meaning shared condition, participants were asked to decide if the target word was related in meaning to the last word of the sentence, regardless of how the word was used in the sentence. Participants were given 20 practice trials before starting the experimental trials. Each trial was initiated by the presentation of a fixation point ("+") in the center of the screen. This fixation remained on the screen until the participant pressed a key on the response box. The sentence frame was presented until the participant made another button press. After the button press the last word of each sentence (i.e., the prime word) was presented for 250 ms, followed by a blank of another 250 ms, until the target word was presented in all capital letters (SOA=500 ms). The target word remained on the screen until the participant made a response or four seconds had elapsed. Trials were randomly selected from each condition.We chose to use the 500 ms SOA for two reasons. First, the 500 ms SOA is interpreted as reflective of integration processes, which is what participants are required to do in the semantic verification task. Second, because previous research by Elston-Güttler & Friederici (2005) demonstrated that during this integration phase, non-natives showed priming for both contextually appropriate and inappropriate meanings of ambiguous words. Therefore, we expected to find similar patterns of priming in the present study.

After completing the computer task, participants completed a language history questionnaire in which they were asked to self-assess their proficiency in reading, writing, speaking and listening in English and Spanish on a ten-point scale. The entire experimental procedure was completed in approximately one hour.

7 Results and Discussion

7.1 Data exclusion criteria

Participants who acquired Spanish later than five years old, and rated either their English or Spanish proficiency lower than five (on a scale from 1 to 10) were excluded from data analyses because they did not meet the bilingualism criteria.

Any participant who had a greater than 30% error rate on the control condition was excluded. Furthermore, any participant who had a greater than 60% error rate on the critical ambiguous conditions was also excluded. We raised the criterion for the critical ambiguous conditions because we expected greater error rates due to our manipulation (forcing participants to reject target words related to a dominant meaning of an ambiguous word).

After applying both exclusion criteria, data from 62 participants were used for further analyses. Thirty nine participants were in the dominant meaning shared condition and 23 were in the subordinate meaning shared condition.

7.2 Language history questionnaire data

The data from the language history questionnaires are summarized in Table 3. Participants reported acquiring Spanish earlier (3.1 years of age) than English (5.6 years of age), [t (61) =3.9, $p < .01$]. Within the context of this study we use the labels "L1" and "L2" according to the relative timing of acquisition. Thus, the language acquired earlier is designated as L1 and L2 refers to the language acquired later on in life. Since participants in the present experiment acquired English somewhat later in life, around six years of age, it is considered to be the L2.

Overall, participants rated their proficiency high in both Spanish (M = 8.5) and English (M = 9.2). However, they consistently rated their English skills higher than their Spanish skills, [t (61) = 2.8, $p < .01$], suggesting that they had become more dominant in their L2. This shift in language dominance from the L1 to the L2 is commonly observed at the University since most of the students complete their academic work in their L2. Participants also reported frequent and daily use of both of their languages.

7.3 Error rate analyses

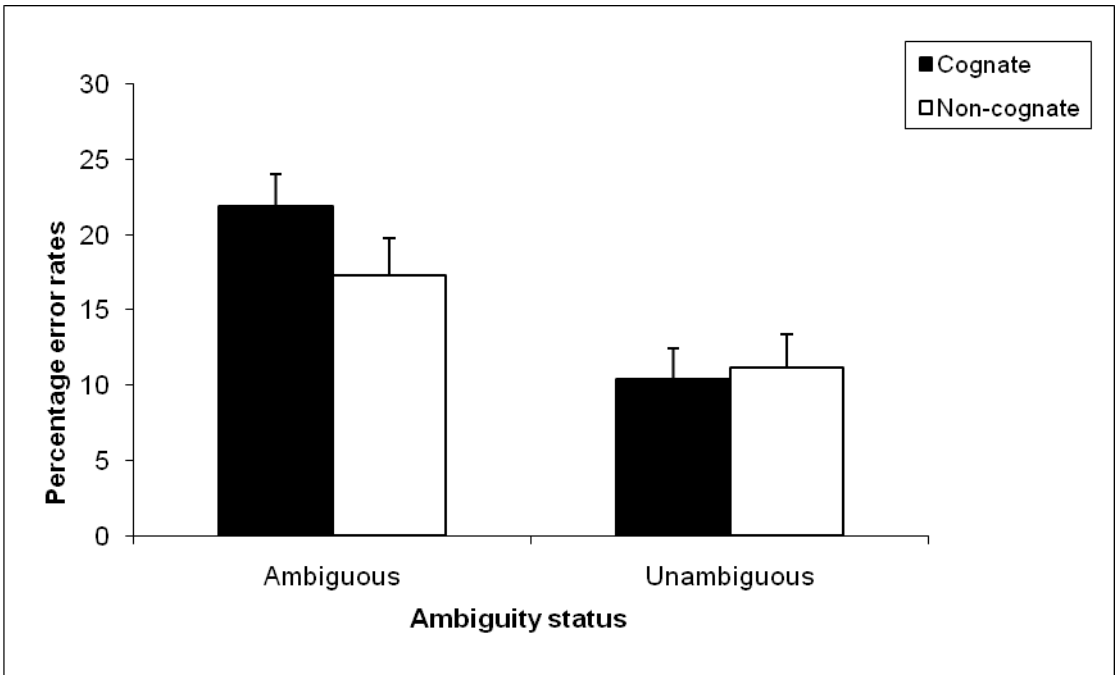
A three-way (meaning shared x ambiguity x cognate status) repeated measures ANOVA was performed on the participants' mean percent error rates for the critical trials. The main effect of meaning shared was significant [F(1, 60) = 7.46 MSE = 3735.7, $p < .01$]. This is likely due in part to the difficulty in accepting target words that were related to the

subordinate meaning of the ambiguous primes on "yes" trials (e.g., accepting "STARVE" after seeing "fast"). This difficulty raised the participants' criterion for a "no" response, thus producing a higher rate of incorrect acceptance. The main effect of ambiguity was significant [F (1, 60) = 99.0 MSE = 15417.3, p < .01]; reflecting the higher error rates for trials in which the prime word was ambiguous versus unambiguous.

Most importantly, the three way interaction was significant [F(1,60)=15.0, MSE=671.1, p< .01]. In order to disentangle this three way interaction and to better address the processing difference between responses to dominant and subordinate shared meanings, two follow up 2 (ambiguity) x 2(cognate) repeated measure ANOVAs were performed for dominate meaning shared and subordinate meaning shared conditions.

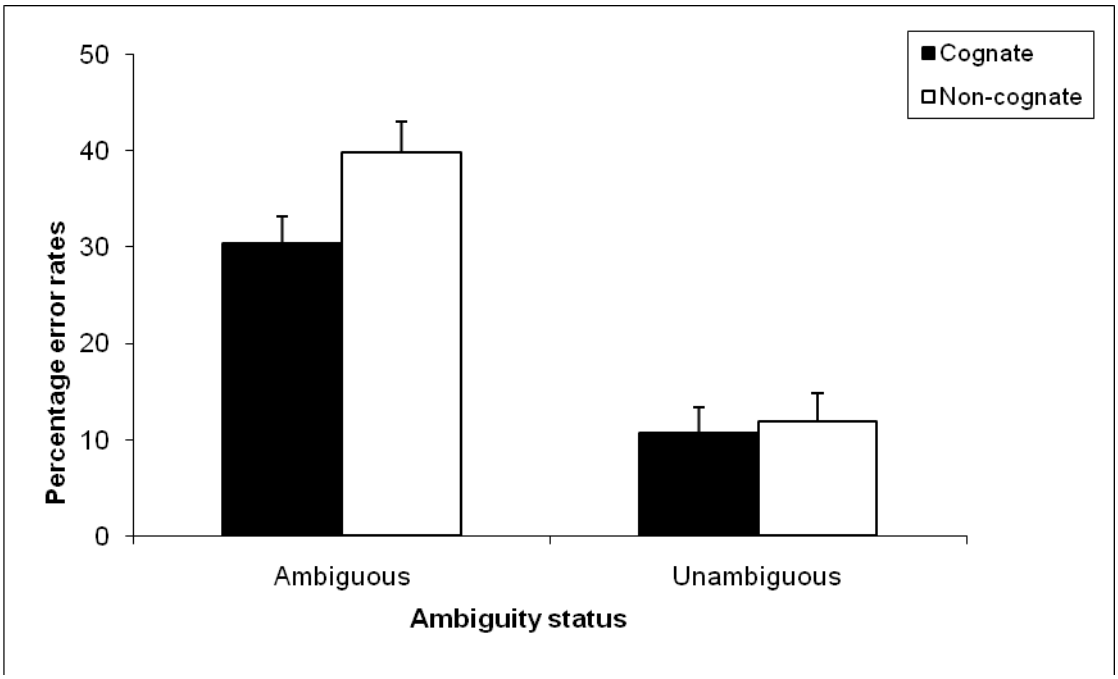
Dominant meaning shared. The main effect of ambiguity was significant [F (1,38)=29.3, MSE=3051.9, p<.01]. Most importantly, the main effect of ambiguity interacted significantly with cognate status [F(1, 38) = 8.5 MSE = 282.7, p < .01]. The follow-up planned comparison showed that for the ambiguous conditions, there was an *increase* in error rates when the prime words were also cognates [t (38) =2.73, p< .01]. In other words, participants had more difficulty rejecting a target word related to the contextually-irrelevant, dominant meaning of an ambiguous prime word if it was shared with Spanish. This finding supports our hypothesis that, when the meaning of an ambiguous word is shared across a bilingual's two languages, it is more strongly activated than an English-exclusive meaning.

Figure 1. Error rates on the critical trials of the semantic verification task in the dominant meaning shared condition.



Subordinate meaning shared. The main effect of ambiguity was also significant [$F(1,22)=58.1$, MSE=10325. 7, $p< .01$]. As in the dominant meaning shared condition, the interaction between ambiguity and cognate was also significant [$F(1,22)=6.0$, MSE=390.1, $p<.05$]. The follow-up planned comparison showed that in the ambiguous conditions, participants made *less* errors when the ambiguous prime words were also cognates with Spanish [t (1,22) =3.9, $p<.01$]. This result reflects the fact that participants found it easier to accept a target word related to the context-irrelevant, subordinate meaning of a prime word if this meaning was shared with Spanish, compared to an English-exclusive meaning. This finding also supports our hypothesis that a subordinate meaning that is shared across a bilingual's two languages would receive stronger activation than a non-shared meaning and would therefore be more easily integrated into the context of a sentence.

Figure 2. Error rates on the critical trials of the semantic verification task in the subordinate meaning shared condition.

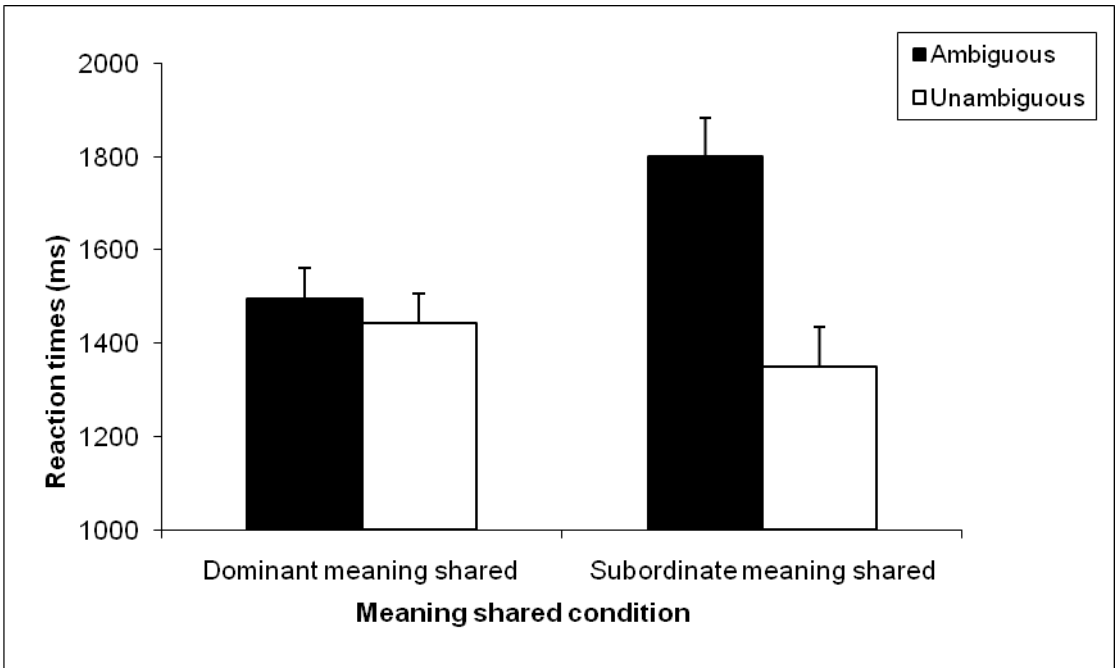


7.4 Reaction time analyses

Analyses on decision latency data were performed for correct trials only. Overall, the main effect of meaning shared was not significant [F (1, 60) = 1.08, MSE=646847.1, p >.05], which suggested that decision latencies for accepting (1469 ms) and rejecting context-irrelevant meanings (1575 ms) did not significantly differ from each other. The main effect of ambiguity was significant [F (1, 60) = 85.4, MSE = 3674815.9, p < .01], reflecting the slower reaction times for trials in which the prime word was ambiguous versus unambiguous.

The main effect of ambiguity significantly interacted with meaning shared [F (1, 60) = 52.6 MSE = 2263381.3, p < .01]. The follow-up planned comparison showed that for the subordinate meaning shared condition, there was an increase in reaction times when the prime words were also ambiguous [F(1,22)=106.53, MSE= 4652470.3, p< .01]. This interaction provides further evidence of the effects of cross-language activation on bilingual lexical disambiguation because the cognate status of a word was embedded in the meanings shared conditions. In other words, when looking across the meaning shared conditions, there was always a cognate meaning that was shared with Spanish (either the dominant or the subordinate).

Figure 3. Mean decision latencies across the ambiguous conditions of the semantic verification task.



Overall the results from this experiment provide evidence that bilingual lexical disambiguation is affected by the co-activation of meanings from the non-target language.

8 General Discussion

The primary objective of the present study was to examine whether cross-language lexical activation influences L2 lexical disambiguation processes for bilinguals. We predicted that when bilinguals confront ambiguous L2 words that are cognates with the L1, co-activation of the L1 representation would influence the time-course and strength with which individual meanings would be activated. The findings confirm our predictions: processing of target words was influenced by whether it shared an identical meaning with Spanish.

In the dominant meaning shared condition there was boosted competition from the co-activated dominant meaning of ambiguous cognate prime words (e.g., novel). Consequently, participants made significantly more errors on trials that required them to maintain activation of subordinate meanings while rejecting target words related to dominant meanings. The subordinate meaning shared served as the perfect mirror image of the dominant meaning shared condition. In that case, error rate data showed that co-activation of shared, subordinate meanings facilitated activation of those meanings in the face of competition from the contextually supported dominant meanings. Thus, bilinguals in the present study showed patterns of non-selective activation for both meanings of the biased ambiguous prime words. This converges with previous research demonstrating that highly proficient bilinguals can

quickly activate the multiple meanings of ambiguous words in ways similar to native speakers (Frenck-Mestre & Prince, 1997).

The fact that most of the findings occurred in the error rate data can be understood through the two-process theory of context effects on lexical activation (Stanovich & West, 1981). According to this theory, context influences word identification by a combination of fast-acting, automatic processes (i.e. spreading activation) that produce early facilitative effects, and slower-acting, conscious-attentional processes that produce later inhibitory effects. Reaction times more generally tap into the fast-acting, automatic processes, while error rates tap into the slower-acting, conscious-attentional processes. Thus, the effects on error rates reflect the nature of the semantic verification task, which requires slower, more conscious driven processes to take place to allow for inhibition of contextually irrelevant meanings, while allowing for integration of relevant meanings.

The pattern of findings for the *non-cognate* conditions are compatible with the reordered access model (RAM) which makes the following assumptions: (1) All meanings of a homonym are exhaustively accessed, (2) The timing of this access depends largely on the relative frequency of the meaning, however, (3) the presence of a biasing context can change the relative ordering of activation. Across both conditions there was a significant cost associated with activation of the subordinate meanings of the non-cognate ambiguous primes, even when it was supported by a preceding sentential context. The RAM accounts for this pattern, first by assuming that the decreased frequency of subordinate meanings prevents them from being quickly activated. Second, although the contextual support of a subordinate meaning allows it to be activated at an earlier time frame, exhaustive access of the dominant meaning forces competition between the two.

While findings from the non-cognate conditions support the RAM in its current form, findings from the *cognate* conditions extend it. In the present study we observed both greater competitive and facilitative effects for shared, cognate meanings. We suggest that the greater magnitude in both inhibitory and facilitative effects were due to cross-language lexical activation of the L1 representations. This co-activation altered the strength with which these meanings became activated making them either more difficult or easier to be integrated into a sentence context.

Based on the findings from this study, it becomes clear that a bilingual model for lexical ambiguity resolution would have to include cross-language activation as an influencing factor. As an extension of the RAM, a bilingual version of the RAM would incorporate cross-language lexical activation as an additional factor that influences the

relative strength with which various meanings become activated and compete. This factor is separable from influences due to differences in meaning frequency that occur through extended language use. Future research can further dissociate the differential contribution of relative meaning frequency and cross-language activation by including language-blocking versus language-mixing manipulations as well as the extent of lexical form overlap of the critical word stimuli.

The present study adds to existing theories and models of homonym processing by comparing disambiguation of words that are ambiguous within a language with those that are ambiguous across languages. Future studies should examine the time-line of the disambiguation of cognates and non-cognates more precisely through methods such as eye-movement monitoring and the use of ERP's. Future research should also examine to what extent the cross-language lexical activation can completely reorder the time-line with which subordinate and dominant meanings are activated.

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Contato: aafontes@miners.utep.edu
lhyeh@miners.utep.edu
aischwartz@utep.edu