

AN INVESTIGATION OF THE INDIVIDUAL DIFFERENCES IN COGNITIVE FACTORS
THAT CONTRIBUTE TO BILINGUAL LEXICAL DISAMBIGUATION

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by

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Abstract

The objective of this study was to investigate the effects of working memory capacity, access to subordinate meanings of L1 homonyms and degree of cross-language activation on the access to subordinate meanings of L2 homonyms. In Experiment 1, Spanish-English bilinguals completed a word recognition task which assessed how quickly and accurately they accessed subordinate meanings of English homonyms that were either noncognates (e.g. *fast/rápido*) or cognates (e.g. *letter/letra*) with Spanish. In Experiment 2, another group of Spanish-English bilinguals read sentences while having their eye-movements recorded for measures of lexical access. On the critical trials, sentences contained a homonym that was either a noncognate (e.g. *fast/rápido*) or cognate with Spanish (e.g. *letter/letra*). The context preceding the target word (i.e. homonym) was either biased to the subordinate meaning or neutral. General analyses from Experiments 1 and 2 showed that access to subordinate meanings of cognate homonyms was facilitated compared to access to subordinate meanings of noncognate homonyms. Analyses of the individual differences factors revealed that access to subordinate meanings of L1 homonyms was the most consistent predictor of access to subordinate meanings of L2 homonyms. These findings are discussed in terms of how these individual differences should be taken into account to better model the dynamics of bilingual lexical disambiguation.

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Introduction

Recent research in adult second language learning has demonstrated that semantically-ambiguous words (aka “homonyms”) are harder to learn than unambiguous words because of a lack of one-to-one mapping between meanings across languages (Degani & Tokowicz, 2010). Furthermore, research with monolinguals has shown that the ability to efficiently select relevant meanings of homonym words is a key characteristic of good comprehenders in reading (Gernsbacher & Faust, 1991). Thus, while homonyms may be difficult to learn, it is particularly important that they be acquired well because the efficiency with which they are processed characterizes good readers. In the present experiments I investigated the influence of three individual differences on lexical disambiguation in the second language (L2): (1) working memory capacity, (2) degree of cross-language activation effects observed during word identification and (3) degree of efficiency of accessing subordinate meanings in the first language (L1). I focused specifically on the extent to which these three factors predict the ability of L2 readers to quickly and accurately access the subordinate meanings of homonyms (e.g., accessing the “weapon” meaning of the English homonym *arm*). These factors were examined in both a single-word context (Experiment 1) and a sentence context (Experiment 2). Before describing the present experiments in more detail, I will first review relevant research on the processing of homonyms performed with monolingual participants, in and out of context. Then, I will review relevant research on bilingual studies of lexical disambiguation, and finally, I will discuss how the three proposed cognitive factors might play a role in bilingual lexical disambiguation.

Monolingual Studies on the Processing of Homonyms

Relatively little is known about the cognitive nature of lexical disambiguation in a second language. However, existing models of lexical disambiguation that have been developed based on monolingual data offer an initial framework for studies with bilinguals. Many studies have demonstrated that all meanings of a homonym are activated during initial stages of word recognition (Azuma & Van Orden, 1997; Rodd, Gaskell & Marslen-Wilson, 2002; Beretta, Fiorentino & Poeppel, 2005; Klepousniotou & Baum, 2007). There is also a large body of research addressing the question of whether the presence of a sentence context would allow for selective activation of the context-appropriate meaning only. This body of research has produced disparate findings concerning the role of a sentence context on meaning activation, and thus, researchers have proposed models of lexical disambiguation that differ in whether they allow for the influence of context on pre-lexical (before the word is uniquely retrieved from the lexicon) meaning access. Exhaustive models assume that all meanings of an homonym are exhaustively accessed prelexically, regardless of context (Frazier & Rayner, 1987; Rayner & Duffy, 1986; Swinney, 1979; Seidenberg, Tanenhaus, Leiman & Bienkowski, 1982; Onifer & Swinney, 1981; Swinney, 1979). Selective models, on the other hand, assume that activation of meanings is influenced by context, and a highly constrained context can potentially allow for selective access of the appropriate meaning even prior to completion of lexical retrieval (Simpson & Kreuger, 1991; Tabossi 1988; Tabossi, Colombo & Job, 1987). For example, Tabossi (1988) found that when a context biases the dominant meaning of a homonym by making salient a characteristic feature of it, thus allowing for both dominance and context to converge on the same semantic information, then the subordinate, contextually irrelevant meaning of the homonym is not accessed.

To account for the findings that a sentence context may indeed constrain meaning activation, other models were developed. These models proposed that all meanings of an homonym are accessed, but that the time course of activation of these meanings is influenced by context. These models are referred to as hybrid models (Duffy, Morris & Rayner, 1988; Kawamoto, 1993; Simpson & Burgess, 1985; Twilley & Dixon, 2000; Kawamoto & Zemblidge, 1992). As an example, the Re-ordered Access Model (RAM) (Duffy et al., 1988) assumes that the relative frequency of the meanings of a homonym and the surrounding sentence context will influence the relative time course with which each meaning becomes activated and selected. According to the RAM, the unselected meaning of a homonym passively decays. Other hybrid models exist and they differ in the extent to which they characterize exhaustive access as mandatory or highly likely, and the extent to which the unselected meaning is actively inhibited, or simply decays with time.

The RAM, has been widely used in previous research because it consistently predicts and explains meaning dominance and context effects (Kambe, Rayner and Duffy, 2001; Sereno, Rayner and Posner, 1998; Sereno, Brewer and O'Donnell, 2003). The general methodology employed across these studies has been to monitor readers' eye movements as they read sentences containing semantically homonym homographs (e.g. novel, spring). Duffy, Morris and Rayner (1988) presented participants with either balanced homographs (homonyms with two equally frequent meanings) (e.g., fan) or unbalanced homographs (homonyms with one meaning more frequent than the other) (e.g., fast). When unbalanced homographs were preceded by a neutral context (disambiguating context after the homonyms), fixations were similar to the control, unambiguous words. This suggests that the more dominant meaning of the word was activated early in processing, not allowing the subordinate meaning to compete for selection.

However, when these same words were preceded by a sentence context that biased the subordinate meaning of the word, longer gaze durations were observed, compared to controls. This suggests that the disambiguating context allowed for the subordinate meaning to become activated earlier and to compete for selection with the dominant meaning. This effect has been consistently observed across many studies (Sereno, O'Donnell & Rayner, 2006; Kambe et al., 2001, Duffy, Kambe & Rayner, 2001) and has been called the subordinate bias effect (SBE).

In the present study I capitalized on the reliability of the subordinate bias effect to examine bilingual activation of multiple meanings homonyms. To extend the predictions of the RAM, in particular the subordinate bias effect, to L2 lexical disambiguation, we must take into account the effect of cross-language activation and how it might interact with influences of meaning dominance and context. The potential role of cross-language activation on meaning activation can provide further insight regarding the extent to which meaning activation is necessarily exhaustive or potentially constrained by information from context and/or language membership. Within the interpretive framework of the RAM, the subordinate bias effect occurs because the context supporting the subordinate meaning allows it to compete early on with the default-activated dominant meaning. If cross-language activation allows for subordinate meanings that are shared across a bilingual's two languages (as would be the case for cognate homonyms) to be accessed even earlier in a biased context this might allow the subordinate meaning to be activated sufficiently early to bypass competition from the dominant meaning. This could produce an elimination of the any observable subordinate bias effect.

Cross-language Activation and its Effects on Lexical Disambiguation

Research on bilingual lexical access has now consistently found it to be language-nonselective in nature (e.g., de Bruin, Dijkstra, Chwilla & Schriefers 2001; Dijkstra, de Bruijn, Schriefers, & Brinke 2000; Dijkstra & Van Hell, 2003; Gollan, Forster, & Frost, 1997; Jared & Kroll, 2001; Van Heuven, Dijkstra, Grainger, & Schriefers, 2001; Schwartz, Kroll, & Diaz, 2007). The implication is that, despite a bilingual's intentions to use only one language, both languages are activated in parallel. One source of evidence for non-selectivity is from the large number of studies showing cognate facilitation, in which bilinguals are faster to recognize a cognate such as "piano" in English and Spanish than a control word (Dijkstra, Grainger, & Van Heuven, 1999; Gollan, et al., 1997; Kroll & Stewart, 1994). Another source of evidence is the finding of homograph inhibition, where bilinguals are slower to recognize or name a homograph such as "fin" than a control word (Jared & Szucs, 2002; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998),

A few recent studies have examined the effect of a sentence context on cross-language lexical access to see if it constrains parallel activation of the non-target lexicon (Libben & Titone, 2009; Duyck, Van Assche, Drieghe & Hartsuiker, 2007; Elston-Güttler, 2000; Elston-Güttler, Gunter, Kotz, 2005; Schwartz & Kroll, 2006; Van Hell & de Groot, 2008). These studies have consistently shown that the simple presence of a sentence is not enough to eliminate nonselective, cross-language activation. For example, several studies have demonstrated persistent cognate facilitation effects when cognates were embedded in a low-constraint sentence context (i.e. sentences containing little semantic information leading to the target word) (Duyck et al., 2007; Schwartz & Kroll, 2006; Van Assche, Duyck, Hartsuiker & Diependaele, 2009; Van Hell & de Groot, 2008). These persistent effects have been observed even when the sentences are

presented in the bilingual's dominant first language (Van Assche et al, 2009). On the other hand, processing of the cognate targets appears language selective when targets are embedded in sentence contexts that highly bias their meaning. For example, in two separate studies effects of cognate facilitation observed in low-constraint sentences were completely eliminated in high-constraint sentences (Schwartz & Kroll, 2006; Van Hell & de Groot, 2008). In other words, the cognate facilitation found in low-constraint sentences was completely eliminated when the same words were embedded in high-constraint sentences. However, recently, Libben and Titone (2009) found evidence for non-selectivity even in high-constrain sentences. It should be noted that these effects were confined to early measures of lexical access (i.e. first fixation durations), suggesting that context may act to limit the time-course of cross-language interactivity.

The sentence context studies summarized above demonstrate that when words share lexical form overlap across languages (cognates and homographs are orthographically similar across languages) their corresponding lexical representations are co-activated. Bilingual sentence context studies have demonstrated that cross-language activation influences lexical access even in the absence of overt form overlap. If the two languages of a bilingual are activated simultaneously during lexical access, even in context, then it is possible that this cross-language activation affects how bilinguals access and activate the multiple meanings of homonyms in general, even when these are not cognates with the non. Studies have directly examined bilingual processing of homonyms in sentence context. Elston-Güttler, Paulmann & Kotz (2005), for example, demonstrated that when the translation of a target word has more than one meaning in the other, non-target, language (it's a homonym in the non-target language) those meanings are activated and influence processing in the target language. They presented German-English participants with German homonyms translated into English to form prime-target pairs (*keifer* in

German has two meanings and thus translates into both “pine” and “jaw”) to test whether competition between the German meanings would cause interference in an English language experiment. Thus, the actual German homonym was not presented, only its’ translations were presented in the non target language. When the prime-target pairs were presented in isolation in a lexical decision task (Experiment 1), the performance of low-proficiency bilinguals showed an inhibitory effect. The authors argued that such results suggest that the two translations of a homonym are connected by inhibitory connections in the mental lexicon.

In Experiment 2, the same materials were presented in a sentence context. The prime word was presented as the last word of the sentence, followed by the target word. In this case, the sentence biased either the dominant or subordinate meaning of the German homonym, and the target was always related to the meaning that was not biased by the sentence. Again, low-proficiency learners showed strong overall inhibitory effects in the ERPs (100-250 ms) and reaction time data. High-proficiency bilinguals, on the other hand, showed no effects on either measure. The authors concluded that the ERP and reaction time effects observed by low-proficiency learners in sentence context make a strong case for a highly integrated lexicon linked at the word form level and a fundamentally non-selective word-recognition system.

Schwartz, Yeh & Shaw (2008) have also examined how cross-language activation influences bilingual lexical disambiguation by testing whether the subordinate bias effect, previously observed in monolingual studies, would increase in magnitude when the ambiguity extends across both languages (by virtue of the homonym also being a cognate). They presented highly proficient Spanish-English bilinguals with sentences that biased the subordinate meaning of an English homonym (e.g. novel – NEW). Thus here, the homonym was presented, in the target language of the experiment. These homonyms were either noncognates (e.g., fast/rápido)

or cognates (novel/novela) with Spanish. Sentences were followed by target words that on critical trials were related to dominant, contextually irrelevant meaning of the homonym (e.g. novel - BOOK). Participants were asked to decide if the follow-up target words were related to the sentence they had just read (thus requiring a “no” response).

Participants exhibited longer reaction times and greater error rates when the last word of the sentence was a homonym and the follow-up target word was related to its dominant meaning. More interestingly, the relative cost of this ambiguity effect was greater when the homonym was also a cognate with Spanish. In other words, an enhanced subordinate bias effect was observed. This suggests that the contextually-irrelevant, dominant meaning received co-activation from both of the bilinguals’ languages thus producing more interference.

Taken together these findings suggest that cross-language activation plays a central role in bilingual lexical disambiguation in both single word and sentence processing. Specifically, these findings suggest that activation of homonym meanings are influenced by cross-language activation of translation equivalents in the other language. In the present experiments, I examined the role of cross-language activation and other cognitive factors that influence bilinguals’ processing of homonyms with a specific focus on the ability to access subordinate meanings of homonyms. In Experiment 1 I expected that subordinate meanings shared with Spanish (i.e. cognates) would be accessed and recognized faster than noncognate subordinate meanings in a primed lexical decision task. This was expected because the co-activation of the bilinguals’ two languages allows subordinate meanings of cognate homonyms to more strongly compete for activation with dominant meanings (e.g. letter – ALPHABET). In Experiment 2 it was hypothesized that the co-activation of cognate subordinate meanings would alter the nature of the SBE in sentence context. More specifically, the co-activation of a cognate subordinate

meaning would enable it to be activated early enough and allow it to bypass competition from the dominant meaning.

L2 Lexical Disambiguation: Individual Difference Factors

I also hypothesized that, in addition to cross-language activation, individual differences in working memory capacity would also influence access to subordinate meanings in an L2. Specifically, I predicted that individual differences in the degree to which bilingual's word recognition performance reflected co-activation of the non-target language (indexed by the magnitude of observed cognate facilitation) would predict how easily bilinguals access subordinate meanings of L2 homonyms particularly when these were also cognates. Since individual differences in lexical access have been found to influence reading (Stanovich 1980; Stanovich, 1986), I hypothesized that there would be individual differences in the degree of cross-language activation, and that it would predict facilitated access to L2 subordinate meanings. Furthermore, because cross-language activation effects have been more consistently observed in isolated than sentence contexts, I also predicted that the degree of the observed cross-language activation would be a significant predictor in a single-word context (Experiment 1) but not in a sentence context (Experiment 2).

In addition to cross-language activation, another factor likely to affect lexical disambiguation in the L2 is working memory capacity. Working memory plays a central role in language because both producing and comprehending language require the processing of a sequence of symbols over time. The process of reading, for example, requires readers to decode individual symbols while constructing meaning for comprehension. These processes tap into working memory resources.

Research with monolinguals has investigated the role of individual differences in working memory capacity in the processing of lexical ambiguity. Miyake, Just and Carpenter (1994), presented participants with sentences in which a balanced or unbalanced homonym was preceded by neutral contexts and disambiguated much later (e.g. “Since Ken really liked the boxer, he took a bus to the nearest pet store to buy the animal). Results showed that when the homonym had one highly frequent meaning, readers with high working memory capacity showed little effect of ambiguity on encountering the disambiguation, irrespective of which meaning of the homonym (dominant or subordinate) turned out to be correct. Participants with low working memory capacity on the other hand, showed a large ambiguity effect when the disambiguation was in favor of the subordinate meaning. Miyake et al., (1994) proposed that participants with high working memory capacity had both interpretations of the homonym readily available, whereas participants with low working memory capacity had only the dominant interpretation available.

Similarly, Gunter, Wagner and Friederici (2003) used event related potentials (ERPs), and found the same ambiguity effect for participants with low working memory capacity as in Miyake et al., (1994). Gunter et al., (2003) presented German-speaking participants with high and low working memory capacities with sentences containing a homonym followed by three words and a disambiguation cue that was either a noun (e.g. a noun related to one of the meanings of the homonym) or a verb (e.g. a verb related to one of the meanings of the homonym) (e.g., *The tone was by the singer sung, when...*). The ERP data revealed that for participants with low working memory capacity the cueing towards the dominant or the subordinate meaning elicited an equivalently large ERP component, suggesting that both meanings were active in working memory. For participants with high working memory capacity,

the dominant disambiguation cue elicited a smaller ERP component than the subordinate one, indicating that for these participants particularly the dominant meaning was active, while the subordinate meaning had been inhibited.

In a study that investigated the role of working memory capacity on L2 lexical disambiguation, Arêas da Luz Fontes and Schwartz (2010), found evidence for a similar role of working memory capacity on homonym processing as seen with monolinguals, as well as an additional role of cross-language activation of cognate meanings on lexical disambiguation, which is unique to bilinguals. Consistent with monolinguals, they found that bilinguals with high working memory capacity were better at inhibiting the inappropriate meaning of homonyms than bilinguals with low working memory capacity. In addition, they found that differences in working memory capacity moderated whether effects of cross-language lexical activation were facilitative or inhibitory in nature. More specifically, bilinguals with high working memory capacity showed better performance in integrating target words into a preceding sentence context when these were cognates across their two languages. This benefit was observed for cognates that had just one meaning across languages (e.g., piano in English and Spanish) as well as cognates that were homonyms in the target language (e.g., novel/*novela* in English and Spanish). Conversely, bilinguals with low working memory capacity showed a cost in performance when integrating target cognate words, even when they converge onto a single semantic representation. This demonstrates that when there are limited working memory resources available, additional activation from the non-target language interferes with lexical processing.

The research reviewed so far clearly demonstrates that individual differences in working memory capacity play an important role in the process of lexical disambiguation for both monolinguals and bilinguals. Therefore, in the present experiments I evaluated how individual