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Bilingual lexical activation in sentence context

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Abstract

The present study investigated the cognitive nature of second language (L2) lexical processing in sentence context. We examined bilinguals' L2 word recognition performance for language-ambiguous words [cognates (e.g., *piano*) and homographs (e.g., *pan*)] in two sentence context experiments with highly proficient Spanish–English bilinguals living in a bilingual community (Experiment 1) and with intermediate proficiency Spanish–English bilinguals living in a monolingual community (Experiment 2). To determine the influence of sentence constraint on cross-language activation, the critical words and their matched controls were inserted in low- and high-constraint sentences. In low-constraint sentences significant cognate facilitation was observed, suggesting that both languages were active and influencing processing. In high-constraint sentences, the effects of cognate facilitation were eliminated. This interaction between cognate status and sentence constraint demonstrates that sentence context can restrict non-selectivity when there is sufficient semantic information to suppress the non-target language. The fact that this interaction was observed for both bilingual groups suggests that even less proficient bilinguals, who do not communicate daily in the L2, can use context to constrain cross-language lexical competition. Implications for current models of bilingual lexical access are discussed.

Keywords: Bilingualism; Lexical access; Sentence processing; Reading

From the primary grades through post-secondary education there is an increasing number of students whose first language is not English. For these students academic success requires not only oral proficiency in a second language (L2) but fluent reading skills as well. Yet, current research suggests that reading fluency in an L2 does not develop at the same rate as oral proficiency; even highly proficient bilinguals have considerably slower reading rates in their L2 (Favreau & Segalowitz, 1983).

How is the cognitive nature of L2 reading distinct from the native language (L1) and how might it account for this decreased reading rate? There are at least two fundamental characteristics that distinguish L2 reading. First, basic word recognition processes may be slowed in L2 due to decreased familiarity and frequency of use of the language. Second, there is now abundant evidence from psycholinguistic research suggesting that bilinguals are not able to selectively turn off one of their languages during comprehension (e.g., De Bruijn, Dijkstra, Chwilla, & Schriefers, 2001; De Groot & Nas, 1991; De Groot, Delmaar, & Lupker, 2000; Dijkstra, De Bruijn, Schriefers, & Ten Brinke, 2000; Dijkstra, Grainger, & Van Heuven, 1999; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Van Heuven, Dijkstra, & Grainger, 1998; Von

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Studnitz & Green, 2002). Therefore, L2 reading may pose a challenge for bilinguals due to the combined factors of slowed processing and cross-language interference.

What cognitive strategies are engaged that allow bilinguals to overcome these obstacles when reading in their L2? We know from within-language research that sentence-level, contextual information guides lexical access in the L1 (Morris, 1994; Simpson, Peterson, Casteel, & Burgess, 1989). Do bilinguals similarly make use of context when reading in their L2? Is this ability to use context moderated by individual differences in L2 proficiency? In the present study, we address these questions by examining the nature of L2 lexical access in sentence context. The primary objective was to determine whether the presence of a sentence context would allow for earlier language selection during lexical access, thereby decreasing activation from the non-target language and to see if such effects would replicate across two bilingual groups of different L2 proficiency.

Lexical access out of context: Monolingual and bilingual studies

Readers are continuously confronted with lexical ambiguity. Furthermore, this ambiguity can occur at multiple lexical levels including semantic (e.g., *bugs*) and phonological (e.g., *lead*). Despite the pervasiveness of lexical ambiguity, skilled readers are still able to quickly process words such as homonyms and homographs and integrate them into the text being read. This has led a number of researchers to examine how the multiple meanings of words are represented, activated, and ultimately selected. In general, studies that have looked at the processing of ambiguous words out of context, such as in a lexical decision task, have found that recognition performance for homonyms are facilitated relative to unambiguous words (Gottlob, Goldinger, Stone, & Van Orden, 1999; Hino & Lupker, 1996; Pexman & Lupker, 1999; Rodd, Gaskell, & Marslen Wilson, 2002). This suggests that the multiple representations of homonyms are activated in parallel. Thus, lexical access, at least in isolated word recognition tasks, involves the initial activation of numerous lexical competitors within the lexicon.

What happens when the lexical ambiguity is cross-linguistic and the reader has proficiency in multiple languages? Does non-selective access similarly apply across multiple languages? Similar to monolingual research, the majority of studies on bilingual word recognition have demonstrated that there is non-selective access of lexical information across a bilingual's two languages in out-of-context tasks (e.g., Brysbaert, 1998; De Bruijn et al., 2001; De Groot & Keijzer, 2000; Dijkstra, Timmermans, & Schriefers, 2000; Dijkstra & Van Hell, 2003; Gollan & Kroll, 2001; Jared & Kroll, 2001; Jared & Szucs, 2002; Marian, Spivey, & Hirsch, 2003; Schwartz, Kroll, & Diaz, in press; Van Hell & Dijkstra, 2002; Von Studnitz & Green, 2002). Furthermore, evidence of non-selectivity persists irrespective of task instructions or participant's expectations or knowledge that they will be presented with words from multiple languages (Dijkstra et al., 2000; Dijkstra & Van Hell, 2003; Dijkstra et al., 1998).

To account for these non-selective results, the Bilingual Interactive Activation plus model (BIA+), proposed by Dijkstra and Van Heuven (2002), assumes that lexical information from a bilingual's two languages is represented in an integrated lexicon, in which there is language non-selective activation. Thus, in the initial stages of lexical access, there is bottom-up, non-selective activation of lexical information across a bilingual's languages and this non-selectivity is not constrained by information outside of the lexicon. The BIA+ also incorporates a distinction between a word identification system (the lexicon) and a task/decision system. Dijkstra and Van Heuven propose that the task/decision system is affected by extra-linguistic factors such as task demands and participant expectations, which in turn can influence the output of the word identification system. The word identification system, on the other hand is directly affected *only* by linguistic factors such as lexical, syntactic, and semantic information. By including both of these systems, the authors can accommodate the wide range of evidence for language non-selectivity and the more specific differences that arise across different experiments, tasks, and contexts.

The BIA+ architecture includes a set of language nodes which act as language tags or representations of language membership. They do not directly affect the relative activation of words within a given language and act solely as an additional representational layer. This architecture therefore assumes that the language membership of the input string does not allow for language selective activation during the initial stages of lexical access.

Since the lexical identification system in the BIA+ is hypothesized to be affected by linguistic context, Dijkstra and Van Heuven (2002) propose that the presence of a sentence context can constrain the degree to which effects of non-selectivity are observed and can even directly affect what information becomes activated in the non-target language. They further suggest that researchers should examine whether the language of the sentence context, in and of itself, is sufficient to constrain non-selective activation. In the present study, we addressed this issue specifically by examining how the effects of cross-language activation are modulated by the presence of sentences that varied in their semantic constraint.

Lexical access in sentence context: Monolingual and bilingual studies

In everyday communication, words are most often encountered in a meaningful context and not in isolation. Does the presence of a meaningful context constrain cross-language activation? In other words, can information activated top-down from semantics influence the bottom-up processes of lexical access? In the monolingual domain, there is general agreement that context aids in the interpretation of ambiguous words. However, what is still debated is the point at which selection of the appropriate meaning takes place and how early in the process of lexical access context can exert its effect. According to context-dependent accounts, the conceptual representations of sentences that readers build have an early influence on lexical access. Thus, language processing is seen as being highly interactive, such that lexical knowledge, world knowledge, and the semantic and syntactic information provided by a sentence interact with the bottom-up processes that drive lexical access. This account is based on the finding that words are processed faster when they are embedded in a congruent sentence context than a neutral or incongruent context (e.g., Simpson et al., 1989; Stanovich & West, 1979).

While such evidence does suggest early influences of sentence context, it has been argued that these effects could be due to intra-lexical priming between words in the sentences. It has therefore been argued by proponents of the context-independent account that the multiple meanings of ambiguous words are initially activated, without any influence from context and the eventual selection of the appropriate meaning occurs only after the word has been accessed (Onifer & Swinney, 1981; Swinney, 1979).

Our understanding of the specific influences of sentence context on lexical access has been further clarified through the use of new methodologies, including neurocognitive methods such as the recording of event-related potentials (ERP) (e.g., Sereno, Brewer, & O'Donnell, 2003) and eye-movement recording (e.g., Binder & Morris, 1995; Dopkins, Morris, & Rayner, 1992; Folk & Morris, 1995; Morris & Folk, 2000; Morris, Rayner, & Pollatsek, 1990; Rayner & Morris, 1991). In a series of studies, Duffy and her colleagues used eye-movement tracking to shed light on how the relative frequency of an ambiguous word's multiple meanings interact with sentence context (Duffy, Kambe, & Rayner, 2001; Rayner, Binder, & Duffy, 1999). In general, these studies suggest that 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. Thus, initial word access is not immune to the effects of sentential context. These findings have led to the development of the "reordered access model," which assumes that, 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. The reordered access model can be considered a hybrid model in that it incorporates both context dependent and context independent mechanisms of lexical access in sentences.

The studies reviewed above provide an important background for approaching the problem of bilingual lexical access in sentence context. If it is indeed the case that sentential context influences the number of lexical competitors activated, then the presence of a sentence could feasibly constrain activation of competitors from the non-target language in bilinguals. However, when studying lexical processing in sentence context, particularly in a second, non-dominant language, it is essential to consider factors related to individual differences in reading skill. We know from a large body of research that there is great variability in people's ability to efficiently decode text and integrate information from text into a coherent mental representation (Carpenter, Miyake, & Just, 1994; Daneman, 1991; Haenggi & Perfetti, 1992; Herdman & LeFevre, 1992; Perfetti, 1994, 1997; Perfetti & Hart, 2001). Additionally, proficiency in an L2 has an impact on the automaticity with which bilinguals activate lexical information in their non-dominant language. For example, highly proficient bilinguals show greater semantic priming than less proficient bilinguals, particularly at short SOA intervals (Favreau & Segalowitz, 1983). As described below the ability to quickly activate semantic information is a critical component of sentence comprehension.

According to the structure building framework, proposed by Gernsbacher and colleagues (Gernsbacher, 1990, 1996, 1997; Gernsbacher & Faust, 1991), the goal of sentence comprehension is to build mental structures that represent the text being read. These structures are built through a combination of enhancement of relative information and suppression of irrelevant information. Enhancement aids in the construction of mental structures by activating the information necessary to create the initial foundation upon which new structures will be created. Suppression works by reducing the activation of irrelevant information.

Low comprehension performers are characterized by less efficient enhancement and suppression mechanisms. Therefore, these readers have an increased difficulty in activating information to build an initial representation of text as well as suppressing contextually irrelevant information, which remains active for a longer period of time. It is important to note that, according to this framework, low comprehension performers are just as sensitive to the information provided by context as high comprehension performers, indeed they are often more reliant on this information since they are less efficient at creating initial structures (Gernsbacher & Faust, 1991). The problem lies within the inefficiency with which they use this information to construct mental representations (see Gernsbacher & St. John, 2001).

In the present study, we examined whether bilinguals reading in their non-native language would show evidence of cross-language lexical activation in sentence context; and whether this activation would at all be modulated by the relative constraint of the sentence context. We further examined what role second language proficiency and exposure would play in modulating effects of cross-language activation by including two, distinct Spanish–English bilingual groups. If less proficient bilinguals activate lexical information less automatically (e.g., Favreau & Segalowitz, 1983) and apply contextual information less efficiently, it is possible that sentence context will not constrain their lexical processing in the same way as it might for more proficient bilinguals.

In Experiment 1, we report findings for bilinguals living in a bilingual and bicultural context in a community located along the US and Mexico border (El Paso, Texas). These bilinguals engaged in daily communication in English and Spanish at home, school and work. In Experiment 2, we report findings for a separate group of bilinguals living in a predominantly Spanish-speaking community whose experiences with the L2 were restricted to the classroom and brief immersion experiences. Most of the published research on bilingual lexical processing has focused on highly proficient bilinguals. By including both intermediate and high proficiency bilinguals, the present study addressed how factors associated with proficiency and frequency of language use may modulate the extent to which processes of L2 lexical access are influenced by contextual constraint. It is important to include in this research base studies that examine lexical processes for bilinguals who do not find themselves in bilingual surroundings and who constitute a legitimate and important bilingual population.

As described earlier, there is a great deal of evidence demonstrating that bilinguals activate lexical information non-selectively from both of their languages during word recognition. Does this cross language lexical activation similarly apply for bilinguals reading in context? One possibility is that the presence of a sentence context, in and of itself, is sufficient to eliminate activation in the non-target language. Another possibility is that sentence context cannot eliminate non-selectivity and that cross-language interactions occur irrespective of sentence constraint. A third alternative falls somewhere between these two extremes, in that context may constrain some aspects of cross-language activation but not others.

There have been very few studies that have examined cross-language influences on bilingual lexical processing in sentence context. In the research that will be summarized here, there is converging evidence that effects of cross-language interaction are most likely to persist in sentence context when the critical words share semantic links across languages (e.g., cognates). One hypothesis is that since sentence comprehension requires the construction of a semantic representation of the text, only cross-language competitors that share semantics remain as viable competitors or are activated early and strongly enough to influence word recognition performance.

Elston-Güttler (2000) examined the degree to which bilinguals' lexical representations in the L2 would activate representations in the L1 both in and out of sentence context. In a primed lexical decision task, she presented highly proficient German–English bilinguals with L2 words whose translation equivalent in the L1 had multiple meanings. For example, the German word "klatchen" can either mean "clap" or "gossip". For half of the participants these words were preceded by single word primes [e.g., *clap* $\rightarrow$ *gossip*] and for the other half they were preceded by a sentence context [e.g., "After the wonderful performance the audience began to *clap* $\rightarrow$ *gossip*]. The results showed consistent priming between "clap" and "gossip" in both the single word and sentence prime conditions. The implication is that L1 lexical forms were activated, even in sentence context. In another experiment, she tested whether similar cross-language interactions would be observed for inter-lingual homographs, which lack a semantic link (e.g., *chef* in German means "boss"). This time there was significant homograph priming only in the single word prime condition. The priming effects disappeared in sentence context. Together the results from the two experiments suggest that lexical entries from the non-target L1 do become active during sentence comprehension, however, only for words that share semantics.

Using a similar sentence context priming paradigm, Van Hell (1998) observed similar cross-language interactions for Dutch–English cognates in sentence context. Unlike Elston-Güttler (2000) she also manipulated sentence constraint. Highly proficient Dutch–English bilinguals read visually presented sentences in their L2, English. The location of the target word was marked with three dashes (e.g., "A green—and a yellow banana lay on the fruit dish"). After four seconds, the sentence disappeared and the target word appeared (e.g., *apple*). Another group of Dutch–English bilinguals were presented with the cognates in a standard lexical decision task (no primes were included). Responses to cognates were strongly facilitated both in the standard lexical decision task and in low-constraint sentences. In high-constraint sentences, however, cognate facilitation disappeared. These results provided converging evidence that lexical information from the non-target L1 becomes active during sentence comprehension. However, the results from both studies further suggested that the relative constraint of the sentence context and the degree to which target words share semantics both modulate the degree of this cross-language interaction.

The present study

The present study investigated cross-language interaction during L2 reading. The experiments reported here extend previous findings on bilingual word recognition by examining the nature of cross-language lexical competition in sentence context for two, separate groups of bilinguals of different L2 proficiency who were living in very different linguistic communities. The major new finding is that effects of cross-language activation, particularly cognate facilitation, observed in low-constraint sentences, were eliminated in high-constraint sentences for both intermediate and high proficiency bilinguals. This finding is compatible with the BIA+ model since it assumes that a sentence context could potentially have a direct impact on cross-language activation through increased activation of semantics. However, the BIA+ model does not fully specify the mechanism through which sentence context exerts its effect. For example, according to the BIA+, sentence context exerts its effect through boosted semantic activation. However, this account does not explain why *cognate* facilitation should be eliminated in high-constraint sentences, since cognates share semantics across languages in all conditions. In the present study, we argue that the elimination of cognate facilitation suggests that there is pre-activation of the language nodes. This in turn, suggests that language nodes can have a direct effect on lexical selection and that they do not simply act as representational tags.

In the present study, we were interested in whether the presence of highly constraining context would modulate cross language interactions and whether the influence of context would be similar across different levels of proficiency. To examine the potential interactions between sentence context and lexical access, English–Spanish cognates (e.g., *piano*) and inter-lingual homographs (e.g., *pan*) were inserted in English high- and low- constraint sentences. We reasoned that if the presence of a sentence context does not affect non-selectivity at all, then processing of the language ambiguous words should reflect the effects of cross-language activation and these effects should be similar to those observed in previous out-of-context studies. On the other hand, if the presence of sentence context allows for language-selective processing, then processing of ambiguous words should not reflect the effects of cross-language interaction and performance for these items should be similar to non-ambiguous control words. A third alternative falls somewhere between these two extremes, in that context may constrain some aspects of cross-language activation but only when the lexical system is provided with sufficiently detailed semantic information (i.e., a highly constraining sentence context). Finally, we were interested whether the degree of cross-language interaction observed would differ for target words that shared semantics across languages (i.e., cognates) in comparison to items that do not share semantics (i.e., inter-lingual homographs). Given the conceptual nature of sentence comprehension, we hypothesized that those lexical competitors that shared semantics from the non-target language would be more strongly activated than competitors that only shared lexical form.

Experiment 1

Method

Participants

Twenty-three participants from the University of Texas at El Paso completed the experiment. All individuals received course credit for their participation. Of these 23 participants one was excluded due to a high error rate in naming responses (greater than 30% error rate) and another was excluded due to poor performance in answering follow-up comprehension questions (see below), bringing the total number of participants to 21.

Materials

Target words. The critical words consisted of 22 cognates (e.g., *piano, band/banda*) and matched control words (e.g., *pencil*) as well as 22 inter-lingual homographs (e.g., *fin*) and their respective matched controls (e.g., *frame*). The cognate pairs were not all form identical but they all had a very high degree of orthographic similarity (e.g., *band/banda*) and were selected from a previous bilingual study (Schwartz et al., in press) in which effects of cross-language activation (cognate facilitation) were observed in an isolated word naming task.[1] The control conditions were created through an item-by-item match in which every critical word was paired with an English control word matched on word frequency in English, and word length (see Table 1).

Critical sentences. The target words were inserted in two types of sentence conditions, high and low constraint. We operationalized "constraint" as the degree to which the sentence frame preceding the target word biased that word. When creating the sentences, critical and control sentences were matched in terms of number of words, syntactic complexity, and the length of the word preceding the target. Also, critical words were never in the word final position of the sentence and a

[1] The full set of materials are available from the first author upon request.

Table 1
Examples of stimuli used in Experiments 1 and 2 and their lexical characteristics

Condition	Example	Word frequency[a]	Word length[b]
Cognate	Piano	54.4	6.0
Cognate control	Pencil	52.1	6.2
Homograph	Fin	42.3	4.5
Homograph control	Frog	35.7	4.7

[a] Kucera and Francis (1967).
[b] Number of letters.

minimum of one word followed the critical word. The maximum length of the sentences was 30 words, with a maximum of 15 words preceding the to-be-named target and 15 words following the target. The entire set of high- and low-constraint sentences was divided into two separate lists so that no participant would see the same target word twice. We verified the constraint manipulation of the sentences in a separate cloze norming experiment. (See Table 2 for an illustration of the critical sentences and Table 3 for the respective mean production probabilities for the target words derived from the cloze norming experiment[2]).

Comprehension sentences. In addition to the critical sentences, 30 filler sentences followed by a comprehension question were presented randomly. The follow-up questions were designed to address the main topic of the sentence it followed (e.g., *The couple lived in a small apartment in Amsterdam. Where did the couple live?*). These 30 fillers were included as a way of assuring that participants were indeed paying attention to the meaning of the sentences and were not included in any of the critical analyses described below. The filler sentences were created so that their syntactic complexity did not differ from the critical sentences and that there were not any linguistic cues that might signal to the participant that a follow-up question would be presented.

Procedure

When participants arrived at the lab they were greeted in English (L2). Instructions were presented on a computer LCD display in English. These instructions were read to the participants out-loud. They were told that they would see sentences in English, presented in the middle of the computer screen, one word at a time. They were instructed that one word in each sentence would appear in red, and that they were to name this word out loud into the microphone, as quickly and accurately as possible. If they did not know a word, they were instructed to make their best guess in pronunciation. They were further told that on some trials the sentences would be followed by a question and that they were to answer this question out loud into the microphone. If they did not know an answer they were encouraged to guess. If they did not guess they said "I don't know."

Participants then completed 10 practice trials. Following practice the experimenter left the room. The RSVP session was audio-digitally recorded and reaction times were recorded in milliseconds by the computer.

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. Each word of the sentence was then presented for 250 milliseconds (ms). The target word was presented in a red font and remained on the screen until either the microphone registered a spoken response, or after 3000 ms had elapsed. The remaining words of the sentence were then presented for 250 ms each. For filler trials, the sentences were presented in the same way, except that they were followed by the presentation of a question, in its entirety. The question remained on the screen until the microphone registered a spoken response or until 10 s had elapsed.

After completing the RSVP 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 10-point scale. The entire experimental procedure was completed in approximately 40 min.

Results and discussion

Language history questionnaire data

The proficiency measures from the language history questionnaire are summarized in Table 4. Overall participants rated their proficiency in both languages quite high, with their L2, English proficiency rated slightly higher (9.2) than their L1, Spanish proficiency (8.6). This difference was not statistically reliable, $t(1, 21) = 1.3$, $p > .05$. Participants reported daily use of both languages in a variety of contexts including home, work and school. It is interesting to note that participants' L2 ratings were consistently higher than their L1 ratings, suggesting that they had become more dominant in their L2. Indeed, in bilingual communities such as El Paso it is not always clear which language should be designated as "L1" or "L2." 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

[2] A second cloze norming study was carried out with English monolinguals as a reliability check and to verify that both bilingual and monolingual subjects perceived these sentences in a similar way. These ratings were very similar to those provided by the bilinguals.

Table 2
Examples of sentence stimuli used in Experiments 1 and 2[a]

Condition	Sentence	
	High constraint	Low constraint
Cognate	Before playing, the composer first wiped the keys of the **piano** at the beginning of the concert	When we entered the dining hall we saw the **piano** in the corner of the room
Cognate control	Before the test, the student looked for some paper and a sharp **pencil** to write with	When I was not looking he kept trying to take the new **pencil** off of my desk
Homograph	From the beach we could see the shark's **fin** pass through the water	We felt a bit nervous when we saw the **fin** of the shark in the distance
Homograph control	At the pond we could see a green **frog** jumping in and out of the water	The school children watched the **frog** jump across the rocks

[a] Target words in bold.

Table 3
Production probabilities for target words embedded in the sentence stimuli used in Experiments 1 and 2

Condition	Sentence	
	High constraint	Low constraint
Cognate	.67	.05
Cognate control	.67	.03
Homograph	66.6	.04
Homograph control	64.8	.05

Table 4
Language experiences and self-assessed proficiency ratings of the Spanish–English bilingual participants ($n = 21$) of Experiment 1

Age of acquisition (years)			
English (L2)	7.2	Spanish (L1)	2.3

Skill	Self-assessed ratings[a]	
	English (L2)	Spanish (L1)
Reading	9.2	8.5
Writing	9.0	7.8
Speaking	9.1	9.0
Listening	9.4	9.1
Mean rating	9.2	8.6

[a] Based on a scale of 1–10.

somewhat later in life, around seven years of age, it is considered to be the L2.

Comprehension performance

To ensure that participants comprehended the sentences they were reading, we analyzed their performance on the filler comprehension questions. The comprehension scores were based on participants' accuracy when answering the follow-up comprehension questions on filler trials. Each response was scored on a range from zero to three. A "0" was given if the answer was incorrect or no answer was given at all. A "1" was given if the answer was correct but not complete. Finally, a "2" was given when the answer was correct and complete. There were a total of 30 fillers, thus the maximum number of possible points was 60. Only participants who scored at least 30 or greater and whose overall naming error rates were below 30% were included in the analyses described below. This criterion led to the exclusion of two participants.

Data trimming procedures

The primary investigator and a trained research assistant independently coded the same subset of participants' spoken responses. A comparison of these ratings demonstrated that the inter-rater reliability exceeded the 95% criterion. Mean reaction times (RTs) for each participant for correct trials were calculated for each participant. RTs that were faster than 200 ms or slower than 2000 ms were counted as outliers and excluded from the analyses. RTs that were more than 2.5 standard deviations above or below a given participant's mean RT were also counted as outliers and excluded. This led to an exclusion of 1.8% of all trials. On 6.3% of the remaining trials the microphone failed to trigger.

Overall analyses

Reaction-time data. To determine whether naming latencies were influenced by sentence constraint, a paired t test was performed on the latencies for all control words in low- and high-constraint sentences. Cognates and homographs were excluded since effects of cross-language activation could taint these latencies. Overall, the average naming latency for target words embedded in high-constraint sentences ($M = 669.4$) was significantly faster than for target words in low-constraint latencies ($M = 702.1$), t_1 $(1,20) = 4.02$, $p < .05$, providing additional evidence that our sentence constraint manipulation was effective.

Error-rate data. Overall the mean percent error rates were quite low (low-constraint sentences: $M = 5.0\%$; high-constraint sentences: $M = 4.3\%$). Although the error rates were slightly lower for high-constraint sentences, this difference was not statistically reliable, $t_1(1,20) = 0.51$, $p = .61$. This lack of significance was likely due to low overall error rates.

Cognate analyses

Reaction-time data. Since items across conditions were matched on an item by item basis for word frequency and length, we report F_1 analyses, treating participants as a random factor. This is the appropriate statistic to employ when items have been matched on variables that correlate highly with the dependent variable. More specifically, since critical and control items were matched on an item-by-item basis on word length and frequency, they were not randomly selected. Furthermore, due to this matching the between-conditions variance would be less than the within-conditions variance, making $F_{\min}$ and F_2 too conservative as statistical tests of significance (see Raaijmakers, 2003; Raaijmakers, Schrijnemakers, & Gremmen, 1999).

The mean naming latencies and error rates for the cognate and control target words in high and low sentence constraint contexts are summarized in Table 5. A two-way (sentence constraint × cognate status) ANOVA was performed on the participants' latency and error rate means. The analysis on latencies revealed a main effect of sentence constraint, $F_1(1,20) = 11.28$ $MSE = 1465.24$, $p < .01$, indicative of the faster reaction times for target words embedded in high-constraint sentences relative to low-constraint sentences. This main effect of constraint was qualified by a two-way interaction with cognate status, $F_1(1,20) = 5.45$, $MSE = 1127.39$, $p < .05$. As evident in Table 5, naming latencies for cognates were faster than non-cognate controls in low-constraint sentences, but this cognate facilitation was eliminated in high-constraint sentences. Follow-up t tests performed with a Bonferroni correction indicated that cognate latencies were significantly faster than control latencies in low-constraint sentences, $t_1(1, 20) = 3.32$, $p < .05$, but not in high-constraint sentences, $t_1(1, 20) = 0.70$, $p = .49$. This suggests that linguistic context, in and of itself, was not sufficient to eliminate effects of non-selectivity since significant cognate facilitation was observed in low-constraint sentences. However, this facilitation was eliminated when targets were embedded in high-constraint sentences, further suggesting that the presence of a rich, semantic context can constrain cross-language activation.

Table 5
Mean latencies (milliseconds) and percent error rates (in parentheses) for the cognates and matched controls in sentence context for Experiment 1

Condition	Sentence constraint	
	Low	High
Cognates	675.6 (2.6%)	664.7 (1.3%)
Controls	702.4 (5.6%)	657.2 (3.9%)
Difference	−26.8* (−3.0)	+7.5 (−2.6)

* $p < .05$.

Error-rate data. The overall error rates were very low. Analyses performed on the error-rate data revealed a main effect of cognate status $F_1(1,20) = 5.20$, $MSE = 32.04$, $p < .05$, reflecting the lower error rate for the cognates relative to the non-cognate controls. This main effect did not interact with sentence constraint, $F_1(1,20) = 0.41$, $MSE = 23.76$, $p = .84$. The pattern of error rates provided further evidence that a sentence context, in and of itself, was not sufficient to eliminate effects of cross-language activation. Indeed, the decreased error rate for cognates did not interact with sentence constraint, however, the lack of this interaction was most likely due to the overall low error rate.

Overall the data from the cognate analyses replicate prior studies (Elston-Güttler, 2000; Van Hell, 1998) by providing evidence for the persistent cross-language activation of cognates in sentence context. Like Van Hell (1998), cognate facilitation was reduced in high-constraint sentences. Furthermore, it is interesting to note that these same cognate items were used in a previous isolated word naming study in which cognate facilitation was observed (Schwartz et al., in press). This provides further support that the observed attenuation of cognate facilitation in the present experiment was due to the sentence constraint manipulation and was unlikely due to some unaccounted for characteristic of the specific items selected. In the next section, we report data for the inter-lingual homograph items which do not share semantics across languages.

Inter-lingual homograph analyses

Reaction-time data

The mean naming latencies and error rates for the inter-lingual homographs and control target words in low- and high- constraint sentence contexts are summarized in Table 6. A two-way (sentence constraint × homograph status) ANOVA was performed on the participants' latency and error rate means. Neither the main effect of sentence constraint, $F_1(1,20) = 1.18$ $MSE = 2580.94$, $p = 0.29$, nor homograph status $F_1(1,20) = 0.05$, $MSE = 761.11$, $p = .82$ were significant; nor was the interaction, $F_1(1,20) = 1.03$, $MSE = 1343.18$, $p = .32$.

Error-rate data

In the analyses performed on the error-rate data neither the main effect of sentence constraint,

Table 6
Mean latencies (milliseconds) and percent error rates (in parentheses) for the inter-lingual homographs and matched controls in sentence context for Experiment 1

Condition	Sentence constraint	
	Low	High
Homographs	695.1 (6.9%)	691.2 (4.3%)
Controls	701.8 (4.3%)	681.6 (4.8%)
Difference	−6.7 (2.6)	+9.6 (−0.5)

$F_1(1,20) = 0.92$, $MSE = 26.72$, $p = .35$, nor the main effect of homograph status, $F_1(1, 20) = 0.41$, $MSE = 59.84$, $p = .53$, nor their interaction, $F_1(1, 20) = 1.43$, $MSE = 33.81$, $p = .25$, were significant.

Overall the inter-lingual homograph analyses failed to reveal any evidence that the cross-language representations of the homographs were activated. This contrasts with the findings from the cognate analyses, in which cross-language activation of cognates was evident, particularly in low-constraint sentences. It is important to note that previous studies have observed similar dissociations between inter-lingual homographs and cognates. As described earlier, Elston-Güttler (2000) did not observe any evidence of cross-language priming for homographs, whereas such priming was observed for cognates. This, in conjunction with the present results suggests that the degree to which lexical access is language non-selective depends critically on both the surrounding linguistic context, and the nature of the cross-language competitor. In a context in which rich, semantic information is provided cross-language competitors that share only lexical form and not meaning, are unlikely to be activated strongly enough to influence processing.

The participants of Experiment 1 were highly proficient bilinguals. Indeed, some rated their L2 proficiency higher than their L1 and may have therefore become L2 dominant. It is possible that bottom-up non-selective activation was constrained by sentence context for these bilinguals due to their high L2 proficiency, which allowed them to efficiently incorporate information from context. To what extent can context constrain non-selectivity when the reader is less proficient in the L2? To address this question in Experiment 2 we collected data from a group of Spanish–English bilinguals who were living in a region in Spain in which they had limited exposure to their L2. We were interested in determining whether similar interactions between the processes of lexical access and sentence comprehension would be observed for a group of intermediate-proficiency bilinguals.

Experiment 2

Method

Participants

Thirty-nine participants from the University of Valencia in Valencia, Spain completed the experiment. Of these 39 participants, 19 met the performance criterion on the task, the other 20 were not included in the analyses reported below. Of these 19 participants, 15 reported high proficiency in Valenciano. Thus, the majority of the participants were trilinguals, with proficiency in Spanish, English, and Valenciano. It should be noted that Valenciano is more similar to Spanish than it is to English. It is therefore unlikely that their proficiency in Valenciano would effect English lexical processing differentially.

Materials

Target words. The critical words consisted of 22 cognates (e.g., *piano*) and matched control words (e.g., *pencil*) as well as 22 inter-lingual homographs (e.g., *fin*) and their respective matched controls (e.g., *frame*). The critical and control words were taken from the same larger pool of words as Experiment 1. A slightly different subset of cognates and homographs were chosen due to differences in Spanish language use that emerge in different communities. For example, the cognate "local" in Spain can mean a bar or a restaurant, making it an inappropriate cognate. Control conditions were created through an item-by-item match in which every critical word was paired with an English control word matched on word frequency and length.

Critical sentences. The target words were inserted in two types of sentence conditions, low- and high-constraint. These sentences were taken from the same larger pool of materials used in Experiment 1. Critical and control sentences were matched in terms of number of words, syntactic complexity, and the length of the word preceding the target. Also, critical words were never in the word final position of the sentence and a minimum of one word followed the critical word. The maximum length of the sentences was 30 words, with a maximum of 15 words preceding the to-be-named target, and 15 words following the target.

Comprehension sentences. The same set of comprehension sentences used in Experiment 1 were used in this experiment.

Procedure

The procedure was the same as that reported in Experiment 1.

Results and discussion

Language history questionnaire data

The proficiency measures from the language history questionnaire are summarized in Table 7. Although participants considered themselves relatively proficient in their L2, they rated their proficiency in this language substantially lower (7.9) than their L1 (9.9) and this difference was statistically reliable, $t(1, 18) = 6.48$, $p < .05$. Unlike the participants of Experiment 1, these participants were clearly more dominant in their L1. Furthermore, they reported using their L2 in a few, restricted environments. Indeed, most of their exposure to the L2 was through previous international travels to English-speaking countries and they did not regularly communicate in their L2 on a daily basis as did the participants in Experiment 1.

Comprehension performance

To ensure that participants comprehended the sentences they were reading, we analyzed their performance on the filler comprehension questions. The comprehension scores were based on participants' accuracy when answering the follow-up comprehension questions on filler trials and the same scoring procedure from Experiment 1 was used. The same two criteria used in Experiment 1 were applied, participants had to have a comprehension score of 30 or greater, and their overall accuracy in naming control words had to be less than 30%. Nineteen participants made this criterion.

Data trimming procedures

The primary investigator and a trained research assistant independently coded the same subset of participants' spoken responses. A comparison of these ratings demonstrated that the inter-rater reliability exceeded the 95% criterion. Mean reaction times (RTs) for correct trials were then calculated for each participant in each condition. RTs that were faster than 200 ms or slower than 2000 ms were considered outliers and excluded from the analyses. RTs that were more than 2.5 standard deviations above or below the participants mean RT were also considered outliers and eliminated from the analyses. These data trimming procedures led to an exclusion of 2.5% of all trials. The microphone failed to pick up spoken responses on another 2.6% of all trials.

Table 7
Language experiences and self-assessed proficiency ratings of the Spanish–English bilingual participants ($n = 19$) of Experiment 2

Age of acquisition (years)			
English (L2)	10.0	Spanish (L1)	2.0
Skill		Self-assessed ratings[a]	
		English (L2)	Spanish (L1)
Reading		7.9	9.9
Writing		7.2	9.7
Speaking		7.4	9.8
Listening		8.0	9.9
Mean rating		7.9	9.9

[a] Based on a scale of 1–10.

Overall analyses

Reaction-time data. To determine whether naming latencies were influenced by sentence constraint, a paired t test was performed on the latencies for all control words. As in Experiment 1, cognates and homographs were excluded since effects of cross-language activation could taint these latencies. Overall, the average naming latencies for target words embedded in high-constraint sentences ($M = 690.0$) were significantly faster than low-constraint latencies ($M = 706.6$), $t_1(1, 18) = 1.88$, $p < .05$.

Error-rate data. The overall mean percent error rates were higher than those observed in Experiment 1 (low-constraint sentences: $M = 13.5\%$; high-constraint sentences: $M = 14.2\%$). The difference in error rates in low- and high-constraint sentences was not statistically reliable, $t_1(1, 18) = 0.28$, $p = .78$.

Cognate analyses

Reaction-time data. The mean naming latencies and error rates for the cognate and control target words in high and low sentence constraint contexts are summarized in Table 8. A two-way (sentence constraint × cognate status) ANOVA was performed on the participants' latency and error rate means. The analysis on the latency means revealed a main effect of cognate status, $F_1(1, 18) = 12.44$ $MSE = 982.0$, $p < .01$, indicative of the faster reaction times for cognate words relative to non-cognate controls. This main effect of cognate status was qualified by a two-way interaction with sentence constraint, $F_1(1, 18) = 8.49$, $MSE = 965.75$, $p < .01$. As is evident in Table 8, the same pattern observed in

Table 8
Mean latencies (milliseconds) and percent error rates (in parentheses) for the cognates and matched controls in sentence context for Experiment 2

Condition	Sentence constraint	
	Low	High
Cognates	662.6 (14.4%)	688.2 (14.4%)
Controls	708.7 (18.8%)	692.8 (15.4%)
Difference	−46.1* (−4.4)	+4.6 (−1.0)

* $p < .05$.

Experiment 1 was replicated. Once again naming latencies for cognates were faster than non-cognate controls in low-constraint sentences, but this cognate facilitation was eliminated in high-constraint sentences. Follow-up t tests performed with a Bonferroni correction indicated that cognate latencies were significantly faster than control latencies in low-constraint sentences, $t_1(1,18) = 4.94$, $p < .01$, but not in high-constraint sentences, $t_1(1,18) = 0.68$, $p = .68$. Therefore, once again we see evidence that a linguistic context, in and of itself, was not sufficient to eliminate effects of non-selectivity since cognate facilitation was observed in low-constraint sentences. However, this facilitation was eliminated when targets were embedded in high-constraint sentences. Thus, these even for these less proficient bilinguals the presence of a rich semantic context constrained lexical activation of the non-target L1.

Error-rate data. The analyses performed on the error-rate data did not reveal a main effect of sentence constraint, $F_1(1,18) = 0.34$, $MSE = 153.28$, $p = .56$; nor of cognate status, $F_1(1,18) = 1.16$, $MSE = 119.24$, $p = .30$; nor an interaction between these two factors, $F_1(1,18) = 0.36$, $MSE = 157.59$, $p = .55$. Although the differences were not statistically reliable, the pattern of error rates was similar to the patter observed with the latency data: There were less naming errors for cognates (14.4%) than non-cognate items (18.8%) in low-constraint items, whereas in high-constraint items the percent error rates for cognates and non-cognate controls were quite similar (14.4 and 15.4%, respectively).

As with Experiment 1, the overall pattern of data from the cognate analyses replicates prior studies demonstrating continued cross-language activation of lexical items that share semantics, which was attenuated in high-constraint contexts (Elston-Güttler, 2000; Van Hell, 1998). In the next section, we report data for the inter-lingual homograph items. The goal was to determine if, like the more proficient bilinguals in Experiment 1, the less proficient bilinguals' performance would reflect the same lack of cross-language activation of lexical competitors that did not share meaning in sentence context.

Inter-lingual homograph analyses

Reaction-time data. The mean naming latencies and error rates for the inter-lingual homographs and control target words in high and low sentence constraint contexts are summarized in Table 9. A two-way (sentence constraint × homograph status) ANOVA was performed on the participants' latency and error rate means. Neither the main effect of sentence constraint, $F_1(1, 18) = 1.63$, $MSE = 2151.44$, $p = .22$, nor homograph status $F_1(1, 18) = 0.24$, $MSE = 570.84$, $p = .63$ were significant, nor was the interaction, $F_1(1, 18) = 0.28$, $MSE = 531.55$, $p = .60$.

Table 9
Mean latencies (milliseconds) and percent error rates (in parentheses) for the inter-lingual homographs and matched controls in sentence context for Experiment 2

Condition	Sentence constraint	
	Low	High
Homographs	699.0 (22.6%)	688.0 (20.5%)
Controls	704.4 (8.2%)	688.2 (13.0%)
Difference	−5.4 (+14.4)*	−0.2 (+7.5)*

* $p < .05$.

Error-rate data. In the analyses performed on the error-rate data revealed a main effect of inter-lingual homograph status, $F_1(1,18) = 33.7$, $MSE = 67.71$, $p < .01$, reflective of the increased naming error rate for inter-lingual homographs (21.6%) relative to non-homographic controls (10.6%). There was no main effect of sentence constraint, $F_1(1,18) = 0.26$, $MSE = 131.94$, $p = .62$, nor did this interact with inter-lingual homograph status, $F_1(1,18) = 2.07$, $MSE = 108.50$, $p = .17$.

The lack of a significant interaction suggests that the L1 representations of the homographs competed for lexical selection and this competition was not decreased by contextual constraint. This contrasts with the findings reported in Experiment 1 as well as those observed in the cognate analyses in the present experiment in which contextual constraint modulated effects of cross-language activation. However, the reader should note that the data reflect a trend in which there is greater homograph inhibition in low-constraint sentences (a difference of 14.4% points) relative to high-constraint sentences (a difference of 7.5% points). Therefore, it seems that there might have been some activation of the non-target L1 representations of the homographs particularly in low-constraint sentences. Since homographs only share form and not semantics across languages this activation may not have been strong enough to produce a significant interaction (see Dijkstra et al., 1998 for similar results in an out of context recognition experiment)

General discussion

The primary objective of the present study was to examine the nature of bilingual lexical activation in sentence context. More specifically, we were interested in determining whether the presence of a sentence context would modulate cross-language, non-selective activation. Overall the findings demonstrated that the mere presence of a sentence context, and the language cues it might provide, were not sufficient to constrain non-selectivity since effects of cross-language activation persisted in low-constraint sentences. Instead, effects of non-selectivity were decreased only when the sentences provided rich semantic information. For example, effects of cognate facilitation persisted in low-constraint sentences and were eliminated only in high-constraint sentences for both the highly proficient bilinguals of Experiment 1 and the less proficient bilinguals of Experiment 2. This suggests that the top-down processes of sentence comprehension can interact directly with the bottom-up processes of lexical access and reduce the number of lexical entries that compete for selection.

A remarkable aspect of these findings is that the two groups of bilinguals differed dramatically in terms of their exposure to and use of the L2. The more proficient bilinguals of Experiment 1 were living in a bilingual community in which they communicated in their L1 and L2 on a daily basis. Furthermore, these bilinguals were receiving most of their university instruction in the L2. The less proficient bilinguals of Experiment 2 had only limited exposure to their L2, which was mostly confined to prior visits to English-speaking countries. Since previous research has demonstrated that the extent to which contextual information constrains lexical activation depends critically on reading proficiency, one might hypothesize that only bilinguals with extensive L2 proficiency would show reduced cross-language activation in high-constraint sentence context. However, the findings from the cognate analyses in Experiments 1 and 2 suggest that even when exposure to the L2 is somewhat limited and the lesser dominant of the two languages, the top-down processes of sentence comprehension can interact directly with the bottom-up processes of lexical access.

To further test the seemingly similar patterns observed across the two experiments, we performed a post hoc ANOVA, in which we combined the performance data from the cognate conditions, for both groups of bilinguals, using experiment (1 or 2) as a between-subjects factor. A 2 (experiment: 1 or 2) $\times$ 2 (sentence constraint: low or high) $\times$ 2 (cognate status: cognate or control) ANOVA performed on the mean latency data revealed a main effect of cognate status, $F_1(1, 39) = 14.82$, $MSE = 12{,}563.62$, $p < .01$, indicative of the faster reaction times for cognates relative to non-cognate controls. This main effect of cognate status was qualified by a two-way interaction with sentence constraint, $F_1(1, 39) = 13.79$, $MSE = 14{,}178.17$, $p < .01$, reflecting the elimination of cognate facilitation in high-constraint sentences. More critically, the three-way interaction between experiment, constraint and cognate status was not significant, $F_1(1, 39) = 0.18$, $MSE = 1{,}027.99$, $p = .72$. This suggests that the influence of sentential constraint on lexical access was similar for both groups of bilinguals.

It is also important to note that the naming latencies across the two groups of bilinguals were quite similar and the main effect of "experiment" was not significant, $F_1(1, 39) = 0.33$, $MSE = 41{,}894.91$, $p = .57$. At first this may seem surprising given the lower proficiency of the bilinguals of Experiment 2. However, there are several factors that likely contributed to the similar latencies. First, the intermediate proficiency bilinguals did have significantly higher naming error rates, $F_1(1, 39) = 0.18$, $MSE = 149.80$, $p < .05$. The reader should recall that error trials were not included in the reaction time analyses and this would significantly lower the reaction time for the intermediate proficiency bilinguals. Second, a naming task is typically executed in a relatively short period of time and is less likely to reflect general proficiency differences. Most importantly, the similarity in naming latencies provides further evidence that the participants of Experiment 2 were fairly proficient in their L2 and capable of successfully comprehending the sentence stimuli.

Unlike the cognates, the pattern of performance for the homograph conditions diverged between the two groups of bilinguals. A 2 (experiment: 1 or 2) $\times$ 2 (sentence constraint: low or high) $\times$ 2 (homograph status: homograph or control) ANOVA performed on the mean accuracy data revealed a main effect of homograph status, $F_1(1, 39) = 24.72$, $MSE = 63.51$, $p < .01$, indicative of the higher error rates for homographs relative to non-homograph controls. This main effect of homograph status was qualified by a two-way interaction with experiment, $F_1(1, 39) = 3.61$, $MSE = 63.51$, $p < .01$. This interaction reflected the greater increase in error rates for inter-lingual homographs for the less proficient bilinguals of Experiment 2 (an increase of 11% points) relative to the slight increase in error rates for the more proficient bilinguals of Experiment 1 (an increase of 1.4% points). Thus, for the more proficient bilinguals there appeared to be minimal activation of the non-target representations of the inter-lingual homographs in either low- or high-constraint sentences. This suggests that for those bilinguals, lexical competitors that are exclusively form-related do not become strongly activated within a semantically driven task such as sentence comprehension. In contrast, the less proficient bilinguals in Experiment 2 showed increased naming error rates for the inter-lingual homographs, particularly in low-constraint sentences. This suggests that for these bilinguals form-related lexical competitors were activated and competed for selection. The reader will recall that the trend in the error-rate data of Experiment 2 reflected some attenuation of homograph inhibition in high-constraint sentences. However, this attenuation was not sufficient to produce a significant interaction and naming performance continued to be significantly affected by inter-lingual homograph status.

The pattern of results for the inter-lingual homograph conditions across the two experiments can be understood through the re-ordered access model proposed by Duffy and colleagues. According to this model, the extent to which the multiple meanings of an ambiguous word will become activated and compete for selection depends on the relative frequency of those meanings and the previous context. For the less-proficient bilinguals the non-target meanings of the inter-lingual homographs were the more dominant, L1 meanings. These meanings were therefore activated fairly automatically and competed for selection with the target, subordinate, L2 meaning. For the more-proficient bilinguals, the alternative meaning may not have as strongly activated since for these individuals the target language, English, had become functionally more dominant.

The re-ordered access model would further predict that these inhibitory effects would be greatest in high-constraint sentences since the additional support for the subordinate meaning would allow it to become activated earlier and more strongly. In the present study, this was not the case. The magnitude of inhibition was not significantly different across the two sentence contexts and the error rates were actually greater in low constraint. One hypothesis is that when the multiple meanings are represented across languages rather than within, that a relatively low-constraint sentence is sufficient to more strongly activate the target meaning allowing it to compete early for selection. This possibility suggests that there might be important differences in how multiple meanings of ambiguous words are activated depending on whether they are across or within languages. However, it should be noted that our dependent measure, naming errors, may not have been sensitive enough to pick up on the time-course differences with which the multiple meanings were activated. Future studies, using more sensitive dependent measures such as eye-tracking should address this issue further.

It is not clear what the re-ordered access model would predict for the processing of cognates in sentence context. This model has been largely tested with within-language ambiguous words with divergent meanings (e.g., homographs such as *lead*) and not convergent meanings, such as cognates, which can only exist across languages (i.e., within-language synonyms which do share meaning are not form-ambiguous and the semantic overlap is rarely perfect). Consequently, the model makes predictions specifically for patterns of inhibition that arise from lexical competition and not facilitative effects that can arise from co-activation of converging semantics. Currently there is not a uniform theoretical account in the literature of how sentence context exerts its influence on bilingual lexical access. We next discuss how a current model of bilingual lexical processing out of context, the BIA+ model, could be extended to account for the present results.

There are several assumptions of the BIA+ model that are supported by the major findings of the present study. Most critical is the assumption that activation within the bilingual lexicon can be directly affected by surrounding linguistic context. The authors defined linguistic contextual effects as those effects "arising from lexical, syntactic or semantic sources (e.g., sentence context)" (Dijkstra & Van Heuven, 2002) [p. 187]. This assumption is clearly supported by the results from the high-constraint sentence conditions, in which effects of cross-language activation (e.g., cognate facilitation) were eliminated.

The BIA+ model also assumes that information regarding a word's language membership becomes activated relatively late and does not have a direct influence on the initial set of lexical candidates that become activated upon presentation of the input string. The modelers recognized the possibility that the presence of a sentence context might produce pre-activation of the language nodes, which in turn could constrain lexical activation from the non-target language. However, this filtering ability would be incompatible with the assumption that the language nodes function only as language tags. The fact that in the present study effects of cross-language interaction persisted in low-constraint sentences provides strong support for the assumption of the limited influence of language membership. If the language membership of the words preceding the critical target words reduced cross-language activation we would have observed either attenuation or elimination of cross-language activation effects even in low-constraint sentences.

Although the BIA+ model can adequately account for several findings from the present study, the model lacks a specific mechanism for how sentential context might influence lexical access. Within the model, sentential context exerts its influence through semantics. However, the exact nature of the semantic representations is under-specified. In the model, no distinctions are made between lexical-level semantic information versus message-level semantic information. Dijkstra and Van Heuven (2002) propose that sentence context exerts its effect through boosted semantics. However, boosted semantics cannot explain why effects of cognate facilitation were eliminated in high-constraint sentences. Cognates share semantics across languages, and boosted semantic activation would not discriminate between them. The elimination of cognate facilitation suggests increasing contextual constraint somehow pre-activates the language nodes. One possibility is that the presence of a highly constraining context allowed for lexical activity in the lexicon to reach a stable state at an earlier time, which in turn, might have allowed for earlier activation of the language nodes.

Although the present study provided evidence of interactions between the top-down processes of sentence comprehension and the bottom-up processes of lexical access, we could not definitively conclude that actual selective access had taken place. The degree to which language selective access is possible can be examined in future studies, using different methodological approaches, such as eye-tracking. The eye-movement record can potentially discriminate between cross-language activity that occurs prior to lexical access versus activity that occurs post-lexical access.

Future research could address the extent to which L2 comprehension skill is dependent on general, cognitive resources or skills specific to reading or L2 proficiency. The psycholinguistic study of bilingual (and multilingual) reading processes is a relatively new area, which has received increasing attention in the past ten years. It is fortunate that there is much reading research from monolingual investigation to draw from. However, it is critical that a rich research base be developed that focuses specifically on the psycholinguistic variables that guide reading in non-native languages.

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