UNIVERSITEIT GENT

FACULTEIT PSYCHOLOGIE EN PEDAGOGISCHE WETENSCHAPPEN

Bilingual word recognition in a sentence context

Eva Van Assche

Promotor: Prof. Dr. Robert J. Hartsuiker

Proefschrift ingediend tot het behalen van de academische graad
van Doctor in de Psychologie

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ACKNOWLEDGEMENTS

Wow, hier is het dan, mijn doctoraat, het resultaat van 3 jaar en 4 maand onderzoek. Ik heb dit onderzoek met veel plezier gedaan, maar ben nu toch superblij dat de stresserende maanden die bij het afronden van een doctoraat horen voorbij zijn en ik kan zeggen dat het bijna klaar is voor de drukker! Voor dit doctoraat heb ik veel hulp, de nodige steun en het vakkundig advies gekregen van vele mensen en hen wil ik allemaal welgemeend bedanken.

Allereerst wil ik mijn promotor Rob Hartsuiker en Fwo-co-promotor/begeleider Wouter Duyck bedanken. Rob, bedankt om zo’n goede promotor te zijn, voor het samen uitdenken en uitwerken van mijn studies en voor alle advies dat je me gegeven hebt. Wouter, je bent eigenlijk altijd al mijn begeleider geweest, van het schrijven van de eerste paper in 1^{e} licentie, over het uitvoeren van het onderzoeksvoorstel in 2^{e} licentie en de scriptie in 3^{e} licentie tot uiteindelijk dit doctoraat. Ik heb ontzettend veel van jou geleerd en vond het altijd een leuke samenwerking. Daarom, dankjewel voor alles.

Jonathan Grainger verdient hier zeker ook een vermelding omdat hij een uitstekend begeleider was van mijn stage in het zonnige Aix-en-Provence. Tijdens deze stage werd me meer en meer duidelijk hoe graag ik zelf wetenschappelijk onderzoek zou willen uitvoeren. Na mijn stage verkreeg ik een beurs van het Fonds voor Wetenschappelijk Onderzoek Vlaanderen (FWO) om vier jaar aan mijn doctoraat te werken en hiervoor wil ik deze organisatie dan ook uitdrukkelijk bedanken.

Bedankt aan de mensen van mijn begeleidingscommissie, Sonja Kotz, Janet van Hell en Timothy Desmet voor hun vakkundig advies.

Dan wil ik ook enkele co-auteurs van papers uit dit doctoraat bedanken. Kevin, bedankt om me te introduceren in de wereld van de lme's. Denis, jou wil ik natuurlijk ook bedanken om me zoveel te leren over oogbewegingsmetingen. Ik kon altijd bij jou terecht met vragen en je was altijd bereid om me advies te geven. Wanneer ik je bestookte met e-mails heb je altijd supersnel gereageerd.

En dan zijn er de vele mensen van de vakgroep die zeker een bedanking verdienen. Gedurende dit doctoraat heb ik met verschillende mensen een bureau gedeeld en hen wil ik bedanken voor het leuke gezelschap! Els, Ine, Denis en Evelyne (in chronologische volgorde), bedankt voor alle leuke ontspannende babbels tijdens het werk. Evelyne, bedankt voor de aanmoedigingen tijdens deze laatste weken! Lies, Christophe, Antoine en Pascal voor alle praktische ondersteuning. Liliane, voor het zorgen voor een propere werkomgeving. De spinning ladies Ilse, Freja en Els voor de ontspannende en intensieve woensdagavond work-outs. Vanaf volgende week ben ik er terug bij. De conditie zal weer wat moeten opgebouwd worden! Maaike, bedankt voor het checken van de Engelse vertaling van mijn stimuli (tijdens jouw kerstvakantie!), voor de leuke praatjes op het werk en het gezelschap op weg naar huis. Sarah, eveneens bedankt voor het nakijken van de Engelse vertaling van Nederlandse stimuli en voor het inspreken van de woordjes voor de fonologische ratings. Kimmy en Freja, bedankt voor het leuke gezelschap op het werk. Ook een dankjewel aan de andere leden van de vakgroep en de mensen van de taalgroep voor alle steun en het leuke gezelschap op congressen.

En natuurlijk wil ik ook de vrienden en familie bedanken. Ik denk dat bijna ieder van jullie op een bepaald moment wel eens deelgenomen heeft aan een experiment van mijn thesis of een rating/vragenlijst ingevuld heeft voor dit doctoraat. Jaja, voor deze plezante jobkes wist ik jullie te vinden ;-) Tim, bedankt voor het nalezen van de Inleiding en Conclusies. Iedereen bedankt voor de aanmoedigingsmails/telefoons in deze laatste weken. Vanaf nu ben ik weer op elk feestje present!

Mama en papa, ongelooflijk bedankt voor alle steun. Jullie staan werkelijk altijd voor mij klaar en helpen me waar jullie ook kunnen. Jullie zorgden ervoor dat ik in ideale omstandigheden kon studeren en gaven me alle kansen.

En dan wil ik natuurlijk ook Kenneth heel erg bedanken voor ja, eigenlijk véééééééél te veel om op te noemen. Ik waardeer enorm wat je allemaal voor mij doet. Kenneth, je bent echt een ongelooflijke schat. You're the best!

Eva,

8 februari 2009.

CHAPTER 1
INTRODUCTION

Ever since it was estimated that about half of the world's population is bilingual (Grosjean, 1982), research on bilingualism has attracted the attention of the scientific community. This attention is well-justified, because bilingualism is relevant to all of us. The term *bilingual* in the psycholinguistic literature does not only apply to people who are perfectly balanced bilinguals having acquired two languages from birth on, rather 'bilingualism is the regular use of two (or more) languages, and bilinguals are those people who need and use two (or more) languages in their every day lives' (Grosjean, 1992, p. 51). Many people have knowledge of more than one language, but there are probably few among them who think about the organization of these languages and about how this 'bilingual status' might influence word processing. This includes issues such as: Are the words of one language activated when reading in the other? Are there any differences in cross-lingual activation between words presented in isolation and words in sentence contexts? How do we process words that are similar across the two languages (e.g., Dutch-English *schip* - *ship*)? Does knowledge of a second language change native-language reading? The most intuitively appealing idea would probably be that bilinguals have two separate lexicons that can be accessed selectively so that each language functions independently of the other. After all, most bilinguals can speak and read in each language without too much intrusions or errors (e.g., Poulisse & Bongaerts, 1994). However, in the last decade, more and more researchers have come to realize that 'the bilingual does not equal the sum of two monolinguals' (Grosjean, 1989). It became clear that the two languages interact with each other when bilinguals are processing words in one language (e.g., Dijkstra, Grainger & van Heuven, 1999; Duyck, 2005; Hartsuiker, Pickering, & Veltkamp, 2004; van Hell & Dijkstra, 2002).

This introduction provides a general theoretical framework for the studies on bilingual word recognition that were carried out for this dissertation. First, we present two influential models for bilingual word processing. One of these will provide the theoretical framework for the current studies. Then, we will discuss important findings on word recognition for words presented in isolation (out-of-context) and for word recognition in sentences. The final section gives an overview of the studies presented in this dissertation.

THEORIES ON BILINGUAL WORD RECOGNITION

LEXICO-SEMANTIC ORGANIZATION

An important line of research in bilingualism relates to the organization of semantic (meaning) and lexical (form) representations in the bilingual language system. The necessity of a distinction between meaning and form representations becomes clear if one considers that the meaning of translation equivalents (e.g., Dutch-English *stoel* - *chair*) does not differ much across languages, whereas most (though not all) words have a different orthography in each language (e.g., *stoel* – *chair*, or for translation equivalents with identical orthographies, *ring* – *ring*). An intuitively plausible assumption would therefore be that bilinguals have one store for conceptual representations and two lexicons for the orthographic representations of each language. An influential model in the literature on lexical-semantic organization which incorporates this assumption is the Revised Hierarchical Model (RHM) (Figure 1) of Kroll and Stewart (1994).

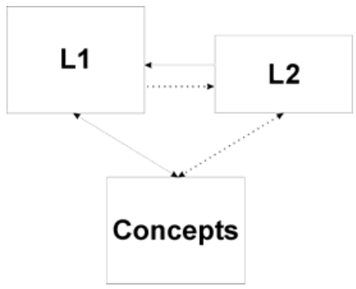

Figure 1. The Revised Hierarchical model of Kroll & Stewart (1994).

In this model, L1 and L2 lexical representations are stored in separate lexicons that are connected to each other and to a common semantic system. As can be seen in Figure 1, the strength of these connections is asymmetric. The connections from lexical representations in the L2 lexicon to their L1 translations are stronger than the other way around. Also, L1 words activate conceptual representations more strongly than L2 words do. The RHM assumes that these asymmetries will disappear as bilinguals become more proficient because L2 lexico-semantic mappings will become stronger. A large number of studies provided evidence in favor of the model (e.g., Kroll & de Groot, 1997; Kroll & Tokowicz, 2005), but there are some recent studies which indicate that lexical representations may be mapped directly onto semantics (e.g., La Heij, Hooglander, Kerling, & Van der Velden, 1996), even at low levels of L2 proficiency (e.g., Duyck & Brysbaert, 2004). Although the RHM is still one of the most dominant models in the literature, its focus is on the interactions between the semantic and lexical systems, rather than on the functioning *within* and interactions *between* the two lexicons of a bilingual. Therefore, the next section discusses a model which focuses more on the lexical organization in bilinguals.

LEXICAL ORGANIZATION

Another important research line focuses on the organization of the bilingual mental lexicon and the process of bilingual word recognition. The most influential model in this context is probably the Bilingual Interactive Activation (BIA) model (Dijkstra & van Heuven, 1998). This is a bilingual extension of the Interactive Activation model (McClelland & Rumelhart, 1981) and is concerned with the processing of orthographic representations. Four years later, an updated version of the BIA model was presented: the BIA+ model (Dijkstra & van Heuven, 2002) (Figure 2). It makes the same two basic assumptions as the earlier BIA model. First, it assumes that L1 and L2 words are represented in an integrated lexicon. Second, it assumes that word recognition proceeds in a language-nonselective way, which means that representations from both languages become activated in parallel. Lexical orthographic representations are activated depending on the overlap with the input stimulus and the resting level activation of the representations (based on frequency, proficiency, etc). Then, the orthographic codes activate the corresponding phonological and semantic representations.

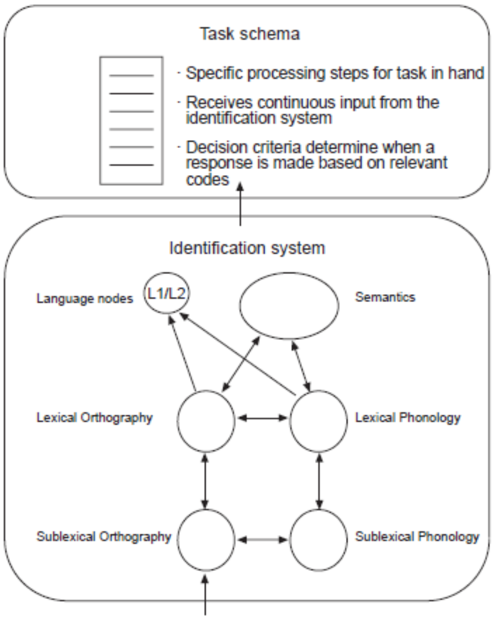

Figure 2. The BIA+ model for bilingual word recognition. Arrows indicate activation flows between representational layers.

The model contains a representational layer containing two *language nodes*, one for each language. In the earlier BIA model, the language nodes had top-down connections to the lexicon. Each language node collected activation from words of the corresponding language and inhibited words of the other language. However, it became clear that the representational and functional aspects of the languages nodes were confounded. For instance, in the BIA model, language switch effects (e.g., Von Studnitz & Green, 1997) were accounted by the language nodes, but this account turned out to be incorrect because several studies indicated that the source of switch costs needed to be located outside the mental lexicon (e.g., Von Studnitz & Green, 2002; Thomas & Allport, 2000). Therefore, in the current BIA+ model, the language nodes only have a representational function as language tags, indicating the language to which an item belongs, and they no longer have top-down connections to the lexicon. For that reason, they can no longer inhibit words (or an entire language), and cannot be used to account for effects of language context or stimulus list composition (e.g., Dijkstra, De Bruijn, Schriefers, & Ten Brinke, 2000; Dijkstra, Van Jaarsveld & Ten Brinke, 1998). In the BIA+ model, these effects are now handled by a task/decision system which specifies decision criteria and processing steps for performing a task. As can be seen from Figure 2, this task/decision system receives continuous input from the word identification system but does not feed back activation into it. Each system is sensitive to specific context effects. Nonlinguistic context (e.g., task demands, participants' expectations) is assumed to affect the task/decision system. Linguistic context (e.g., semantic and syntactic constraints), on the other hand, is assumed to directly affect activation in the word identification system. This indicates that although the BIA+ model was originally designed for word recognition out-of-context, it also makes predictions on how linguistic context (e.g., a sentence context) might influence activation in the word identification system, even without top-down activation from language nodes. These interactions between context and word recognition constitute the main focus of the current dissertation.

Dijkstra and van Heuven suggest that the word identification system is part of a larger system in which sentence parsing and language production are also represented (e.g., Levelt, Roelofs, & Meyer, 1999). They propose that the sentence parsing system may directly interact with the word identification system. This means that syntactic and semantic context information may affect word recognition. If bilingual context effects proceed in a similar way as monolingual word recognition in sentences, this may change the degree of language-nonselectivity in bilingual word recognition. Dijkstra and van Heuven contrasted two viewpoints on how the language of the preceding sentence could modulate cross-lingual activations in the integrated lexicon. A first alternative is that the language nodes can be pre-activated by the sentence. This activation should function as a link between sentence and lexical levels so that the language of the sentence could affect word recognition. However, the second alternative is that this pre-activation will not be sufficient, because Dijkstra and van Heuven stated earlier that language nodes cannot inhibit words to any considerable extent. This leads them to conclude that the language information of the sentence does not provide strong selection constraints on bilingual word recognition. However, they do propose that the semantic constraint of a sentence may directly affect activation in the word identification system. However, they do not specify the exact mechanism that can give rise to these predicted context effects.

The aim of the present dissertation is to test whether these predictions of the BIA+ model regarding sentence context effects can be confirmed. Two main research questions were formulated with respect to this issue: (a) Is bilingual lexical access modulated by the mere presentation of a sentence context and the language cue it provides, and (b) If not, is lexical access modulated by the semantic constraint provided by the sentence? Before we move on to a more detailed discussion of these research questions and the various experiments included in this dissertation, the next section provides an overview of studies on bilingual word recognition out-of-context and in sentences, in order to show how the assumptions of the BIA+ model were investigated in previous studies.

BILINGUAL WORD RECOGNITION

In recent years, a general consensus has been reached on the fact that words from both languages are activated in a language-nonselective way. Many studies have demonstrated that lexical representations of the first language are accessed when people are reading in their second language (e.g., Brysbaert, van Dyck, & van de Poel, 1999; Dijkstra et al., 1999; Duyck, 2005; Duyck, Diependaele, Drieghe, & Brysbaert, 2004; Haigh & Jared, 2007; Jared & Kroll, 2001; Lemhöfer & Dijkstra, 2004) and vice versa (e.g., Duyck, 2005; van Hell & Dijkstra, 2002). To investigate this cross-lingual activation, the processing of cognates is often compared to the processing of language unambiguous words (e.g., Caramazza & Brones, 1979; Dijkstra et al., 1999; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Lemhöfer & Dijkstra, 2004). Dijkstra et al. (1999) note that most studies define cognates as translation equivalents with identical orthographies (e.g., Dutch-English *ring – ring*). However, de Groot and Nas (1991) define cognates differently as translation equivalents with *similar* writings and pronunciations (e.g. *schip – ship*) (cf. van Hell & Dijkstra, 2002). In the current dissertation, we follow the definition of de Groot and Nas, controlling for the degree of orthographic overlap of the translation equivalents either by distinguishing identical and nonidentical cognates (Chapter 2), or by calculating a more sensitive measure of translation equivalent similarity, namely, the degree of orthographic overlap (Van Orden, 1987) between translation equivalents (Chapters 3-6). If bilinguals are asked to perform a task in one language and their performance turns out to be different for cognates than for noncognate controls that are matched on all variables that could affect their processing speed, this is taken as evidence for language-nonselective activation. For instance, many studies have shown that cognates are recognized or produced faster than monolingual control words (i.e., *the cognate facilitation effect*) (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004). Lemhöfer, Dijkstra, and Michel (2004) even showed that this effect accumulates over languages. They tested Dutch-English-German trilinguals performing a German (L3) lexical decision task (word/nonword response) and reported faster responses for L1-L2-L3 cognates than for L1-L3 cognates. Cognate facilitation even occurs when bilinguals perform a lexical decision task in their native and dominant language (van Hell & Dijkstra, 2002). This means that even the second language gets activated strongly enough to influence native-language word recognition.

A theoretical explanation of this cognate facilitation effect can be given in light of the BIA+ model (Dijkstra & van Heuven, 2002). Upon the presentation of a word, orthographic, phonological, and semantic representations become activated in parallel depending on the overlap with the word. As cognate translations have very similar orthographic (and phonological) representations, the convergent activation of the orthographic, phonological and semantic codes speeds up the activation of cognates compared to noncognates and results in faster word recognition. In fact, Dijkstra (2005) even suggests the possibility of a special representation for cognates, with a strong connection between orthographic and semantic representations (cf. Pecher, 2001).

BILINGUAL WORD RECOGNITION IN SENTENCES

Because the language-nonselective activation of words in the two languages is now generally agreed upon in bilingualism research, it may be time to test the ecological validity of these studies. After all, people rarely read lists of isolated words, but instead, words are embedded in meaningful sentences. And, this is not merely an obvious generalization, as the processing of words in isolation may differ in important ways from word processing during sentence reading. For instance, it is possible that the presentation of words in a sentence context restricts lexical activation to words of the target (sentence) language only. In the monolingual domain, it has been shown that semantic and syntactic restrictions imposed by a sentence are used to speed up recognition of upcoming words (e.g., Schwanenflugel & LaCount, 1988; Stanovich & West, 1983). For instance, many studies have shown that context modulates lexical access for ambiguous words (e.g., *bank* as a riverside or a financial institution) (e.g., Binder & Rayner, 1998; Onifer & Swinney, 1981; Simpson, 1984). Meaning activation in neutral sentences is determined by the relative frequencies of the ambiguous word's meanings, but this activation can be modulated by a biasing context (e.g., Duffy, Kambe, & Rayner, 2001). Also, previous research has shown that words embedded in a predictive sentence context are processed faster than words embedded in a neutral sentence context (e.g., Balota, Pollatsek, & Rayner, 1985; Ehrlich & Rayner, 1981; Rayner & Well, 1996; Stanovich & West, 1983). These monolingual studies indicate that sentence context can restrict semantic, syntactic, and lexical activation for words appearing later in the sentence.

The question now is whether these sentence context effects in monolinguals generalize to bilinguals. Although there is a single study of Altarriba, Kroll, Sholl, and Rayner (1996) that investigated word recognition in a sentence context for mixed-language sentences, all unilingual studies investigating bilingual sentence reading were carried out only very recently (e.g., Elston-Güttler, Gunter, & Kotz, 2005; Libben & Titone, in press; Schwartz & Kroll, 2006; van Hell & de Groot, 2008). The work of Altarriba et al. (1996) suggests that the semantic constraint of a sentence may indeed be used to restrict lexical access to words of only one language. In the critical condition of their study, Spanish-English bilinguals read English (L2) low- or high-constraint sentences in which the target word was replaced by its Spanish translation. Examples of such low- and high-constraint sentences are *He always placed all of his dinero* [money] *on a silver dish on his dresser* and *He wanted to deposit all of his dinero* [money] *at the credit union*, respectively. Reading times for high-frequency Spanish words in high-constraint sentences were longer relative to reading times for the same target in a low-constraint sentence. Although the words *dinero* and *money* both met the syntactic and semantic restrictions of the sentence, facilitation was only observed for the word that also met the lexical restriction of the language of the sentence. This indicates that a high-constraint sentence does not only generate semantic and syntactic restrictions, but that it also directs lexical access to the language of the sentence. However, the study of Altarriba et al. used mixed-language sentences that did not provide a natural reading context and this may have had an influence on lexical access.

There are several more recent studies which have used unilingual sentences to investigate cross-lingual activation in a sentence context by testing the recognition (or production) of cognates or interlingual homographs (i.e., words that share orthography but not meaning, e.g., Dutch *room* [cream] vs. English *room*) (e.g., Elston-Güttler et al., 2005; Libben & Titone, in press; Schwartz & Kroll, 2006; van Hell & de Groot, 2008). These studies seem to indicate that the mere presentation in a sentence context does not modulate lexical access, whereas lexical activation can be modulated by a semantically constraining sentence. The study of Elston-Güttler et al. (2005) showed that cross-lingual activation is very sensitive to the influence of a sentence context and the previous activation state of the two languages. They tested the recognition of interlingual homographs by German-English bilinguals. These homographs were presented at the end of a relatively low-constraint sentence (e.g., *The woman gave her friend a pretty gift* [poison]). After presentation of the sentence, a target word replaced the sentence that was either related to the L1-meaning of the homograph (*poison*, which is the translation of the German meaning of *gift*) or unrelated to the control sentence not containing a homograph (e.g., *The woman gave her friend a pretty shell*). Targets were recognized faster after the related homograph sentence than after the unrelated control sentence, but only in the first block of the experiment and only for participants who saw a German film prior to the experiment, boosting the L1 activation. This seems to indicate that sentence constraint effects are very sensitive to task circumstances.

More important for the present dissertation however, are the studies by Schwartz and Kroll (2006), van Hell and de Groot (2008) and Libben and Titone (in press) because they used the robust marker of cross-lingual activation effects that was also used in this dissertation: the cognate facilitation effect. Schwartz and Kroll (2006) tested cognate and homograph effects in Spanish-English bilinguals. Low- and high-constraint sentences were presented word by word using rapid serial visual presentation. The target word (printed in red) had to be named. Cognate facilitation was observed in low-constraint sentences, but not in high-constraint ones. No reaction time differences were found for homographs and controls in either low- or high-constraint sentences, but less proficient bilinguals made more naming errors, especially in low-constraint sentences. Although the results for homographs were somewhat inconclusive, the results for cognate processing show that the semantic constraint of a sentence can restrict cross-lingual activation effects.

Similar results were obtained by van Hell and de Groot (2008) for Dutch-English bilinguals. The participants had to perform an L2 lexical decision task or a translation task in forward (from L1 to L2) or in backward direction (from L2 to L1). In the lexical decision task, each sentence was presented as a whole on the screen for 4 s and the location of the target was marked with dashes (e.g., the high-constraint sentence *The best cabin of the ship belongs to the* ---; target *captain*). The target word for lexical decision was presented immediately after the sentence context disappeared from the screen. In the translation tasks, sentence contexts were presented as a whole or using rapid serial visual presentation. Significant cognate facilitation was observed after the presentation of a low-constraint sentence. However, after reading a high-constraint sentence, cognate effects were no longer observed in the lexical decision task and strongly diminished in the translation tasks.

Finally, after the publication of the first eyetracking study (Chapter 2) of this dissertation and before the writing of this Introduction, a recent study has adopted the same approach. Libben and Titone (in press) tested cognate and homograph effects in French-English bilinguals. Eye movements were recorded while the bilinguals read low- and high-constraint sentences. The results showed cognate facilitation and interlingual homograph interference in low-constraint sentences. However, in high-constraint sentences, these cross-lingual interaction effects were only observed on early stage comprehension measures (e.g., first fixation duration, gaze duration). No cognate facilitation or homograph interference was obtained on late stage measures (e.g., total reading time). These results seem to indicate that lexical access in bilinguals is nonselective at early stages but becomes selective at later stages for high-constraint sentences. However, note that, contrary to Schwartz and Kroll (2006) and van Hell and de Groot (2008), Libben and Titone only used form-identical cognates.

In sum, these few empirical studies on bilingual sentence reading indicate that the mere presentation of a sentence and the language cue it provides does not restrict lexical access in bilinguals. However, mixed results have been obtained for semantically constraining sentences.

THE PRESENT DISSERTATION

The current dissertation is aimed at providing a comprehensive view, testing a homogeneous population of Dutch-English bilinguals, on how the mere presentation of a sentence context, and the semantic constraint it provides, modulates language-nonselective activation in the bilingual lexicon, both for L1 and for L2 processing. We hope that the results from this investigation may contribute to the further development and refinement of current models on bilingualism (e.g., Dijkstra & van Heuven, 2002) in order to be able to provide a detailed account of the top-down influence of a sentence context on lexical access.

In order to investigate reading in its most natural way, we used the eyetracking methodology. This method has several important advantages over lexical decision or naming. First, it allows reading as in every day life and thereby provides the most natural experimental operationalization of reading. Second, there is no need for any overt response (e.g., as in lexical decision) that may be subject to strategic factors not directly related to word recognition. And finally, it allows to investigate the timecourse of lexical activation by dissociating several early (reflecting initial lexical access) and late reading time measures (reflecting higher-order processes) (Rayner, 1998).

Previous research has consistently shown that cognate processing is facilitated in bilinguals, for word recognition in L2 as well as for word recognition in the L1 (e.g., Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004; van Hell & Dijkstra, 2002). We therefore decided to use this cognate facilitation effect as a strong and reliable marker of nonselective activation in the studies reported in this dissertation.

SENTENCE PROCESSING IN L2

In *Chapter 2*, word recognition in a sentence context in L2 is investigated in three experiments with Dutch-English bilinguals. As discussed above, the BIA+ model (Dijkstra & van Heuven, 2002) predicts that the language information provided by a sentence does not provide strong selection constraints on lexical access. Therefore, we predict that cross-language interaction effects will occur in low-constraint sentences to the same extent as for word recognition out-of-context. Schwartz and Kroll (2006) already showed that the mere presentation in a sentence does not restrict lexical access for naming, while van Hell and de Groot (2008) reached the same conclusion in a lexical decision and translation tasks. Similarly, Libben and Titone (in press) showed that cross-lingual interaction effects still occurred in low-constraint sentences using the eyetracking method. In the present study, the eyetracking method is also used to investigate lexical access in sentences because it provides a time-sensitive measurement by which several early and late processes can be dissociated.

The BIA+ model is an interactive activation model of bilingual word reading, which means that representations become activated and interact with each other depending on the overlap with the input. Cognate facilitation is assumed to originate from the convergent activation of orthographic, phonological, and semantic codes compared to noncognates. As a consequence, Dijkstra and van Heuven predict that the size of the cognate facilitation effect depends on their degree of cross-linguistic overlap. We will test this prediction by including identical (e.g., *ring – ring*) and nonidentical cognates (e.g., *schip – ship*) in the stimulus set. If larger cross-lingual overlap triggers faster word activation, cognate facilitation should be stronger for identical than for nonidentical cognates.

SENTENCE PROCESSING IN L1

Whereas Chapter 2 deals with influences of the native and dominant language on reading in the second language, *Chapter 3* investigates whether knowledge of a second language influences word recognition in native-language sentence reading. As indicated above, resting level activation of representations in the BIA+ model is dependent on proficiency and subjective frequency. For the unbalanced bilinguals in most studies, representations in L2 are generally of lower subjective frequency than L1 representations. Therefore, they are activated more slowly than L1 representations. Then, activated orthographic representations activate the corresponding phonological and semantic representations. This implies that L2 phonological and semantic codes are delayed in activation relative to L1 representations (the *temporal delay assumption*). A consequence of the temporal delay assumption is that influences of L1 on L2 processing should be stronger than influences of L2 on L1 processing. This is indeed what has been observed in many word recognition studies (e.g., Duyck, 2005; Jared & Kroll, 2001; Haigh & Jared, 2007; but see Brysbaert et al., 1999; Duyck & Brysbaert, 2004; Van Wijnendaele & Brysbaert, 2002). In order to demonstrate the existence of a profoundly language-nonselective lexical system, word recognition in the native language should be investigated. This provides a very strong test of nonselective lexical access because we test for an influence of the weaker language on reading in the dominant language.

Chapter 3 presents two experiments in which (a) the cognate facilitation effect in L1 is replicated for words out-of-context (van Hell & Dijkstra, 2002) and (b) in which we investigate how language information of a sentence context may influence this cross-lingual activation. As discussed before, the BIA+ model predicts that the language of a sentence does not provide selection constraints on lexical access. The finding of cognate effects in sentence contexts would therefore provide very strong evidence for a fundamentally nonselective language system. In addition, we fine-tuned the distinction between identical and nonidentical cognates in Chapter 2 by calculating cross-lingual overlap for each word on Van Orden's (1987) similarity measure. According to the BIA+ model, cross-lingual activation spreading is a function of cross-lingual similarity between lexical representations in the integrated lexicon. This should result in faster word recognition for words with increasing degrees of overlap.

In *Chapter 4*, we present a replication experiment testing the same research question as in the previous chapter with a different stimulus set. Investigating cross-lingual activation in native-language sentence reading provides a conservative test of a nonselective bilingual lexical system.

SEMANTIC CONSTRAINT EFFECTS IN L2

Chapter 5 will test whether lexical access is modulated by the semantic constraint of a sentence in L2. According to the BIA+ model, semantic context may exert constraints on lexical access, in a way that is similar to semantic context effects in the monolingual domain (e.g., Lucas, 1999). Altarriba et al. (1996) confirmed this prediction for bilinguals by showing that a semantically constraining sentence does not only generate conceptual restrictions, but also lexical restrictions for words later in the sentence. Similarly, Schwartz and Kroll (2006) and van Hell and de Groot (2008) no longer observed cognate facilitation for words embedded in high-constraint sentences. However, identical cognate facilitation in high-constraint sentences was obtained by Libben and Titone (in press) on early reading time measures. As Libben and Titone only investigated identical cognate processing, it is important to study how the degree of cross-lingual overlap of the translation equivalents influences these effects in high-constraint sentences. Therefore, continuous cognate facilitation was investigated by calculating cross-lingual overlap for each target word. Also, we believe there are reasons for further investigation of this issue through the more time-sensitive and natural measurement of eyetracking. First, Altarriba et al. used mixed-language sentences which may have fundamentally changed cross-lingual interactions in comparison to unilingual sentences. Second, presenting the sentence context in advance as van Hell and de Groot did or using rapid serial visual presentation as Schwartz and Kroll did may allow participants more time to anticipate the target in high-constraint sentences. This extra time compared to natural reading may therefore mask cross-lingual activation spreading occurring early during lexical access. For the above reasons, it seems appropriate to investigate semantic constraint effects on lexical access using more sensitive measurements such as eyetracking. Chapter 4 reports on three experiments testing cognate facilitation in low- and high-constraint sentences.

SEMANTIC CONSTRAINT EFFECTS IN L1

In *Chapter 6*, we test the same research question as in the previous chapter for reading in the native language. Investigating cross-lingual activation in the native language when semantic constraint is provided probably provides the strongest test of a nonselective language system reported in the current dissertation.

With the work presented in the present dissertation we hope to contribute to the recently developed research line of sentence context effects on lexical access in bilinguals.

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CHAPTER 2
VISUAL WORD RECOGNITION BY BILINGUALS IN A SENTENCE CONTEXT: EVIDENCE FOR NONSELECTIVE LEXICAL ACCESS

Journal of Experimental Psychology: Learning, Memory & Cognition, 2007, 33, 663-679 [1]

Recent research on bilingualism has shown that lexical access in visual word recognition by bilinguals is not selective with respect to language. In the present study, the authors investigated language-independent lexical access in bilinguals reading sentences, which constitutes a strong unilingual linguistic context. In the first experiment, Dutch-English bilinguals performing a second language (L2) lexical decision task were faster to recognize identical and nonidentical cognate words (e.g., banaan – banana) presented in isolation than control words. A second experiment replicated this effect when the same set of cognates was presented as the final words of low-constraint sentences. In a third experiment that used eyetracking, the authors showed that early target reading time measures also yield cognate facilitation, but only for identical cognates. These results suggest that a sentence context may influence, but does not nullify, cross-lingual lexical interactions during early visual word recognition by bilinguals.

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[1] This paper was authored by Wouter Duyck and co-authored by Eva Van Assche, Denis Drieghe and Robert Hartsuiker.
For reasons of consistency across chapters, the dependent measure 'Cumulative region reading time' in the article was labeled 'Regression path duration' in this dissertation.

INTRODUCTION

During the last decade, research on visual word recognition in bilinguals has been dominated by studies investigating whether both languages are processed by functionally and structurally independent systems. The most intuitively appealing theory about this issue would probably be that bilinguals have two separate language systems and lexicons: one for the native language (L1) and one for the second language (L2). However, a lot of evidence has been gathered against this hypothesis: interlingual interactions have been observed at different representational levels, even when bilinguals are processing unilingual sets of words and therefore have no reason to keep an irrelevant language active. Thus far, the majority of these studies have focused on orthographic lexical representations. They have consistently shown that access to these representations is not language specific. Orthographic lexical representations from L2 are accessed during (and interact early with) L1 reading and vice versa (e.g., Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, Timmermans, & Schriefers, 2000; van Hell & Dijkstra, 2002; for a recent review, see Dijkstra & van Heuven, 2002). Recently, a few studies have shown that the language-independent lexical access claim also holds for phonological representations. For example, Duyck (2005) has shown that masked nonword primes are coded through L1 grapheme conversion rules when reading L2 target words (and vice versa), suggesting that phonological representations from one language may be activated when reading in another language (see also Jared & Kroll, 2001).

Because the ongoing debate has almost been settled in favor of this language-independent lexical access hypothesis (for both orthographic and phonological lexical representations), it may be time to put into question the ecological validity and generalizability of these studies on lexical autonomy.

Whereas almost all these studies have investigated the recognition of words presented in isolation, word recognition in both L1 and L2 rarely occurs out of context. Words are almost always embedded in meaningful sentences and these may constitute an important influence on lexical access in general and on the degree of cross-lingual lexical interactions in particular. From the monolingual domain it is well known that the semantic and syntactic framework that one constructs when reading a sentence provides an important top-down influence on lexical access of the words appearing further in the sentence. For example, there is ample evidence that more predictable words are processed faster in a variety of production and recognition tasks such as naming (e.g., McClelland & O'Regan, 1981; Stanovich & West, 1983), lexical decision (e.g., Fischler & Bloom, 1979, 1980; Schwanenflugel & LaCount, 1988; Schwanenflugel & Shoben, 1985), and speech monitoring (e.g., Cole & Perfetti, 1980). Similarly, eyetracking studies have consistently shown that more predictable words are skipped more often, and yield shorter fixation times (e.g., Balota, Pollatsek, & Rayner, 1985; Ehrlich & Rayner, 1981; Rayner & Well, 1996). These studies show that readers use sentence contexts to generate semantic, syntactic, and lexical feature restrictions to facilitate the processing of subsequent expected words (e.g., Schwanenflugel & LaCount, 1988; see also Schwanenflugel & Shoben, 1985; Stanovich & West, 1981). For the present study and for the issue of language-independent lexical access in bilinguals, it is important to note that these findings also suggest that it may be plausible to assume that bilinguals use the language of a sentence as a language cue to direct lexical access of words appearing later in the sentence. Limiting or focusing lexical search to representations from a specific language would be very economical, because bilinguals have to consider almost twice as many lexical representations during word recognition than monolinguals (e.g., Gollan, Montoya, Fennema-Notestine, & Morris, 2005).

An interesting finding is that Altarriba, Kroll, Sholl, and Rayner (1996) showed that lexical representations from a specific language may indeed be selectively inhibited during lexical retrieval processes that interact with higher level (semantic) sentence context effects. Using eyetracking with Spanish-English bilinguals, they found that the recognition of code-switched (or mixed-language) L1 words inserted in high-constraint L2 sentences is inhibited (relative to the same words embedded in low-constraint sentences). For example, processing of the L1 word *dinero* is inhibited in the sentence *He wanted to deposit all of his dinero* [money] *at the credit union,* even though that L1 word meets the semantic and syntactic feature restrictions imposed by the sentence. Because processing of the L2 translation equivalent *money* in the same sentence does not yield inhibition, but facilitation, this shows that sentence contexts may indeed inhibit activation of lexical representations in a nontarget language so that only lexical representations belonging to the sentence language become activated during recognition. This suggests that the language of a sentence may indeed be used as a cue to guide lexical access. However, whereas the study of Altarriba et al. provides evidence for this general principle, because it used code-switched, high-constraint sentences, it cannot provide an answer to the question of lexical autonomy in regular, unilingual language processing with less artificially constrained sentences.

Similar context effects on the degree of cross-lingual activation, but not imposed by a linguistic sentence context, have been reported for example by Jared and Kroll (2001). Using English-French bilinguals, they showed that L1 words with L2 word-body enemies (e.g., the word *bait* contains the letter sequence *ait,* which is pronounced differently in French) are named slower than controls but only after participants named a block of L2 filler words prior to the experiment. Similarly, Elston-Güttler, Gunter and Kotz (2005) found that the L1 meaning of interlingual homographs (words that are written the same but have different meanings across languages, e.g., *room*, which means cream in Dutch) is activated during L2 processing, but only during the first half of the L2 experiment, and only for participants who saw an L1 movie instead of an L2 movie prior to the experiment. These studies also show that nontarget language lexical activation may indeed be susceptible to language context. For a theoretical account of possible linguistic and nonlinguistic context effects on selective lexical access during bilingual word recognition, we refer to our discussion of the bilingual extension of the well-known interactive activation (IA) model for monolingual word recognition (BIA+ model) of Dijkstra and colleagues (e.g., Dijkstra et al., 1999; Dijkstra & van Heuven, 2002) in the General Discussion section.

It is clear that none of these studies investigating context effects on nontarget language activation directly assess the linguistic context effect of unilingual sentences on cross-lingual lexical interactions during recognition of words embedded in these sentences. Therefore, it is the goal of the present study to test whether bilinguals use the language of a sentence as a linguistic cue to guide lexical access in unilingual sentence processing. It may be the case that lexical access in visual word recognition by bilinguals is language-independent in isolation but that the unilingual linguistic context in real life sentence processing is so strong that lexical representations from another language have virtually no effect on word recognition in (sequences of) unilingual sentences. It is surprising that there are very few data on this issue, which contrasts with the large number of studies in the monolingual domain that investigated sentence context effects on lexical access. However, it would seriously limit the relevance and ecological validity of the findings in isolated bilingual word recognition if no reliable evidence for language-independent lexical access in a sentence context can be obtained.

Before we discuss the very few earlier studies on word recognition by bilinguals in a sentence context and go into more detail about the present study, we briefly summarize the main experimental findings in isolated word recognition. This enables us to establish a reliable marker of language-independent lexical access for use in the sentence studies of this article.

LANGUAGE-INDEPENDENT LEXICAL ACCESS: STUDIES ON ISOLATED WORD RECOGNITION

To our knowledge, the first study on lexical autonomy is that of Caramazza and Brones (1979). They investigated lexical access in Spanish-English bilinguals by looking at the recognition of cognate words. These are translation equivalents that also share orthography and/or phonology across languages (e.g., a Dutch-English cognate is *lip*). They found that bilingual participants responded more quickly to L2 cognates than to L2 control words in a lexical decision task. Such a cognate facilitation effect is commonly attributed to the fact that the L1 lexical representation of the cognate is also activated to a certain degree during L2 word recognition, and spreads some of this activation to the L2 lexical representation of the cognate. Hence, they were the first to find evidence for the currently dominant theory that access to lexical representations in bilinguals is not language specific.[2] Later, several authors replicated this cognate facilitation effect in L2 (e.g., Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004; Schwartz, Kroll, & Diaz, 2007). Also, Lemhöfer, Dijkstra, and Michel (2004) showed that this effect may accumulate over languages: using Dutch-English-German trilinguals, they reported faster responses to third language (L3) words that are cognates with both L1 and L2 than for exclusive L3-L1 cognates.

Initially, no cognate facilitation effect was found in L1 (e.g., Caramazza & Brones, 1979; Cristoffanini, Kirsner, & Milech, 1986). However, better controlled studies have recently reported evidence that does support this strong test of nonselective lexical access. Testing Dutch-English-French trilinguals, van Hell and Dijkstra (2002) found a facilitation

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[2] Interestingly, whereas this effect has become the textbook example for evidence against lexical autonomy, Caramazza and Brones (1979) did not interpret their cognate facilitation effect as such. Instead, the effect was used to distinguish between models of lexical access that required serial orthography to phonology coding and parallel coding models.

effect for L1 words that were cognates with respect to L2 (for similar results, see Font, 2001). Also, the same effect was replicated for L1-L3 cognates, but only for participants that were very proficient in French (L3). These are very noteworthy results because their critical stimuli were mostly near-cognates (85% and 75% for L2 and L3, respectively), which are not completely orthographically (and phonologically) identical (e.g., Dutch-English: *bakker – baker*; Dutch-French: *muur – mur*). We find it surprising that the cognate effect survived these differences, suggesting that there is also strong activation spreading between representations of near-cognates. Van Hell and Dijkstra attributed the apparent contradiction between their symmetric cognate facilitation effect and the earlier asymmetric cognate effects to a possible influence of language proficiency: their L1-L3 cognate facilitation effect was only significant with bilinguals who were quite proficient with respect to L3. So apparently, the occurrence of cross-language lexical interactions in L1 processing requires a certain level of L2/L3 proficiency.

In all of the previously mentioned studies, the critical words (cognates) are often overlapping across languages with respect to orthographic, phonological, and semantic representations. Therefore, the cognate facilitation effect probably originates from convergent activation spreading across languages from all of these representational levels. The first study that systematically manipulated the cross-lingual overlap for these different levels is that of Dijkstra et al. (1999). Using a lexical decision task with Dutch-English bilinguals, they investigated the recognition of L2 words that varied on the degree of cross-lingual overlap with respect to semantics (S), orthography (O), and phonology (P). They also obtained a cognate facilitation effect (SOP and SO items). Contrastingly, words that only shared phonology (P) across languages were recognized slower (interlingual homophones, e.g., *leaf* and *lief* [sweet]). Combinations of phonological overlap with either orthography or semantics (OP and SP items) did not yield reliable effects. A follow-up study by Lemhöfer and Dijkstra (2004) reported comparable findings for similar SOP items, but they did not replicate the inhibition effect for P items. Also, Schwartz et al. (2007) found faster reaction times (RTs) for SOP than for SO cognates, suggesting phonological facilitation in the presence of SO overlap instead of inhibition. Mixed results were also obtained in studies that focused more on exclusive orthographic interactions (the O dimension) across languages, typically by looking at interlingual homographs. These studies have yielded homograph inhibition effects (e.g., Jared & Szucs, 2002), null effects (e.g., Altenberg & Cairns, 1983), or facilitation effects, depending on task demands and stimulus list composition (e.g., Dijkstra, De Bruijn, Schriefers, & Ten Brinke, 2000; Dijkstra, Timmermans, & Schriefers, 2000; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998). This complicated pattern of results contrasts with the consistent replication of cognate facilitation effects and suggests it is unadvisable to use homograph instead of cognate processing when studying lexical autonomy in a sentence context.

Whereas the most convincing and consistent body of evidence comes from the cognate facilitation effect, it is important to note that the evidence for language-independent lexical access in word recognition by bilinguals is not restricted to cognate effects. Van Heuven, Dijkstra and Grainger (1998) proposed a different and elegant way to investigate this issue. They started from the common finding in monolingual research that word recognition depends on a word's neighborhood size (i.e., the number of words that are orthographically identical except for one letter; e.g., Grainger, 1990). Van Heuven et al. orthogonally manipulated targets' neighborhood size in both L1 and L2 and found that word recognition depends on the neighborhood size of the word in both languages, showing that L1 (Dutch) word forms were activated during L2 (English) word recognition.

Finally, these findings from the visual word recognition literature have analogues in auditory word recognition. The most convincing evidence here comes from a series of studies by Marian and colleagues (Marian & Spivey, 2003; Marian, Spivey, & Hirsch, 2003; Spivey & Marian, 1999). Using an eyetracking paradigm with real objects, they repeatedly found that participants instructed in L2 to pick up target objects often looked at distractor objects that were phonologically similar in L1 to the respective L2 target. For example, Russian-English bilinguals instructed in English to "pick up the *marker*" often looked at a stamp, because its Russian translation equivalent (*marka*) is phonologically similar to the English target word *marker*. Similar results were obtained by Weber and Cutler (2004). Using a picture version of the same paradigm, they also found that Dutch-English bilinguals hearing English (L2) target words (e.g., *desk*) made longer eye fixations on distractor pictures with Dutch (L1) names phonologically related to the English target (e.g., a picture of a *deksel* [lid]). Note that in the studies of Marian and colleagues, the short imperatives (such as *pick up the [target]*) are repeated across trials, and can hardly be considered a meaningful sentence context. In fact, Marian and colleagues also only draw conclusions about their data with respect to word recognition, not sentence processing. Hence, these studies offer elegant auditory analogues for the findings in isolated visual word recognition, but they do not offer empirical evidence for the issue of sentence context effects on word processing (either visual or auditory).

In sum, it should be clear that lexical access in bilinguals is not language specific. Effects of orthographic/phonological (either inhibitory or facilitatory) and semantic cross-lingual overlap have often been obtained in both L1 and L2 unilingual word recognition, even though information from the other language is not relevant for the task at hand. It is also clear that the degree of lexical selectivity is not a simple additive function of cross-lingual overlap on these three representational dimensions. Instead, the interactions between these dimensions may be very complex (e.g., as mentioned above, see Dijkstra et al., 1999; Schwartz et al., 2007). However, it can be concluded that the cognate facilitation effect, commonly interpreted as evidence against lexical autonomy, has consistently been replicated in a large number of studies using different languages, stimuli, and tasks (e.g., lexical decision: see above; word translation: de Groot, Dannenburg, & van

Hell, 1994; Sánchez-Casas, Davis, & Garcia-Albea, 1992; picture naming: Costa, Caramazza, & Sebastian-Galles, 2000; progressive desmasking: Dijkstra et al., 1999). Therefore, this effect may be considered a reliable benchmark test of lexical autonomy in a sentence context.

VISUAL WORD RECOGNITION BY BILINGUALS IN A SENTENCE CONTEXT

Before we turn to the present study, it is important to briefly discuss what is known already about word recognition by bilinguals in a sentence context. Even though this is crucial for the generalizability and ecological validity of the conclusions drawn from isolated word recognition studies, there are surprisingly few studies that have tackled this issue, in contrast with the monolingual domain.

The first study investigating sentence processing by bilinguals is that of Altarriba et al. (1996). As discussed earlier, they found that processing of code-switched L1 words in high-constraint L2 sentences is inhibited (e.g., *He wanted to deposit all of his dinero* [money] *at the credit union*). Because these targets share all semantic and syntactic features with the expected L2 word, but still are inhibited, this offers evidence for the general principle that sentence contexts may be used by bilinguals to guide lexical access to representations belonging to the same language as the sentence in which target words are embedded. We find it important for the present study that a similar mechanism might come into play when reading unilingual sentences. Because bilinguals do not expect to see an L2 word when reading in L1 (or vice versa), the lexical representation of cognates in the nontarget language (just as all other lexical representations in that language) might be inhibited when reading unilingual sentences, such that no cognate facilitation effect emerges. However, as noted earlier, because the study of Altarriba et al. used mixed-language high-constraint sentences, it does not provide a direct answer to the question of lexical autonomy in unilingual language processing with less artificially constrained sentences.

More direct evidence, using unilingual sentences, comes from van Hell (1998; these data are also reported in van Hell, 2005). Using Dutch-English bilinguals, she presented high- and low-constraint L2 sentences in which a target word (embedded or at the end of the sentence) was replaced by dashes (e.g., *a green --- and a yellow banana lay on the fruit dish*; target *apple*). After 4 s, the sentence was replaced by a centered target word on which the participants had to perform a lexical decision judgment. Target words were either cognates or control words. In low-constraint sentences, she replicated the cognate facilitation effect found in studies that presented words in isolation studies (see above). In high-constraint sentences, no cognate effect was found, suggesting that lexical access in L2 reading may still be influenced by semantic expectations. Similar findings for word production were recently reported by Schwartz and Kroll (2006). They found a similar cognate facilitation effect for target words appearing in the middle of a sentence in an L2 word naming task. Just as van Hell (1998), they found that this cognate facilitation effect only emerged in low-constraint sentences.

To our knowledge, the only other data on bilingual lexical autonomy in a sentence context come from Elston-Güttler and colleagues (Elston-Güttler, Gunter, & Kotz, 2005; see also Elston-Güttler, Paulmann, & Kotz, 2005), who tested German-English bilinguals. These authors investigated the recognition of homographs in an L2 sentence context, using a lexical decision task. Triggered by a button press, these homographs were presented as the final words of an L2 sentence (e.g., *The woman gave her friend an expensive GIFT*), and served as the primes for targets that replaced the homographs. Target words could either refer to the L1 meaning of the homograph (e.g., *poison,* the German meaning of *gift*) or not. When these prime-target pairs were presented in isolation, the L2 homograph always primed its L1 meaning, suggesting language-independent lexical access. However, as noted earlier, homograph priming in a sentence context was only found during the first half of the experiment, for participants who saw a German movie prior to the experiment, increasing L1 salience. Elston-Güttler et al. (2005) claimed that participants adapted their lexical decision thresholds during the experiment and gradually "*zoomed into*" the all-L2 task. These findings show that the degree of cross-lingual interactions in the processing of homographs is very sensitive to top-down influences, which follows the mixed homograph findings in isolated word recognition. A final inconsistency lies in the fact that cross-lingual interactions were observed even though the sentences that Elston-Güttler et al. used were all quite high-constraint. This contrasts with van Hell (1998, 2005), who only obtained a cognate facilitation effect with words appearing in low-constraint sentences.

THE PRESENT STUDY

There is a large body of evidence from the monolingual sentence processing domain that lexical access is guided by lexically, semantically, and/or syntactically driven expectations generated through sentence context (e.g., Balota et al., 1985; Ehrlich & Rayner, 1981; Fischler & Bloom, 1980; McClelland & O'Regan, 1981; Rayner & Well, 1996; Schwanenflugel & LaCount, 1988; Schwanenflugel & Shoben, 1985; Stanovich & West, 1983). In the present study, we investigated whether the language in which a sentence appears is used by bilinguals to guide lexical search/access toward lexical representations of a specific language. More specific, the focus of this study was to investigate whether the linguistic context provided by a sentence nullifies activation in nontarget language lexical representations, and resulting cross-lingual interactions, during recognition of words embedded in that sentence. If this is the case, lexical access in everyday reading by bilinguals may be functionally language specific, even if it is not in isolation. At present, the only study that assessed such a linguistic sentence context effect in bilinguals is that of Altarriba et al. (1996)

discussed above. However, because they used mixed-language sentences, this study cannot provide an answer to the issue of language-selective lexical access during unilingual language processing. Also, other studies focusing on context effects have investigated task demands, stimulus list composition (Dijkstra et al., 1998; Dijkstra et al., 2000) or nontarget language salience (Elston-Güttler et al., 2005; Jared & Kroll, 2001), but not effects of sentence contexts.

Because this is the first study trying to show language-independent lexical access in a sentence context using a lexical decision task (without words presented outside of the sentence) and normal reading, it was advisable to use a strong and reliable marker of cross-lingual interactions. Because earlier research, both in isolation (see above, e.g., Dijkstra et al., 2000) and in a sentence context (see above, e.g., Elston-Güttler et al., 2005), has shown that homograph effects are inconsistent and subject to top-down influences, we implemented the more reliable and consistent cognate facilitation effect found in single-word studies in a sentence context to maximize chances of observing cross-lingual interactions. This constitutes a first benchmark test of language selectivity of lexical access in a sentence context.

Because the cognate facilitation effect seems to be more reliable in L2 than in L1 (see above), we decided to use an L2 reading task. Similar to van Hell and Dijkstra (2002), our stimuli were mostly near-cognates, which are orthographically/phonologically very similar but not identical (e.g., *ship* – *schip*). This way, the experimental language context is almost strictly unilingual (probably more than everyday life texts) because the stimuli are unambiguous with respect to the language to which they belong. This is not the case in studies that used a high proportion of homograph stimuli (e.g., Elston-Güttler et al., 2005; Schwartz & Kroll, 2006). This may be important because Grosjean (1997; see also Soares & Grosjean, 1984) suggested that the degree of lexical autonomy depends on the “language mode” that a bilingual is in: depending on the language context and the bilinguals’ expectations, lexical access may be more or less selective. Therefore, our primarily near-cognate stimulus set, just as that of van Hell and Dijkstra, constitutes a very strong test of lexical autonomy. We did, however, include a few identical cognates as well, allowing us to investigate whether the degree of cross-lingual overlap interacts with the cognate effect in a sentence context. But, for the reasons outlined above, the proportion of language-ambiguous words (identical cognates) was kept extremely low (i.e., 6.67% of all word targets).

In our first experiment, we used a standard L2 lexical decision task (similar to that of van Hell & Dijkstra, 2002) with word targets presented in isolation. This was necessary to validate our stimuli before using them in a sentence reading task. In the second experiment, we used a lexical decision task with the same word targets (cognates and controls) as final words of sentences presented through serial visual presentation (SVP) (see also Schwartz & Kroll, 2006). Previous studies have demonstrated that this method is susceptible to lexical factors (Altarriba et al., 1996). Also, because of the fast rate of presentation, it is practically impossible for the participants to translate the sentence while reading. In the third experiment, we used an eyetracking paradigm, which is as close to normal reading as possible in an experimental setting and excludes strategic processes specific to the lexical decision task. Also, in contrast with SVP, the same word targets were appearing somewhere in the middle of the sentences and could not be identified (e.g., by using uppercase letters, Experiment 2), which also makes the task less similar to isolated lexical decision. This technique is more sensitive than the SVP experiment, and by comparing different reading time measures, it allows for an assessment of the timecourse of cross-lingual lexical interactions. To our knowledge, this is the first study ever to investigate visual word recognition in a monolingual sentence context by bilinguals.

Because the aim of the present study is to investigate the exclusive influence of the linguistic contexts provided by sentences, we considered it important to exclude as much as possible all other possible top-down influences that might interact with this context effect and with target recognition. Therefore, we wanted to minimize semantically driven expectations with respect to the target word (e.g., see Altarriba et al., 1996), and we only used low-constraint sentences in which the target word was plausible, but not predictable. Also, note that the earlier bilingual sentence studies are quite inconsistent with respect to the effect of semantic constraint. For example, van Hell (1998; see also Schwartz & Kroll, 2006) only obtained a cognate effect in low-constraint sentences, whereas Elston-Güttler et al. (2005) obtained their cross-lingual effects with homographs in relatively high-constraint sentences.

We believe that this study constitutes a stronger test of lexical autonomy in a sentence context than the studies that tackled this issue earlier. First, in the studies of van Hell (1998) and Elston-Güttler et al. (2005), participants had to respond to target words presented outside the actual sentence contexts, making the task more similar to isolated lexical decision. In the present study, target words were effectively embedded in the sentences (Experiment 2: final word targets; Experiment 3: embedded target words). Second, because both near-cognates and identical cognates were included in the materials, the present study also investigates whether any cognate effect in sentence context interacts with form overlap between translation equivalents. No study has tested this so far. Third, because we only used low-constraint sentences, this study has the methodological advantage that cognate and control targets could be presented in the same sentence. In the studies of Van Hell (1998) and Schwartz and Kroll (2006), which also used high-constraint sentences, this was not the case. Of course, even with sentences matched for plausibility, length and target position, one cannot exclude with certainty that obtained cognate effects may be a partial confound of differing preceding words. Fourth, the study by Schwartz and Kroll (2006) used word naming, which also comprises a production component. Because the locus of the obtained cognate facilitation effect may also be situated in this production phase (as indicated by cognate effects in other production tasks, such as picture naming; e.g., Costa et al., 2000), the present study extends their findings for word production to pure visual word recognition (lexical decision, eyetracking). This allows us to attribute any cognate facilitation effect more directly to the lexical access process. Fifth, it should also be noted that Schwartz and Kroll presented both homographs and cognates. Consequently, there were quite some language-ambiguous words in these experiments 42.05% of all word targets: 22 homographs and 15 identical cognates, out of 22), which may have increased salience relative to natural unilingual language contexts (see the language mode theory of Grosjean, 1997, which is discussed earlier). Because we did not present homographs, used mostly nonidentical cognates, and included L2 filler targets, our stimulus set was much more unambiguous with respect to language (e.g., Experiment 1: 6.67% of word targets were identical cognates). Finally, this is the first study to use eyetracking to tackle this issue. Because this technique allows participants to read normally as in everyday life, it excludes most factors inherent to experimental tasks as the source for cross-lingual lexical interactions.

EXPERIMENT 1

Experiment 1 constituted a replication of the L2 cognate facilitation effect (e.g., Dijkstra et al., 1999), to validate our stimulus set for use in the sentence studies.

METHOD

Participants. The participants were 36 Dutch-English bilinguals: 33 psychology students from Ghent University and 3 volunteers. The students participated for course requirements or a small monetary fee. Of these 36 participants, 2 were excluded because of poor performance in the lexical decision task (their mean error rate was more than 2.5 standard deviations above the overall mean error rate) All participants started to learn English in a scholastic setting around the age of 14-15 (formal English courses are mandatory at that age in the Belgian school system), and lived in an L1 dominant environment, speaking Dutch at home, at school, with friends, and so forth. All of them were regularly exposed to their L2 (English) through Belgian popular media and entertainment (music, Internet, films, television, etc.). Like most people in Belgium, all participants also have some knowledge of French, but this was reported as their third language. Participants were asked to rate their L1 and L2 proficiency with respect to several skills (reading, writing, speaking, general proficiency) on a 7-point Likert scale ranging from *very bad* to *very good* after the actual experiment. Also, general L3 proficiency was assessed. Means are reported in Table 1. Mean self-reported general L1 (M = 5.7), L2 (M = 4.9) and L3 proficiency (M = 4.1) differed significantly (all ps < .001) as shown by a sign test (because proficiency ratings did not meet the assumptions for parametric testing, proficiency differences were tested by nonparametric statistics).

Table 1. Self-assessed ratings (7-point Likert scale) of L1, L2, and L3 proficiency (Experiments 1, 2 and 3).

	Skill	Experiment 1	Experiment 2	Experiment 3
L1 (Dutch)	Writing	5.8 (1.0)	5.8 (0.8)	5.9 (1.0)
	Speaking	5.5 (1.2)	5.9 (0.7)	5.9 (1.0)
	Reading	6.1 (0.9)	6.2 (0.8)	6.1 (1.0)
	General Proficiency	5.7 (0.9)	5.9 (0.6)	5.9 (0.8)
L2 (English)	Writing	4.5 (1.2)	4.2 (1.0)	5.2 (0.8)
	Speaking	4.9 (1.1)	4.5 (1.1)	5.4 (0.8)
	Reading	5.3 (1.0)	5.2 (0.9)	5.7 (0.8)
	General Proficiency	4.9 (0.9)	4.7 (0.8)	5.2 (1.0)
L3 (French)	General Proficiency	4.1 (1.0)	4.1 (1.1)	4.3 (1.1)

Note. Standard deviations are indicated in parentheses. L1 = native language, L2 = second language, L3 = third language.

Stimulus materials. The target stimuli consisted of 240 items: 30 Dutch-English cognates, 30 English (L2) control words, 60 L2 filler words (that did not exist in L1 or sounded like existing L1 words), and 120 nonwords. All targets were three to eight letters long. The cognates were selected from the cognate stimuli of Dijkstra et al. (1999) and van Hell and Dijkstra (2002). A few additional items were extracted from the CELEX lexical database (Baayen, Piepenbrock, & Van Rijn, 1993). We only selected those cognates for which a control word could be found meeting all the criteria mentioned below and for which both the cognate and its control could be inserted in the same low-constraint sentence as the final word (Experiment 2) or one of the middle words (Experiment 3). This resulted in a list of 22 nonidentical and 8 identical Dutch-English cognates. According to the word similarity measure developed by Van Orden (1987)[3], identical cognates (M = 1.0) and nonidentical cognates (M = 0.75) differed significantly with respect to the word similarity with their translation equivalents ($p < .001$). Using the WordGen stimulus generation program (Duyck, Desmet, Verbeke, & Brysbaert, 2004), we generated a control word for each cognate (item by item), which was matched with respect to word length (identical), word frequency, number of syllables (identical), word class (all words were nouns), and neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977) (see Table 2). The cognates and control words did not differ from each other with respect to any of these variables (dependent samples sign tests yielded ps > .64). Also, identical and nonidentical cognates did not differ on any of these variables (Kolmogorov-Smirnov tests yielded ps > .46). The selected cognates and their control words are included in Appendix A.

[3] Van Orden (1987) defines graphemic similarity (GS) between two letter strings as $GS = 10([50F + 30V + 10C)/A] + 5T + 27B + 18E)$, where F = number of pairs of adjacent letters in the same order shared by word pairs; V = number of pairs of adjacent letters in reverse order shared by word pairs; C = number of single letters shared by word pairs; A = average number of letters in the two words; T = ratio of number of letters in the shorter word to the number of letters in the longer; B = 1 if the two words share the first letter, else B = 0; and E = 1 if the two words share the last letter, else E = 0. Then 'standardized' Orthographic Similarity (OS) between word X and Y is $OS_{XY} = GS_{XY} / GS_{YY}$. For more details concerning this measure, we refer to Van Orden (1987).

Table 2. Stimulus examples and mean lexical characteristics (Experiments 1, 2, and 3)

Condition	Example	Number of letters	Number of syllables	Word frequency[a]	Neighbor-hood size[b]
L2 cognates	apple [appel]	4.67 (1.1)	1.30 (0.5)	1.79 (0.4)	7.27 (6.1)
L2 control words	brush [borstal]	4.67 (1.1)	1.30 (0.5)	1.76 (0.4)	7.17 (5.8)
p		*identical*	*identical*	> *.99*	> *.64*
L2 identical cognates	ring [ring]	4.00 (0.8)	1.13 (0.4)	1.88 (0.4)	9.80 (5.7)
L2 nonidentical cognates	cat [kat]	4.90 (1.2)	1.36 (0.6)	1.76 (0.4)	6.40 (6.1)
p		> *.59*	> *.98*	> *.73*	> *.46*

Note. Standard deviations are displayed between parentheses. Reported *p* values indicate significance levels of dependent samples comparisons between cognates and controls (matched item by item), and independent samples comparisons between identical and nonidentical cognates. Native language (L1) translation equivalents are indicated between brackets. L2 = second language.
[a] Logarithm of word frequency per million words according to the CELEX lexical database (word lemmata) (Baayen et al., 1993). [b] Neighborhood size (Coltheart et al., 1977) calculated using the WordGen program (Duyck et al., 2004) on the basis of the CELEX lemma database (Baayen et al., 1993).

The English (L2) filler words were also randomly selected from the CELEX database. They were matched with the cognates and control words with respect to all of the parameters mentioned above (*p*s > .20). Using the WordGen program, we generated 120 nonword targets that were orthographically and phonologically legal in English. Again, they were matched with cognates and control words with respect to word length (identical), neighborhood size and summated bigram frequency (*p*s > .55), which may be considered a measure of word likeness in a given language (Duyck et al., 2004).

Procedure. Participants were tested in small groups. It was not possible to see the computer screen of another participant. Participants received written instructions in L2 to perform an L2 lexical decision task. Care was taken to convince participants that the experiment was about L2 processing, to prevent awareness of the fact that L1 was crucial for the experiment. Instructions mentioned that 10 practice trials and several experimental trials would follow. The participants were instructed to react to the target word and press one button if the presented letter string was an existing English (L2) word or another button if this was not the case. Half of the participants had to press the right button for *word* response, and the left button for a *nonword*. For the other half of the participants, this was reversed. All participants completed the 240 experimental trials in a random order. Each of the targets was presented only once.

Every trial started with the presentation of a centered fixation point ("+") for 800 ms. Three hundred ms later, the word or nonword target was presented, centered on the screen. The target stayed on the screen until the participant responded, or until the maximum response time (2500 ms) was exceeded. The intertrial interval was 700 ms.

After the experiment, all participants completed a short questionnaire, assessing their self-reported L1 and L2 reading, speaking, writing, and general proficiency level on a 7-point Likert scale. Also, the participants received a list with the cognate and control word targets to verify that they actually knew the L2 words.

RESULTS

The proportion of incorrect responses to word targets was 4.56%. These trials were excluded from all RT analyses. Also, RTs that were faster than 200 ms and RTs that were more than 2.5 standard deviations below or above the participant's mean RT for word targets were excluded from the analyses (2.36% of the data). Analyses of variance (ANOVAs) were performed across participants and across items with Target type (cognate vs. control) and Overlap (identical vs. nonidentical) as independent variables.

The dependent variable was the mean RT across trials. For theoretically relevant cognate effects, effect sizes are indicated (Cohen's *d*). Additionally, because accuracy scores did not meet parametric testing criteria, we analyzed Target type effects for identical and nonidentical cognates using nonparametric sign-tests, which were also run across participants and across items. RTs for the nonidentical cognate *bread* and its control *horse* were discarded from analyses because of an ungrammaticality in their sentence context for the following experiments (see further). Mean RTs and proportion of errors as a function of Target type are presented in Table 3.

Table 3. Mean RTs (ms) and Accuracy (% errors) across participants as a function of Target type and Overlap (Experiment 1: isolation)

	Example	RT	Accuracy
Identical Cognates	LIP [lip]	549 (11.3)	2.6 (0.9)
Controls	PIG [varken]	598 (14.4)	7.0 (1.6)
Effect		*49*$^{***,\,*}$	*4.4*$^{*,\,ns}$
Nonidentical Cognates	SHIP [schip]	567 (10.4)	4.9 (1.1)
Controls	FARM [boerderij]	591 (15.1)	4.1 (1,0)
Effect		*24*$^{**,\,*}$	*-0.8*$^{ns,\,ns}$

Note. Standard errors are indicated in parentheses. Asteriks indicate significance levels of planned comparisons between cognates and their controls, respectively, across participants (before the comma) and items (after the comma). Native language (L1) translation equivalents are indicated in brackets.
p < .05, ** *p* < .01, *** *p* < .001, ^{ns} not significant.

Latencies. The effect of Target type on RTs was significant: cognates (M = 555) were recognized more quickly than control words (M = 592; d = 1.36) [$F_1(1,33) = 30.35$, $p < .001$, $MSE = 1499$; $F_2(1,27) = 15.27$, $p < .001$, *MSE* = 1223]. Also, this cognate effect interacted with the degree of cross-lingual overlap: the facilitation effect was stronger for identical cognates than for nonidentical cognates [$F_1(1,33) = 4.31$, $p = .045$, *MSE* = 1172], an effect that was in the expected direction, but not significant, in the analysis by items [$F_2(1,27) = 1{,}68$, $p = .205$, *MSE* = 1223]. Planned comparisons showed that the RT difference between identical cognates (*M* = 549) and their controls (*M* = 598) was significant (*d* = 1.18) [$F_1(1,33) = 23.11$, $p < .001$, *MSE* = 1749; $F_2(1,7) = 11.32$, $p = .012$, *MSE* = 1010]. Similarly, nonidentical cognates (*M* = 567) were recognized faster than their controls (*M* = 591, *d* = 0.82) [$F_1(1,33) = 10.97$, $p = .002$, *MSE* = 921; $F_2(1,20) = 5.82$, $p = .026$, *MSE* = 1297].

The fact that the interaction effect between Target type and Overlap did not reach significance in the analysis by items may be due to the small number of items in the identical cognate condition. Also, there may be some variability in the size of the effect within the nonidentical condition because of the variability in overlap of nonidentical cognates with their translation equivalents. To assess this interaction in a more sensitive fashion using a continuous measure of cross-lingual similarity, we calculated the correlation between Van Orden's (1987) orthographic similarity of translation equivalents (described above) and the size of the cognate effect by items. As expected, this correlation was positive ($r = .21$), suggesting larger cognate effects with increasing cross-lingual lexical similarity but not significant ($p = .27$).

Accuracy. Participants made fewer errors on cognate trials (*M* = 3.7) than on control trials (*M* = 5.5). Sign tests revealed that this difference was almost significant in the analysis by participants [$Z_1 = 1.70$, $p = .089$; $Z_2 = 0.00$, $p = .999$]. Table 3 shows that this tendency was especially due to smaller error rates for identical cognates (*M* = 2.6), relative to their controls (*M* = 7.0), a difference which was significant in the analysis across participants [$Z_1 = 2.25$, $p = .024$; $Z_2 = 0.89$, $p = .371$]. The small accuracy difference between nonidentical cognates (M = 4.9) and their controls (M = 4.1) was not significant [$Z_1 = 0.40$, $p = .689$; $Z_2 = 0.27$, $p = .789$].

DISCUSSION

Experiment 1 was a replication of the L2 cognate facilitation effect (see earlier, e.g., Dijkstra et al., 1999; van Hell & Dijkstra, 2002). As expected, we obtained a cognate facilitation effect in an L2 lexical decision task: participants responded more quickly on cognate trials than on control trials. Moreover, the effect interacted with the degree of cross-linguistic overlap: the facilitation effect on the RTs was stronger for identical cognates (e.g., *lip*) than for nonidentical cognates (e.g., *ship* – *schip*), which still yielded a significant facilitation effect. As for the accuracy data, participants also made fewer errors on cognate trials than on controls, but this cognate effect was only significant for the identical cognates in the analysis by participants.

First, these findings confirm earlier studies that also reported an L2 cognate facilitation effect (e.g., Dijkstra et al., 1999). This is an interesting finding because this is the first study after that of van Hell and Dijkstra (2002) that obtained a cognate facilitation effect with stimuli that are mostly unambiguous with respect to the language to which they belong. Whereas other studies have often used a larger proportion of identical cognates and homographs, the present study used mostly near-cognates (only 6.67% of all word targets were identical cognates). This effect adds further strength to the growing body of evidence that lexical access in bilinguals is not language specific. Second, at a methodological level, these findings show that the selected cognate/control word lists constitute an appropriate stimulus set to investigate lexical access by bilinguals in a sentence context.

EXPERIMENT 2

In Experiment 2, we investigated whether the strong unilingual context provided by a sentence affects lexical access of the same (near-) cognate and control words appearing at the end of that sentence. To be able to compare any cognate facilitation effect directly to the effect obtained in isolation, we also used a lexical decision task in the present experiment. Unlike previous studies of bilingual sentence reading however (e.g., Elston-Güttler et al., 2005; van Hell & Dijkstra, 2002), the target words in this experiment were actually a part of the preceding sentence. Similar to Schwartz and Kroll (2006), who studied word production, a SVP technique was used to implement serial word (sentence) reading.

METHOD

Participants. The participants were 33 additional Dutch-English bilingual volunteers. They were selected from the same population as the participants in Experiment 1, and they had a similar L2 learning background. None of them participated in the first experiment. Of these 33 participants, 1 was excluded because of poor performance in the lexical decision task (his mean error rate was more than 2.5 standard deviations above the overall mean error rate). Mean self-assessed L1 ($M = 5.9$), L2 ($M = 4.7$), and L3 ($M = 4.1$) general proficiency differed significantly (see also Table 1) ($ps < .001$).

Stimulus materials. The critical target stimuli consisted of the 30 Dutch-English cognates (8 identical; 22 nonidentical) and their 30 control words used in Experiment 1 (see Appendix A). For each of these pairs, a sentence was constructed that could contain both the cognate and its control as the final word (e.g., *Lucia went to the market and returned with a beautiful CAT* [cognate] / *BAG* [control]) (see Appendix B). Participants saw each sentence only once, with either the cognate or the control word as the target word. Therefore, two stimulus lists were used, counterbalanced over participants. Again, these lists were matched on word length, number of syllables, word frequency, and neighborhood size (*p*s > .59).

Neither the cognates nor the control words were predictable from the sentence context. Similar to Schwartz and Kroll (2006) and van Hell (1998, 2005), this was assessed in a sentence completion study, conducted with 23 participants from the same population who did not take part in any of the experiments. Participants were asked to complete the 30 sentences with an English target. As expected, mean production probabilities for identical cognates, nonidentical cognates, and their control words were extremely low (identical: 0.005, control: 0.005; nonidentical: 0.047, control: 0.043), similar to the production probabilities in the low-constraint conditions of Schwartz and Kroll. Production probabilities for the two types of cognates and control words did not differ from each other (sign tests yielded *p*s > .47). In addition, we also conducted a rating study, in which 54 additional participants rated the predictability of the target words in the sentences on a 6-point scale. Because the critical sentences were all low constraint, we also included 30 filler sentences with a highly predictable final target word to make this rating task more natural. Sentences with identical and nonidentical cognates as the final words were not rated as more predictable than sentences with the control words as the final words (identical: $M = 1.57$ and $M = 1.25$, respectively; nonidentical: $M = 1.49$ and $M = 1.24$, respectively; sign test *p*s > .28).

As noncritical stimuli, we also constructed 15 low-constraint filler sentences containing English filler target words and 45 filler sentences, which had nonword targets as the final words. These filler sentences were comparable with the sentences used for the cognates and control words, so that there were no linguistic cues that a nonword target would follow. The filler targets were taken from the filler targets of Experiment 1 and were matched with the critical (cognate/control) targets with respect to word length, number of syllables, word frequency and neighborhood size (see the *Materials* section of Experiment 1, *p*s > .10). As in Experiment 1, the nonword targets were all orthographically and phonologically legal English nonwords, constructed with the WordGen program (Duyck et al., 2004). As in Experiment 1, they were matched with the word targets with respect to word length (identical) neighborhood size, and summated bigram frequency (*p*s > .45), which may be considered a measure of a nonword's word likeness in a given language (Duyck et al., 2004).

Procedure. The procedure was identical to Experiment 1, except that participants were now instructed to perform a lexical decision task to word targets appearing as the final words of sentences, which were presented with SVP (see also Schwartz & Kroll, 2006). Words were subsequently presented, centered on the screen during 700ms. This presentation rate is considerably slower than typical L1 SVP experiments, because a pilot experiment indicated that this was the rate at which participants (of a similar L2 proficiency level) indicated that they could comfortably process the L2 sentences. Following earlier SVP research (e.g., Wright & Garrett, 1984), the appearance of the target word was indicated by a beep accompanying the preceding word, which also stayed somewhat longer on the screen (1200 ms). Target words were also presented in capital letters, as a cue to respond. The ITI was 1200 ms. Each participant completed the 90 experimental trials (including fillers) in a random order. Each of the sentences was only presented once, either with the cognate or its control as the target word. To ensure that the participants actually read the sentences, we used the same recognition task as Elston-Güttler et al. (2005). After each block of 10 sentences, four sentences were presented, two of which were shown in the preceding block. Participants had to indicate for each of these four sentences whether it appeared in the preceding block by pushing a button on a response box. Mean accuracy on this verification task was very high (*M* = 90.9%, *SD* = 5.6).

RESULTS

The proportion of incorrect responses to word targets was 6.68%. These trials were excluded from all RT analyses. The outlier criteria were the same as those described in Experiment 1 (2.74% of data points were excluded). ANOVAs were performed across participants and across items with Target type (cognate vs. control) and Overlap (identical vs. nonidentical) as independent variables. The dependent variable was the mean RT across trials. For theoretically relevant cognate effects, effect sizes are indicated (Cohen's *d*). Again, accuracy scores were analyzed by means of nonparametric sign-tests, which were also run across participants and across items. Also, RTs for the nonidentical cognate *bread* and its control *horse* were again discarded from all analyses because *bread* was preceded by an indefinite article (*a*), which is grammatical is Dutch, but not in English (see Appendix B). Mean RTs and proportion of errors as a function of Target type are presented in Table 4.

Table 4. Mean RTs (ms) and Accuracy (% errors) across participants as a function of Target type and Overlap (Experiment 2: serial visual presentation)

	RT	Accuracy
Identical Cognates	618 (17.5)	3.6 (1.3)
Controls	729 (25.9)	8.0 (1.9)
Effect	$111^{***, *}$	$4.4^{ns, ns}$
Nonidentical Cognates	646 (17.5)	4.6 (1.4)
Controls	684 (24.1)	4.8 (1.2)
Effect	$38^{**, *}$	$0.2^{ns, ns}$

Note. Standard errors are indicated in parentheses. Asteriks indicate significance levels of planned comparisons between cognates and their controls, respectively, across participants (before the comma) and items (after the comma).
$p < .05$, $^{**} p < .01$, $^{***} p < .001$, ^{ns} not significant.

Latencies. Similar to the isolation experiment (Experiment 1), the effect of Target type on RTs was significant (d = 1.45) [F_1(1,31) = 32.40, p < .001, MSE = 5506; F_2(1,27) = 16.58, p < .001, MSE = 2881]: cognates (M = 632) were recognized more quickly than control words (M = 706). Again, this cognate facilitation effect interacted with Overlap. The cognate effect was significantly stronger for identical than for nonidentical cognates [F_1(1,31) = 7.88, p = .009, MSE = 5451], although this interaction did not reach significance in the analyses by items [F_2(1,27) = 2.45, p = .129, MSE = 2881]. Planned comparisons showed that responses to identical cognates (M = 618) were significantly faster than responses to their control words (M = 729; d = 1.21) [F_1(1,31) = 22.69, p < .001, MSE = 8737; F_2(1,7) = 9.34, p = .018, MSE = 3385]. Also, nonidentical cognates (M = 646) were recognized faster than their control words (M = 684; d = 0.76) [F_1(1,31) = 10.42, p = .002, MSE = 2220; F_2(1,20) = 6.06, p = .023, MSE = 2705].

Finally, following the same logic as in Expeirment 1, we again calculated the correlation between Van Orden’s (1987) orthographic similarity of translation equivalents, and the size of the cognate effect by items. This correlation was significant and positive, r = .36, p = .05. Hence, the size of the cognate effect increased as a function of lexical similarity between targets and their (near-) cognate translation equivalents.

Accuracy. Participants made fewer errors on cognate trials (M = 4.1) than on control trials (M = 6.4). Sign tests revealed that this difference was not significant [Z_1 = 1.49, p = .137; Z_2 = 0.75, p = .453]. Similarly, the large accuracy difference between identical cognates (M = 3.6) and their controls (M = 8.0) was not significant [Z_1 = 1.12, p = .264; Z_2 = 0.50, p = .617]. The small accuracy difference between nonidentical cognates (M = 4.6) and their controls (M = 4.8) was also not significant [Z_1 = 0.21, p = .831; Z_2 = 0.29, p = .773].

DISCUSSION

The results were very similar to those of Experiment 1. Again, we obtained a cognate facilitation effect. The two types of cognates (identical and nonidentical) were recognized significantly faster than control words. Also, the cognate effect interacted with the degree of cross-lingual overlap. Facilitation was stronger for identical cognates than for nonidentical cognates. We find it surprising that, in absolute terms, the obtained cognate facilitation effects were larger in this experiment than in Experiment 1. However, mean RTs in this experiment were more than 100 ms slower, which makes it hard to compare these effects. Indeed, effect sizes for identical and nonidentical cognate effects were similar in both experiments.

In conclusion, we replicated the cognate facilitation effect obtained earlier in isolated word recognition studies (Experiment 1; Dijkstra et al., 1999; van Hell & Dijkstra, 2002). These results offer strong evidence that lexical access in sentence reading by bilinguals is language independent. Following earlier studies investigating word naming (Schwartz & Kroll, 2006) and recognition of isolated target words outside the actual sentence (e.g., Elston-Güttler et al., 2005; van Hell, 1998), this is the first study to demonstrate language-independent lexical access of words embedded in a sentence with a pure visual word recognition task.

EXPERIMENT 3

In this final experiment, we used the same set of cognates in an eyetracking paradigm. Because this technique does not require a response and allows participants to read normally, it excludes all factors inherent to experimental tasks, used in previous studies and in the previous experiments, as a source for cross-lingual lexical interactions. Also, its temporal resolution and sensitivity allow us to further investigate the timecourse of cross-lingual interactions. If these interactions occur during early stages of word recognition, as isolated visual word recognition studies suggest, cognate effects should be visible in early reading time measures. Given the fact that reasonably good correlations have been obtained between lexical decision and eye fixation times (Schilling, Rayner, & Chumbley, 1998), it is therefore reasonable to assume that the cognate effects obtained in isolation (Experiment 1) should also show up in eyetracking results, if of course they are not nullified by sentence context.

METHOD

Participants. The participants were 34 additional Dutch-English bilingual psychology students from Ghent University, who received a small fee for participation. They were selected from the same population as the participants in the previous experiments, and they had a similar L2 learning background. None of them participated in one of the previous experiments. They all had normal or corrected-to-normal vision. Mean self-assessed L1 (M = 5.9), L2 (M = 5.2), and L3 (M = 4.3) general proficiency differed significantly (see also Table 1) (ps < .001).

Stimulus materials. The critical target stimuli consisted of the 30 Dutch-English cognates (8 identical; 22 nonidentical) and their 30 control words used in Experiments 1 and 2 (see Appendix A). For each of these pairs, a sentence was constructed that could contain both the cognate and its control as one of the middle words. These sentences were based on the sentences from Experiment 2, but with a change in word order or with the addition of an extra phrase, so that the target word was no longer the final word of the sentence (e.g., *Lucia went to the market and returned with a beautiful CAT* [cognate] / *BAG* [control] was changed to *Lucia returned with a beautiful CAT* [cognate] / *BAG* [control] *from the market*) (see Appendix B). Participants saw each sentence only once, with either the cognate or the control word as the target word. Therefore, the same two stimulus lists were used as in Experiment 2, counterbalanced over subjects.

Both cognate and control words were not predictable from the sentence context. Similar to Experiment 2, this was assessed through a sentence completion study and plausibility ratings (see above). The completion study was conducted with 26 participants from the same population who did not take part in any of the experiments. Participants were asked to complete the 30 sentences expected to provide low-constraint contexts with an English target. As expected, mean production probabilities for identical cognates, nonidentical cognates and their control words were again extremely low (identical: 0.005, control: 0.019; nonidentical: 0.045, control: 0.058). As in Experiment 2, these production probabilities did not differ from each other (sign test *p*s > .90). For the rating study, 30 participants rated the predictability of the target words in the sentences using the same procedure as in Experiment 2. Identical and nonidentical cognates did not yield higher predictability ratings than the control words (identical: M = 1.08 and M = 0.87, respectively; nonidentical: M = 1.14 and M = 0.95, respectively; sign test *p*s > .28).

As noncritical stimuli, 30 filler sentences were constructed (mostly those from Experiment 2). Because the task was now reading instead of lexical decision, the nonword targets and their sentences were no longer needed.

Apparatus. Eye movements were recorded by a Senso-Motoric Instruments (Teltow, Germany) video-based pupil tracking system (SMI Eyelink). Viewing was binocular but eye movements were recorded from the right eye only. A high-speed video camera was used for recording. It was positioned underneath the monitored eye and held in place by head-mounted gear. The system has a spatial resolution of 20 seconds of arc. Fixation locations were sampled every 4 ms and these raw data were used to determine the different measures of oculomotor activity during reading. The display was 69 cm from the subject's eye and three characters were equal to 1° of visual angle. A chin rest was used to reduce head movements during the experiment.

Procedure. Before the experiment started, participants were informed that the study was about the comprehension of sentences that were displayed on a computer screen. Each sentence was presented as a whole on a single line of the screen in New Courier font. Participants were asked to read at their normal speed and to answer any questions that would follow the sentence. These questions were simple comprehension questions following one fourth of the trials (only after filler trials). The participants had no difficulty answering these questions, with an overall accuracy rate of 97.6%. Explaining the experiment to the participant combined with setting up the eye-cameras and calibrating the eyetracking system took approximately 10 minutes. The calibration consisted of a standard 9-point grid. Following the initial calibration, the participant was given 10 practice trials to become familiar with the procedure before reading the experimental sentences. The 30 experimental sentences were presented in a pseudorandom order, together with 30 filler sentences. Participants stopped a trial by pressing a button. The whole session lasted about half an hour.

RESULTS

We examined the first fixation duration (FFD), the gaze duration (GD) and the regression path duration (RPD) on the target word.[4] We removed 6.7

[4] The FFD is the duration of the first fixation during the first passage through the respective region, independent of the number of fixations that were made on that word/region. The GD is the sum of the fixations from the moment the eyes land on the word of interest (for the first time) until the moment they move off again. The RPD can be defined as the time elapsing from encountering a given region for the first time until a region to the right of the interest region is fixated. The difference between RPD and GD is that regressions originating from a

% of the data from the analyses because of track loss, because the fixation was shorter than 100 ms, or because the reader did not start reading the sentence at the leftmost word (see Morrison, 1984; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989, for justification). For each measure, ANOVAs were again performed with Target type (cognate vs. control) and Overlap (identical vs. nonidentical) as independent variables, across participants and across items.

Mean fixation times across participants by Target type and Overlap are shown in Table 5. The overall effect of Target type was almost significant for the FFD on the target word [$F_1(1,33) = 3.17$, $p = .063$, $MSE = 1539$; $F_2(1,27 = 4.24$, $p = .049$, $MSE = 605$]. This effect however, interacted significantly with the degree of cross-lingual overlap [$F_1(1,33) = 4.21$, $p = .048$, $MSE = 2010$; $F_2(1,27) = 4.90$, $p = .036$, $MSE = 605$]. Planned comparisons showed that FFDs were significantly shorter ($M = 249$) for identical cognates than for their controls ($M = 278$; $d = 0.55$) [$F_1(1,33) = 4.97$, $p = .033$, $MSE = 2823$; $F_2(1,7) = 6.77$, $p = .035$, $MSE = 563$]. Interestingly, this effect was not significant for nonidentical cognates [both Fs < 1]. For GDs, the effect of Target type was also significant [$F_1(1,33) = 7.71$, $p = .008$, $MSE = 2393$; $F_2(1,27) = 5.19$, $p = .031$, $MSE = 1445$]. Again, the effect of Target type tended to interact with Overlap [$F_1(1,33) = 3.73$, $p = .062$, $MSE = 3473$; $F_2(1,27) = 2.76$, $p = .108$, $MSE = 1445$]. Similar to the FFD analysis, planned comparisons showed that GDs were significantly shorter for identical cognates ($M = 262$) than for their controls ($M = 305$; $d = 0.65$) [$F_1(1,33) = 7.07$, $p = .012$, $MSE = 4411$; $F_2(1,7) = 8.67$, $p = .022$, $MSE = 893$]. Again, there was no cognate effect for nonidentical cognates [both $Fs < 1$]. A similar pattern of results emerged for RPDs. The effect of Target type was significant [$F_1(1,33) = 4.32$, $p = .046$, $MSE = 7894$; $F_2(1,27) =$

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particular region are added to the RPD of that region, but they are not added to the GD. If the region of interest is skipped, this is scored as a missing value for all these measures.

4.30, p = .048, MSE = 3780], but its interaction with Overlap tended towards significance [$F_1(1,33) = 2.54$, p = .121, MSE = 6489; $F_2(1,27) = 1.41$, p = .246, MSE = 3780]. Again, RPDs were significantly shorter for identical cognates (M = 292) than for their controls (M = 346; d = 0.61) [$F_1(1,33)$ = 6.09, p = .019, MSE = 8042, $F_2(1,7) = 7.33$, p = .030, MSE = 1893]. There was no cognate effect on RPDs for nonidentical cognates [both Fs < 1].

Similar to Experiment 2, we also investigated whether the obtained cognate effects on FFDs correlated with Van Orden's (1987) orthographic similarity measure of targets and their (near-) cognate translation equivalents. Again, this correlation was significant and positive, r = .37, p = .05. Hence, the size of the cognate effect on FFDs increased as a function of lexical similarity between targets and their (near-) cognate translation equivalents.

Table 5. First fixation duration (FFD), Gaze duration (GD) and Regression path duration (RPD) on the target word

	target word$_n$		
	FFD	GD	RPD
Identical cognates	249 (8.2)	262 (9.8)	292 (12.5)
Controls	278 (9.5)	305 (12.0)	346 (15.9)
Effect	*29**,*	*43**,*	*54**,*
Nonidentical cognates	252 (7.5)	283 (10.1)	345 (15.1)
Controls	249 (7.2)	287 (10.0)	355 (16.0)
Effect	*-3*$^{ns, ns}$	*4*$^{ns, ns}$	*10*$^{ns, ns}$

Note. Reported means are presented (in ms) as a function of Target type and Overlap. Standard errors are indicated in parentheses. Asteriks indicate significance levels of planned comparisons between cognates and their controls, respectively, across participants (before the comma) and items (after the comma).
p < .05, ^{ns} not significant.

DISCUSSION

The analyses above showed clear cognate effects on the reading times of the target word for identical cognates but not for nonidentical cognates. Planned comparisons showed significantly faster FFDs, GDs and RPDs for identical cognates than for their controls (effects of respectively 29, 43, and 54 ms, respectively). There were no cognate effects at all for nonidentical cognates (all *F*s < 1).

In general, these results show that sentence context may nullify the L2 cognate effects obtained in isolation when cross-lingual activation spreading is weaker (nonidentical cognates) but not when the lexical overlap between languages is at a maximum (identical cognates). We find it important that these strong effects for identical cognates already emerged during the first fixation of the targets. This is consistent with the notion in the literature that cross-lingual lexical interactions occur early during visual word recognition (e.g., Dijkstra et al., 1999).

GENERAL DISCUSSION

Earlier research has shown that lexical access in bilingual word recognition is not language specific, even when only one language needs to be activated to perform the experimental task (e.g., Brysbaert, Van Dyck, & Van de Poel, 1999; Caramazza & Brones, 1979; de Groot et al., 1994; Dijkstra et al., 1999; Dijkstra et al., 2000; Dijkstra et al., 1998; Duyck, 2005; Duyck, Diependaele, Drieghe, & Brysbaert, 2004; Jared & Kroll, 2001; Lemhöfer & Dijkstra, 2004; Lemhöfer et al., 2004; van Hell & Dijkstra, 2002; van Heuven et al., 1998; Van Wijnendaele & Brysbaert, 2002). These findings, and therefore also the modeling of bilingual word recognition (the BIA+ model of Dijkstra and colleagues, e.g., Dijkstra et al., 1999; Dijkstra & van Heuven, 2002) are almost exclusively based on isolated word recognition studies. However, word recognition in both L1 and L2 (by bilinguals) rarely occurs out of context. Therefore, the goal of the present study was to investigate whether bilingual readers use the language of a sentence to guide lexical search/access toward lexical representations belonging to that specific language. More specific, we tested whether the degree of cross-lingual interactions during word recognition is affected by the strong unilingual linguistic context that is provided by (sequences of) sentences. First, we will shortly summarize our main findings and relate them to earlier research on this issue. Second, we will discuss the theoretical implications of these findings.

In Experiment 1, we replicated the cognate facilitation effect, which several studies have obtained with various tasks, bilinguals, languages, and stimuli (e.g., Costa et al., 2000; de Groot et al., 1994; Dijkstra et al., 1999; Lemhöfer et al., 2004; van Hell & Dijkstra, 2002). Using an L2 lexical decision task with word targets presented in isolation, we found that cognates are recognized more quickly (and more accurately) than control words. Also, this facilitation effect interacted with the degree of cross-lingual overlap: cognate facilitation was stronger for identical (e.g., *lip*) than for nonidentical cognates (e.g., *ship*). In Experiment 2, we replicated this effect with the same cognate and control targets as the final words of a low-constraint sentence, presented through SVP. Again, the effect interacted with the degree of cross-lingual overlap. Experiment 3 was set up to test whether the cognate facilitation effect could also be obtained with a more natural reading task. Eyetracking yielded shorter reading times for identical cognates but not for nonidentical cognates. These effects showed up in FFDs, GDs, and RPDs. This shows that the cross-lingual lexical interactions responsible for the cognate effect occur early in word recognition, which is consistent with the isolated word recognition literature (e.g., Dijkstra et al., 1999).

These findings have a number of theoretical implications. First, these findings add further strength to the growing body of evidence that lexical access in isolated word recognition by bilinguals is not language specific (Experiment 1). In addition, the interactions of cognate status with the cross-lingual overlap also show that the amount of activation spreading from one language's lexical representation to another's, is a function of the similarity between the translation equivalents. Second, these findings show that the top-down linguistic context provided by sentences does not generate enough lexical restrictions to completely nullify the activation coming from the nontarget language cognate representation (Experiments 2 and 3). Hence, bilingual readers do not use the language of a sentence as an early language selection cue to restrict lexical search to a particular language. Third, whereas sentence context does not render lexical access language specific, it did interact with the degree of cross-lingual activation spreading. In Experiment 3, eyetracking results show that the low-constraint sentence contexts used in this study were strong enough to counteract the cognate facilitation effect in normal reading when cross-lingual activation transfer was weak (nonidentical cognates), but not when it was at a maximum (identical cognates).

In general terms, our results are compatible with the few earlier studies on bilingual sentence reading discussed earlier. First, van Hell (1998, 2005) also obtained a cognate facilitation effect with targets that were primed by a sentence context. However, in her study, the targets were presented outside, and 4 s after the actual sentence (e.g., *a green --- and a yellow banana lay on the fruit dish*; target *apple*). This task is quite similar to a lexical decision task in isolation. The same applies to the study of Elston-Güttler et al. (2005). In her study, German-English homograph target words were also presented after a sentence (which had the target's prime as the final word, e.g., *the woman gave her friend an expensive GIFT*", target *poison*). Second, our results are very similar to those recently reported by Schwartz and Kroll (2006) for word production. They also reported an L2 cognate facilitation effect for cognate words appearing in a sentence context, using word naming, which also entails a production component. Because earlier production studies without a word recognition phase (e.g., picture naming, Costa et al., 2000) have also reported cognate effects, this production component may also have caused the cognate effect of Schwartz and Kroll. Therefore, the present study constitutes an important extension of their findings to pure word recognition (lexical decision, eyetracking). Also, the present study rules out a possible alternative explanation for Schwartz and Kroll's results. In their study, 42% of all word targets to be named (22 homographs + 15 identical cognates, out of 22), were ambiguous with respect to the language to which they belong. This may have artificially increased the salience of the nontarget language relative to more natural language contexts. Grosjean's (1997) language mode theory for example (see also Soares & Grosjean, 1984), suggests that the bilingual lexical system may function more or less language independent, depending on the 'language mode' that a bilingual is in. Such a bilingual language mode may be activated for example by the presence of many language ambiguous words in the stimuli. Evidence that nontarget language salience may influence the degree of cross-language interactions comes also from the study of Elston-Güttler et al. (2005). As indicated earlier, they found that interlingual homographs activated their nontarget language's meaning, but only after participants had seen a nontarget language movie prior to the experiment, increasing its salience. The 42% language ambiguous stimuli in the study of Schwartz and Kroll (2006) might have triggered a similar mechanism. This alternative explanation does not apply to the cross-lingual interactions found in the present study, because the proportion of language ambiguous stimuli was much lower and much more comparable to everyday language (e.g., Experiment 1: 6.67%; Experiment 2: 17.8%).

The effects observed for nonidentical cognates also rule out an alternative explanation of the cognate effect, which does not necessarily imply language-independent lexical access. Gollan, Forster, and Frost (1997) for example, have suggested that cognates may share the same lexical representation in the bilingual lexicon. Any cognate effect may then be a confound of a cumulative frequency effect, because cognates are encountered much more often (when reading both L1 and L2 texts). This account cannot explain the current findings (and those obtained with nonidentical cognates by van Hell & Dijkstra, 2002), because nonidentical cognates cannot be represented through the same lexical representation (e.g., the orthographic representations of the near-cognates *castle* and *kasteel* are actually quite dissimilar). Note, however, that this does not rule out the possibility that identical cognate facilitation effects have a different origin than nonidentical cognate facilitation, and they are indeed due to the cumulative frequency hypothesis discussed above.

A second alternative explanation for the cognate effects obtained in this study concerns the fact that most (all but two) of our identical cognates were actually Dutch-English-French cognates.[5] Because our Dutch-English participants generally also had knowledge of French (mean self-reported general L3 proficiency ratings ranging from 3.6 to 4.3), it may be the case that the obtained identical cognate effects have arisen not only from activation spreading from L2, but also from L3. Indeed, Lemhöfer et al. (2004) reported faster responses to L3 words that are cognates with both L1 and L2 than for exclusive L3-L1 cognates. In our study, these L1-L2-L3 cognates yielded a mean facilitation effect of 62 ms in Experiment 1, for example, whereas L1-L2 cognates showed a 27 ms effect. However, this difference was not significant ($p > .37$), most likely because this test only contained two L1-L2 cognates. If the eight identical cognates were ranked according to the cognate effect that they elicited, exclusive L1-L2 cognates occupied ranks 3 and 8, which also suggests that the influence of this factor is rather limited. In addition, reanalyzing our data with participants' L3

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[5] We would like to thank an anonymous reviewer for this suggestion.

proficiency as a covariate in analyses by participants, and targets' lexical overlap with L3 translation equivalents (Van Orden's, 1987, measure) as a covariate in analyses by participants, did not yield reliable L3 effects for any of the experiments. Finally, note that whereas this trilingual accumulative cognate hypothesis for identical cognate effects cannot be excluded with absolute certainty, we believe this would only add further strength to our claim of nonselective lexical access. Such a mechanism would imply that not only L1 influences L2 word recognition (which may be very plausible), but also that L3 lexical representations become activated during L2 processing in a sentence context, which is more surprising.

Finally, it is important to discuss the implications of the present study for the future development of models of bilingual language processing. At present, the most explicit model of visual word recognition in bilinguals is the BIA+ model of Dijkstra and van Heuven (e.g., Dijkstra et al., 1999; Dijkstra & van Heuven, 2002). Following its predecessor (BIA), BIA+ is a bilingual extension of the well-known Interactive Activation (IA) model for monolingual word recognition (e.g., McClelland & Rumelhart, 1981). In BIA+, language nodes have been added (supplementary to word, letter and feature nodes), and L2 words are represented in a unitary word-level lexicon. The model assumes that word recognition processes are initially nonselective, as word activation is affected by lexical representations from both languages. Therefore, the model can easily account for the cognate facilitation effects observed in Experiment 1. Also, by assuming that cross-lingual facilitatory activation spreading is a function of word similarity (much in the way intralexical activation is in the IA), the model may also explain our finding that cognate facilitation is stronger for identical cognates. Although the model was originally designed to explain empirical findings in out-of-context recognition tasks, its recent version may also account for the sentence context effects obtained in this study. In BIA+ (unlike the previous BIA model), there are no top-down connections from language nodes; these nodes are just passive language tags (necessary for lexical decision). Influences of high-level factors are dealt with at a "task schema" level, which receives input from the nonselective word identification system. Both linguistic and nonlinguistic factors may influence this task schema system, which in turn has a top-down influence on activation in the word identification system (the lexicon). Nonlinguistic factors may be instructions, task demands, or task-related strategies. In this architecture, decision criteria, in a isolated lexical decision task for example, may change as a function of stimulus list composition (e.g., Dijkstra, De Bruijn, et al., 2000; Dijkstra, Timmermans, & Schriefers, 2000; Dijkstra et al., 1998) without assuming that such top-down factors influence activation in the lexical representations itself. Linguistic factors may be of a lexical, syntactic, or semantic origin, and they may be provided by sentence context, like in the present study. Because we did not manipulate the semantic (or syntactic) context in which our target words appeared, the present study specifically investigated whether the linguistic context provided by a sentence is used by bilingual readers as an early language selection mechanism to guide lexical search of words appearing in that sentence, thereby influencing the functional selectivity of the fundamentally nonselective system.

The implications of our results with respect to this issue are twofold. First, the identical cognate effect obtained in Experiment 1 was still present in the sentence contexts of Experiments 2 and 3. This suggests that the influence of linguistic factors on cross-lingual interactions in the word identification system (lexicon) of the BIA+ model should be relatively small and that lexical access during word recognition by bilinguals in sentence contexts is functionally not language selective. Second, the eyetracking results from Experiment 3 suggest that unilingual linguistic sentence contexts may still interact with lexical variables such as cross-lingual overlap, thereby influencing the degree of cross-lingual activation transfer (the cognate effect). In normal reading, the sentence context effect was strong enough to counteract the cognate effect when the cross-lingual form overlap between translation equivalents was not complete (nonidentical cognates), but not when it was at a maximum (identical cognates). In Experiment 2 however, which used a lexical decision task, the nonidentical cognate effect, was still present despite the unilingual sentence context. This shows that the interactions in BIA+ between context and lexical variables may also interact with task-specific factors. It may be the case that lexical representations reach a stable state sooner in normal reading than in a lexical decision task so that chances are smaller for weak cross-lingual activation spreading (nonidentical cognates) to influence word recognition. A similar mechanism might be responsible for the observations of van Hell (1998) and Schwartz and Kroll (2006) that cognate facilitation disappeared in high-constraint sentences. In such sentences, lexical search and access may be speeded so much by the semantic feature restrictions imposed by the sentence, that nontarget language representations have no chance to influence word recognition (even for identical cognates). Future modeling will have to show the plausibility of these speculative hypotheses.

To summarize, the cognate facilitation effects obtained in the present study offer strong evidence that lexical access in bilinguals may be language independent both in isolated word recognition and in sentence embedded word recognition. The linguistic context provided by sentences may, however, interact with other lexical variables of words to be recognized, such as the degree of cross-lingual overlap of translation equivalents, and influence or even overcome the cross-lingual spreading of activation.

In conclusion, the interest for bilingual language processing has grown substantially during the last decade. However, the understanding of bilingual language processing is by far not at the level of the monolingual domain. We believe an important step to achieve this is to extend the present research in bilinguals to sentence processing. This may be one of the more important developments in bilingual research for the coming years. As one of the few studies on this issue, we hope that the present work may contribute to this.

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APPENDIX A

Critical stimuli Experiments 1, 2, and 3: Dutch-English cognates and their respective L2 control words

Cognate type	**L2 cognate**	**L2 control word**
Identical	bar	gun
	chaos	abuse
	fort	dive
	lip	pig
	plan	sign
	ring	coat
	sport	shark
	test	sink
Nonidentical	apple [appel]	brush
	author [auteur]	victim
	bell [bel]	tail
	book [boek]	head
	bread [brood]	horse
	castle [kasteel]	donkey
	cat [kat]	bag
	clock [klok]	witch
	dance [dans]	smile
	dream [droom]	smell
	fist [vuist]	herb
	flag [vlag]	jump
	hammer [hamer]	pillow
	hope [hoop]	fear
	island [eiland]	forest
	knee [knie]	bird
	nation [natie]	border
	nose [neus]	pool
	paradise [paradijs]	boundary
	pepper [peper]	cherry
	rose [roos]	cave
	ship [schip]	farm

Note. L1 (Dutch) translation equivalents of nonidentical cognates are indicated in brackets. L1 = native language; L2 = second language.

APPENDIX B

Sentence contexts of Experiments 2 and 3

Experiment 2 (final word targets)	Experiment 3 (embedded word target)
1. Luke went to the supermarket and bought *an APPLE* / *a BRUSH*	1. Luke bought *an APPLE* / *a BRUSH* in the supermarket
2. The audience of the murderplay appreciated the great work by the *AUTHOR* / *VICTIM*	2. The work of the *AUTHOR* / *VICTIM* was appreciated by the audience of the murderplay
3. He waited impatiently to see the new *BAR* / *GUN*	3. He wanted to see the new *BAR* / *GUN* and waited impatiently
4. The naughty boy pulled the cow's *BELL* / *TAIL*	4. The naughty boy pulled the *BELL* / *TAIL* of the cow
5. Tim was baking pancakes when one of them fell on my *BOOK* / *HEAD*	5. One of the pancakes landed on my *BOOK* / *HEAD* because Tim was not careful baking them
6. The rich farmer gave the poor man a *BREAD* / *HORSE* *	6. The poor man got a *BREAD* / *HORSE* from the rich farmer*
7. They were walking in the woods when they saw a grey *CASTLE* / *DONKEY*	7. They saw a grey *CASTLE* / *DONKEY* while they were walking in the woods
8. Lucia went to the market and returned with a beautiful *CAT* / *BAG*	8. Lucia returned with a beautiful *CAT* / *BAG* from the market
9. In countries where a war is going on. there is a lot of *CHAOS* / *ABUSE*	9. There is a lot of *CHAOS* / *ABUSE* in countries where a war is going on
10. It is a mistake to think that in the Middle Ages each village had his own *CLOCK* / *WITCH*	10. The idea that every village had its own *CLOCK* / *WITCH* in the Middle Ages is wrong
11. I would like you to repeat that *DANCE* / *SMILE*	11. I would like you to repeat that *DANCE* / *SMILE* until it is perfect
12. She became awake because of the weird *DREAM* / *SMELL*	12. The weird *DREAM* / *SMELL* woke her up
13. The knight used his sword to cut off the *FIST* / *HERB*	13. The knight cut off the *FIST* / *HERB* using his sword
14. The Olympic athlete was really proud of his *FLAG* / *JUMP*	14. His extraordinary *FLAG* / *JUMP* made the Olympic athlete really proud

15. The first price went to the child that made the most beautiful *FORT* / *DIVE*	15 The child that made the most beautiful *FORT* / *DIVE* received the first price
16. They had a fight and she hurt him using a *HAMMER* / *PILLOW*	16. She hurt him using a *HAMMER* / *PILLOW* when they had a fight
17. After the police paid him a visit, he had no more *HOPE* / *FEAR*	17. He had no more *HOPE* / *FEAR* after the police paid him a visit
18. On our vacation to Madeira we saw a very beautiful *ISLAND* / *FOREST*	18. We saw a very beautiful *ISLAND* / *FOREST* on our vacation to Madeira
19. The shooter felt very guilty when he hit the child's *KNEE* / *BIRD*	19. The shooter hit the child's *KNEE* / *BIRD* and felt very guilty
20. The other children often laughed at Mike's fat *LIP* / *PIG*	20. The other children often laughed at the fat *LIP* / *PIG* of Mike
21. The war moved up to the middle of the *NATION* / *BORDER*	21. The war moved up to the middle of the *NATION* / *BORDER* and became very violent
22. Ten thousand euros is a lot of money for a new *NOSE* / *POOL*	22. Ten thousand euros for a new *NOSE* / *POOL* is a lot of money
23. The atmosphere changed so much we were sure we had reached the *PARADISE* / *BOUNDARY*	23. We were sure we had reached the *PARADISE* / *BOUNDARY* because the atmosphere changed so much
24. The awful dish tasted like *PEPPER* / *CHERRY*	24. The dish tasted like *PEPPER* / *CHERRY* and was awful
25. He did not know what to do and waited desperately for the lord's *PLAN* / *SIGN*	25. He waited desperately for the lord's *PLAN* / *SIGN* because he did not know what to do
26. Hilda was showing off her new *RING* / *COAT*	26. Hilda bought a new *RING* / *COAT* and showed it to everyone
27. On their walk to the park they saw a *ROSE* / *CAVE*	27. They saw a *ROSE* / *CAVE* while they were walking in the park
28. Uncle Mark sold his house and spent all the money on a *SHIP* / *FARM*	28. Uncle Mark bought a *SHIP* / *FARM* with the money he had received after the sale of his old house
29. Mary wants to go see a very special type of *SPORT* / *SHARK*	29. There is a very special type of *SPORT* / *SHARK* that Mary wants to go see
30. Gary was working on the *TEST* / *SINK*	30. Gary was working on the *TEST* / *SINK* in the evening

Note. Targets and control words are displayed in capital letters.
* This sentence was excluded from all analyses because the word *bread* may be preceeded by an indefinite article in Dutch, but not in English. We thank an anonymous reviewer for this suggestion.

CHAPTER 3
DOES BILINGUALISM CHANGE NATIVE-LANGUAGE READING? COGNATE EFFECTS IN A SENTENCE CONTEXT

Psychological Science (in press)[1]

Becoming a bilingual can change a person's cognitive functioning and language processing in a number of ways. This study focused on how knowledge of a second language (L2) influences native-language (L1) sentence reading. We used the cognate facilitation effect as a marker of cross-lingual activations in both languages. Cognates (e.g., Dutch-English schip [ship]) and controls were presented in a sentence context, while eye movements were monitored. Results showed faster reading times for cognates than for controls. Thus, this study shows that one of our most automated skills, reading in our native language, is changed by the knowledge of a second language.

[1] This paper was co-authored by Wouter Duyck, Robert Hartsuiker, and Kevin Diependaele.

INTRODUCTION

Research in cognitive psychology has shown that becoming a bilingual can change one's cognitive system in several ways, even beyond the language domain. For instance, Bialystok and colleagues have shown that bilinguals are more efficient in tasks that tap into cognitive control (e.g., Bialystok, Craik, & Ryan, 2006). Most research however has focused on how bilingualism influences language processing in general. For instance, Ameel, Storms, Malt, and Sloman (2005) showed that linguistic category boundaries in each language can move toward one another in bilinguals, at least for the concrete objects used in their study. Also, it has been observed that bilinguals are slower in naming pictures in their first language than monolinguals (Gollan, Montoya, Cera, & Sandoval, 2008; Ivanova & Costa, 2008). However, picture naming is a relatively controlled task and not as highly automated as native-language reading. As Reichle, Pollatsek, Fisher, and Rayner (1998, p. 125) argue, reading is "the most important and ubiquitous skill that people acquire for which they were not biologically programmed". Native English speakers read with an impressive speed of three to five fixations per second and saccades go forward about five to nine character positions in the sentence (Reichle et al., 1998).

The present study investigates whether knowledge of a second language can influence this highly automated skill of reading in one's native language. Are bilinguals able to restrict lexical access to representations in the (native) language of the text, or is their other (non-native) language also activated, strongly enough to influence reading? Studies on isolated (out-of-context) word recognition demonstrated interactions between a bilingual's two languages (e.g., Dijkstra, Grainger, & van Heuven, 1999; Duyck, 2005; Jared & Kroll, 2001; van Heuven, Dijkstra, & Grainger, 1998). For instance, bilinguals are faster in reading cognates (translation equivalents with full or partial form overlap, e.g., Dutch-English: *sport-sport*; Dutch-German: *dier-Tier*) than control words (Dijkstra et al., 1999). This *cognate facilitation effect,* observed in second-language (L2) reading (e.g., Dijkstra et al., 1999) and in native-language (L1) reading (van Hell & Dijkstra, 2002), has typically been explained by assuming language-nonselective activation in the two languages. The presentation of a word in one language activates orthographic, phonological, and semantic representations of all known languages. This cross-lingual activation spreading from these three codes speeds up the activation of cognates compared to control words, and results in faster word recognition times.

However, a strong theory of language-nonselective lexical access requires a more stringent and ecologically valid test. Obviously, people rarely read words presented in isolation. Instead, words are usually encountered in meaningful sentences. The fact that people read a coherent set of words in one language may influence lexical access and the degree of cross-lingual activations in the two languages. Using the language of the sentence as a cue to guide lexical access for upcoming words would indeed be a very efficient strategy to speed up word recognition, because this would limit lexical search to lexical entries of only one language.

We addressed this issue by investigating cross-lingual activations in native-language sentence reading by bilinguals. This provides a very conservative test of a profoundly nonselective language system, because we tested for an influence of the weaker L2, learned in adolescence, on native sentence reading, which is a highly automated skill. While this situation has never been explored, a few studies have investigated the reverse situation, namely native-language influences on non-native sentence reading. These studies show that lexical access during L2 sentence reading does not seem to operate in a language-selective way (Altarriba, Kroll, Sholl, & Rayner, 1996; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Schwartz & Kroll, 2006; van Hell & de Groot, 2008), although sentence context seems to constrain L2 reading in bilinguals somewhat (depending on sentence constraint and degree of orthographic overlap between cognates). This may not be very surprising because it is likely to be extremely difficult for unbalanced bilinguals, like the majority of bilinguals who participated in these studies, to "turn off" their native and dominant language. Indeed, many word recognition studies reported much stronger influences of L1 on L2 processing than of L2 on L1 processing (e.g., Dijkstra & van Heuven, 2002; Duyck, 2005). This is why a strong test to demonstrate the existence of a lexical system that is profoundly not language-selective is to study bilinguals while reading in their native language, the challenging approach taken here.

In a pretest, we replicated the L1 cognate facilitation effect for words presented in isolation (van Hell & Dijkstra, 2002) with a set of 40 cognates and control words that were matched on word class (all words were nouns), word length (identical), number of syllables, word frequency, neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977), and bigram frequency. Cognates and controls are presented in Appendix A. Forty-two Dutch-English bilinguals performed a Dutch (L1) lexical decision task (word/nonword decision) on these words, Dutch filler words and nonwords. Linear mixed-effects models analyses in which frequency was included as a control variable showed significantly faster reaction times for cognates (M = 493 ms) than for controls (M = 507 ms) [$F(1,3067) = 7.70$, $p < .01$]. We also used a continuous measure of cognate status by defining cross-lingual similarity between each word and its translation (e.g., *piloot-pilot*: 0.95; *schaap-sheep*: 0.52; *eend-duck*: 0.08) using the word similarity metric developed by Van Orden (1987). This analysis shows a gradual effect of cross-lingual overlap on word processing: recognition of Dutch words was facilitated when words had higher degrees of orthographic similarity with English [$F(1,3067) = 4.45$, $p < .05$]. This pretest demonstrates that L2 lexical representations become active when bilinguals read L1 words in isolation, and constitutes a validation of these materials for the actual sentence study.

The present study investigates whether L2 knowledge may still influence lexical access in an L1 sentence context, even though the language of the sentence (L1) provides a highly efficient cue for lexical search. We presented the exact same cognates and controls in an L1 sentence context while monitoring eye movements. This methodology, which taps into early stages of word recognition, is a very good test of naturalistic reading because it does not require an experimental task with a decision component (e.g., lexical decision).

METHOD

PARTICIPANTS

Forty-five students from Ghent University participated in the experiment. They were unbalanced Dutch-English bilinguals who started to learn English around age 14-15 in secondary school. They were exposed regularly to their L2 through Belgian popular media and English textbooks.

STIMULUS MATERIALS

The 40 cognate-control pairs of the pretest were inserted in an L1 sentence context that could contain both the cognate and a control word (e.g., *Ben heeft een oude OVEN/LADE gevonden tussen de rommel op zolder* [*Ben found an old OVEN/DRAWER among the rubbish in the attic*]). The sentence contexts are presented in Appendix B. By presenting the cognate and its control word in the same low-constraint sentence context, we avoided confounding effects of preceding words across conditions (see also Duyck et al., 2007). Predictability of the sentences was assessed in a sentence completion study with 30 further participants. Mean production probabilities for cognates and control words showed that the sentences were indeed of low-constraint (cognates: 0.024; controls: 0.029). Participants saw each sentence only once, with either the cognate or the control word. The same 40 filler sentences were presented to each participant.

APPARATUS

Eye movements were recorded from the right eye with an Eyelink 1000 eye tracking device (SR Research). Viewing was binocular, but eye movements were recorded from the right eye only. Fixation locations were sampled every millisecond. Each sentence was presented as a whole on a single line on the screen. The sentences were presented in black on a white background in mono-spaced Courier font.

PROCEDURE

Before the start of the experiment, participants were informed that the experiment was about the comprehension of sentences presented on a screen. Participants were asked to read at their normal reading speed. Participants stopped a trial by pressing a button. During the experiment, comprehension questions were asked following 25% of the trials. Verbal responses were recorded by the experimenter without providing feedback. Overall accuracy of these answers was 97%. The 40 experimental sentences and 40 filler sentences were randomly presented. Calibration consisted of a standard 9-point grid.

RESULTS

We fitted linear mixed-effects models, as implemented in the *Lme4* library (Bates, 2007) in *R* (R Development Core Team, 2007), to the first fixation durations (FFDs), (log-transformed) gaze durations (GDs), and (log-transformed) regression path durations (RPDs).[2] Fixation times that were two standard deviations above each participant's condition mean were removed from analyses (3.1% of the data for FFD, 3.7% for GD, and 4.3% for RPD). Additionally, 25.2% of the data was removed from analyses because the word was skipped or the sentence was not read in a beginning-to-end way (5.7%). There were no significant differences in data removal across conditions. Mean FFD, GD and RPD are shown in Table 1.

Table 1. FFD, GD, and RPD on the target word (in ms). Standard deviations are indicated between brackets.

Word type	FFD	GD	RPD
Cognate	196 (49)	205 (63)	239 (108)
Control	201 (53)	213 (66)	249 (111)

Each analysis included crossed random effects for participants and sentence frames (see Baayen, Davidson, & Bates, 2008).[3] To control for effects of parafoveal preview, we included the distance of the prior fixation from target word as a control variable. This resulted in significant non-linear effects of this variable, consistent with monolingual eyetracking studies (e.g., Vitu, McConkie, Kerr, & O'Regan, 2001). If this control variable was

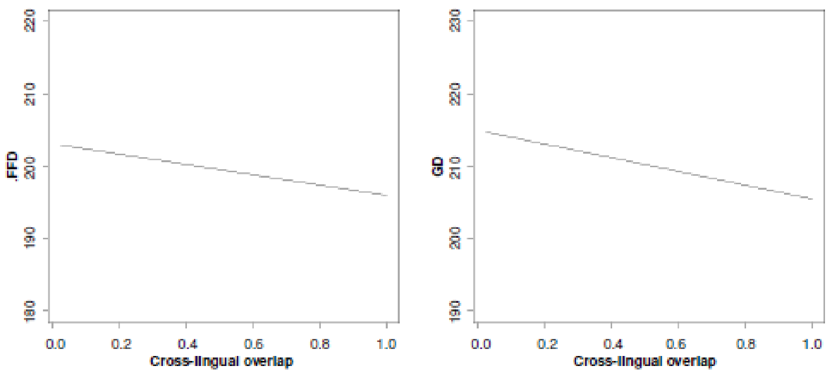
[2] The FFD is the duration of the first fixation during the first passage through the respective region. The GD is the sum of the fixation durations from the moment the eyes land on the word of interest until the moment they move off again. The RPD is the time elapsing from encountering a given region for the first time until a region to the right of the interest region is fixated.

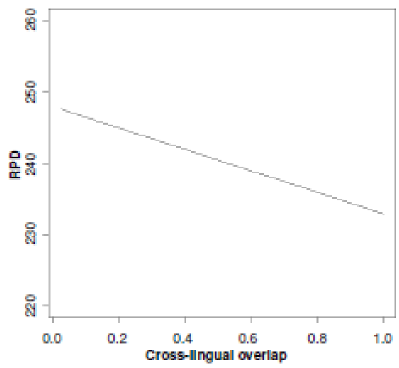
[3] Likelihood ratio tests showed that additionally including a random effect for items did not improve the fit of the models.

removed from analyses, effects of cross-lingual overlap became somewhat weaker, but the pattern of results did not change.

Gaze durations and regression path durations were shorter for cognates than for controls [GD: $F(1,1172) = 3.82$, $p < .05$; RPD: $F(1,1163) = 3.61$, $p < .05$]. The effect was marginally significant in the FFD data [$F(1,1184) = 2.04$, $p = .09$]. Figure 1 shows that reading time measures decrease when orthographic overlap increases (Van Orden, 1987). This continuous effect was significant for all three reading time measures [FFD: $F(1,1184) = 3.71$, $p < .05$; GD: $F(1,1172) = 4.56$, $p < .05$; RPD $F(1,1163) = 5.17$, $p < .05$]. This indicates that the reading of Dutch words was facilitated when words had higher degrees of orthographic similarity with English.

Figure 1. Graphs depicting the decrease in FFD, GD, and RPD as a function of cross-lingual overlap in the main experiment





Note. Some examples of words with varying degrees of cross-lingual overlap are: piloot [pilot] 0.95; boter [butter] 0.70; schaap [sheep] 0.52; ober [waiter] 0.35; eend [duck] 0.08.

REPLICATION

In order to ensure the reliability of our findings, we carried out a replication of this experiment with a different set of stimuli, namely the 30 cognates used in the L2 reading study of Duyck et al. (2007), and 30 new matched Dutch (L1) control words. Of these 30 cognates, only one was also used in the previous experiment. The participants were 64 further students with the same language background. The obtained results were very similar: again, we observed faster first fixation durations for cognates (M = 210 ms) than for control words (M = 216 ms) [$F(1,1087) = 3.32$, $p < .05$]. Similarly, the continuous analyses showed shorter reading times for Dutch words with higher degrees of cross-lingual orthographic similarity with English in FFD data [$F(1,1087) = 5.02$, $p < .05$]. This effect was marginally significant in GD data [$F(1,1077) = 2.50$, $p = .07$] and not significant in RPD data [$F < 1$]. Most importantly, this replication again yielded a significant cognate facilitation effect on an early reading time measure, using a different set of stimuli.

DISCUSSION

The present study shows that knowledge of a second language changes native-language reading. Early reading time measures (FFD and GD) were shorter for cognates than for control words when presented in an L1-context, as shown by two experiments using different sets of words. The presence of a cognate effect in native sentence processing proves that representations of a nondominant language, which is not relevant for text comprehension, are activated strongly enough to affect word recognition in the mother tongue. This goes beyond previous studies on the effects of other languages on native-language processing, which used relatively controlled tasks such as picture naming and motion event description (e.g., Bialystok et al., 2006; Hohenstein, Eisenberg, & Naigles, 2006; Laufer, 2003). In the present study, cross-lingual interactions emerged during a fast and highly automated language processing skill.

These results have several important theoretical implications. First, they provide strong evidence for the theoretical viewpoint that the bilingual language system is profoundly language nonselective, even during native-language processing. Reading a word in one language automatically activates word representations from the target *and* nontarget language. The obtained continuous effects of overlap indicate that this spreading of activation is a function of cross-lingual similarity between lexical representations, not restricted within the language to which these belong (as interactive activation models of bilingual word reading, such as BIA+ would predict, Dijkstra & van Heuven, 2002). Second, our results point to a limited role for top-down lexical restrictions generated by sentences on lexical activation in the bilingual lexicon. The presentation of words in a sentence context did not nullify cross-lingual lexical activations, even though restricting lexical search to entries from the target language would constitute an efficient lexical search strategy. Third, the results go beyond bilingual word recognition in that they show that sentence comprehension in L1 is influenced by knowledge of the L2. In conjunction with recent studies on bilingual sentence parsing (e.g., Dussias & Cramer Scaltz, 2008) and bilingual sentence production (e.g., Hartsuiker, Pickering, & Veltkamp, 2004) this finding argues for a bilingual sentence processing system that is highly integrated across languages.

To conclude, our study demonstrated that even when bilinguals are reading sentences in their native language, there is an influence of knowledge of a nondominant language. Becoming a bilingual means one will never read the newspaper again in the same way: It changes one of our seemingly most automatic skills, namely reading in our native language.

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APPENDIX A

Critical stimuli used in the main experiment: Dutch-English cognates and Dutch control words

L1 cognate	L1 control word
baby	eend
bakker [baker]	kapper
boter [butter]	ijzer
bruid [bride]	taart
circus	tehuis
concert	toestel
donder [thunder]	wekker
duivel [devil]	ridder
film	spel
hand	hals
hobby	boete
honing [honey]	vrucht
hotel	buurt
kabel [cable]	gevel
lamp	reis
menu	ober
monster	vlinder
muis [mouse]	kous
muziek [music]	geheim
naam [name]	hond
nagel [nail]	emmer
oven	lade
pilot [pilot]	konijn
planeet [planet]	weefsel
schaap [sheep]	varken
schoen [shoe]	wortel
school	jongen
sneeuw [snow]	herfst
sport	tocht
storm	straf
straat [street]	gebied
student	houding
taxi	dame

tent	verf
tunnel	kachel
vinger [finger]	geweer
vork [fork]	bril
water	paard
winter	keizer
zand [sand]	stof

Note. Translation equivalents of nonidentical cognates are indicated between brackets.

APPENDIX B

Sentence contexts used in the main experiment

L1 sentence contexts
1. Mark wist niet dat een BABY / EEND zoveel kabaal kon maken. [Mark did not know that a BABY / DUCK could be so noisy.]
2. Tim was op weg naar de BAKKER / KAPPER toen zijn vriendin hem opbelde. [Tim was on his way to the BAKER'S / HAIRDRESSER when his girlfriend called him up.]
3. De school bezocht een bedrijf waar BOTER / IJZER gemaakt wordt. [The school visited a company that produces BUTTER / IRON.]
4. Iedereen was het erover eens dat de BRUID / TAART heel mooi was. [Everybody agreed that the BRIDE / PIE looked very beautiful.]
5. De eigenaars van het CIRCUS / TEHUIS worden voor de rechter gedaagd. [The owners of the CIRCUS / HOME are being brought to trial.]
6. Hij was over het CONCERT / TOESTEL aan het praten toen zijn vrouw binnenkwam. [He was talking about the CONCERT / APPLIANCE when his wife entered.]
7. Het geluid van de DONDER / WEKKER maakte haar hond altijd een beetje bang. [The sound of the THUNDER / ALARM always scared her dog a little bit.]
8. Het verhaal over die DUIVEL / RIDDER kon de kinderen heel erg boeien. [The story about the DEVIL / KNIGHT fascinated the children tremendously.]
9. Ze was vergeten hoe die FILM / dat SPEL nu ook alweer heette. [She forgot the name of the FILM / GAME.]
10. Lisa moest de wonde aan haar HAND / HALS laten verzorgen door de dokter. [Lisa needed a doctor to take care of the wound on her HAND / NECK.]
11. Zijn moeder zei hem dat ze die dure HOBBY / BOETE niet wil betalen. [His mother told him she would not pay (for) this expensive HOBBY / FINE.]
12. Sarah kreeg een beetje van die lekkere HONING / VRUCHT van de vriendelijke gids. [Sarah got a little bit of that delicious HONEY / FRUIT from the kind guide.]
13. Ze was een beetje bang toen ze in dat grauwe HOTEL / die grauwe BUURT de weg moest vragen. [She was a bit scared when she had to ask for the way in that grimy HOTE L/ NEIGHBORHOOD.]
14. Ze schrokken toen ze zagen de KABEL / GEVEL helemaal kapot was. [They

were shocked when they saw that the CABLE / HOUSEFRONT was completely broken.]

15. Nils vond dat hij voor die dure LAMP / REIS momenteel niet genoeg geld had. [Nils thought that he did not have enough money for this expensive LAMP / JOURNEY.]

16. Volgens Ann zorgde dat bekende MENU / die bekende OBER ervoor dat dit restaurant veel klanten had. [According to Ann, this well-known MENU / WAITER attracted many costumers for the restaurant.]

17. Patrick hielp zijn neefje toen hij een MONSTER / VLINDER uit de film wou gaan tekenen. [Patrick helped his nephew when he wanted to draw a MONSTER / BUTTERFLY from the movie.]

18. Lisa werd heel kwaad toen Koen die vieze MUIS / KOUS voor de grap naar haar gooide. [Lisa got very angry when Koen threw the dirty MOUSE / SOCK at her for fun.]

19. Ze was verbaasd toen ze zijn MUZIEK / GEHEIM uiteindelijk toch te horen kreeg. [She was surprised when she finally got to hear his MUSIC / SECRET.]

20. Nina vond de NAAM / HOND van haar broer altijd al heel leuk. [Nina had always liked her brother's NAME / DOG.]

21. Ze gaf de klusjesman telkens een NAGEL / EMMER aan zodat hij makkelijk kon werken. [She always passed the handyman a NAIL / BUCKET so that he could work well.]

22. Bert heeft een oude OVEN / LADE gevonden tussen de rommel op zolder. [Bert has found an old OVEN / DRAWER among the rubbish in the attic.]

23. Zijn jongste zoontje wou zich als een PILOOT / KONIJN verkleden voor carnaval. [His youngest son wanted to dress up as a PILOT / RABBIT for carnival.]

24. Die onbekende PLANEET / dat onbekende WEEFSEL hield de wetenschappers jaren in de ban. [That unknown PLANET / TISSUE captivated the researchers for years.]

25. De kleuter maakte een tekening van het SCHAAP / VARKEN op de boerderij. [The young child made a drawing of the SHEEP / PIG at the farm.]

26. Hun hond werd ziek nadat hij een stuk van een SCHOEN / WORTEL opgegeten had. [Their dog got sick after eating a piece of a SHOE / CARROT.]

27. Ze vertelde dat ze die SCHOOL / JONGEN helemaal niet goed genoeg vond. [She told that this SCHOOL / BOY was not good enough.]

28. Kim vond dat de vroege SNEEUW / HERFST het landschap een verlaten indruk gaf. [Kim thought that the early SNOW / FALL created an air of loneliness in the scenery.]

29. Julia had schrik dat hij die SPORT / TOCHT niet zou aankunnen. [Julia was afraid that he was not prepared for that SPORT / JOURNEY.]

30. Kris had nooit gedacht dat de STORM / STRAF zo zwaar zou zijn. [Kris never thought that the STORM / PUNISHMENT would be so severe.]

31. Julie zei dat die STRAAT / dat GEBIED erg gericht is op de toeristen. [Julie told me that that STREET / AREA is much aimed at tourists.]

32. Ze kreeg te horen dat deze STUDENT / HOUDING hier niet zal worden aanvaard. [She was told that this STUDENT / ATTITUDE would not be accepted here.]

33. Zij beval hem om die TAXI / DAME zo goed mogelijk te volgen. [She ordered him to follow that TAXI / LADY as best one can.]

34. Melissa vroeg haar vriend even de TENT / VERF te dragen omdat het te zwaar werd. [Melissa asked her boyfriend to carry the TENT / PAINT for a while because it was too heavy.]

35. Kevin vertelde dat die TUNNEL / KACHEL dringend zal moeten vernieuwd worden. [Kevin said that the TUNNEL / STOVE would have to be repaired urgently.]

36. Tijdens een schermutseling met de gangster kreeg de agent een VINGER / GEWEER in zijn oog. [The policeman got a FINGER / GUN in his eye during the skirmish with the gangster.]

37. Erik waarschuwde zijn zoontje nogmaals dat een VORK / BRIL niet om mee te spelen is. [Erik warned his son once again not to play with the FORK / GLASSES.]

38. Lynn gebruikte een speciale kleur om het WATER / PAARD mooi te kunnen schilderen. [Lynn used a special color to paint the WATER / HORSE more beautifully.]

39. Hij vertelde over de vorige WINTER / KEIZER aan iedereen die het horen wou. [He told about the last WINTER / EMPEROR to anyone who would listen.]

40. Ze was helemaal niet tevreden over het hotel omdat er veel ZAND / STOF op de vloer lag. [She was not satisfied with the hotel because there was a lot of SAND / DUST lying on the floor.]

Note. Cognates and controls are displayed in capital letters. The English translation is indicated between brackets.

CHAPTER 4
COGNATE EFECTS IN NATIVE-LANGUAGE READING: A FURTHER INVESTIGATION[1]

The current chapter reports on a replication experiment in which cognate facilitation effects were investigated in native-language sentence reading. Using a different stimulus set as the main experiment of Chapter 3, we presented cognates (e.g., vlag – flag) and controls in low constraint sentences. Dutch-English bilinguals silently read these sentences while eye movements were monitored. Results showed faster reading times for cognates than for controls. Moreover, this cognate facilitation was shown to be a continuous and gradual effect: facilitation gradually increased as a function of cross-lingual overlap between translation equivalents. This study supports the generalizability of the native-language sentence reading results of Chapter 3.

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[1] This paper was co-authored by Wouter Duyck and Robert Hartsuiker.

INTRODUCTION

The present study was set out to provide additional evidence that corroborates our striking findings of Chapter 3, in which we observed cognate effects in native-language sentence reading. In bilingual research, many studies have provided evidence for the activation of lexical representations in the first language (L1) when processing words in the second language (L2) (e.g., Dijkstra, Grainger & van Heuven, 1999; Duyck, 2005). Van Hell and Dijkstra (2002) even showed that native-language word recognition is influenced by knowledge of a second and third language. These studies provide strong evidence for a language-nonselective bilingual language system. However, most research focused on the recognition of words out-of-context, whereas bilinguals generally read words presented in meaningful sentences. It is therefore important to test whether this evidence for cross-lingual activation in bilinguals can be generalized to word processing in sentences. It might well be that bilinguals use the language of the sentence as a cue to guide lexical access to words of the target language. This would actually provide a very efficient strategy because lexical search would be directed to words of only one language. Several studies already investigated this issue for sentence processing in L2 (e.g., Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Schwartz & Kroll, 2006; van Hell & de Groot, 2008). They showed that the mere presentation of words in a sentence context does not modulate cross-lingual interaction effects. This indicates that the language of the sentence does not provide strong selection constraints on lexical access for L2 reading. In the main experiment of Chapter 3 (Van Assche, Duyck, Hartsuiker, & Diependaele, in press), we tested whether representations in the nondominant L2 are activated during L1 sentence reading. As a marker for cross-lingual interaction effects, the cognate facilitation effect (i.e., faster recognition of cognates (Dutch-

English: *schip – ship*) than of noncognate controls) was used. We presented cognates and control words in low constraint sentences (e.g., *Bert heeft een oude OVEN / LADE gevonden tussen de rommel op zolder.* [*Bert has found an old OVEN / DRAWER among the rubbish in the attic.*]) while eye movements were monitored. The results for Dutch-English bilinguals yielded faster reading times for cognates than for controls. Moreover, we showed that cognate facilitation is a gradual and continuous effect, depending on the degree of cross-lingual overlap of the translation equivalents. These results provide a very conservative test of the profoundly nonselective bilingual system because it is not evident that a weaker language should influence sentence reading in the native language.

In order to ensure the reliability and generalizability of our claims, we carried out a new L1 sentence reading experiment with a(n) (almost) completely distinct set of cognate materials (only 1 of the 30 cognates was also used in the main experiment of Chapter 3). This eyetracking experiment is described very briefly in Chapter 3 in a single paragraph (as the 'replication experiment') and is described in more detail in the current chapter.

METHOD

PARTICIPANTS

Sixty-four students from Ghent University participated in the experiment. They were all Dutch-English bilinguals with the same language background as the participants of the main experiment of Chapter 3. They started to learn English around age 14 at secondary school for about 3-4 hours a week. As they are regularly exposed to their L2 through popular media or English university textbooks, they were all quite proficient in their L2. Participants were paid or received course credit for their participation. After the experiment was finished, they were asked to rate their L1 and L2 proficiency with respect to several skills (reading, writing, speaking, and general proficiency) on a 7-point Likert scale ranging from *very bad* to *very good*. Mean self-reported general L1 ($M = 6.0$) and L2 ($M= 5.0$) proficiency differed significantly (dependent samples t-test yielded $p < .001$).

STIMULUS MATERIALS

The stimuli consisted of the 30 cognates of Duyck et al. (2007) and Dutch control words matched to the cognates on word class (all words were nouns), word length, number of syllables, word frequency and neighborhood size. The cognates and controls are presented in Appendix A. Of these 30 cognates, only one was also used in the main experiment of Chapter 3. These cognate-control pairs were inserted in an L1 sentence context that could contain both the cognate and the control word (e.g., *Haar moeder maakte een kleurrijke VLAG / JURK voor elk meisje van de klas.* [*Her mother made a colourful FLAG / DRESS for each girl of the class.*]) (see Appendix B). Participants saw each sentence only once, with either the cognate or the control word. Hence, two stimulus lists were used, counterbalanced over participants. Additionally, 30 filler sentences were presented.

SENTENCE COMPLETION

To verify that all sentences were of low constraint, a sentence completion study was conducted with 33 further participants. Participants saw each sentence with the cognate/control removed. They were instructed to fill in the first word of the sentence completion that came to mind when reading the sentence frame. Completion scores indicated that the sentences were indeed of low constraint (mean production probabilities for cognates: 0.020; control: 0.009). Dependent samples t-tests on production probabilities showed no significant differences between cognates and noncognates (p > .24).

APPARATUS

The apparatus was identical to the one used in the main experiment of Chapter 3. Eye movements were recorded using an SR Research Eyelink 1000 eye tracking device. Viewing was binocular, but eye movements were recorded from the right eye only. Participants' gaze locations were monitored every millisecond. Sentences were displayed on a single line in mono-spaced Courier font. Sentences were presented in black on a white background.

PROCEDURE

The procedure was identical to this in the main experiment of Chapter 3. Participants were instructed to read the sentences for comprehension. They stopped a trial by pressing a button. During the experiment, comprehension questions were asked following 25% of the trials. Verbal responses were recorded by the experimenter. The overall accuracy of 99% showed that the participants read the sentences attentively.

RESULTS

The procedure of fitting linear mixed-effects models to the first fixation durations (FFDs), gaze durations (GDs) and Regression path durations (RPDs) was identical to the main experiment of Chapter 3. We excluded trials that were outliers (FFD 2.4%, GD 3.0%, and RPD 3.5%), trials in which the word was skipped (28.6%), trials in which the reader did not start reading the sentence at the leftmost word (3.4%), and trials in which the reader did not read the sentence in a beginning-to-end way (8.8%). There were no significant differences in data removal across conditions. Mean FFD, GD, and RPD are presented in Table 1. Each analysis included crossed random effects for participants and sentence frames (Baayen, Davidson, & Bates, 2008). To control for effects of parafoveal preview, we included the distance of the prior fixation from the target word as a control variable (see Vitu, McConkie, Kerr, & O'Regan, 2001).

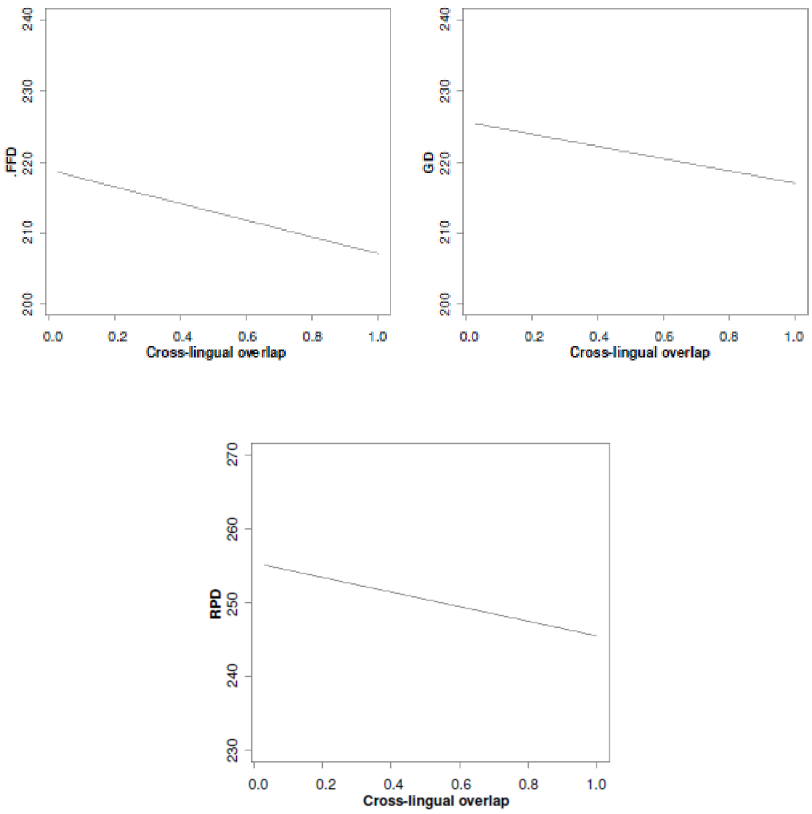
Table 1. First fixation duration (FFD), Gaze duration (GD) and Regression path duration (RPD) on the target word (in ms)

Word type	FFD	GD	RPD
Cognate	210 (60)	222 (77)	251 (112)
Control	216 (68)	225 (76)	257 (118)

Note. Standard deviations are indicated between brackets.

First fixation durations were shorter for cognates than for control words [$F(1,1087) = 3.32$, $p < .05$]. No significant effects were found for GD [$F(1,1077) = 1.37$, $p = .15$] and RPD [$F < 1$]. We also used a continuous measure of cognate status by defining cross-lingual overlap between each word and its translation (e.g., *peper* – *pepper*: 0.94; *appel* – *apple*: 0.70; *hond* – *dog*: 0.10) using the orthographic overlap measure of Van Orden (1987). Figure 1 shows shorter reading times for Dutch words with higher degrees of orthographic similarity with English. This continuous effect was significant in FFD data [$F(1,1087) = 5.02$, $p < .05$], marginally significant in GD data [$F(1,1077) = 2.50$, $p = .07$] and not significant in RPD data [$F < 1$]. For each reading time measure, significant non-linear effects of Prior fixation distance were observed [$ps < .01$]. Fixations on the target were shorter when the previous fixation was close to the target word. The slope of this effect decreased with distance.

Figure 1. Graphs depicting the decrease in FFD, GD, and RPD as a function of cross-lingual overlap



DISCUSSION

This replication experiment again yielded significant cognate facilitation effects with a different set of stimuli. Early reading time measures (FFD) were shorter for cognates than for controls when presented in an L1 sentence context. Moreover, cognate facilitation was shown to be a continuous effect because cognate facilitation gradually increased as a function of cross-lingual similarity. The present experiment provides a valuable replication of the main experiment in Chapter 3: again, we showed that knowledge of a second language influences native-language reading, even though we used a different stimulus set. This strengthens the reliability and generalizability of our previous findings.

The current study shows that the language context provided by the sentence does not restrict lexical activation in the bilingual lexicon. This is in agreement with earlier studies on L2 sentence processing (e.g., Duyck et al. 2007; Schwartz & Kroll, 2006; van Hell & de Groot, 2008). In addition, this study showed cognate facilitation effects during native-language reading with the exact same set of stimuli that were used to investigate cognate facilitation in second-language reading (Duyck et al., 2007). Because these two studies used exactly the same cognates, together they illustrate that the same cross-lingual effects emerge during L1 and L2 reading. Also, because Duyck et al. (2007) only tested a dichotomous distinction between identical and nonidentical cognates, the continuous effect of orthographic overlap in the present study provides an important extension to these earlier findings: it is not strictly the case that identical cognates yield facilitation effects and nonidentical cognates do not. Instead, cross-lingual (facilitatory) activation spreading is a function of the similarity between lexical representations of translation equivalents. This is exactly what one would expect on the basis of interactive activation models of word recognition, such as the BIA+ model (Dijkstra & van Heuven, 2002).

In sum, we again showed that the mere presentation of words in a sentence does not restrict cross-lingual interaction effects in bilinguals during native-language reading. This indicates a limited role for top-down lexical restrictions generated by sentences on the cross-lingual activation in the bilingual lexicon.

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APPENDIX A

Critical stimuli: Dutch-English cognates and Dutch control words

L1 cognate	**L1 control word**
appel [apple]	lepel
auteur [author]	keizer
bar	tas
bel [bell]	jas
boek [book]	zaak
brood [bread]	paard
chaos	gezag
dans [dance]	reus
droom [dream]	straf
eiland [island]	gevaar
fort	zuil
hamer [hammer]	gebak
hoop [hope]	kerk
kasteel [castle]	sleutel
kat [cat]	rok
klok [clock]	bijl
knie [knee]	fles
lip	oom
natie [nation]	hoeve
neus [nose]	hond
paradijs [paradise]	magazijn
peper [pepper]	azijn
plan [plan]	volk
ring	bril
roos [rose]	doos
schip [ship]	krant
sport	bocht
test	buis
vlag [flag]	jurk
vuist [fist]	knoop

Note. Translation equivalents of nonidentical cognates are indicated between brackets.

APPENDIX B

Sentence contexts used in the current experiment

L1 sentence contexts
1. Tijdens het begin van de lunch zag ze dat ze haar APPEL / LEPEL vergeten was. [At the beginning of her lunchtime, she noticed that she had forgotten her APPLE / SPOON.]
2. Hij kende de AUTEUR / KEIZER persoonlijk en kon een bezoek voor hen regelen. [He knew the AUTHOR / EMPEROR personally and could arrange them a visit.]
3. Emma wil haar vriend laten zien welke BAR / TAS ze het leukst vindt. [Emma wants to show her boyfriend which BAR / BAG she likes most.]
4. Tim vertelde dat zijn nieuwe BEL / JAS al na enkele weken kapot was. [Tim told that his new BELL / COAT was broken/torn only after a few weeks.]
5. Het controversiële BOEK / De controversiële ZAAK lokte een storm van protest uit. [The controversial BOOK / CASE provoked a storm of protests.]
6. De arme man kreeg een BROOD / PAARD van de rijke boer. [The poor man got a BREAD / HORSE from the rich farmer.]
7. Tijdens het sollicitatiegesprek bleek dat de kandidaat moeilijk met CHAOS / GEZAG kon omgaan. [It became clear during the job interview that the candidate had trouble dealing with CHAOS / AUTHORITY.]
8. De komiek deed de DANS / REUS na en kreeg een groot applaus van het publiek. [The comedian imitated the DANCE / GIANT and earned much applause from the audience.]
9. Ze vertelde over haar DROOM / STRAF van gisteren aan haar ouders. [She told her parents about her DREAM / PUNISHMENT of yesterday.]
10. Ze hadden nooit gedacht dat het EILAND / GEVAAR zo groot zou zijn. [They had never thought that the ISLAND / DANGER would be so big.]
11. Toen ze voorbij het grote FORT / de grote ZUIL wandelden keken alle kinderen aandachtig. [All children looked attentively when they passed by the big FORT / COLUMN.]
12. De man dacht dat hij de HAMER / het GEBAK hier had laten liggen. [The man thought that he had left the HAMMER / PASTRIES here.]
13. In deze barre tijden hield enkel de HOOP / KERK de mensen op de been. [During these rough days, only HOPE / the CHURCH kept people going.]

14. De zoektocht naar het KASTEEL / SLEUTEL hield iedereen van de jeugdbeweging in de ban. [The search for the CASTLE / KEY held all children of the youth movement spellbound.]

15. Hij zag de KAT / ROK op de tafel liggen. [He saw the CAT / SKIRT lying on the table.]

16. De twee dromerige vrienden zagen de vorm van een KLOK / BIJL in de wolken. [The two dreamy friends discerned the shape of a CLOCK / an AXE in the clouds.]

17. Tijdens het cafégevecht kreeg Tom een KNIE / FLES in zijn maag. [During the bar fight, Tom was hit in the stomach by a KNEE / BOTTLE.]

18. Jeroen schaamde zich voor zijn dikke LIP / OOM en wou er niet over praten. [Jeroen was ashamed of his fat LIP / UNCLE and did not want to talk about it/him.]

19. De onderhandelingen met inwoners van de NATIE / HOEVE zullen binnen enkele dagen beginnen. [The negotiations with the inhabitants of the NATION / FARMHOUSE will start within a few days.]

20. De brutale kleuter sloeg luid kraaiend op de NEUS / HOND van de buurman. [The cheeky infant hit the NOSE / DOG of the neighbour.]

21. Ze beschreef haar huis als een PARADIJS / MAGAZIJN aan iedereen die het horen wou. [She described her house as a PARADISE / WAREHOUSE to everyone who cared to listen.]

22. Het kind was allergisch aan PEPER / AZIJN en kon het gerecht niet eten. [The child was allergic to PEPPER / VINEGAR and could not eat the dish.]

23. Hij wilde alles weten over het PLAN / VOLK toen hij de les verliet. [He wanted to know everything about the PLAN / PEOPLE at the end of the class.]

24. Jans vrouw bleef ontredderd achter toen ze hoorde dat de dief haar RING / BRIL gestolen had. [Jan’s wife was left upset when she heard that the thief had stolen her RING / GLASSES.]

25. Zijn vriendin komt aangewandeld met een ROOS / DOOS in haar handen. [His friend is approaching with/carrying a ROSE / BOX in her hands.]

26. Hij wil informatie vinden over de waarde van dit historisch SCHIP / deze historische KRANT op het internet. [He wants to find some information about the value of this historic SHIP / NEWSPAPER on the internet.]

27. Die gevaarlijke SPORT / BOCHT heeft hem het leven gekost. [That dangerous SPORT/BEND cost him his life.]

28. Hij moest terug naar huis rijden toen bleek dat hij de TEST / BUIS vergeten was. [He had to drive back home when he noticed that he had forgotten the TEST / TUBE.]

29. Haar moeder maakte een kleurrijke VLAG / JURK voor elk meisje van de klas. [Her mother made a colourful FLAG / DRESS for each girl of the class.]

30. De man tekende eerst de algemene omtrek van de VUIST / KNOOP vooraleer deze in te kleuren. [The man first drew the general contours of the FIST / BUTTON

before coloring it in.]

Note. Cognates and control words are displayed in capital letters.

CHAPTER 5
THE INFLUENCE OF SEMANTIC CONSTRAINTS ON BILINGUAL WORD RECOGNITION DURING SENTENCE READING

Revised manuscript submitted for publication[1]

The present study investigates how semantic constraint of a sentence context modulates language-nonselective activation in bilingual visual word recognition. We recorded Dutch-English bilinguals' eye movements while they read cognates and controls in low and high semantically constrained sentences in their second language. Contrary to prior research, early and late comprehension measures yielded cognate facilitation, both for low- and high-constraint sentences. Facilitation increased gradually as a function of cross-lingual overlap between translation equivalents. Experiment 2 showed that the same stimuli did not yield cognate effects in English monolingual controls, ensuring that these effects were not due to any uncontrolled stimulus characteristics. The present study supports models of bilingual word recognition with a limited role for top-down influences of semantic constraints on lexical access.

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[1] This paper was co-authored by Denis Drieghe, Wouter Duyck, and Robert Hartsuiker.

INTRODUCTION

Ever since it was estimated that about half of the world's population is bilingual (Grosjean, 1982), research on bilingualism has attracted the attention of a growing community of researchers. An important issue in this domain concerns the organization of the bilingual language system. The simplest theory would probably be that bilinguals have two separate lexicons, one for each language. When reading in one language, only words from the corresponding lexicon become activated. However, many studies have shown that the organization of the bilingual lexicon is not that straightforward. These studies discovered that lexical representations of the first language (L1) are accessed when people are reading in their second language (L2) (e.g., Brysbaert, van Dyck, & Van de Poel, 1999; Costa, Caramazza, & Sebastian-Galles, 2000; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, Timmermans, & Schriefers, 2000; Duyck, 2005; Duyck, Diependaele, Drieghe, & Brysbaert, 2004; Haigh & Jared, 2007; Jared & Kroll, 2001; Lemhöfer & Dijkstra, 2004; Schwartz, Kroll, & Diaz, 2007) and vice versa (e.g., Duyck, 2005; Van Assche, Duyck, Hartsuiker, & Diependaele, in press; van Hell & Dijkstra, 2002). Similarly, studies on auditory word recognition (e.g., Marian, Blumenfeld, & Boukrina, 2008; Marian, Spivey, & Hirsch, 2003), word production (e.g., Costa, Santesteban, & Cano, 2005; Kroll, Bobb, & Wodniecka, 2006), and the bilingual Stroop task (e.g., Altarriba & Mathis, 1997; Chen & Ho, 1986; Tzelgov, Henik, & Leiser, 1990; Tzelgov, Henik, Sneg, & Baruch, 1996) have also provided evidence for language-nonselective activation of lexical representations in both languages. In the present study, we investigated whether cross-lingual lexical activation transfer is modulated by the semantic constraint imposed by a sentence. In the following sections, we first discuss the cognate facilitation effect, which is a reliable marker of nonselective activation.

Then, we present monolingual and bilingual studies regarding the role of sentence constraint on lexical access.

ISOLATED WORD RECOGNITION

Many bilingual studies have investigated lexical activation in the nontarget language by presenting cognates (translation equivalents with full or partial form overlap, e.g., Dutch-English *schip-ship*) and matched control stimuli in isolation using tasks such as visual lexical decision (e.g., Caramazza & Brones, 1979; Dijkstra et al., 1999; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Lemhöfer & Dijkstra, 2004), picture naming (e.g., Costa et al., 2000; Gollan & Acenas, 2004), and word naming (e.g., Schwartz et al., 2007). These studies have demonstrated that cognates are recognized or produced faster than monolingual matched control words (i.e. the *cognate facilitation effect*). In Lemhöfer, Dijkstra, and Michel (2004), this effect is shown to accumulate over languages: using Dutch-English-German trilinguals performing a German (L3) lexical decision task, they report faster responses for L1-L2-L3 cognates than for L1-L3 cognates. Additionally, cognate facilitation even occurs when bilinguals perform a lexical decision task in their native language (Van Assche et al., in press; van Hell & Dijkstra, 2002). These results provide very strong evidence for language-nonselective activation of lexical representations.

Theoretical explanations of this cognate effect can be divided into two general categories. A first category proposes a similar type of representation for cognates and noncognates, but with varying degrees of orthographic, phonological, and semantic overlap (e.g., Dijkstra & van Heuven, 2002; van Hell & de Groot, 1998). The currently most explicit model of bilingual word recognition in this category is the Bilingual Interactive Activation+ (BIA+) model (Dijkstra & van Heuven, 2002). This updated version of the original BIA model (Dijkstra et al., 1999; Dijkstra & van Heuven, 1998) is a bilingual extension of the well-known Interactive Activation model

(McClelland & Rumelhart, 1981). It assumes that the bilingual lexicon contains entries from both languages in a unified store and is accessed in a language-nonselective way. Upon the presentation of a word, orthographic, phonological, and semantic representations become activated (bottom-up) in both languages depending on the overlap with the input word. The cross-lingual activation spreading from these three codes speeds up the activation of cognates compared to noncognates. A second category of theoretical models assumes that there are qualitative differences in the representation of cognates and noncognates (de Groot & Nas, 1991; Kirsner, Lalor, & Hird, 1993; Sánchez-Casas & García-Albea, 2005). For instance, in the model of Kirsner et al. (1993), morphology is an important aspect in the organization of the bilingual lexicon. Cognate translations are considered as a special type of morphologically related items. Sánchez-Casas and García-Albea (2005) propose an extension of the BIA model (Dijkstra & van Heuven, 1998) in which cognate translations share a common morphological root, while noncognate translations do not. The morphological level is supposed to be a mediating level between meaning and form. In the current study on the role of sentence constraint on lexical access, we also test whether cognate facilitation is a continuous effect based on the degree of cross-lingual overlap in the two languages. Such continuous effects of cross-lingual overlap would be more in line with the first group of models than with the second one, as there is no reason to expect graded effects of cognate status if it is assumed that cognates have qualitatively different representations from noncognates.

Although the BIA model was originally designed to account for isolated (out-of-context) visual word recognition, the recent BIA+ model (Dijkstra & van Heuven, 2002) also makes predictions on how linguistic context effects may influence language-nonselective activation transfer, starting out from a distinction between a word identification system (the bilingual lexicon) and a task/decision system. Linguistic context (e.g., semantic and syntactic constraints) is assumed to directly affect activation in the word identification system. Nonlinguistic context (e.g., task instructions, participant's expectations) on the other hand, is assumed to affect the task/decision system. The BIA+ model also includes a set of language nodes which act as language membership representations within the word identification system. This influence of language membership is relatively small (these nodes have no top-down connections in BIA+, unlike the earlier BIA) indicating that it will generally not affect word recognition. As language information does not provide strong selection constraints, we predict that the mere presentation of a word in a sentence context (and the language cues it provides) should not modulate cross-lingual activations. However, Dijkstra and van Heuven predict that a semantic linguistic context may impose constraints on the degree of non-selectivity through boosted semantics which feed back to the orthographic level. The present study sets out to test this prediction that lexical access is influenced by semantic constraint of a sentence.

WORD RECOGNITION IN SENTENCE CONTEXTS

From the monolingual domain, it is well known that contextual information guides lexical access in L1. For instance, many studies have shown that context aids in the interpretation of ambiguous words (e.g, *bank* as a riverside or a financial institution) (e.g., Binder & Rayner, 1998; Onifer & Swinney, 1981; Rayner & Frazier, 1989). In a neutral sentence context, meaning activation is determined by the relative frequencies of the ambiguous word's meanings. However, a strong biasing context can alter this activation (e.g., Duffy, Kambe, & Rayner, 2001). Also, many studies have shown that more predictable words (originating from a predictive sentence context) are processed faster than non-predictable words (e.g., Schwanenflugel & LaCount, 1988; Schwanenflugel & Shoben, 1985; Stanovich & West, 1983). In eyetracking paradigms, these predictable words are skipped more often and get shorter fixation durations (e.g., Balota, Pollatsek, & Rayner, 1985; Rayner & Well, 1996). In short, these studies demonstrate that sentence context is used to generate semantic, syntactic, and lexical restrictions for the processing of upcoming words in a sentence (e.g., Schwanenflugel & LaCount, 1988).

The present study tests whether these monolingual sentence effects generalize to the bilingual domain, focusing on the following research question: is lexical access and its susceptibility to cross-lingual interaction effects modulated by the semantic constraint of the sentence? A study by Altarriba, Kroll, Sholl, and Rayner (1996; see also Altarriba, Kambe, Pollatsek, & Rayner, 2001, on cognate processing in low-constraint sentences) on a related issue suggests that the semantic context of a sentence may indeed be used to selectively activate words of only one language. In this study, Spanish-English bilinguals read English (L2) low- or high-constraint sentences while their eye movements were being recorded. In one condition, the target word was replaced by its Spanish translation. An example is the low-constraint sentence *They chose a calle* [street] *that could be easily closed off for the parade* or the high-constraint sentence *You need to look both ways before crossing a calle* [street] *as busy as that one*. The presentation of a high-frequency Spanish word in a high-constraint sentence resulted in longer reading times on first fixation duration (relative to the presentation of the same target in a low-constraint sentence). This result did not occur for low-frequency Spanish words, most likely because lexical access of low-frequency words occurs more slowly, resulting in more processing time to resolve the conflict. When the English target was presented in a high-constraint sentence, reading times were facilitated compared to a low-constraint sentence. Although the words *calle* and *street* both met the syntactic and semantic restrictions of the high-constraint sentence, facilitation was only found for the word that met the lexical restriction of the language of the sentence. This suggests that a semantically constraining sentence context can be used as a cue for lexical access, by activating not only semantic and syntactic restrictions for upcoming words, but also its language.

Schwanenflugel and LaCount (1988) explained the effect of semantic constraint in a feature restriction model. According to this model, a low-constraint sentence generates fewer feature restrictions for an upcoming word than a high-constraint sentence. For example, reading the sentence *A bubble gum got stuck on the sole of his* ___ will generate substantially more features for the upcoming words than reading the sentence *His wife bought him a* ___. Reading will only be facilitated for words that match the features that were generated. In the bilingual case, this would result in the activation of the same semantic representation across languages, at least for the concrete nouns used in most studies (e.g., Kroll & de Groot, 1997; van Hell & de Groot, 1998). Furthermore, the study by Altarriba et al. (1996) has shown that bilinguals do not only generate semantic restrictions, but also lexical restrictions for upcoming words. This line of reasoning, predicts that the cognate advantage originating from the lexical overlap across languages will be reduced in high-constraint sentences because the semantic context restricts lexical activation in both cognates and noncognates alike. Therefore, it is to be expected that the cross-lingual activation of lexical representations for cognate words (resulting in cognate facilitation when no semantic constraints are imposed) will no longer exert significant effects when semantic constraints are imposed. However, Altarriba et al. used stimuli in which words from both languages were mixed in one sentence. Although mixed-language texts are used in some parts of the world, unilingual texts provide a more ecologically valid reading situation. It is possible that the use of mixed-language sentences may have fundamentally changed lexical access. It may therefore be premature to draw definite conclusions from this study about more natural unilingual language processing, which is the condition under investigation in the current study.

Interestingly, only a few recent studies have investigated cross-lingual activation in a sentence context by testing the speed and accuracy of recognizing (or producing) words that constitute lexical representations in both languages of a bilingual, namely cognates and interlingual homographs (words that share orthography but not meaning, e.g., Spanish-English *fin* [end]). These studies converge on the conclusion that a low-constraint sentence context cannot eliminate activation of the non-target language (e.g., Duyck et al., 2007; Elston-Güttler, Gunter, & Kotz, 2005; Schwartz & Kroll, 2006; van Hell & de Groot, 2008). However, a semantically constraining sentence was found to annul or diminish cross-lingual activations (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008).

In Duyck et al. (2007), Dutch-English bilinguals read English (L2) low-constraint sentences containing a cognate or a control word (e.g., *Hilda bought a new RING / COAT and showed it to everyone*; *ring*, but not *coat*, is a cognate with Dutch) in an eyetracking paradigm. The goal of this study was to investigate if the sentence context and the language cue it provides could be used to speed up word recognition, because this would limit lexical search to words of only one language. Cognate facilitation was observed on early reading time measures (first fixation durations and gaze durations), but only for identical cognates (i.e., cognates with identical orthographies across languages, e.g., Dutch-English *ring* – *ring*). It seems that the sentence context was strong enough to counteract the cognate effect when cross-lingual orthographic overlap was not sufficiently strong (nonidentical cognates). But when cross-lingual orthographic overlap was complete (identical cognates), lexical interactions between languages occurred during sentence reading, as was the case for words presented in isolation.

Another study by Elston-Güttler et al. (2005) showed that cross-lingual activation is very sensitive to the influence of a sentence context. They tested the recognition of interlingual homographs by German-English bilinguals. These homographs were presented at the end of a sentence context with a relatively open end (e.g., *The woman gave her friend a pretty*

GIFT) and served as the prime for targets that replaced the sentence. Targets were either related to the L1-meaning of the homograph (e.g., *poison* which is the translation of the German meaning of *gift*) or unrelated to the control prime (e.g., *The woman gave her friend a pretty SHELL*). Lexical decision times on these targets showed semantic priming from L1-primes, but only in the first block of the experiment and only for participants who saw a German movie prior to the experiment. From this, the authors argued that cross-lingual priming from L1 to L2 was weak because of constraints imposed by the sentence.

Studies by van Hell and de Groot (2008) and Schwartz and Kroll (2006) provided evidence for the above-mentioned prediction regarding the reduction of the cognate advantage due to the generation of lexical and semantic restrictions in a high-constraint sentence (e.g., Altarriba et al., 1996; Schwanenflugel & LaCount, 1988). Both studies found cognate facilitation in low-constraint sentences, but this effect disappeared when cognates and controls were embedded in high-constraint sentences. In van Hell and de Groot, Dutch-English bilinguals performed an L2 lexical decision task or translated target words in forward (from L1 to L2) or in backward direction (from L2 to L1). Sentence contexts, in which the location of the target word was marked with three dashes, were presented on a computer screen (e.g., *The best cabin of the ship belongs to the* ---; target *captain*). The target word was presented immediately after the sentence disappeared from the screen. After reading a high-constraint sentence context, cognate facilitation was no longer observed in lexical decision and strongly diminished in both translation tasks. In low-constraint sentences, cognate effects were still present. This suggests that cross-lingual activations can be restricted by a semantically constraining sentence.

Schwartz and Kroll (2006) reported similar results for word naming by Spanish-English bilinguals. They presented cognates and interlingual homographs appearing in low- and high-constraint sentences. The participants were divided in groups of more and less proficient bilinguals.

Sentences were presented word by word using rapid serial visual presentation and the target (printed in red) had to be named. In both groups of bilinguals, cognate facilitation was observed in low-constraint sentences, but not in high-constraint ones. Again, this suggests that the top-down effect of sentence constraint can modulate cross-lingual activations in the bilingual lexicon. No reaction time differences were found for homographs and controls in low- and high-constraint sentences, for both groups of bilinguals. However, less proficient bilinguals showed increasing naming error scores, particularly in low-constraint sentences. In this regard, the authors grant that their results were somewhat inconclusive: "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." (Schwartz & Kroll, 2006) [p. 209]. The mixed results for homograph processing might be clarified by using a more sensitive measure such as eyetracking, which is the approach taken in the present study.

As interesting as the above results are, we think that they may not reflect the whole picture, for a number of reasons. First, presenting the sentence context in advance or using rapid serial visual presentation may require more memory resources as participants need to keep the preceding words in memory. In eyetracking, participants can easily make a regression to previous parts of the sentence and might therefore require less memory resources. If participants are obliged to read within a fixed time window, more time might be available for the participant to anticipate the expected word compared to when reading at their own pace. Being able to anticipate the target in a high-constraint sentence may therefore mask the cross-lingual activation spreading that occurs during lexical access in natural sentence reading. Second, the fact that cognate facilitation disappeared in high-constraint sentences might be the result of processes occurring after lexical access had taken place. Lexical decision tasks may involve decision-making strategies or postlexical checking strategies. Similarly, naming tasks require extra processing time for pronouncing the target. These processes might disguise the actual effects reflecting lexical access.

Therefore, more sensitive measurements such as eyetracking may be more suitable to measure the effects of cross-language activations. This method was used in the present study and has several important advantages over lexical decision or naming. First, it allows participants to read normally as in everyday life and it does not require overt decisions, which may yield processes that mask the lexical interaction effects. Second, the timecourse of activations can be uncovered by dissociating several early (reflecting initial lexical access) and late reading time measures (reflecting higher-order processes such as semantic integration) (Rayner, 1998).

THE PRESENT STUDY

The goal of this study is to test whether a semantic context imposed by a sentence influences cross-lingual activations. To our knowledge, after Altarriba et al. (1996) who used code-switched sentences, no study has ever tested semantic constraint effects on lexical activations in unilingual sentence reading using the temporal resolution provided by eyetracking. This study therefore constitutes an important extension of Duyck et al. (2007) and can provide answers about two main issues in bilingual research. First, it should provide clear insights regarding the influence of semantic constraints on lexical access. We argued that if cross-lingual interactions do occur in a semantically constraining sentence, we should be able to measure them. The finding of cross-lingual interactions in high-constraint sentences implies that in the further development of bilingual models (e.g., Dijkstra & van Heuven, 2002), a limited role should be assigned for semantic top-down influences on the profoundly nonselective bilingual language system. Second, the use of a continuous measure of cognate status, based on cross-lingual similarity between translation equivalents, allows a more sensitive analysis of possible gradual effects on word processing. Moreover, they can provide new insights regarding the representation of cognates and noncognates in bilingual memory, as finding continuous effects of cross-lingual overlap would be more in line with models proposing a similar representation for cognates and noncognates (e.g., Dijkstra & van Heuven, 2002; Thomas & van Heuven, 2005; van Hell & de Groot, 1998) than with models assuming qualitatively different representations for cognates and noncognates (e.g., de Groot & Nas, 1991; Sánchez-Casas & García-Albea, 2005).

We decided to use a strong and reliable marker of nonselective activation: the cognate facilitation effect. In previous studies (e.g., Caramazza & Brones, 1979; Dijkstra, et al., 1999; Schwartz & Kroll, 2006; van Hell & de Groot, 2008), each cognate was considered an item of a homogeneous group (the cognate group) that was compared to a group of items containing noncognate words (the control group). No explicit distinction was made between effects for identical and nonidentical cognates. However, Duyck et al. (2007) showed that the degree of orthographic overlap between languages may influence the cognate facilitation effect in sentence reading. Therefore, we adopted this more fine-grained approach, and fine-tuned it by using a continuous measure of cognate status for analyses instead of the dichotomous cross-lingual overlap manipulation (identical vs. nonidentical cognates) of Duyck et al. We calculated cross-lingual similarity between (a) each cognate word and its translation (e.g., *pilot-piloot*: 0.89) and (b) between each control word and its translation (e.g., *habit-gewoonte*: 0.04) using the word similarity measure developed by Van Orden (1987).[2] In addition, several studies have shown the importance

[2] Van Orden (1987, p. 196) defines graphemic similarity (GS) between two letter strings as $GS = 10([50F + 30V + 10C)/A] + 5T + 27B + 18E)$ with F = number of pairs of adjacent letters in the same order, shared by pairs; V = number of pairs of adjacent letters in reverse order, shared by pairs; C = number of single letters shared by word pairs; A = average number of letters in the two words; T = ratio of number of letters in the shorter word to the

of phonological overlap in the cognate effect (e.g., Dijkstra et al., 1999; Schwartz et al., 2007). For instance, Schwartz et al. (2007) showed that English-Spanish bilinguals' naming times for cognates were a function of both the orthographic and phonological similarity in the two languages. As the Van Orden measure does not take into account phonological overlap, we also collected bilinguals' ratings for each target word and its translation with respect to phonological and orthographic overlap.

Experiment 1 presented cognates and control words in low- and high-constraint sentences while eye movements were monitored. The use of the eyetracking method allows assessing the time course of cross-lingual lexical interactions and is probably the closest experimental operationalization of natural reading. Experiment 2 was a monolingual control experiment with native English participants.

EXPERIMENT 1: DUTCH-ENGLISH BILINGUALS

METHOD

Participants. Sixty-two students from Ghent University participated in the experiment. They were all late Dutch-English bilinguals who started to learn English around age 14 at secondary school for about 3-4 hours a week. In Belgium, students are regularly exposed to their L2 through popular media or English university textbooks. The criteria for recruitment stipulated that the participants should have good knowledge of English. Participants did not know that their knowledge of Dutch would be of any relevance to the

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number of letters in the longer; *B* = if first two letters are the same *B* = 1 else *B* = 0; *E* = if last two letters are the same *E* = 1 else *E* = 0. Then, Van Orden calculates Orthographic Similarity by determining the ratio between the GS of word 1 with itself and the GS of word 1 and word 2. For more details concerning this measure, we refer to Van Orden (1987).

experiment. Participants were paid or received course credit for their participation. After the experiment was finished, they were asked to rate their L1 and L2 proficiency with respect to several skills (reading, writing, speaking, and general proficiency) on a 7-point Likert scale ranging from *very bad* to *very good*. Mean self-reported general L1 (M = 6.2) and L2 (M = 5.3) proficiency differed significantly (dependent samples t-tests yielded ps < .001). Means are reported in Table 1.

Table 1. Self-assessed ratings (7-point Likert scale) of L1 and L2 proficiency in Experiment 1

Language	Skill	Experiment 1
L1 (Dutch)	Writing	6.3 (0.6)
	Speaking	6.2 (0.8)
	Reading	6.5 (0.6)
	General Proficiency	6.2 (0.6)
L2 (English)	Writing	5.0 (0.6)
	Speaking	5.2 (0.8)
	Reading	5.7 (0.8)
	General Proficiency	5.3 (0.7)

Note. Standard deviations are displayed in parentheses.

Stimulus materials. The original target stimuli consisted of 46 cognates of three to eight letters in length which varied in their degree of Dutch-English orthographic similarity. Using the WordGen stimulus generation program (Duyck, Desmet, Verbeke, & Brysbaert, 2004), we selected 46 English noncognate control words matched (on an item by item basis) to the cognates with respect to word length (identical), number of syllables, word frequency, neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977), and word class (all words were nouns). Paired samples t-tests showed no significant differences on any of these variables (all ps > .16). This matching ensured that there were no correlations between any of the matching variables and degree of cross-lingual overlap (cognate status). Based on Van Orden's (1987) measure, we defined cognates as words with an orthographic overlap score of 0.40 or more. This resulted in the removal of 4 word pairs because these targets' orthographic overlap in both languages was too low for a cognate (*sea* - *zee*: 0.08) or too high for a noncognate (*king* – *koning*: 0.74; *liar* – *leugenaar*: 0.55; *walk* – *wandeling*: 0.40).

For each target word of the original set, a low- and high-constraint sentence context was constructed, resulting in 184 sentences. Sentences for cognates and noncognates were matched in terms of number of words, syntactic structure, and the length of the word preceding the target. Critical words were never in the final position of the sentence. A minimum of five words preceded the target and a minimum of two words followed the target. A native speaker of English checked that all stimuli were correct English sentences. The sentences were divided across two presentation lists so that no participant would see the same cognate or control word twice. Additionally, 36 filler sentences and 10 practice sentences, all of comparable syntactic complexity as the target sentences, were added to each list.

Pilot experiment 1. To verify the context manipulation of the cognate and noncognate sentences, a sentence completion study was conducted with 35 additional Ghent University students. Each participant was presented with the 184 sentence frames up to the target word. They were instructed to type in the first word of the sentence completion that came to mind when reading the sentence frame. Based on these results, 4 cognate-noncognate pairs were removed because completion scores in the high-constraint condition did not reach 60% or because there was an alternative completion with a high production probability. Additionally, we removed 6 pairs because the production probabilities between the cognate and control differed more than 20%. The above-mentioned exclusion of 4 pairs based on the overlap scores and the removal of these 10 pairs based on the sentence completion resulted in a set of 32 cognate-control pairs that entered analyses. The target words and their Van Orden's (1987) overlap measure are presented in Appendix A. Dependent samples t-tests on production probabilities for the remaining 32 pairs of targets in low- and high-constraint sentences showed no significant differences between cognates and noncognates (all *p*s > .16). Also, production probabilities in high-constraint sentences were significantly higher than in low-constraint sentences ($p < .001$) (see Table 2), showing that our constraint manipulation was effective. The low- and high-constraint sentences for each cognate-control pair are shown in Appendix B.

Table 2. Production probabilities for cognates and controls presented in low- and high-constraint sentences

	Sentence constraint	
Word type	Low	High
Cognate	.05 (.09)	.89 (.09)
Control	.04 (.08)	.86 (.09)

Note. Standard deviations are indicated in parentheses.

Including these 32 word pairs in the analyses did not affect the matching between cognates and controls on word length, number of syllables, word frequency, neighborhood size, and bigram frequency (*p*s > .12). Means on these matching variables are presented in Table 3.

Table 3. Mean lexical characteristics of the 32 target words (Experiments 1 and 2)

Word type	Number of letters	Number of syllables	Word frequency [a]	Neighborhood size [b]	Bigram frequency [c]
Cognates	5.22 (1.18)	1.43 (0.50)	1.85 (0.43)	4.41 (4.35)	9044.28 (5436.89)
Controls	5.22 (1.18)	1.43 (0.50)	1.87 (0.45)	4.69 (5.09)	8588.69 (4972.54)
p	identical	identical	> .76	> .36	>.12

Note. Standard deviations are indicated in parentheses. Reported *p*-values indicate significance levels of dependent samples t-tests between cognates and controls. [a] Mean log frequency per million words, according to the CELEX lemma database (Baayen, Piepenbrock, & van Rijn, 1993). [b] Neighborhood size (Coltheart et al., 1977) calculated using the WordGen program (Duyck et al., 2004) on the basis of the CELEX lexical database (Baayen et al., 1993). [c] Mean summated bigram frequency (calculated using WordGen, Duyck et al., 2004)

Pilot experiments 2 and 3. In order to provide a measure of orthographic and phonological overlap for each target word and its translation, we conducted two rating studies. In the first rating study, 19 bilingual participants from the same population as those of the actual experiment had to rate the orthographic similarity of the translation pairs on a seven-point Likert scale (1 indicating an unequal spelling and 7 an equal spelling). We created four lists in which word pairs were presented in a different order. Each list contained all the word pairs and subjects wrote down their answers. In the second rating study, 21 further subjects rated the phonological similarity of the translation pairs on a seven-point Likert scale (1 indicating an unequal pronunciation and 7 an equal pronunciation). Subjects listened to each word pair and wrote down their answers. Again, we used 4 different orders for presenting the word pairs. Each rating study started with three practice items. Mean orthographic and phonological rating scores of the 32 target pairs are presented in Appendix A. As expected, there was a significant correlation between Van Orden's (1987) overlap measure and the orthographic ratings (r = .97). Similarly, the correlations between Van Orden's measure and the phonological ratings (r = .91) and between the orthographic and phonological ratings (r = .94) were significant. In the analyses, we combined the orthographic and phonological ratings by calculating their mean value and we presented it as the variable combined orthographic and phonological rating.

Pilot experiment 4. To validate the target words for use in sentence contexts, we conducted a lexical decision task on the cognates and controls presented out-of-context with 29 additional Dutch-English bilinguals from Ghent University with the same language background as the participants of Experiment 1. In addition to the target words, 46 English filler words and 138 orthographically regular and pronounceable nonwords were added to the stimulus list. Every participant saw a different randomized order of the 276 trials. Each trial consisted of the presentation of a centered fixation point for 800 ms, a 300 ms interstimulus interval, the central presentation of the letter string and an intertrial interval of 700 ms.

Mixed-effects models analyses (Baayen, 2007) were run on the reaction time (RT) and accuracy data for the 32 cognate-control pairs. Incorrect responses (5.8% of the data) and RTs that were more than 2.5 standard deviations below or above the participant's mean RT for cognates and controls were excluded from analyses (2.7% of the data). RT data were inverse transformed (i.e. -1/RT) to reduce the skew in the distribution. We applied the Markov Chain Monte Carlo (MCMC) sampling method (with a sample size of 10.000) to obtain *p*-values for the coefficients in the RT analysis (Baayen, Davidson, & Bates, 2008). We first present the analyses based on the discrete manipulation of cognates vs. controls (cf. Dijkstra et al., 1999; Lemhöfer et al., 2004; van Hell & de Groot, 2008). Then, we provide the continuous analyses of orthographic overlap based on (a) the Van Orden (1987) orthographic similarity measure and (b) the combined orthographic and phonological ratings for each target. Word frequency (i.e., logarithm of word frequency per million words according to the CELEX lexical database, Baayen et al., 1993) of the targets was included as a (continuous) control variable. Random intercepts were included for subjects and items (Baayen et al., 2008). Logistic models were used for the binomially distributed error data.

Analyses including the factor Word type (cognate vs. control) showed that RTs to cognates (*M* = 512 ms) were faster than RTs to controls (*M* = 543 ms) [$F(1,1696) = 19.17$, $p < .001$]. Also, we observed a significant effect of Frequency [$F(1,1696) = 25.34$, $p < .001$], indicating that more frequent words were recognized faster. The error analysis showed no significant differences in error percentages for cognates (*M* = 4.8%) and controls (*M* = 6.8%) [$z = 1.27$, $p = .21$], but fewer errors for more frequent words [$z = 4.67$, $p < .001$].

The results of the analyses on the continuous measure of cognate status using Van Orden's (1987) measure indicated that the recognition of English words was facilitated when they had higher degrees of orthographic similarity with Dutch [$F(1,1696) = 24.69$, $p < .001$]. And again, more frequent words were recognized faster [$F(1,1696) = 25.80$, $p < .001$]. The error analysis yielded no significant effect of Overlap [$z = 1.61$, $p = .11$] and a significant effect of Frequency [$z = 4.74$, $p < .001$], showing more errors for low-frequent words. The analyses on the combined measure of orthographic and phonological overlap yielded the same pattern of results: a continuous effect of Overlap [$F(1,1696) = 23.80$, $p < .001$] and an effect of Frequency [$F(1, 1696) = 24.93$]. The error analysis indicated no significant effect of Overlap [$z = 1.37$, $p = .17$] and a significant effect of Frequency [$z = 4.64$, $p < .001$]. A graph of the RT results on Van Orden's overlap measure presented in Figure 1.[3]

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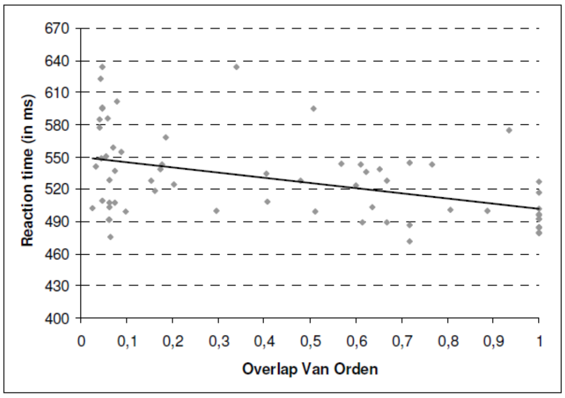
[3] As the two continuous measures of cross-lingual overlap are strongly correlated, we only presented the graphs on Van Orden's overlap here and in the subsequent analyses.

Figure 1. Graph depicting the decrease in RT as a function of cross-lingual overlap on mean target RTs in Pilot experiment 4. The straight line represents the best linear fit.



This lexical decision task showed that cognates were processed faster than controls. Interestingly, analyses also showed that this cognate facilitation effect becomes gradually stronger as a continuous function of cross-lingual overlap. As such, the lexical decision task on the targets presented out-of-context provided a validation of the materials for use in sentences in the actual eyetracking experiment.

Apparatus. Eye movements were recorded using an SR Research Eyelink 1000 eye tracking device. Viewing was binocular, but eye movements were recorded from the right eye only. The tracker monitored participants' gaze locations every millisecond. All sentences were displayed on no more than two lines with a maximum length of 85 characters per line and all letters were lowercase (except when capitals were appropriate) and in mono-spaced Courier font. Targets were never the final word of a line, nor the first word of the second line. The sentences were presented in black on a white background.

Procedure. Before the start of the experiment, participants were informed that the experiment was about the comprehension of sentences presented on a screen. We emphasized that it was important to read the sentences as naturally as possible for comprehension (as if one was reading a book or a newspaper). Sentences were presented as a whole on the screen. Participants pressed a button after reading the sentence. Then, a new sentence appeared on the screen or a comprehension question followed. Comprehension questions appeared on the screen in 36 trials and needed a yes- or no-response by pressing one of two response buttons. Overall accuracy on these questions was 96%, indicating that participants read the sentences attentively. The 126 sentences were presented in a random order to each participant and were preceded by 10 practice sentences. Calibration consisted of a standard 9-point grid. The whole session including camera setup and calibration lasted about half an hour.

Data analysis. Mixed-effects models, as implemented in the *Lme4* library (Bates, 2007) in *R* (R Development Core Team), were fitted to four eye movement measures. We examined both early, first-pass measures and a late eye tracking measure (Rayner, 1998). First-pass measures included *first fixation duration* (FFD), *gaze duration* (GD), and *percentage of skipped targets*. The FFD is the duration of the first fixation during the first passage through the region of the target. The GD is the sum of fixations from the moment the eyes land on the target (for the first time) until the moment they move off again. Rayner (1998) stated that for most of the time, FFD and GD yield similar results. The decision to skip a word occurs very early in processing the target based on parafoveal vision. If the reader skipped the word, this was coded as a missing value for the FFD, GD, and RPD measures. These early measures are typically assumed to reflect initial lexical access and word identification processes. The later stage measure, *regression path duration* (RPD) (also named *cumulative region reading time*), is assumed to reflect higher-order processes such as ambiguity resolution and semantic integration. The RPD is the sum of all fixations from the first fixation on the target until a word to the right of the target is fixated.

Regressions originating from a particular region are added to the RPD of that region, but they are not added to the GD. Assuming that cognate effects arise from nonselective lexical access to the bilingual lexicon, we predicted cognate effects to show up in early reading time measures. RPD is supposed to reflect higher-order processes and we therefore did not assume this measure to reflect cognate processing. However, if readers do not make many regressions from the target word, GD and RPD will be very similar because GD is completely included in RPD. Still, the RPD measure provides an indication of the degree of regressions made from the target and the processing difficulty of the sentences.

Prior to analyses, fixations shorter than 100ms (for justification, see Morrison, 1984; Rayner, Sereno, Morris, Schmauder, & Clifton, 1989) or longer than 800 ms were removed. After also removing trials in which calibration was inadequate, 0.1% of the trials were deleted. Analyses were run on the 32 cognate-noncognate pairs included in the analyses of the lexical decision task. We will first report the analyses on the discrete variable Word type (cognate vs. control). Then, we present the analyses on the continuous variable Overlap defined by the Van Orden (1987) similarity measure and the overlap measure defined by the combined orthographic and phonological ratings. Each analysis considered the effect of Constraint as a variable. Random intercepts were included for subjects and items for the four eye movement measures and random slopes regarding the constraint factor for items were included for FFD, GD, and RPD.[4] Logistic models were used for the binomially distributed skipping data. To control for effects of parafoveal preview, we also included the distance of the prior fixation from

[4] Model comparisons showed that including random slopes regarding the factor Constraint for items significantly improved the fit of the models for FFD (χ^2s > 22.77, *p*s < .001), GD (χ^2s > 20.45, *p*s < .001), and RPD (χ^2s > 35.45, *p*s < .001), but not for skipping (χ^2s < 1) in the discrete and continuous analyses.

target word as the control variable Prior fixation distance (cf. Van Assche et al., in press; see e.g., Vitu, McConkie, Kerr, & O'Regan, 2001). The possibility of a non-linear effect of this factor was considered. As in the lexical decision task, frequency of the targets was included as a control variable. Outliers on Prior fixation distance (exceeding a distance of more than 20 character spaces) were removed (0.1% of the data for FFD, GD, RPD, and skipping). After calculation of the skipping percentages on the target word, we removed the trials in which the target was skipped (17.8% in the high-constraint condition; 14.4% in the low-constraint condition) from the analyses of FFD, GD, and RPD. We applied the MCMC sampling method (with a sample size of 10.000) to obtain *p*-values for the coefficients in the RT analysis. Prior to analyses, the reading times on FFD, GD, and RPD were log-transformed to reduce the skew in the distribution.

RESULTS

Word type (cognate vs. control). There was no significant interaction between Word type and Constraint for FFD, GD, and RPD [all *F*s < 1], and therefore this interaction was removed from the model and the model was tested again. Results showed significantly faster reading times for cognates than for controls on FFD [$F(1,3311) = 5.80$, $p < .01$], GD [$F(1,3311) = 4.97$, $p < .01$], and [RPD $F(1,3311) = 5.32$, $p < .01$]. Also, reading times in high-constraint sentences were faster than in low-constraint sentences on all measures [FFD: $F(1,3311) = 12.81$, $p < .001$; GD: $F(1,3311) = 27.37$, $p < .001$; RPD: $F(1,3311) = 21.93$, $p < .001$], illustrating the successful manipulation of sentence constraint. Means are presented in Table 4.

Table 4. First fixation duration (FFD), Gaze duration (GD), Regression path duration (RPD) and skipping percentages on the target word in Experiment 1

Constraint	Word type	FFD	GD	RPD	Skipping
Low	Cognate	230 (72)	263 (109)	298 (162)	16.3 (36.9)
	Control	239 (82)	275 (115)	321 (188)	12.5 (33.1)
Effect		*9*	*12*	*23*	*-3.8*
High	Cognate	219 (70)	240 (96)	270 (143)	19.2 (39.4)
	Control	228 (72)	253 (101)	287 (157)	16.4 (37.1)
Effect		*9*	*13*	*17*	*-2.8*

Note. Standard deviations are indicated in parentheses.

The effect of Frequency was significant on FFD [$F(1,3311) = 6.87$, $p < .05$] and GD [$F(1,3311) = 9.19$, $p < .01$], indicating shorter reading times for more frequent words. This effect was not significant on RPD [$F(1,3311) = 2.74$, $p = .11$]. Significant non-linear effects of Prior fixation distance were observed for all dependent measures [FFD-linear, FFD-quadratic, GD-linear, GD-quadratic, RPD-linear, RPD-quadratic: all *p*s < .001]. Fixations on the target were shorter when the previous fixation was close to the target word. However, the slope of this effect decreased with distance.

As in the reading time analyses, the results for skipping showed no significant interaction between Word type and Constraint [$z < 1$] and, as a result, it was removed from the model and the model was tested again. Cognates were skipped more often than controls [$z = 3.00$, $p < .05$]. Words in high-constraint sentences were skipped more than in low-constraint sentences [$z = 3.65$, $p < .05$]. Also, skipping increased for more frequent words [$z = 1.78$, $p = .08$] and significant non-linear effects of Prior fixation distance were observed [all *p*s < .001].

We tested contrasts to investigate if the cognate effect was present in low- and high-constraint sentences separately. The mixed-effects models analyses with MCMC sampling adjustment of the degrees of freedom for the test statistic showed (marginally significant) faster reading times for cognates than for controls in low-constraint sentences [FFD: t = 1.81, p = .07; GD: t = 1.69, p = .10; RPD: t = 1.92, p = .06] and significant cognate facilitation in high-constraint sentences [FFD: t = 2.52, p < .05; GD: t = 2.66, p < .05; RPD: t = 2.36, p < .05]. Results on skipping yielded more word skipping on cognates than on controls in both low-constraint [z = 2.43, p < .05] and high-constraint sentences [z = 2.11, p < .05].

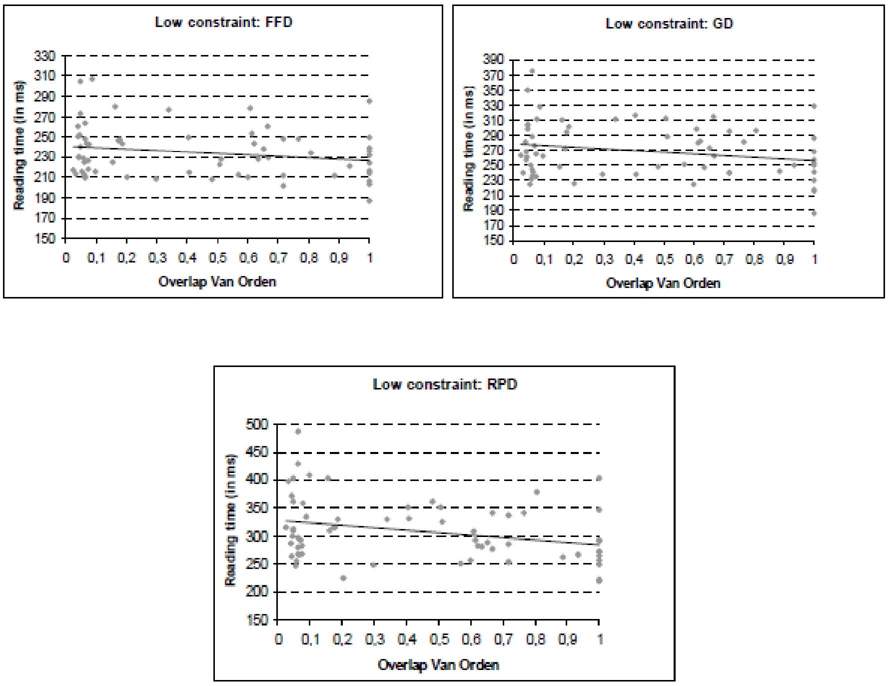
Orthographic overlap (Van Orden). Analyses on this continuous measure of cognate status showed no significant interaction of Overlap and Constraint on FFD, GD, and RPD [all Fs < 1], and so we tested a model without the interaction. This showed faster reading times for words with more cross-lingual orthographic overlap [FFD: $F(1,3311)$ = 5.17, p < .05; GD: $F(1,3311)$ = 5.52, p < .01; RPD: $F(1,3311)$ = 7.92, p < .01]. As in the previous model including the factor Word type, we observed significant effects of Constraint [all ps < .001] and Prior fixation distance [all ps < .001] on all three reading time measures. The effect of Frequency was significant for FFD [p < .05] and GD [p < .01], but not for RPD [p = .10].

In the analyses on skipping percentages, we first removed the nonsignificant interaction between Overlap and Constraint from the model [z < 1]. The model was tested again and showed that words with higher degrees of cross-lingual overlap were skipped more often [z = 2.49, p < .05]. Similar to the previous analyses on Word type, the results yielded significant effects of Constraint [p < .001], Prior fixation distance [ps < .001], and a marginally significant effect of Frequency [p = .08].

Separate contrasts showed significant facilitation for words with increasing orthographic overlap in low-constraint [FFD: t = 1.82, p = .07; GD: t = 2.34, p < .05; RPD: t = 2.91, p < .01] and high-constraint sentences

[FFD: $t = 2.33$, $p < .05$; GD: $t = 2.45$, $p < .05$; RPD: $t = 2.50$, $p < .05$]. Results on skipping percentages showed significant effects of Overlap in low-constraint sentences [$z = 2.22$, $p < .05$], but not in high-constraint sentences [$z = 1.56$, $p = .12$]. Graphs of these effects on reading times and skipping rates are presented in Figures 2 and 3, respectively.

Figure 2. Graphs depicting the decrease in First fixation duration (FFD), Gaze duration (GD) and Regression path duration (RPD) as a function of cross-lingual overlap on mean target reading times in low- and high-constraint sentences in Experiment 1. The straight line represents the best linear fit.



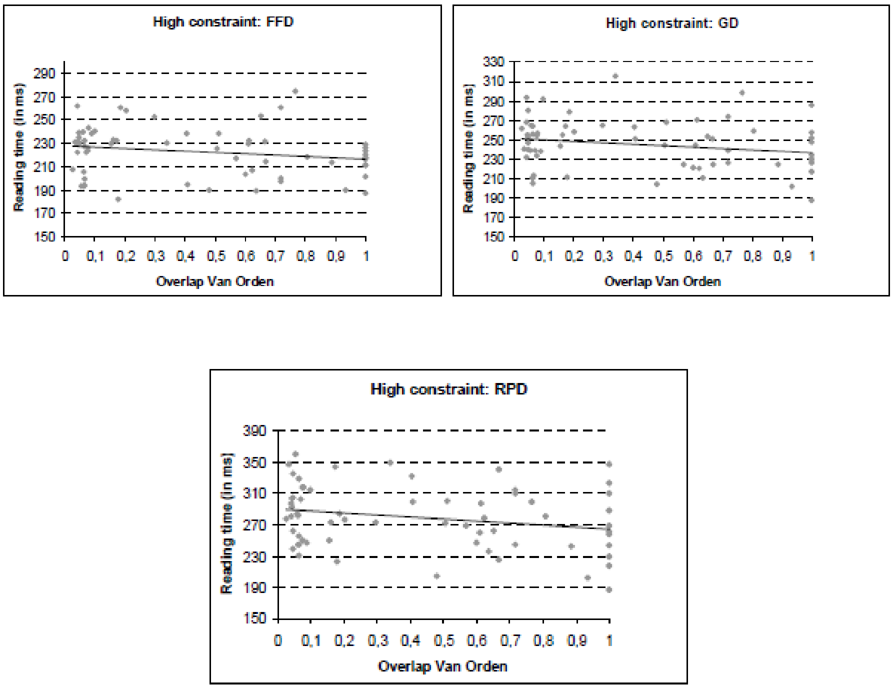
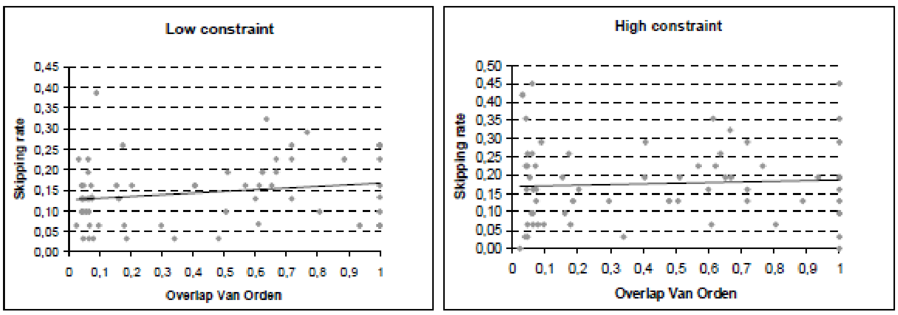


Figure 3. Graphs depicting the increase in skipping rate as a function of cross-lingual overlap on mean target skipping rates in low- and high-constraint sentences in Experiment 1. The straight line represents the best linear fit.



Orthographic and phonological overlap (ratings). The results of this continuous measure of cognate status showed no significant interaction of Overlap and Constraint [all *F*s < 1]. Consequently, this interaction was removed from the model and the model was tested again. Target words were processed faster with increasing cross-lingual overlap on all three reading time measures [FFD: $F(1,3311) = 5.44$, $p < .01$; GD: $F(1,3311) = 5.97$, $p < .01$; RPD: $F(1,3311) = 6.11$, $p < .01$]. As in the analyses on Word type and Overlap defined by Van Orden's (1987) measure, we observed significant effects of Constraint [all *p*s < .001] and Prior fixation distance [all *p*s < .001] on FFD, GD, and RPD. The effect of Frequency was significant for FFD and GD [*p*s < .05], but not for RPD [$p = .12$].

After removing the nonsignificant interaction of Overlap and Constraint from the skipping analysis, the results showed that target words were more likely to be skipped if they had higher degrees of orthographic and phonological overlap [$z = 3.53$, $p < .001$]. Furthermore, skipping increased for words with more cross-lingual overlap [$z = 3.65$, $p < .001$]. We observed significant effects of Prior fixation distance [*p*s < .001] and no significant effect of Frequency [$z = 1.66$, $p = .10$].

We tested contrasts to check if the effect of Overlap was significant in both low- and high-constraint sentences. In general, there were significant effects of Overlap in both low-constraint [FFD: $t = 1.62$, $p = .10$; GD: $t = 2.22$, $p < .05$; RPD: $t = 2.61$, $p < .05$] and high-constraint sentences [FFD: $t = 2.52$, $p < .05$; GD: $t = 2.57$, $p < .05$; RPD: $t = 2.17$, $p < .05$], although the effect of FFD in low-constraint sentences did not reach significance. Significantly more skipping was observed with increasing cross-lingual overlap in low-constraint [$z = 2.82$, $p < .01$] and high-constraint sentences [$z = 2.51$, $p < .05$].

DISCUSSION

In contrast to the results of studies using lexical decision or naming, which observed no cognate effects in high-constraint sentences (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008), the present eyetracking experiment clearly showed a cognate facilitation effect in high-constraint sentences. Cognate effects were not modulated by sentence constraint and this was shown in three separate analyses, each using a different measure of cognate status. The first analysis tested the discrete effect of cognates vs. controls (cf. the analyses in Schwartz & Kroll, 2006; van Hell & de Groot, 2008). Reading times on FFD, GD, and RPD were faster for cognates than for controls, both in low- and high-constraint sentences. Also, cognates were skipped more often than controls, and this effect occurred in both low- and high-constraint sentences.[5]

The second analysis examined whether cognate facilitation is a continuous process, based on the degree of cross-lingual orthographic overlap. To this end, each cognate and control received an orthographic overlap score based on Van Orden's (1987) word similarity measure. Based on models that assume a similar representation for cognates and noncognates with varying degrees of orthographic, phonological, and semantic overlap (e.g., Dijkstra & van Heuven, 2002; Thomas & van Heuven, 2005), we predicted faster reading times for words with higher degrees of cross-lingual overlap. The results showed that this was indeed the case: word reading was faster as cross-lingual overlap of the targets increased. This was true for FFD, GD, and RPD in both low- and high-constraint sentences. Skipping percentages were higher with increased cross-lingual overlap, but only in low-constraint sentences.

[5] Traditional repeated measures analyses of variance (ANOVAs) on the discrete manipulation of cognate status (cognate vs. control) showed similar results. The results of these analyses are presented in Appendix C.

The third analysis tested the continuous effect of combined phonological and orthographic overlap based on ratings of each target and its translation equivalent. Although this continuous effect failed to reach significance on FFD in low-constraint sentences, it was significant on FFD in high-constraint sentences and on GD, RPD, and skipping, in both low- and high-constraint sentences.

To summarize, clear-cut cognate facilitation effects were observed in semantically constraining sentences using discrete and continuous measures of cognate status and this has important repercussions for the conceptualization of the influence of semantic constraint on lexical access in bilinguals. Specifically, the results indicate that there is only a limited influence of semantic constraint because the semantic constraint imposed by a sentence did not nullify cross-lingual interaction effects in lexical access. Experiment 2 tested the same stimuli in a group of participants who had no knowledge of Dutch, and so should not be influenced by cognate status.

EXPERIMENT 2: ENGLISH MONOLINGUALS

A monolingual control experiment was carried out to ensure that the observed cognate effects were indeed due to non-target language activation, and thus to the bilingual nature of the participants. Although we carefully controlled our stimulus materials, it cannot be completely excluded with absolute certainty that other factors inherent to the materials that were not taken into account may have influenced the results. For this reason, an eyetracking experiment was run with a group of English monolinguals who had no knowledge of Dutch. They saw the same low- and high-constraint cognate and noncognate sentences as the bilinguals. If the observed cognate facilitation in low- and high-constraint sentences is a result of cross-lingual interactions in the bilingual lexicon, this effect should disappear for participants without knowledge of Dutch.

METHOD

Participants. Twenty-four members of the University of Massachusetts community participated. All were native speakers of English and indicated that they did not have any knowledge of the Dutch language or any exposure to the Dutch language worth mentioning. The participants had normal or corrected-to-normal vision and were either paid or were given course credits to participate in the experiment.

Stimulus materials, Apparatus, and Procedure. The materials and procedure were identical to those used in Experiment 1, and the apparatus was comparable to that used in Experiment 1. Accuracy on the comprehension questions was 97%.

RESULTS

We excluded 1.1% of the trials on the basis of the same criteria that were used in Experiment 1. Mixed-effects models were fit to the four dependent eye movement measures and the same variables were included. Analyses were run on the 32 cognate-noncognate pairs included in the analyses of the previous experiment. Participants and items were included as random effects for analyses on FFD, GD, and RPD and random slopes regarding the constraint factor for items in the analyses on skipping rate.[6]

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[6] Model comparisons showed that the estimated variance-covariance for the factor 'items' in the analyses on FFD, GD, and RPD was singular. Therefore, random slopes regarding the factor Constraint were not included in these analyses. Including random slopes regarding the factor Constraint for items did improve the fit of the model for skipping rates in the discrete and continuous analyses (χ^2s > 7.26, *p*s < .05).

After calculation of the skipping percentages on the target word, we removed the trials in which the target was skipped (26.4% of the trials) from the analyses of FFD, GD, and RPD. We log-transformed the reading times on FFD, GD, and RPD to reduce the skew in the distribution. We will first report the analyses on the discrete variable Word type (cognate vs. control). Then, we present the analyses on the continuous variable Overlap defined by Van Orden's (1987) measure. Finally, we report the analyses on Overlap defined by the combined orthographic and phonological ratings.

Word type (cognate vs. control). After removing the nonsignificant interaction of Word type and Constraint [all *F*s < 1] from the model, results showed a main effect of Constraint for FFD, GD, RPD [all *p*s < .001], and skipping percentages [$z = 1.79$, $p = .07$], just as in the bilingual experiment. Target words in high-constraint sentences (FFD $M = 210$; GD $M = 224$; RPD $M = 260$; skip $M = 29.8$) were read faster and were skipped more often than in low-constraint sentences (FFD $M = 222$; GD $M = 240$; RPD $M = 294$; skip $M = 23.1$). However, in these monolinguals, there was no main effect of Word type on FFD, GD, RPD [all *F*s < 1] and skipping [$z < 1$]. As in the bilinguals, there were non-linear effects of Prior fixation distance on all dependent measures [all *p*s < .001]. The effect of Frequency was not significant[7] [all *F*s < 2.50, all *p*s > .12; $z = 1.18$, $p = .23$]. Contrasts yielded no significant effect of Word type tested in low- [all *t*s < 1; $z < 1$] and high-constraint sentences [all *t*s < 1; $z < 1$]. Means are presented in Table 5.

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[7] In contrast to Experiment 1, there was no frequency effect. Although this may appear surprising, it is important to note that the present study tested only a very limited range of frequency (see Appendix A). It is likely that this range was insufficient to yield an L1 frequency effect in monolinguals, but sufficient to create such an L2 frequency effect in bilinguals. Indeed a recent lexical decision study by Duyck, Desmet, Vanderelst, and Hartsuiker (2008), also using Dutch-English bilinguals and a monolingual American control group, showed that the word frequency effect is about twice as large when reading in a second language compared to when reading in the native language (for similar results, see Gollan, Montoya, Cera, & Sandoval, 2008).

Table 5. First fixation duration (FFD), Gaze duration (GD), Regression path duration (RPD) and skipping percentages on the target word in Experiment 2

Constraint	Word type	FFD	GD	RPD	Skipping
Low	Cognate	224 (71)	242 (96)	303 (196)	23.7 (42.6)
	Control	221 (64)	238 (93)	286 (158)	23.7 (42.6)
Effect		*-3*	*-4*	*-17*	*0*
High	Cognate	210 (62)	223 (81)	263 (172)	28.5 (45.2)
	Control	210 (55)	226 (71)	257 (170)	30.3 (46.0)
Effect		*0*	*3*	*-6*	*1.8*

Note. Standard deviations are indicated in parentheses.

Orthographic overlap (Van Orden). The nonsignificant interaction of Overlap and Constraint was removed from the model and the model was tested again. Results showed no main effect of Overlap on FFD, GD, RPD [all Fs < 1], and skipping [$z < 1$] and no effect in both low-constraint [all ts < 1; $z < 1$] and high-constraint sentences [all ts < 1; $z < 1$]. As in the analyses on Word type, there were significant effects of Constraint [all ps < .001] and Prior fixation distance [all ps < .05]. The effect of Frequency was not significant [all Fs < 2.50, ps > .12; $z = 1.16$, $p = .25$].

Orthographic and phonological overlap (ratings). After removing the nonsignificant interaction of Overlap and Constraint from the model, results showed no main effect of Overlap on FFD, GD, RPD [all Fs < 1], and skipping [$z < 1$] and no effect in both low-constraint [all ts < 1; $z < 1$] and high-constraint sentences [all ts < 1; $z < 1$]. As in the bilingual experiment, there were significant effects of Constraint [all ps < .01] and Prior fixation distance [all ps < .05]. The effect of Frequency was not significant [all Fs < 2.57, ps > .11; $z =1.15$, $p = .25$].

DISCUSSION

Monolingual English readers with no knowledge of Dutch read the cognate and noncognate words equally fast, even though exactly the same materials were presented as in the previous experiment with bilinguals. Consistent with other studies, and similar to Experiment 1, there was a highly significant effect of constraint on all eye-movement measures. This demonstrates that the current control experiment had sufficient power to detect significant effects on each of these measures. More importantly, the absence of cognate facilitation in this monolingual group shows that the cognate effects in Experiment 1 indeed resulted from lexical activations in the Dutch language when bilinguals read English sentences.

GENERAL DISCUSSION

In the present study, we examined how a semantic context modulates lexical activation transfer between languages in the bilingual lexicon. In Experiment 1, cognates and controls were presented in low- and high-constraint sentences while eye movements were monitored. As expected, we observed main effects of semantic constraint, demonstrating that our constraint manipulation was effective. More importantly, the results revealed clear cognate facilitation effects in both low- and high-constraint sentences. These effects were shown in three different analyses on (a) the discrete effect of cognate status (cognate vs. control), (b) the continuous effect of orthographic overlap between translation equivalents (Van Orden, 1987), and (c) the continuous effect of orthographic and phonological overlap between translation equivalents (ratings). Cognates were read faster than controls in both low- and high-constraint sentences on FFD, GD, and RPD. Also, cognates were skipped more often than controls. The continuous analyses based on Van Orden's (1987) orthographic overlap measure showed that this cognate facilitation was a continuous and gradual effect: reading times were faster for words with more cross-lingual orthographic overlap on FFD, GD, and RPD, in both low- and high-constraint sentences. The continuous effect on skipping rates was significant in low-constraint sentences only. The other continuous analyses on the combined orthographic and phonological ratings yielded shorter reading times with increasing overlap on GD, RPD, and skipping rates, in both low- and high-constraint sentences. Results on FFD were only significant for high-constraint sentences, although there was a clear trend in the low-constraint sentences. In sum, the analyses convincingly show the existence of discrete and continuous cognate facilitation on several early (skipping, FFD, GD) and late reading time measures (RPD) in both low- *and* high-constraint sentences.

Our interpretation is corroborated by a control experiment with English monolinguals (Experiment 2) in which no cognate effects were observed for any reading time measure, even though this experiment again showed the same main effect of our sentence constraint manipulation. We therefore conclude that cognate facilitation in the bilinguals partaking in Experiment 1 is indeed due to their knowledge of Dutch and cannot be due to confounds in stimulus selection.

The pattern of results for high-constraint sentences is very different from earlier studies on cognate processing in semantically constraining sentences (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008). For instance, van Hell and de Groot (2008) obtained no cognate facilitation in a lexical decision task for targets that were primed by a high-constraint sentence context (e.g., *The best cabin of the ship belongs to the* ---; target *captain*). Similarly, Schwartz and Kroll (2006) presented sentences word by word using rapid serial visual presentation. They observed no cognate facilitation on target naming times in high-constraint sentences. The differences between the current study and previous studies might be a result of the different methodology used. As mentioned in the introductory section, reading within a fixed time window (e.g., using rapid serial visual presentation) might allow more time for the participant to anticipate the expected word compared to when reading at their own pace. Being able to anticipate the expected word in high-constraint sentences may therefore mask cross-lingual interactions during lexical access. Also, lexical decision tasks may involve decision-making strategies or postlexical checking strategies and naming tasks require extra processing time for pronouncing the target. It is possible that these processes might disguise the actual effects reflecting lexical interactions. We therefore argue that the eyetracking method may be more suitable to capture early lexical interactions in both languages and our results show that the use of this method can indeed lead to very different results.

As opposed to the results for high-constraint sentences, the pattern for low-constraint sentences is in agreement with the few earlier studies on bilingual word processing discussed in the above. Schwartz and Kroll (2006) and van Hell and de Groot (2008) found that the mere presence of a sentence context did not modulate cross-lingual interactions because cognate facilitation was observed in low-constraint sentences. In a more natural reading task without the need of an overt response (as in lexical decision or naming), Duyck et al. (2007) also reported cognate facilitation in low-constraint sentences for identical cognates (e.g., *ring – ring*), but not for nonidentical cognates (e.g., *schip – ship*). This result highlights the importance of cross-lingual overlap. Our current study provides an important extension of Duyck et al. in at least two ways. First, as Duyck et al. only tested low-constraint sentences, this is the first eyetracking study to investigate semantic constraint on bilingual lexical access in within-language sentences. As such, the present findings allow generalizing their claim of nonselective lexical access in bilingual reading to highly semantically constrained sentences. Second, fine-tuning the dichotomous manipulation of cross-lingual overlap of Duyck et al. (identical vs. nonidentical cognates) by including a continuous measure reveals that there is probably not a strict qualitative difference between cognate effects of identical and nonidentical translation equivalent pairs. Instead, we show that cognate facilitation increases as a gradual and continuous function of cross-lingual overlap.

The present new findings of cognate effects in high-constraint sentences have a number of theoretical implications. First, the results show that a strong (high-constraint) semantic context does not necessarily affect lexical access in the bilingual language system. It seems that the presentation of a semantic context effectively restricts conceptual information, as shown by the main effects of semantic constraint, but does not reduce the nonselective activation of lexical entries. This indicates that the bilingual language system is profoundly nonselective with a limited influence of top-down semantic restrictions on lexical activations. Second, the gradual and continuous cognate effects we observed provide new insights in the representation of cognates. Some models propose a similar representation for cognates and noncognates, with varying degrees of orthographic, phonological, and semantic overlap (e.g., Dijkstra & van Heuven, 2002; Thomas & van Heuven, 2005; van Hell & de Groot, 1998), while others assume qualitatively different representations for cognates and noncognates (e.g., de Groot & Nas, 1991; Sánchez-Casas & García-Albea, 2005). The finding of continuous effects of cross-lingual overlap is more in line with the former group of models than with the latter, as there is no reason to expect graded effects of cognate status if cognates are assumed to have qualitatively different representations from noncognates. Also, finding graded effects of cognate status is important for further modeling of the bilingual lexicon. Within the logic of interactive activation models of visual word recognition (e.g., the BIA+ model of Dijkstra and van Heuven, 2002), the cognate effect, originating from activation spreading between lexical representations, should indeed be a function of the degree of similarity (overlap) of lexical representations.

Finally, the results of the present study have important implications for the future development of models of bilingual language processing. We discuss this in the context of the BIA+ model (Dijkstra & van Heuven, 2002). With regard to linguistic context effects, Dijkstra and van Heuven propose that the word identification system is part of a much larger Language User system that also includes sentence parsing and language production. They suggest that linguistic context information may exert constraints on the degree of cross-lingual activation transfer. Indeed, the modulation of cognate effects in high-constraint sentences in previous studies (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008) is typically explained by assuming that a high-constraint sentence activates a set of semantic (cf. Schwanenflugel & LaCount, 1988) and lexical restrictions and thereby reduces the number of lexical candidates (see also Altarriba et al., 1996). However, the present results show that even a very strong semantic context does not necessarily eliminate cross-lingual activation effects, if a sensitive measure of natural reading is used. Therefore, the present findings constrain the importance of top-down influences of semantic activation on lexical access in future developments of the BIA+ model.

In conclusion, the present study on natural reading in semantically constraining sentences provides important new insights in the bilingual language system. Contrary to previous studies, we obtained cognate facilitation effects in high-constraint sentences. Moreover, cognate facilitation was shown to be a continuous effect as larger degrees of cross-lingual overlap speeded up word recognition. The results offer strong evidence for a bilingual language system that is profoundly nonselective, and with a limited role for top-down effects arising from semantic context.

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APPENDIX A

Dutch-English target words of Experiments 1 and 2

L2 cognate	Overlap Van Orden (1987)	Orth overlap rating	Phon overlap rating	Frequency[a]	L2 noncognate	Overlap Van Orden (1987)	Orth overlap rating	Phon overlap rating	Frequency[a]
book [boek]	0.72	5.16	6.52	2.62	face [gezicht]	0.06	1.00	1.14	2.79
bride [bruid]	0.60	4.37	4.38	1.11	scarf [sjaal]	0.34	2.11	1.67	1.11
captain [kapitein]	0.41	4.47	4.95	1.87	chicken [kip]	0.07	1.37	1.95	1.63
circle [cirkel]	0.61	4.89	5.57	1.90	church [kerk]	0.05	1.32	1.90	2.27
coffee [koffie]	0.48	3.89	6.62	1.97	bottle [fles]	0.18	1.00	1.00	2.11
dance [dans]	0.61	5.11	5.76	2.02	queen [koningin]	0.17	1.42	2.24	1.72
dream [droom]	0.62	5.11	4.76	2.09	cloud [wolk]	0.15	1.26	1.38	1.81
finger [vinger]	0.64	5.95	5.05	2.13	corner [hoek]	0.08	1.00	1.10	2.11
flag [vlag]	0.57	5.84	5.10	1.46	cage [kooi]	0.05	1.58	2.95	1.28
fruit [fruit]	1.00	7.00	5.14	1.85	knife [mes]	0.06	1.05	1.10	1.69
hair [haar]	0.67	5.00	4.71	2.32	size [maat]	0.20	1.00	1.00	2.11
hotel [hotel]	1.00	7.00	6.43	2.16	money [geld]	0.06	1.00	1.00	2.59
lip [lip]	1.00	7.00	7.00	1.92	law [wet]	0.09	1.37	1.10	2.33
model [model]	1.00	7.00	5.81	1.92	delay [vertraging]	0.05	1.05	1.10	1.65
nail [nagel]	0.67	3.16	3.14	1.49	tail [staart]	0.16	1.26	1.29	1.63
news [nieuws]	0.65	4.37	5.52	2.07	farm [boerderij]	0.03	1.00	1.00	1.99
nose [neus]	0.41	4.21	4.43	1.93	wife [vrouw]	0.06	1.74	1.67	2.41
pepper [peper]	0.94	5.68	4.67	1.08	shower [douche]	0.10	1.21	1.14	1.45
pilot [piloot]	0.89	5.68	5.29	1.43	habit [gewoonte]	0.04	1.05	1.19	1.81
police [politie]	0.72	4.68	4.14	2.34	secret [geheim]	0.07	1.58	1.00	2.05
ring [ring]	1.00	7.00	6.38	2.18	wing [vleugel]	0.04	1.11	1.10	1.80
school [school]	1.00	7.00	5.38	2.68	future [toekomst]	0.06	1.00	1.05	2.30
sheep [schaap]	0.51	4.42	4.29	1.62	witch [heks]	0.06	1.00	1.62	1.53
shoulder [schouder]	0.81	4.84	4.00	2.15	mountain [berg]	0.03	1.00	1.05	1.95
sock [sok]	0.77	5.47	6.29	1.30	duck [eend]	0.07	1.05	1.00	1.32
soup [soep]	0.72	5.05	6.38	1.32	frog [kikker]	0.05	1.00	1.05	0.95
sport [sport]	1.00	7.00	5.76	1.62	shark [haai]	0.19	1.37	1.14	1.32
station [station]	1.00	7.00	5.24	2.11	teacher [leraar]	0.30	1.28	1.10	2.17
storm [storm]	1.00	7.00	6.29	1.61	giant [reus]	0.04	1.05	1.00	1.67
student [student]	1.00	7.00	5.81	2.44	country [land]	0.05	1.00	1.00	2.75
thunder [donder]	0.51	3.21	3.95	1.23	witness [getuige]	0.08	1.00	1.00	1.70
tunnel [tunnel]	1.00	7.00	6.05	1.28	lawyer [advocaat]	0.05	1.00	1.05	1.72
MEAN	**0.77**	**5.55**	**5.34**	**1.85**	**MEAN**	**0.10**	**1.19**	**1.28**	**1.87**

Note. L1 (Dutch) translation equivalents are indicated in brackets. [a] Mean log frequency per million according to the CELEX lemma database (Baayen et al., 1993).

APPENDIX B

Sentence contexts of Experiments 1 and 2

Cognate / low-constraint	Control / low-constraint
1. He went to the shop to buy a **book** that he needed for school.	1. She did not want to look at her **face** while she was crying.
2. The person who is standing near Eveline is the **bride** in her white dress.	2. A present your mother likes very much is a **scarf** made of wool.
3. Someone who can tell you more about it is the **captain** and he has a huge responsibility.	3. The animal responsible for the funny noise was a **chicken** and we all had to laugh.
4. Your drawing will look much better when you draw this little **circle** with a sharp pencil.	4. Everyone is very quiet when the guide tells about the **church** in the city centre.
5. He wants to stop for moment because he wants to buy a pack of this **coffee** in the shop.	5. He wants to stop for a moment because he wants to buy a special type of **bottle** in this shop.
6. Ann has seen a popular **dance** in Belgium.	6. That proud lady is the most famous **queen** in Europe.
7. Her daughter goes to that therapist because he can analyze every **dream** she had.	7. The drawing is not yet finished because he is still working on the **cloud** in the sky.
8. The doctor disinfected the wound on his **finger** with some disinfectant.	8. The old chair used to stand in the **corner** until Marc threw it out.
9. If Els wants to participate in the tournament, she has to bring the famous **flag** in her suitcase.	9. If Eveline wants to see those animals, she has to find the special **cage** they are in.
10. If you are able to go to the supermarket, you have to buy a lot of **fruit** for me.	10. If you want to clean his desk, you have to be careful for the **knife** he uses to open letters.
11. He spilled wine on her **hair** but he cleaned it up in a few seconds.	11. Fanny realized that she had chosen the wrong **size** but she couldn't return the dress to the store anymore.
12. When they are in Brussels, they always pass by a beautiful **hotel** with an impressive pool.	12. When John entered the room, he saw some **money** lying on the floor.
13. Kate removed the blood on her swollen **lip** after the game.	13. Politicians of the new party are talking about a **law** for their country.

14. Her sister tried becoming a successful **model** in many different ways.	14. Her colleague has told her about the long **delay** at that administration.
15. Her mother asked Lisa to fix the broken **nail** on her left foot.	15. Her mother completed the carnival costume by adding a small **tail** to it.
16. My husband always tapes the **news** in the evening.	16. My friend did not pay much for this **farm** in the south of France.
17. My girlfriend hates her **nose** and wants to have it changed.	17. Our new friend talked to his **wife** and told her the whole story.
18. It would taste even better, if you added some extra tomatoes and **pepper** to the meal.	18. We could place the order, if you could decide on a **shower** for the bathroom.
19. The man sitting over there is a **pilot** and is admired a lot.	19. This visit has become a **habit** and is much appreciated.
20. If you like to have a job nearby, you can join the **police** in our village.	20. If you see your boss next week, you have to tell him about the **secret** very carefully.
21. Olivia's mother surprised her with a beautiful **ring** from the jeweler.	21. The new vet cannot take care of the wounded **wing** on the bird's left side.
22. If Michael wants to know more about this topic, he has to go to **school** this weekend.	22. If you meet this man next week, you will be able to talk about the **future** of the company.
23. The animal she sees standing in the sand is a **sheep** living on that farm.	23. The girl standing in front of the class painted a **witch** on this canvas.
24. She wanted to help the victim of the crash and disinfected the wound on his **shoulder** very carefully.	24. The painter wanted to work at his own pace and painted the view on the **mountain** very precise.
25. After the crime, they looked for a hat and a **sock** to identify the poor victim.	25. When Gary was young, he kept a rabbit and a **duck** in his room.
26. A hot dish which mother likes is **soup** or consommé.	26. A small animal that lives in a garden is a **frog** or a toad.
27. Kelly has never seen that type of **sport** in Canada.	27. The group was surprised by a large **shark** in the sea.
28. My friend sometimes arrives too late at the **station** in Brussels.	28. The new group always sings a song for the **teacher** on an excursion.
29. The friendly boy and his girlfriend are telling about the **storm** of last year.	29. The boy who is standing over there is called the **giant** of his class.
30. The man who you just met was a **student** at that university.	30. Ben visited the beautiful **country** which attracts many tourists.
31. When she was standing outside, she could see the house and hear the **thunder** in the air.	31. If Maria arrives on time, we will contact the **witness** and bring him here.
32. The girl carrying the heavy bags	32. The woman who lives near you just

approached the **tunnel** and was scared to go in it.	contacted a **lawyer** and told him the whole story.

Cognate / high-constraint	Control / high-constraint
1. He went to the library to get a **book** that he needed for school.	1. She could tell from the look on his **face** that he was very mad.
2. The person who wears a white dress on her wedding day is usually the **bride** and nobody else.	2. Something to wear around your neck to keep warm is a **scarf** made of wool.
3. The person who is on charge on a ship is the **captain** and he has a huge responsibility.	3. The animal that lays eggs for our consumption is a **chicken** and it usually lives on a farm.
4. You can tell it is a full moon when its shape forms a perfect **circle** without any imperfections.	4. Everyone has to be quiet when the priest says prayers in his **church** at the altar.
5. He is not quite awake yet because he still needs to drink a cup of black **coffee** this morning.	5. He does not want a glass because he wants to drink out of the **bottle** this evening.
6. Salsa has become a popular **dance** in Belgium.	6. Elizabeth II of Great-Britain is the most famous **queen** in Europe.
7. Her daughter woke up screaming because she had a bad **dream** that night.	7. The sun is no longer shining because it disappeared behind a big **cloud** in the sky.
8. The happy bride put the ring on the **finger** of her husband.	8. The naughty child has to stand in the **corner** of the living room.
9. If Justine Henin wins in the Olympics, she gets to carry the Belgian **flag** around the stadium.	9. If Eveline wants to free the canary birds, she has to open the iron **cage** they are in.
10. If you want to stay in good health, you have to eat 5 pieces of **fruit** every day.	10. If you want to cut your meat, you have to take a **knife** from the drawer.
11. The exotic dancer wears a rose in her blonde **hair** but she will remove it later.	11. Fanny asks for the blue shoes in a larger **size** but the store no longer has them.
12. When they are on a holiday, they always sleep in a luxurious **hotel** with a beautiful pool.	12. When they win the lottery, the will have plenty of **money** for buying a house.
13. Kate stuck a moustache on her upper **lip** for Halloween.	13. Breaking and entering into a house is against the **law** in every country.
14. Naomi Campbell is a very famous	14. The train has been announced with a

model all over the world.	5 minutes **delay** in the station.
15. She goes to the manicurist to fix the broken **nail** on her left hand.	15. The cow chases insects away by moving her long **tail** from left to right.
16. My husband always watches the seven o'clock **news** in the evening.	16. My uncle has more than a hundred cows on his organic **farm** in the south of France.
17. Every person smells with his **nose** and listens with his ears.	17. The unfaithful man cheated on his **wife** and had absolutely no regrets.
18. It would taste even better, if you added some extra salt and **pepper** to the meal.	18. It would be a lot easier, if you choose between a bath and a **shower** right now.
19. Someone who flies a plane is called a **pilot** and is admired a lot.	19. Something you do regularly is a **habit** and everyone has them.
20. If you see a robbery in the street, you have to call the **police** on this number.	20. If someone tells you confidential information, you have to keep this a **secret** very carefully.
21. Olivia's boyfriend proposed to her with an expensive **ring** from the jeweler.	21. The poor bird cannot fly away with its broken **wing** on its left side.
22. If a child wants to learn how to read and write, it has to go to **school** every day of the week.	22. If you dream about events that will happen, you are able to look into the **future** of your life.
23. The animal that is shaved for its wool is a **sheep** living on a farm.	23. A woman flying on a broom at night is a **witch** to most people.
24. He wanted to attract the attention of the blind man and tapped gently on the man's left **shoulder** with his finger.	24. The alpinist wanted to climb at his own pace and reached the top of the **mountain** around noon.
25. On each foot, we usually wear a shoe and a **sock** to keep our feet warm.	25. When Gary was young, he always confused a goose and a **duck** when naming animals.
26. A hot first course that is eaten with a spoon is **soup** or consommé.	26. A green animal that jumps around in a pond is a **frog** or a toad.
27. Volleyball has always been the favorite **sport** of Sandra and her sister.	27. The surfers were attacked by a dangerous **shark** in the sea.
28. That train always arrives on time at the **station** in Brussels.	28. All the children walk in line behind the **teacher** on excursions.
29. A weather condition with lots of wind and rain is called a **storm** in our language.	29. A person who is extremely tall is called a **giant** in our language.
30. A person enrolled in university is a **student** of that university.	30. France is a beautiful **country** that attracts many tourists.
31. When is storms outside, you can see the lightning and hear the **thunder** in the air.	31. When you see a crime happening, you are a **witness** and you can provide information.
32. An underground passageway for car	32. The person who defends you in

traffic is called a **tunnel** and can be very long.	court is called a **lawyer** and has to be tough.

Note. Target words are printed in bold.

APPENDIX C

		FFD	GD	RPD	Skipping
Main effects	Word type	$F_1 = 16.80, p < .001$	$F_1 = 10.65, p < .01$	$F_1 = 8.17, p < .01$	$F_1 = 10.91, p < .01$
		$F_2 = 5.07, p < .05$	$F_2 = 3.49, p = .07$	$F_2 = 4.11, p = .05$	$F_2 = 5.82, p < .05$
		Min$F' = 3.89, p = .05$	Min$F' = 3.63, p = .11$	Min$F' = 2.73, p = .10$	Min$F' = 3.80, p = .06$
	Constraint	$F_1 = 33.63, p < .001$	$F_1 = 47.39, p < .001$	$F_1 = 26.87, p < .001$	$F_1 = 4.78, p < .05$
		$F_2 = 15.82, p < .001$	$F_2 = 33.47, p < .001$	$F_2 = 16.38, p < .001$	$F_2 = 8.34, p < .01$
		Min$F' = 10.76, p < .01$	Min$F' = 19.62, p < .001$	Min$F' = 10.78, p < .01$	Min$F' = 3.04, p = .09$
Interaction	Word type	$F_1 < 1$	$F_1 < 1$	$F_1 < 1$	$F_1 < 1$
	*	$F_2 < 1$	$F_2 < 1$	$F_2 < 1$	$F_2 < 1$
	Constraint	Min$F' < 1$	Min$F' < 1$	Min $F' < 1$	Min $F' < 1$
Planned	Word type /	$F_1 = 7.66, p < .01$	$F_1 = 4.18, p < .05$	$F_1 = 4.06, p < .05$	$F_1 = 8.99, p < .01$
comparisons	low	$F_2 = 2.47, p = .13$	$F_2 = 1.63, p = .21$	$F_2 = 2.60, p = .12$	$F_2 = 7.65, p < .01$
	constraint	Min$F' = 1.87, p = .18$	Min$F' = 1.17, p = .28$	Min$F' = 1.58, p = .21$	Min$F' = 4.13, p < .05$
	Word type /	$F_1 = 11.31, p < .01$	$F_1 = 6.68, p < .05$	$F_1 = 5.96, p < .05$	$F_1 = 3.13, p = .08$
	high	$F_2 = 3.58, p = .07$	$F_2 = 3.34, p = .08$	$F_2 = 2.77, p = .11$	$F_2 = 1.82, p = .19$
	constraint	Min$F' = 2.72, p = .11$	Min$F' = 2.23, p = .14$	Min$F' = 1.89, p = .17$	Min $F' = 1.15, p = .29$

CHAPTER 6
SEMANTIC CONSTRAINT EFFECTS ON BILINGUAL LEXICAL ACCESS IN NATIVE-LANGUAGE SENTENCE READING[1]

Recent studies on bilingual visual word recognition have shown that lexical access is not selective when processing native-language words out-of-context, and even in sentences. The present study investigated whether semantic information provided by sentences modulates this language-nonselective activation. In Experiment 1, Dutch-English bilinguals performed a Dutch lexical decision task on cognates and control words. In Experiment 2, we recorded eye movements while they read cognates and controls in low and high semantically constrained sentences in their first language. The results showed no cognate effects in both low and high constraint sentences, although cross-lingual interaction effects in native-language, low constraint sentences have been found in an earlier study. Possible explanations of the results are provided which indicate that cross-lingual activation effects in L1 may be very sensitive to stimulus and participant characteristics.

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[1] This paper was co-authored by Wouter Duyck and Robert Hartsuiker.

INTRODUCTION

In the last decade, evidence has accumulated for the view that a bilingual is not just the sum of two monolinguals (Grosjean, 1989), but rather a person who has developed a different language system from that of monolinguals. For instance, a lot of studies on visual word recognition (e.g., Brysbaert, Van Dyck, & Van de Poel, 1999; Dijkstra, Grainger & van Heuven, 1999; Duyck, 2005), word production (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Kroll, Bobb, & Wodniecka, 2006) and auditory word recognition (e.g., Blumenfeld & Marian, 2007; Marian, Blumenfeld, & Boukrina, 2008) have shown that the lexical representations of the native language (L1) become activated and influence word processing in the second language (L2). It has even been shown that L2 representations become activated and influence word processing in purely native-language contexts (e.g., Duyck, 2005; Van Assche, Duyck, Hartsuiker, & Diependaele, in press; van Hell & Dijkstra, 2002; Van Wijnendaele & Brysbaert, 2002). Most of these studies however, are concerned with word processing out-of-context. Therefore, in the present study on native-language (L1) visual word recognition, we investigated whether these cross-lingual interaction effects are modulated by the presence of a sentence context and by the semantic constraint imposed by the sentence. Before we turn to this research question, we discuss some studies that provide evidence for the activation of L2 representations when processing L1 words. Next, we present an overview of earlier studies that have investigated how the presentation of words in a sentence context might modulate cross-lingual activations.

BILINGUAL WORD RECOGNITION IN L1

In bilingual research, a consensus has been reached that representations in the native language become activated and influence word recognition in the second language (e.g., Costa et al., 2000; Dijkstra et al., 1999; Duyck, 2005; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Jared & Kroll, 2001; Schwartz, Kroll, & Diaz, 2007). More interesting for the current study however, is the fact that these cross-lingual activations even occur when bilinguals are reading in their native and dominant language (e.g., Bijeljac-Babic, Biardeau, & Grainger, 1997; Dijkstra, Timmermans, & Schriefers, 2000; Duyck, 2005; Van Assche et al., in press; Spivey & Marian, 1999; van Hell & Dijkstra, 2002; Van Heuven, Dijkstra, & Grainger, 1998; Van Wijnendaele & Brysbaert, 2002). For instance, Bijeljac-Babic et al. (1997) showed that L2 word neighbours presented as primes inhibited target word recognition in the L1 for highly proficient French-English bilinguals. Similarly, van Heuven et al. (1998) demonstrated that the recognition of L1 target words is affected by the number of L2 orthographic neighbours. Although effects were stronger for L2 targets than for L1 targets, the results clearly show that even when performing a task in the native language, there is language-nonselective activation of lexical representations. These cross-lingual interaction effects have not only been obtained with respect to orthographic representations, but also with respect to phonological representations. For instance, Van Wijnendaele and Brysbaert (2002) showed that cross-lingual phonological priming is not only possible from L1 to L2, but also from L2 to L1 in French-Dutch bilinguals. Similar results were obtained by Duyck (2005) who showed faster recognition of L1 targets (e.g., *car*) when primed by L2 pseudohomophone primes of the target's translation (*outo*). However, some studies did not observe evidence for L2 phonological coding when performing a task in L1 (e.g., Duyck, 2005; Haigh & Jared, 2007; Jared & Kroll, 2001). For instance, Jared and Kroll (2001) examined whether the existence of word-body neighbours (e.g., the English word *bait* contains the word body *ait* which is pronounced differently when in appears in a French word such as *fait*) in the nontarget language influences word naming performance. They reported no effects of L2 phonology on L1 naming performance in the first block of the experiment. Effects of cross-lingual phonological activation were only reported for more fluent bilinguals after naming a block of L2 filler words, boosting L2 activation.

In the present study, we used cognate words (words with the same meaning in both languages and with full or partial form overlap across languages, e.g., Dutch-German, *dier – Tier*) to investigate cross-lingual lexical access when reading in the native language. Because cognates have a high degree of semantic, orthographic, and phonological overlap across languages, they are typically processed faster than noncognates, and they therefore provide a measure of the degree of cross-lingual activation. This cognate facilitation effect has been consistently found in many studies on visual word recognition in the L2 (Duyck et al., 2007; Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004; Lemhöfer; Dijkstra, & Michel, 2004; Schwartz & Kroll, 2006; van Hell & de Groot, 2008), and more importantly, in a few studies on L1 word recognition (e.g., Van Assche et al., in press; van Hell & Dijkstra, 2002). The study of van Hell and Dijkstra (2002) was the first to show that cognate facilitation effects can be obtained in an exclusively native-language context. They investigated the influence of L2 and L3 on reading in the L1. Two groups of Dutch-English-French bilinguals with low and high proficiency in French performed a Dutch lexical decision task. The critical stimuli were L1-L2 cognates and L1-L3 cognates. For both groups of bilinguals, results yielded faster lexical decisions for L1-L2 cognates than for matched noncognates. However, only the bilinguals who were highly proficient in French showed cognate facilitation for L1-L3 cognates. These results provide strong evidence for language-nonselective activation in the bilingual lexicon because the nondominant languages exert an influence on L1. A minimal proficiency in the nondominant language seems necessary however in order to obtain cognate effects.

An interpretation of the cognate effect can be given within the framework of an influential model of bilingual visual word recognition, the BIA+ model (Dijkstra & van Heuven, 2002). This predecessor of the original BIA model (Dijkstra & van Heuven, 1998) is a bilingual extension of the well-known Interactive Activation model of visual word recognition (McClelland & Rumelhart, 1981). The model includes an integrated lexicon for both languages and assumes language-nonselective lexical access to this bilingual lexicon. Upon the presentation of a word, orthographic, phonological, and semantic representations become activated in both languages depending on the overlap with the input word (bottom-up). The cross-lingual activation spreading of these three codes results in faster word recognition for cognates compared to noncognates. In the BIA+ model, a distinction is made between the word identification system (the bilingual lexicon) and the task/decision system. Linguistic context, arising from lexical, syntactic or semantic restrictions (e.g., a sentence context) is assumed to directly affect the word identification system. Nonlinguistic context (e.g., task instructions, task features, and participant's expectations) on the other hand, is assumed to affect the task/decision system. Within this architecture, although access to the word identification system is basically nonselective, under particular condition, word recognition may function in a language-selective way. Indeed, Dijkstra and van Heuven explicitly state that linguistic context information may restrict language-nonselective activation in bilinguals. Surprisingly, only a few recent studies have investigated cross-lingual activation in a sentence context, as most bilingual studies have used an isolated lexical decision task, a very popular paradigm to investigate word recognition. We discuss these few sentence studies in the next section.

BILINGUAL WORD RECOGNITION IN SENTENCES

In recent years, as many studies have documented language-nonselective activation for words out-of-context, questions have emerged on how the mere presentation of words in a sentence context and the semantic constraint it provides might influence this cross-lingual activation spreading. A few studies already investigated this issue for word processing in the L2 (e.g., Altarriba, Kroll, Sholl, & Rayner, 1996; Duyck et al., 2007; Elston-Güttler, Gunter & Kotz, 2005; Schwartz & Kroll, 2006; Van Assche, Drieghe, Duyck, & Hartsuiker, submitted; van Hell & de Groot, 2008), while, to our knowledge, only one study has investigated word processing in L1 sentences (Van Assche et al., in press). A study by Altarriba et al. (1996) suggests that the semantic context of a sentence may be used to restrict activation to words of only one language. They monitored Spanish-English bilinguals' eye movements while reading English low or high semantically constrained sentences. In one condition, the English target word was replaced by its Spanish translation. An example of a low- and high-constraint sentence in which the target word is presented in Spanish is *Mary and Jim wanted to ask the maestra* [teacher] *for help after class* and *He entered the classroom to ask the maestra* [teacher] *for help with his assignment* respectively. Surprisingly, the presentation of a high-frequency Spanish word in a high-constraint sentence yielded longer, and not shorter, reading times relative to the presentation of the same target in a low-constraint sentence. This was not the case for a low-frequency Spanish word, probably because lexical access of low-frequency words occurs more slowly, resulting in more processing time for resolving the conflict. Presenting the English target words yielded faster reading times in high-constraint sentences compared to low-constraint sentences, consistent with earlier monolingual demonstrations of sentence constraint effects in eyetracking research (e.g., Balota, Pollatsek, & Rayner, 1985; Rayner & Well, 1996). The results suggest that a high-constraint sentence not only generates semantic constraints for the upcoming words (*maestra* and *teacher* both met the conceptual restrictions of the sentence), but that it also generates lexical constraints, such as the language to which upcoming words are likely to belong.

The effect of semantic constraint has been explained by Schwanenflugel and LaCount (1988) in a feature restriction model. This model states that a high-constraint sentence generates more features for upcoming words than a low-constraint sentence. Reading will only be facilitated if the target word matches the features that were generated by the sentence context. In bilinguals, this would result in the activation of the same conceptual representations across languages, at least for concrete nouns (e.g., Kroll & de Groot, 1997; van Hell & de Groot, 1998). Altarriba et al. (1996) showed that bilinguals also generate specific lexical restrictions for upcoming words. This predicts that cognate processing should no longer be facilitated in high-constraint sentences because of the restricted activation of nontarget representations. After all, the generation of lexical restrictions works in the same way for cognates and noncognates. However, the discussion of bilingual sentence studies in the next paragraphs shows that this prediction has not unambiguously been confirmed.

Several studies have investigated the processing of cognates, as a marker of cross-lingual activation effects, in L2 sentence contexts (e.g., Duyck et al., 2007; Schwartz & Kroll, 2006; Van Assche et al., submitted; van Hell & de Groot, 2008). These studies converge on the conclusion that a low-constraint sentence, and the language cue it provides, does not modulate the bilingual word recognition process. However, mixed results have been obtained for cognate processing in semantically constrained sentences. In the study by Schwartz and Kroll (2006) with Spanish-English bilinguals, low- and high-constraint sentences were presented using rapid serial visual presentation. The target word (printed in red) had to be named out loud. Cognate facilitation was observed in low-constraint sentences, but not in high-constraint sentences. Similar results were obtained by van Hell and de Groot (2008). In this study, Dutch-English bilinguals performed an L2 lexical decision task or translated target words in forward (from L1 to L2) or in backward direction (from L2 to L1). In the lexical decision task, each sentence context was presented as a whole on the screen. The location of the target word was marked with three dashes (e.g., the high-constraint sentence

The best cabin of the ship belongs to the ---; target *captain*) and the target word was presented immediately after the sentence disappeared from the screen. In the translation tasks, sentence context were presented as a whole or using rapid serial visual presentation. After presentation of a low-constraint sentence, significant cognate facilitation was observed. However, after reading a high-constraint sentence, cognate effects were no longer present in the lexical decision task and much weaker in both translation tasks.

Evidence for the fact that the mere presentation of a word in an L2 sentence does not restrict activation spreading to representations of a single language in the bilingual lexicon has also been obtained in two studies using more sensitive measures such as eyetracking (e.g., Duyck et al., 2007; Van Assche et al., submitted). This method allows participants to read normally as in everyday life and does not require any overt responses (such as lexical decision or naming). Duyck et al. (2007) tested Dutch-English bilinguals while they read low-constraint sentences in which the cognate or its control were embedded (e.g., *Hilda bought a new RING / COAT and showed it to everyone*; *ring* is a cognate; *coat* is a control word). Cognate facilitation was observed on early reading time measures (such as first fixations), but only for identical cognates (i.e., cognates with identical orthographies across languages, e.g., *ring – ring*). It seems that when cross-lingual orthographic overlap was not complete, the sentence context was strong enough to counteract the cognate effect. Van Assche et al. (submitted) fine-tuned this distinction between identical and nonidentical cognates by calculating the degree of orthographic overlap on Van Orden's (1987) word similarity measure[2] for each cognate and control on a scale from 0 to 1 (e.g., English-

[2] Van Orden (1987, p. 196) defines graphemic similarity (GD) between two letter string as GS = 10([(50F + 30V + 10C)/A] + 5T + 27B + 18E) with F = number of pairs of adjacent letters in the same order, shared by pairs; V = number of pairs of adjacent letters in reverse

Dutch cognate *book* - *boek*: 0.72; control *face* - *gezicht*: 0.06). In low-constraint sentences, discrete cognate facilitation (cognate vs. control) was observed and this was shown to be a gradual and continuous effect: word recognition was negatively correlated with, and a linear function of cross-lingual orthographic overlap. Similar results were obtained with a measure which included both orthographic and phonological overlap. However, the main finding of Van Assche et al. was that significant cognate effects were also observed in high-constraint sentences, as opposed to the results of previous studies (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008). It seems that the use of the time-sensitive eyetracking measures uncovers the early interaction effects that were not observed in the naming task of Schwartz and Kroll (2006) or the lexical decision and translation tasks of van Hell and de Groot (2008).

As far as we know, only one study has investigated cross-lingual activation effects during the processing of native-language sentences. Van Hell and Dijkstra (2002) already provided strong evidence for language-nonselective lexical access by showing cognate facilitation for native-language words out-of-context. However, it was unclear how a linguistic context provided by a sentence may restrict this cross-lingual activation. Therefore, Van Assche et al. (in press) tested whether the presentation of target words in a sentence may influence the degree of cross-lingual activation in the two languages. To this end, we presented low constraint sentences that could include both the cognate and its control (e.g., *Ben heeft een oude OVEN / LADE gevonden tussen de rommel op zolder.* [*Ben found an old OVEN / DRAWER among the rubbish in the attic.*]; *oven* is a Dutch-

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order, shared by pairs; *C* = number of single letters shared by word pairs; *A* = average number of letters in two words; *T* = ratio of number of letters in the shorter word to the number or letters in the longer; *B* = if the first two letters are the same *B* = 1 else *B* = 0; *E* = if last two letters are the same *E* = 1 else *E* = 0. Then, Van Orden calculates Orthographic Similarity by determining the ratio between the GS of word 1 with itself and the GS of word 1 and word 2. For more details concerning this measure, we refer to Van Orden (1987).

English cognate; *lade* is a control word). In a main experiment and a replication that tested different sets of words, cognate facilitation was observed on early reading time measures, both as a discrete effect of cognates vs. controls and as a continuous facilitation effect of cross-lingual orthographic overlap. This implies that even when native-language processing is concerned, bilinguals are different from monolinguals: the mere knowledge of a second language affects a highly automated skill as sentence reading in the mother tongue. These findings provide strong evidence for language-nonselective activation in the bilingual lexicon. However, in order to determine the boundaries of these cross-lingual activation effects, it is necessary to investigate how semantic constraint effects influence cross-lingual activation spreading.

Van Assche et al.'s (submitted) eyetracking study already showed that, contrary to previous studies (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008), cognate facilitation can be observed in second-language high-constraint sentences. This means that the semantic constraint of a sentence cannot limit cross-lingual interactions in the L2. In the present study, we investigated whether the same conclusion holds for word recognition in native-language sentences. Finding an influence of L2 activations while reading high-constraint L1 sentences, would provide very strong evidence for the theoretical viewpoint that the bilingual language system is profoundly language-nonselective. Experiment 1 used a standard L1 lexical decision task to replicate the cognate facilitation effect in isolation (van Hell & Dijkstra, 2002; Van Assche et al., in press) with a new set of stimuli. In Experiment 2, we presented these stimuli in low- and high-constraint sentences while eye movements were monitored.

EXPERIMENT 1: WORD RECOGNITION OUT-OF-CONTEXT

METHOD

Participants. Thirty-three students from Ghent University participated in the experiment. They were all late Dutch-English bilinguals who started to learn English around age 14 at secondary school for about 3-4 hours a week. In Belgium, students are regularly exposed to their L2 through popular media (music, film, television) or English university text books. The participants were paid or received course credit for their participation. After the experiment was completed, they were asked to rate their L1 and L2 proficiency with respect to several skills (reading, writing, speaking, and general proficiency) on a seven-point Likert scale ranging from *very bad* to *very good*. Mean self-reported general L1 (M = 6.00) and L2 proficiency (M = 5.00) differed significantly (dependent samples t-test ps < .001). Means on the different skills are presented in Table 1.

Table 1. Self-assessed ratings (7-point Likert scale) of L1 and L2 proficiency (Experiments 1 and 2)

Language	Skill	Experiment 1	Experiment 2
L1 (Dutch)	Writing	5.9	6.1
	Speaking	5.8	6.3
	Reading	6.1	6.2
	General proficiency	6.0	6.1
L2 (English)	Writing	4.6	4.8
	Speaking	4.8	4.9
	Reading	5.3	5.3
	General Proficiency	5.0	4.8

Stimulus materials. The target stimuli consisted of 42 Dutch-English cognates of four to eight letters long that varied in their degree of orthographic similarity across the two languages. Using the WordGen stimulus generation program (Duyck, Desmet, Verbeke, & Brysbaert, 2004), we generated a noncognate control word for each cognate, that was matched to the cognate (item by item) with respect to word class (all words were nouns), word length (identical), number of syllables, word frequency, neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977), and bigram frequency. The cognates and control words did not differ from each other on any of these variables (dependent samples t-tests *p*s > .13) Means are reported in Table 2. Cognates and controls are listed in Appendix A.

Table 2. Mean lexical characteristics of the target words (Experiments 1 and 2)

Word type	Number of letters	Number of syllables	Word frequency [a]	Neighbor-hood size [b]	Bigram frequency [c]
Cognates	5.21 (1.14)	1.45 (.55)	1.57 (.41)	5.05 (4.22)	3989.07 (20751.84)
Noncognates	5.21 (1.14)	1.45 (.59)	1.50 (.41)	4.83 (4.05)	39310.76 (20749.75)
p	*identical*	*> .99*	*> .13*	*> .48*	*> .58*

Note. Standard deviations are indicated in parentheses. Reported *p*-values indicate significance levels of dependent samples t-tests between cognates and controls. [a] Mean log frequency per million words, according to the CELEX lemma database (Baayen, Piepenbrock, & van Rijn, 1993). [b] Neighborhood size (Coltheart et al., 1977) calculated using the WordGen program (Duyck et al., 2004) on the basis of the CELEX lexical database (Baayen et al., 1993). [c] Mean summated bigram frequency (calculated using WordGen, Duyck et al., 2004).

Additionally, we selected 42 filler words form the CELEX lexical database (Baayen, Piepenbrock, & Van Rijn, 1993). They were matched to the cognates and controls with respect to all of the parameters mentioned above (all *p*s > .36). Using the WordGen program (Duyck et al., 2004), 126 nonwords were selected that were orthographically and phonologically legal in Dutch. They were matched to the target words on word length, neighborhood size and bigram frequency (all *p*s > .26).

Procedure. Participants were tested in small groups of four persons. They were placed sufficiently far from each other and could not see the screen of another participant. Participants received oral and written instructions to decide on each trial if the presented letter string was a real English word or not by pressing one of two response buttons. They were instructed to press the right button for a *word* response and the left button for a *nonword*. It was emphasized to make this decision as quickly and accurately as possible. Each participant saw a different randomized order of the 276 trials. Each target word was presented only once; 10 practice trials preceded the experiment.

Each trial started with the presentation of a centered fixation point for 800 ms. After a 300 ms interstimulus interval, the letter string was presented in the middle of the screen. It remained there until the participant's response or until the maximum response time of 2500 ms was exceeded. The intertrial interval was 700 ms. After the experiment, participants completed a questionnaire assessing their self-reported L1 and L2 reading, speaking, writing, and general skills on a 7-point Likert scale.

Rating studies. We conducted two rating studies to provide a measure of orthographic and phonological overlap for each target word and its translation (see also Van Assche et al., submitted). In the first rating study, 19 bilinguals from the same population as those of Experiment 1 had to rate the orthographic similarity of each cognate and its translation and of each control and its translation on a 7-point Likert scale (1 indicating that the translation pairs had an unequal spelling and 7 indicating an equal spelling). Before the experiment, three example ratings for stimuli not included in the actual list were given (*stoel – chair*: 1; *lamp – lamp*: 7; *appel - apple*: 5). We created four lists in which word pairs were presented in a different order. Each list contained all the word pairs and subjects wrote down their answers. In the second rating study, 21 further subjects rated the phonological similarity of the translation pairs on a 7-point Likert scale (1 indicating an unequal pronunciation and 7 an equal pronunciation). Again, we used 4 different orders for presenting the word pairs and three example ratings were given before the experiment. Subjects listened to each word pair and wrote down their answers. Each rating study started with three practice items. For each target word, the mean orthographic and phonological rating score is presented in Appendix A. The Van Orden (1987) measure of orthographic overlap was strongly correlated with the orthographic ratings (r = .97), the phonological ratings (r = .90) and the mean of the orthographic and phonological ratings (r = .95).

Data Analysis. Mixed-effects models analyses (Baayen, 2007), as implemented in the *Lme4* library (Bates, 2007) in *R* (R Development Core Team), were fitted to the reaction time (RT) and accuracy data. There was no averaging of the data prior to analyses and RT data were inverse transformed (i.e., -1/RT) to reduce the skew in the distribution. Incorrect responses (3.4% of the data) and RTs that were more than 2.5 standard deviations below or above the participant's mean RT for cognates and controls (1.6% of the data) were excluded from the RT analysis. The Markov Chain Monte Carlo (MCMC) sampling method (with a sample size of 10.000) was applied to obtain *p*-values for the coefficients in the RT analysis (Baayen, Davidson, & Bates, 2008). Random intercepts were included for subjects and items (Baayen et al., 2008). Frequency of the target words was included as a continuous control variable. Logistic models were used for the binomially distributed error data. We present the results of three different analyses on (a) the discrete variable Word type (cognate vs. control), (b) the continuous variable Overlap based on Van Orden's (1987) measure of orthographic overlap, and (c) the variable Overlap based on the combined orthographic and phonological ratings.

RESULTS

Word type (cognate vs. control). Although there was a numerical trend showing faster RTs for cognates (*M* = 463 ms) than for controls (*M* = 471 ms), results showed no significant effect of Word type [$F(1,2630) = 2.61$, $p = .28$] in the RT analysis[3] or accuracy analysis [$z < 1$]. Reaction times were faster [$F(1,2630) = 38.24$, $p < .001$] and less errors were made [$z = 3.94$, $p < .001$] as a function of increasing frequency of the targets.

Orthographic overlap (Van Orden). We observed no significant effect of Overlap on RTs [$F < 1$] and error scores [$z < 1$]. The effect of Frequency was significant on RTs [$F(1,2630) = 39.25$, $p < .001$] and error scores [$z = 3.96$, $p < .001$].

Orthographic and phonological overlap (ratings). Again, no significant effect of Overlap was observed on RTs [$F(1,2630) = 1.95$, $p = .41$] and error scores [$z < 1$]. The effects of Frequency was significant in the RT analysis [$F(1,2630) = 38.23$, $p < .001$] and accuracy analysis [$z = 3.94$, $p < .001$].

DISCUSSION

Contrary to previous studies (van Hell & Dijkstra, 2002; Van Assche et al., in press), no significant cognate facilitation effects were observed. However, there was a numerical trend towards faster RTs for cognates than for controls. The failure to find clear cognate facilitation might be a consequence of the task that was used. The lexical decision task may involve decision-making or postlexical checking strategies which may obscure the subtle cognate effect. We therefore decided to still test the same cognates

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[3] Traditional repeated measures analyses of variance (ANOVAs) on the discrete manipulation of cognate status (cognate vs. control) did show significant effects of Word type [$F_1(1,32) = 6.82$, $p < .05$; $F_2(1,41) = 3.00$, $p = .09$].

and controls in low- and high-constraint sentences while eye movements were monitored. This method allows natural reading and taps into very early interaction effects by dissociating early and late reading time measures. Van Assche et al. (in press) already showed that the mere presentation of words in a sentence context does not diminish cross-lingual activation because cognate effects were still observed in L1 low-constraint sentences. As it is not implausible to assume that eye movement measures might uncover interaction effects that do not emerge clearly in the lexical decision task, and on the basis of the results obtained by Van Assche et al., we predict the occurrence of cognate effects when reading low-constraint sentences. However, the main goal of Experiment 2 was to test for the effects of semantic constraint imposed by a sentence. If the bilingual language system is profoundly nonselective, we should be able to measure a cognate effect in the reading of L1 high-constraint sentences, similar to such effects obtained in L2 reading (Van Assche et al., submitted).

EXPERIMENT 2: SENTENCE PROCESSING

METHOD

Participants. The participants were 49 further Ghent University students from the same population as the participants of Experiment 1. They received course credit or were paid for their participation. Mean self-reported general L1 (M = 6.1) and L2 (M = 4.8) proficiency differed significantly (dependent samples t-tests yielded ps < .001) (see also Table 1). There was no difference in mean general L1 and L2 proficiency between the participants of Experiments 1 and 2 (independent samples t-test yielded ps > .24).

Stimulus materials. For each target word, a low- and high-constraint sentence context was constructed (see Appendix B). This resulted in 168 sentences. Sentences for cognates and noncognates were matched with respect to number of words, syntactic structure, and the length of the word preceding the target. A minimum of 4 words and a maximum of 14 words preceded the target. Critical words were never in the final position of the sentence and were always followed by at least two words. The sentences were divided across two presentation lists so that no participant would see the same cognate or noncognate twice. In addition, the same 42 filler and practice sentences, all of comparable syntactic complexity as the target sentences, were added to each list.

Sentence completion. Predictability of the targets within sentences was assessed in a sentence completion study with 23 further participants who did not take part in any of the main experiments. They were presented with the 168 sentence frames up to the target word. Instructions were to type in the first word that came to mind when reading the sentence frame. Dependent samples t-tests on the production probabilities showed no significant differences between cognate and noncognate targets in low-constraint ($p > .06$) and high-constraint sentences ($p > .37$). Moreover, production probabilities in high constraint sentences were significantly higher than in low constraint sentences ($p < .001$). Means are presented in Table 3.

Table 3. Mean sentence completion ratings in low- and high-constraint sentences

	Sentence constraint	
Word type	Low	High
Cognate	.01 (.02)	.92 (.10)
Control	.03 (.05)	.90 (.10)

Note. Standard deviations are indicated between parentheses.

Apparatus. Eye movements were recorded on a SR Research Eyelink 1000 eye tracking device. Viewing was binocular, but eye movements were recorded from the right eye only. Participants' gaze location was monitored every millisecond. Each sentence was displayed on no more than two lines with a maximum of 85 characters per line. All letters were lowercase (except when capitals were appropriate) and in mono-spaced Courier font. Targets were never the final word of a line, nor the first word of the second line. The sentences were presented in black on a white background. One visual degree equaled three characters.

Procedure. Before the start of the experiment, we informed participants that the experiment was about the comprehension of sentences presented on a screen. We emphasized that it was important to read the sentences as naturally as possible for comprehension (as if one was reading a book or a magazine). Sentences were presented as a whole on the screen. After reading the sentence, participants pressed a button that initiated the disappearance of the sentence. Then, a new sentence was presented on the screen or a comprehension question followed. Comprehension questions appeared on the screen on 25% of the trials (only after filler sentences). Participants made a yes- or no-response by pressing one of two response buttons. Overall accuracy on these questions was 96%, which indicated that participants read the sentences attentively.

The total of 136 sentences was presented in a random order to each participant. They were preceded by 10 practice trials. Calibration consisted of a standard 9-point grid. The whole session including camera setup and calibration lasted about half an hour.

Data analysis. Mixed-effects models were fit to both early, first-pass measures and late eyetracking measures (Rayner, 1998). First-pass measures included *first fixation duration* (FFD) and *gaze duration* (GD). The FFD is the duration of the first fixation during the first passage through the region of the target. The GD is the sum of fixations from the moment the eyes land on the target for the first time until the moment they move off again. These early measures are generally assumed to reflect initial lexical access and word identification processes. A later stage measure is *regression path duration* (RPD) (also named *cumulative region reading time*). It is assumed to reflect higher-order processes such as ambiguity resolution and semantic integration. The RPD is defined as the sum of all fixations from the moment the eyes first land on the target until the moment they move off again and a region to the right of the target is fixated. Regressions originating from a particular region are added to the RPD of that region, but they are not added to the GD. If a reader skipped a word, this was coded as a missing value for the FFD, GD, and RPD.

Fixation times that were two standard deviations above each participant's condition mean (Word type x Constraint) were removed from analyses (3.1% of the data for FFD, 3.4% for GD, and 4.0% for RPD). Trials in which the word was skipped were excluded (28.8% in low-constraint and 33.0% in high-constraint sentences) As in Experiment 1, we will first report the analyses on the discrete variable Word type (cognate vs. control). Then we present the continuous analyses on the variable Overlap defined by Van Orden's (1987) similarity measure and the variable Overlap defined by the combined orthographic and phonological ratings. In each analysis, the effect of Constraint (low-constraint vs. high-constraint sentence) was considered as a variable. Random intercepts were included for subjects and items. Random slopes regarding the factor Constraint were included for items for the three eye movement measures.[4] We also included the distance of the prior fixation before the target word as a control variable to control for effects of parafoveal preview (cf. Van Assche et al., in press; see e.g., Vitu, McConkie, Kerr, & O'Regan, 2001). The possibility of a non-linear effect of this factor was considered. Outliers on Prior fixation distance (exceeding a distance of more than 20 character spaces) were removed (0.4% of the data). Also, trials in which the participant did not read the sentence in a beginning-to-end way were removed from analyses (6.6%). We applied the MCMC sampling method (with a sample size of 10.000) to obtain *p*-values for the coefficients in the analyses. Prior to analyses, reading times on GD and RPD were log-transformed to reduce the skew in the distribution.

RESULTS

Word type (cognate vs. control). There was no significant interaction between Word type and Constraint for FFD, GD, and RPD [all Fs < 1], and therefore this interaction was removed from the model and the model was tested again. The results showed faster reading times in high-constraint sentences than in low-constraint sentences on all measures [FFD: $F(1,2440) = 50.47$, $p < .001$; GD: $F(1,2430) = 62.48$, $p < .001$; RPD: $F(1,2415) = 58.10$, $p < .001$], illustrating the successful constraint manipulation. There was no difference in reading times between cognates and controls on FFDs, GDs, and RPDs [all Fs < 1]. Significant non-linear effects of Prior fixation

[4] Model comparisons showed that including random slopes regarding the factor Constraint for items significantly improved the fit of the models for FFD [χ^2s > 9.40, ps < .01], GD [χ^2s > 16.47, ps < .001], and RPD [χ^2s > 9.17, ps < .01].

distance were observed for all dependent measures [FFD-linear, FFD-quadratic, GD-linear, GD-quadratic, RPD-linear, and RPD-quadratic: all *p*s < .001]. Fixations were shorter when the previous fixation was close to the target word. The slope of this effect decreased with distance.

We tested contrasts to investigate whether the cognate effect might be present in low- or high-constraint sentences, each considered separately. The mixed-effects models analyses with MCMC sampling adjustment of the degrees of freedom for the test statistic showed no significant differences for cognates and controls in low- or high-constraint sentences [all *t*s < 1]. Mean reading times are presented in Table 4.

Table 4. First fixation duration (FFD), Gaze duration (GD) and Regression path duration (RPD) on the target word in Experiment 2

Constraint	Word type	FFD	GD	RPD
Low	Cognate	199 (47)	206 (60)	232 (97)
	Control	201 (51)	209 (61)	240 (117)
Effect		*2*	*3*	*8*
High	Cognate	184 (41)	189 (48)	204 (74)
	Control	185 (43)	187 (47)	209 (87)
Effect		*1*	*-1*	*5*

Note. Standard deviations are indicated in parentheses.

Orthographic overlap (Van Orden). After removing the nonsignificant interaction between Overlap and Constraint [all *F*s < 1] from the model, the results showed that reading times in high-constraint sentences were faster than in low-constraint sentences for FFDs, GDs, and RPDs [all *p*s < .001]. Significant non-linear effects of Prior fixation distance were observed for all dependent measures [all *p*s < 1]. No significant effects of Overlap were observed for all reading times measures [*F*s < 1]. Contrasts showed no significant effects of Overlap in both low- and high-constraint sentences [all *t*s < 1].

Orthographic and phonological overlap (ratings). Given the high correlation between Van Orden's measure and the orthographic and phonological ratings, results were very similar to the previous analyses. The nonsignificant interaction between Overlap and Constraint [all Fs < 1] was removed from the model. Results showed faster reading times in high- than in low-constraint sentences on all reading time measures [all ps < .001]. Significant non-linear effects of Prior fixation distance were observed for all dependent measures [all ps < 1]. No significant effects of Overlap were observed for all reading times measures [Fs < 1]. Contrasts yielded no significant effects of Overlap in both low- and high-constraint sentences [all ts < 1.01].

DISCUSSION

The present experiment failed to find cognate effects in low- or high-constraint sentences. The failure to observe cognate facilitation in low-constraint sentences is particularly surprising because this effect has been shown in two earlier experiments (Van Assche et al., in press). The results do show significantly faster reading times in high-constraint sentences than in low-constraint sentences on all three reading time measures. This confirms our constraint manipulation and indicates that the experiment had sufficient power to detect significant effects on each of these measures.

GENERAL DISCUSSION

The aim of the present study was to investigate whether lexical access is modulated by semantic constraint in native-language sentence reading. In Experiment 1, we tested a set of cognates and controls in an L1 lexical decision task. Although there was a numerical trend toward faster reaction times for cognates than for controls, this difference was not statistically reliable. In Experiment 2, these targets were presented in low- and high-constraint sentences while eye movements were monitored. No differences in reading times for cognates and controls were found, both in low- and high-constraint sentences. Also, a continuous manipulation of cross-lingual orthographic overlap based on Van Orden's (1987) similarity measure yielded no effects. Results did show faster reading times for targets in high-constraint than in low-constraint sentences.

The fact that we found no cognate effect for words out-of-context contrasts with previous studies of van Hell and Dijkstra (2002) and Van Assche et al. (in press), which both showed facilitatory processing for cognates compared to noncognates. In our study, there only was a numerical trend that could indicate possible cognate facilitation. As the lexical decision task is susceptible to decision-making strategies or postlexical checking strategies, we reasoned that this reaction time measure might not fully capture early cross-lingual activation effects. Therefore, we considered it important to investigate L1 word recognition while measuring eye movements. This methodology allows very early measurements (first fixations are typically around 200-230 ms), while the lexical decision times are only about 500-600 ms. It is possible that early interaction effects are not uncovered in lexical decision times but can be reflected in reading time measures. Van Assche et al. already showed that the mere presentation of words in a sentence context does not eliminate L1 cognate facilitation. We expected to observe the same cognate effects in low-constraint sentences, but surprisingly, the results yielded no difference between cognates and controls on all three reading time measures.

The main goal of this study was to investigate whether cross-lingual activation effects are modulated by the semantic constraint of a sentence. Van Assche et al. (submitted) showed for sentence reading in the L2 that even the semantic constraints of a sentence do not modulate nonselective access. This result already provided strong evidence for a profoundly language-nonselective lexicon, but the present study aimed at providing even stronger evidence, because we tested for an influence of the weaker L2 on reading high-constraint sentences in the L1. However, we did not observe any difference in reading times for cognates and controls in high-constraint sentences. As cognate effects were also not observed in the lexical decision task out-of-context and in the low-constraint sentences, we cannot draw any definite conclusions on how semantic constraints imposed by the sentence modulate nonselective access to the bilingual lexicon.

The current findings suggest that L2 lexical representations are not activated strong enough to influence word recognition in the L1, even when words are presented out-of-context. In earlier studies however, cross-lingual activations have been shown to exert significant influence on L1 word recognition out-of-context (van Hell & Dijkstra, 2002) and on word recognition in sentences (Van Assche et al., in press). There may be several possible explanations for this apparent inconsistency in results. First, the most likely reason for the difference between studies may be the L2 proficiency of the participants. Van Hell and Dijkstra (2002) also only obtained L1-L3 cognate effects for participants who were highly proficient in L3. This indicates that the occurrence of cross-lingual interactions in L1 processing requires a certain level of L2/L3 proficiency. Although the current study tested bilinguals with the same language background as Van Assche et al. (in press), it seems that L2 proficiency may have been lower in the present study. In Van Assche et al. and the present study, participants rated their general L1 and L2 proficiency on a 7-point Likert scale ranging from *very bad* to *very good*. Mean general L2 proficiency in the current Experiment 2 (M = 4.8) was indeed lower than in Van Assche et al.'s main experiment (M =5.2) [independent samples t-test yielded t = 2.43, p < .05], but was not significantly different from general L2 proficiency in Van Assche et al.'s replication experiment (M = 5.0) [t = 1.16, p = .25]. The mean difference in general L1-L2 proficiency in the present Experiment 2 (M diff = 1.34) was higher than in Van Assche et al.'s main experiment (M diff =

1.00) [*t* = 1.83, *p* = .07], but was not significantly different from the mean difference in general L1-L2 proficiency in Van Assche et al.'s replication experiment (*M* diff = 1.09) [*t* = 1.39, *p* = .17]. This indicates that there were indeed L2 proficiency differences between the current study and Van Assche et al. Similar differences in proficiency might be responsible for the different results for words out-of-context between the current Experiment 1 and van Hell and Dijkstra (2002). Therefore, in future research, it will be interesting to investigate how L2 proficiency influences cross-language activation effects in native-language sentence reading.

A second explanation for the sentence context experiments may lie in the fact that sentence contexts were necessarily different for cognates and controls in the present study (e.g., *Om zijn moeder te helpen zocht hij de juiste CODE van dit valiesje* [In order to help his mother, he looked for the correct CODE of the suitcase] vs. *Om zijn moeder te plezieren gebruikte hij de sterke LIJM van zijn grootvader* [In order to please his mother, he used the strong GLUE of his grandfather]; *code* is the cognate, *lijm* the control word), while this was not the case for the sentences in Van Assche et al. (in press) (e.g., *Ben heeft een oude OVEN / LADE gevonden tussen de rommel op zolder* [Ben found an old OVEN / DRAWER among the rubbish in the attic]; *oven* is the cognate, *drawer* the control word). Although the current sentence contexts were carefully matched on relevant variables such as syntactic structure and length of the word preceding the target, the occurrence of cognates and controls in different sentences might have increased variance in target processing time that is not attributable to the critical manipulations or other variables in the linear mixed-effects models. As such, this necessary methodological complexity may have obscured the subtle L1 cognate effects. Note that this was not the case in the study of Van Assche et al. (in press), in which cognates and controls were presented in exactly the same sentences (across participants).

As a final explanation for the inconsistency across studies, we carefully checked the stimulus characteristics of the critical cognate and control stimuli, in order to evaluate whether these may be different from the previous studies that we conducted. For instance, Dijkstra et al. (2000) showed that reaction times for homographs were slower than for controls in an L1 lexical decision task. This effect was stronger when the homograph was high frequent in the nontarget language. This means that high frequent nontarget words may exert stronger effects on word recognition. However, there were no significant differences in frequency or other relevant word variables (e.g., word length, number of word neighbors) between the current stimulus set and the ones in the experiments of Van Assche et al. (in press).

In the BIA+ model of Dijkstra and van Heuven (2002), it is stated that language information cannot provide strong constraints on lexical access in bilingual word recognition. Therefore, the mere presentation of words in a low-constraint sentence context should not modulate nonselective access. This is indeed what has been found in earlier studies on word processing in the L2 (e.g., Duyck et al., 2007; Schwartz & Kroll, 2006; Van Assche et al., submitted; van Hell & de Groot, 2008) and in the L1 (Van Assche et al., in press). Although the present study did not observe cognate effects in low-or-high constraint sentences, this cannot be taken as evidence for an influence of a linguistic and semantic context on cross-lingual activation, as we also did not observe cognate effects for words out-of-context.

The BIA+ model explains effects of L1 and L2 proficiency by assuming that orthographic representations from both languages are activated depending on the overlap with the target and on the resting level activation of the individual words. This resting level activation may be dependent on subjective frequency of use or L2 proficiency. Most studies on bilingualism test unbalanced bilinguals which means that L2 representations have lower resting level activations and are therefore more slowly activated than L1 representations. This directly explains why effects of L2 on L1 are often smaller than those of L1 on L2 (cf. Bijeljac-Babic et al., 1997; Duyck, 2005; Jared & Kroll, 2001). If the bilinguals in the present study were less proficient than those in Van Assche et al. (in press) and van Hell and Dijkstra (2002), representations in L2 may have been activated too slowly to exert significant effects because of the lower resting activation levels in L2.

In summary, the present study investigated cross-lingual activations when reading native-language sentences which provided low or high semantic constraints. We observed no evidence for language-nonselective access in L1 reading, both for words in isolation and for words presented in low- and high-constraint sentences. The results indicate that parallel activation may be very sensitive to stimulus and participant characteristics. A challenge for future research will be to investigate which circumstances allow the basically nonselective bilingual language system to function in a language-selective way.

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APPENDIX A

Dutch-English target words of Experiments 1 and 2

Cognate	Overlap Van Orden (1987)	Orth overlap rating	Phon overlap rating	Noncognate	Overlap Van Orden (1987)	Orth overlap rating	Phon overlap rating
baard [beard]	0.78	4.68	4.19	fiets [bike]	0.09	1.05	1.00
bakker [baker]	0.95	6.00	5.29	kikker [frog]	0.06	1.00	1.05
boek [book]	0.67	5.16	6.52	boom [tree]	0.05	1.11	1.00
bruid [bride]	0.60	4.37	4.38	beurs [Stock Exchange]	0.04	1.00	1.00
code [code]	1.00	7.00	5.62	lijm [glue]	0.08	1.11	1.14
concert [concert]	1.00	7.00	5.86	ketting [chain]	0.15	1.21	1.33
dans [dance]	0.60	5.11	5.76	bril [glasses]	0.04	1.11	1.00
droom [dream]	0.66	5.11	4.76	vlees [meat]	0.06	1.16	1.14
duivel [devil]	0.69	4.47	4.86	vijand [enemy]	0.05	1.00	1.10
fruit [fruit]	1.00	7.00	5.14	pruik [wig]	0.06	1.00	1.24
glas [glass]	0.86	5.74	6.14	slot [lock]	0.23	2.00	1.95
hamer [hammer]	0.89	5.89	5.38	jager [hunter]	0.34	1.26	1.38
hotel [hotel]	1.00	7.00	6.43	kogel [bullet]	0.12	1.16	1.14
klas [class]	0.48	4.74	6.29	rook [smoke]	0.20	1.58	2.29
klok [clock]	0.40	4.84	6.38	buik [belly]	0.31	2.11	2.38
koffie [coffee]	0.46	3.89	6.62	bureau [desk]	0.06	1.05	1.00
menu [menu]	1.00	7.00	5.24	egel [hedgehog]	0.19	1.16	1.00
muis [mouse]	0.38	4.16	5.00	bord [plate]	0.04	1.05	1.29
nagel [nail]	0.69	3.16	3.14	boete [penalty]	0.25	1.00	1.19
nieuws [news]	0.68	4.37	5.52	struik [bush]	0.08	1.05	1.05
oven [oven]	1.00	7.00	5.52	riem [belt]	0.08	1.05	1.00
park [park]	1.00	7.00	6.19	grot [cave]	0.05	1.00	1.05
peper [pepper]	0.94	5.68	4.67	lepel [spoon]	0.07	1.05	1.05
piloot [pilot]	0.95	5.68	5.29	konijn [rabbit]	0.06	1.00	1.00
plan [plan]	1.00	7.00	5.76	stad [city]	0.08	1.05	1.48
prins [prince]	0.65	5.11	6.43	straf [punishment]	0.05	1.00	1.00
prinses [princess]	0.83	5.26	6.10	getuige [witness]	0.09	1.00	1.00
ring [ring]	1.00	7.00	6.38	berg [mountain]	0.02	1.00	1.05
schaap [sheep]	0.52	4.42	4.29	kapper [hairdresser]	0.27	1.11	1.00
schoen [shoe]	0.60	4.58	3.38	herfst [autumn]	0.06	1.00	1.00
schouder [shoulder]	0.81	4.84	4.00	rekening [bill]	0.06	1.00	1.05
sigaar [cigar]	0.57	4.63	5.52	deksel [lid]	0.06	1.00	1.00
sneeuw [snow]	0.66	3.84	5.00	koorts [fever]	0.05	1.11	1.10
sport [sport]	1.00	7.00	5.76	bloem [flower]	0.18	1.05	1.05
station [station]	1.00	7.00	5.24	sleutel [key]	0.04	1.00	1.05
storm [storm]	1.00	7.00	6.29	broek [trousers]	0.15	1.16	1.05
straat [street]	0.69	5.05	4.76	strand [beach]	0.06	1.11	1.10
telefoon [telephone]	0.62	5.00	5.95	schilder [painter]	0.32	1.37	1.33
tent [tent]	1.00	7.00	6.52	verf [paint]	0.04	1.00	1.10
trein [train]	0.78	5.11	5.05	vogel [bird]	0.04	1.16	1.00
vlag [flag]	0.57	5.84	5.10	heks [witch]	0.06	1.00	1.62
winter [winter]	1.00	7.00	6.52	ridder [knight]	0.07	1.21	1.10

Note. English translations are indicated in brackets.

APPENDIX B

Low- and high-constraint contexts. The first sentence is always the cognate sentence and the second is the control sentence. Cognates and controls are printed in bold. English translations are presented in brackets.

Low-constraint L1 sentence contexts

1. **baard [beard] – fiets [bike]**
Zijn collega heeft een zwarte **baard** en draagt een pet op zijn hoofd.
[His colleague has a black beard and wears a cap on his head.]
Zijn collega heeft een goede **fiets** en komt hiermee naar het werk.
[His colleague has a good bicycle and uses it to go to work.]

2. **bakker [baker] – kikker [frog]**
De man die mijn vader kent is een **bakker** en wil meehelpen aan het project.
[The man who knows my father is a baker and wants to help with the project.]
Het dier dat mijn vriendin zag was een **kikker** en zie je soms aan een vijver.
[The animal that my friend saw was a frog and it is sometimes to be seen at the pond.]

3. **boek [book] – boom [tree]**
Bert verborg de postkaart in een **boek** toen er iemand binnenkwam.
[Bert hid the postcard in a book as someone was coming in.]
Eric zette de doos naast de **boom** toen er meerdere gasten aankwamen.
[Eric placed the box next to the tree as several guests were arriving.]

4. **bruid [bride] – beurs [Stock Exchange]**
De vrouw in het rode kleed op het terras is de **bruid** van dit huwelijksfeest.
[The woman in the red dress on the terrace is the bride of the wedding ceremony.]
Het gebouw aan de overkant van de straat is de **beurs** van dit land.
[The building across the street is the Stock Exchange of the country.]

5. **code [code] – lijm [glue]**
Om zijn moeder te helpen zocht hij de juiste **code** van dit valiesje.
[In order to help his mother, he looked for the correct code of the suitcase.]
Om zijn moeder te plezieren gebruikte hij de sterke **lijm** van zijn grootvader.
[In order to please his mother, he used the strong glue of his grandfather.]

6. **concert [concert] – ketting [chain]**
Mijn vriendin Hannah vertelde gisteren over het **concert** op het marktplein van Leuven.
[Yesterday, my friend Hannah talked about the concert at the marketplace of Leuven.]
Mijn vriendin Hannah kocht gisteren een **ketting** in deze winkel in Leuven.
[My friend Hannah bought a necklace in the store in Leuven yesterday.]

7. **dans [dance] – bril [glasses]**
Lisa kijkt vol bewondering naar de **dans** die het koppel uitvoert.
[Lisa is watching the dance that the couple is performing with admiration.]
Kenneth zoekt al een tijd naar zijn **bril** die hij gisteren weggelegd had.
[Kenneth is looking for his glasses that he put away yesterday.]

8. **droom [dream] – vlees [meat]**
Tijdens het etentje vertelde mijn broer over de leuke **droom** van gisteren.
[During dinner, my brother talked about the amusing dream he has had yesterday.]
Mijn schoonzus at gisteren maar een beetje **vlees** bij het avondeten.
[My sister-in-law only ate a little bit of meat at yesterday’s dinner.]

9. **duivel [devil] – vijand [enemy]**
Frank verkleedde zich als een spook en Patrick als een **duivel** op het carnavalsbal.
[Frank dressed up as a ghost and Patrick as a devil for the carnival party.]
Frank speelde de rol van postbode en Erik speelde de **vijand** in het toneelstuk.
[Frank played the part of the postman and Erik played the enemy in the stage play.]

10. **fruit [fruit] – pruik [wig]**
Als je naar de supermarkt gaat, moet je een kilo **fruit** voor me meebrengen.
[If you go to the supermarket, you have to bring me a kilo of fruits.]
Als je deze voormiddag tijd hebt, kan je naar die winkelier om een **pruik** te kopen.
[If you happen to have time this morning, you can go to that shopkeeper to buy a wig.]

11. **glas [glass] – slot [lock]**
Hij vroeg zijn moeder een groot **glas** met een rietje.
[He asked his mother for a big glass with a straw.]
Zijn vader schilderde het **slot** van de voordeur.
[His father painted the lock of the front door.]

12. **hamer [hammer] – jager [hunter]**
De man die aan de deuren werkt, zoekt een **hamer** en vraagt ook iets te drinken.
[The man who is fixing the doors is looking for a hammer and also asks for a drink.]
De man die een praatje met Els maakt, is een **jager** en kent geen genade.
[The man who is talking to Els is a hunter and shows no mercy.]

13. **hotel [hotel] – kogel [bullet]**
In Brussel wandelt Kelly altijd langs een **hotel** met een zwembad.
[In Brussels, Kelly always walks by a hotel with a swimming pool.]
In Brussel kocht Tony voor zijn missie één **kogel** van hoge kwaliteit.
[When he was in Brussels, Tony bought one bullet of high quality for his mission.]

14. **klas [class] – rook [smoke]**
Het kind zoekt zijn **klas** en begint ongerust te worden.

[The child is searching his classroom and is getting worried.]
De buurjongen ziet de **rook** en gaat direct het huis binnen.
[The boy next door sees the smoke and enters the house immediately.]

15. **klok [clock] – buik [belly]**
Mila wil een mooi cadeau kopen en zoekt naar een **klok** voor in de woonkamer.
[Mila wants to buy a nice present and is looking for a clock for the living room.]
Nico ontmoet haar voor het eerst na de operatie en kijkt naar haar **buik** met het litteken.
[Nico meets her for the first time after surgery and looks at her belly with the scar.]

16. **koffie [coffee] – bureau [desk]**
De vrouw was broccoli vergeten kopen, maar kocht wel het juiste pak **koffie** in de winkel.
[The woman forgot to buy broccoli, but did buy the right pack of coffee in the shop.]
De vrouw ruimde snel de kabels op en liep terug naar haar **bureau** op de tweede verdieping.
[The woman quickly put away the cables and returned to her office on the second floor.]

17. **menu [menu] – egel [hedgehog]**
De meneer met de tweeling in de kinderwagen vraagt het **menu** en informeert naar twee kinderstoelen.
[The man with the twins in the buggy asks for the menu and asks for two baby chairs.]
Het diertje met het speciale uiterlijk in de tuin is een **egel** en is een beschermde diersoort.
[The little animal with the special features in the garden is a hedgehog and it belongs to a protected species.]

18. **muis [mouse] – bord [plate]**
Haar broer die graag in de tuin loopt, zag een **muis** en kwam snel binnen.
[Her brother, who likes to walk in the garden, quickly came in after he had seen a mouse.]
Haar broer die ongeduldig wachtte, nam een **bord** en zette zich al aan tafel.
[Her brother, who was waiting impatiently, took a plate and sat down at the table.]

19. **nagel [nail] – boete [penalty]**
Julie kan eindelijk naar de dokter en toont hem de pijnlijke **nagel** aan haar linkerhand.
[Julie finally made it to the doctor’s and shows him the painful nail on her left hand.]
Siena kan eindelijk haar man bereiken en vertelt hem over de hoge **boete** die ze kreeg.
[Siena has finally reached her husband and tells him about the high penalty she has received.]

20. **nieuws [news] – struik [bush]**
Haar man vertelt vaak over het **nieuws** na een lange werkdag.
[Her husband often talks about the news after a long working day.]
De muis kroop snel achter de **struik** na de korte achtervolging.
[The mouse quickly crawled behind the bushes after the short chase.]

21. **oven [oven] – riem [belt]**
Om zijn vrouw te verrassen kocht hij een **oven** met veel functies.
[He bought a multifunctional oven to surprise his wife.]
Om haar man te verrassen kocht ze een **riem** uit mooi leder.
[She bought a fine-leather belt to surprise her husband.]

22. **park [park] – grot [cave]**
De ouders en hun kinderen praatten over het **park** en vonden het heel mooi.
[The parents and their children were talking about the park and about how much they liked it.]
De ouders en hun kinderen praatten over de **grot** en vonden ze heel mooi.
[The parents and their children were talking about the cave and about how much they liked it.]

23. **peper [pepper] – lepel [spoon]**
De maaltijd zou nog beter smaken met extra tomaten en **peper** eraan toegevoegd.
[The meal would taste even better if extra tomatoes and pepper were added.]
Het kindje wou liever drummen met een stok en een **lepel** op een bord.
[The little child preferred to drum on the plate with a stick and a spoon.]

24. **piloot [pilot] – konijn [rabbit]**
De vriendin van mijn tante zag de **piloot** en werd smoorverliefd.
[The friend of my aunt saw the pilot and fell head over heels in love with him.]
De vriendin van mijn tante zag het **konijn** en wou het direct meenemen.
[The friend of my aunt saw the rabbit and wanted to take it with her right away.]

25. **plan [plan] – stad [city]**
De broers wilden hen verrassen en praatten over het nieuwe **plan** met hun vrienden.
[The brothers wanted to surprise them and discussed the new plan with their friends.]
De broers wilden op avontuur en gingen naar de onbekende **stad** met hun vrienden.
[The brothers were looking for adventure and visited the unknown city with their friends.]

26. **prins [prince] – straf [punishment]**
In het boek ontmoette het hoofdpersonage een **prins** en ze leefden nog lang en gelukkig.
[The main character of the book met a prince and they lived happily ever after.]
In het boek kreeg het hoofdpersonage een **straf** en dit deed hem veel verdriet.
[The main character of the book was punished, which distressed him a lot.]

27. **prinses [princess] – getuige [witness]**
De dochter van Rick zag de **prinses** en mocht haar hand schudden.
[The daughter of Rick saw the princess and was allowed to shake her hand.]
Die collega van Gent ontmoette de **getuige** en verkreeg belangrijke informatie.
[That colleague from Ghent met the witness and got important information.]

28. **ring [ring] – berg [mountain]**
Ze zocht al uren in de tuin en eindelijk vond ze zijn **ring** in het zand.
[She had been searching in the garden for hours when she finally found his ring in the sand.]
Hij wachtte hier al uren en eindelijk schilderde hij de **berg** bij zonsondergang.
[He had been waiting here for hours before he could finally paint the mountain in the sunset light.]

29. **schaap [sheep] – kapper [hairdresser]**
Om haar blij te maken hielp hij het **schaap** dat verderop in de wei stond.
[To please her, he helped the sheep that was standing down the grasslands.]
Om niet op te vallen ging ze naar de **kapper** die verderop in de straat woonde.
[In order not to attract attention, she went to the hairdresser's who was living down the street.]

30. **schoen [shoe] – herfst [autumn]**
De kleine kat krabde aan de stof van zijn **schoen** en maakte er een scheur in.
[The little cat scratched at the fabrics of his shoe and tore it up.]
De vriendin van mijn grootmoeder denkt weemoedig aan de **herfst** en vertelt over haar jeugd.
[My grandmother's friend is nostalgically thinking about the autumn and tells us about her youth.]

31. **schouder [shoulder] – rekening [bill]**
Hij probeerde zijn vriendin in te halen en verwondde haar **schouder** met de stok.
[Trying to catch up with his girlfriend, he hurt her shoulder with the stick.]
Hij zocht in de koffer van de auto en vond de **rekening** van het restaurant.
[He searched in the back of his car and found the bill of the restaurant.]

32. **sigaar [cigar] – deksel [lid]**
Frank kwam terug van een verre reis en kocht een **sigaar** voor zijn grootvader.
[Frank returned from a long journey and bought a cigar for his grandfather.]
Vera ruimde de rommel op en zocht het **deksel** voor deze doos.
[Vera cleaned up the mess and looked for the lid of the box.]

33. **sneeuw [snow] – koorts [fever]**
Toen ze het dorpje eindelijk bereikten, viel de **sneeuw** met bakken uit de lucht.
[When they finally reached the village, it was snowing heavily.]
Toen ze na de reis eindelijk thuis kwam, had ze **koorts** en hevige maagkrampen.
[When she finally got back home from the journey, she was suffering from a fever and severe stomach cramps.]

34. **sport [sport] – bloem [flower]**
Dit was altijd al de favoriete **sport** van Sandra en haar zus.
[This has always been the favorite sport of Sandra and her sister.]
Dit was altijd al de favoriete **bloem** van Lydia en haar zus.
[This has always been the favorite flower of Lydia and her sister.]

35. **station [station] – sleutel [key]**
Mijn vriend komt soms te laat in het **station** van Brussel.
[My friend sometimes arrives too late in Brussels station.]
Mijn vriend vergeet bijna altijd de **sleutel** van ons huis.
[My boyfriend nearly always forgets the key of our house.]

36. **storm [storm] – broek [trousers]**
De leraar met zijn kort haar en baard vertelt over de **storm** die vorig jaar de school

verwoestte.
[The teacher with the short hair and the beard tells us about last year's storm that ruined the school.]
Mijn vriendin met haar blond haar en piercing kocht de **broek** die ze in het uitstalraam gezien had.
[My friend with the blond hair and the piercing bought the pair of trousers that was on display in the window.]

37. **straat [street] – strand [beach]**
De groep zong een lied op de **straat** voor ons hotel.
[The musicians were singing a song on the street in front of our hotel.]
De man bestudeerde zijn tekst op het **strand** voor ons hotel.
[The man was studying his text on the beach in front of our hotel.]

38. **telefoon [telephone] – schilder [painter]**
Haar vriendin van het werk verkocht een goede **telefoon** en ze kreeg direct reactie.
[Her friend from work who was selling a good telephone quickly got reactions.]
Haar vriendin van het werk regelde een goede **schilder** en dit kostte veel geld.
[Her friend from work hired a good painter and this cost her a lot of money.]

39. **tent [tent] – verf [paint]**
De sluwe man verbergt zich achter de kleine **tent** op het plein.
[The wily fellow hides behind the small tent on the square.]
De man koopt een grote pot van deze mooie **verf** voor de slaapkamer.
[The man is buying a pot of nice paint for the bedroom.]

40. **trein [train] – vogel [bird]**
Haar broertje dat morgen jarig is, wil een **trein** met vele wagons.
[Her little brother who celebrates his birthday tomorrow wants a train with a lot of wagons.]
Haar broertje dat morgen jarig is, tekent een **vogel** in zijn kleurboek.
[Her little brother who celebrates his birthday tomorrow is drawing a bird in his colouring book.]

41. **vlag [flag] – heks [witch]**
Peter en Sarah wilden een kopie van de bekende **vlag**, maar ook een speciaal souvenir.
[Peter and Sarah wanted to buy a copy of the famous flag as well as a special souvenir.]
Jean en Sarah wilden een poster van de opvallende **heks**, maar ook van het lieve elfje.
[Jean and Sarah wanted to buy the poster with the special looking witch as well as the poster with the sweet fairy.]

42. **winter [winter] – ridder [knight]**
De vrouw van de burgemeester vertelt over de **winter** van vorig jaar.
[The wife of the mayor tells about last year's winter.]
De leraar en zijn klas fantaseren over de **ridder** uit het verhaal.
[The teacher and the children fantasize about the knight from the tale.]

High-constraint L1 sentence contexts

1. **baard [beard] – fiets [bike]**
Sinterklaas heeft een lange grijze **baard** en draagt een mijter op zijn hoofd.
[Santa Claus has a long grey beard and wears a mitre on his head.]
De wielrenner viel van zijn nieuwe mooie **fiets** en moest naar het ziekenhuis.
[The cyclist fell off his beautiful new bike and had to go to the hospital.]

2. **bakker [baker] – kikker [frog]**
De persoon die brood verkoopt is een **bakker** en moet vroeg opstaan in de ochtend.
[The person selling bread is a baker and he has to get up early in the morning.]
Het groene diertje dat kwaakt is een **kikker** en leeft vaak in de vijver in de tuin.
[The little green animal that quacks is a frog and it usually lives in the pond in the garden.]

3. **boek [book] – boom [tree]**
Tim scheurde de bladzijde uit het **boek** toen hij kwaad werd.
[Tim tore the page out of the book as he got angry.]
Wim liep tegen de tak van een **boom** toen hij even niet oplette.
[Wim ran into the branch of a tree as he was not paying attention for a moment.]

4. **bruid [bride] – beurs [Stock Exchange]**
De vrouw in het witte kleed op de huwelijksdag is de **bruid** en niemand anders.
[The woman in the white dress on the wedding day is the bride and nobody else.]
De plaats waar aandelen verhandeld worden is de **beurs** en is altijd druk.
[The location where shares are traded is the Stock Exchange and it is always busy.]

5. **code [code] – lijm [glue]**
Om de kluis te openen toetste hij de geheime **code** in op het klavier.
[To open the safe, he entered the secret code on the keyboard.]
Om de gebroken vaas te plakken gebruikte hij sterke **lijm** van deze winkel.
[To repair the broken vase, he used strong glue from the shop.]

6. **concert [concert] – ketting [chain]**
De rockgroep U2 geeft zaterdag een extra **concert** in het Koning Boudewijnstadion.
[The rock group U2 is playing a concert on Saturday at the Koning Boudewijn stadium.]
De agressieve leeuw hangt vast met een zware **ketting** in zijn kooi in de zoo.
[The aggressive lion is tethered with a heavy chain in his cage at the zoo.]

7. **dans [dance] – bril [glasses]**
Tango is een bekende Argentijnse **dans** die heel populair is.
[Tango is a famous Argentine dance that is very popular.]
Opa kan bijna niets zien zonder zijn **bril** die hij enkele jaren geleden kocht.
[Grandpa can hardly see without his glasses, which he bought a couple of years ago.]

8. **droom [dream] – vlees [meat]**
Tijdens mijn slaap had ik een rare **droom** over marsmannetjes.
[When I was sleeping I had a weird dream about Martians.]
Als vegetariër eet ik nooit een stuk **vlees** bij de maaltijd.
[As I am a vegetarian, I never eat meat with my meals.]

9. **duivel [devil] – vijand [enemy]**
Peter verkleedde zich als een engel en Geert als een **duivel** op het carnavalsbal.
[Peter dressed up as an angel and Geert as a devil at the carnival ball.]
Peter is zeker geen vriend, integendeel, hij is mijn **vijand** in het dorp.
[Peter is definitely not my friend, on the contrary, he is my enemy in the village.]

10. **fruit [fruit] – pruik [wig]**
Als je in goede gezondheid wil blijven moet je vijf stukken **fruit** eten elke dag.
[If you want to stay in good health, you have to eat five pieces of fruit every day.]
Als je als vrouw kaal bent, kan je naar een speciale winkel om een **pruik** te kopen.
[If you are a bald woman, you can go to a special store to buy a wig.]

11. **glas [glass] – slot [lock]**
Hij schonk de cola in een groot **glas** met veel ijs.
[He poured out the coke in a large glass with a lot of ice.]
Zijn sleutel brak af in het **slot** van de voordeur.
[His key broke off in the lock of the front door.]

12. **hamer [hammer] – jager [hunter]**
Een werktuig om nagels in de muur te kloppen is een **hamer** en moet voorzichtig gebruikt worden.
[A tool for putting nails in the wall is a hammer and it needs to be used cautiously.]
Iemand die in de vrije natuur dieren doodschiet is een **jager** en moet snel zijn.
[Someone who shoots and kills animals in the open air is a hunter and he needs to be quick.]

13. **hotel [hotel] – kogel [bullet]**
Op reis logeert Rick altijd in een luxueus **hotel** met een zwembad.
[When being on a trip, Rick always stays in a luxurious hotel with a pool.]
Gisterenavond bevatte Jack zijn revolver nog één **kogel** van hoge kwaliteit.
[Last evening, Jack's revolver contained only one high-quality bullet.]

14. **klas [class] – rook [smoke]**
Een leraar staat voor de **klas** en leert kinderen nieuwe dingen.
[A teacher teaches to the class and learns the children new things.]
De brandweerman ziet niets door de zwarte **rook** en maakt rechtsomkeer.
[The fireman cannot see anything because of the black smoke and he turns his heels.]

15. **klok [clock] – buik [belly]**
De man wil weten hoe laat het is en kijkt naar de grote **klok** die in de kamer hangt.
[The man wants to know what time it is and looks at the large clock in the room.]
Lisa is voor de eerste keer zwanger en toont fier haar dikke **buik** die mooi rond is.
[Lisa is pregnant for the first time and she proudly shows her thick belly that is beautifully round.]

16. **koffie [coffee] – bureau [desk]**
De vrouw houdt niet van thee, maar lust wel graag een kopje **koffie** in de ochtend.
[The woman does not like tea, but she is fond of a cup of coffee in the morning.]
De secretaresse zocht het formulier maar vond het niet tussen de papieren op haar **bureau** in het kantoor.
[The secretary looked for the form but did not find it among the papers on her desk at the office.]

17. **menu [menu] – egel [hedgehog]**
Een lijst met gerechten in een restaurant is een **menu** en staat meestal buiten uitgestald.
[A list of dishes in a restaurant make up a menu and the menu is usually displayed outside.]
Een diertje met veel stekels op zijn lichaam is een **egel** en is een beschermde diersoort.
[An animal with a lot of spines on its body is a hedgehog and it is a protected species.]

18. **muis [mouse] – bord [plate]**
Het grijs diertje dat katten graag vangen is een **muis** en kan snel lopen.
[The little grey animal that cats like to catch is a mouse and it can run very fast.]
Het grote ronde voorwerp waarop ons eten ligt, is een **bord** en moet afgewassen worden.
[The big round object that contains our food is a plate and it needs to be washed.]

19. **nagel [nail] – boete [penalty]**
Emily moet dringend naar de manicure want ze heeft een gebroken **nagel** aan haar linkerhand.
[Emily needs to go to the manicurist urgently because she has got a broken nail on her left hand.]
Hij reed te hard en de politie gaf hem een hoge **boete** van meer dan 1000 euro.
[He was speeding and the police fined him 1000 euros.]

20. **nieuws [news] – struik [bush]**
Mijn man kijkt om zeven uur altijd naar het **nieuws** op de televisie.
[My husband always watches the seven o'clock news on television.]
Het kind plukt enkel braambessen van die ene **struik** in het bos.
[The child only picks blackberries of that one particular bush in the forest.]

21. **oven [oven] – riem [belt]**
Om koekjes bruin te bakken gebruik je een **oven** of een pan.
[In order to brown biscuits, you have to use an oven or a pan.]
Om een broek op te houden gebruik je een **riem** of een lint.
[In order to keep up a pair of trousers, you have to use a belt or a ribbon.]

22. **park [park] – grot [cave]**
Een groene zone midden in een stad is een **park** en lokt veel mensen in de zomer.
[A green area in the city is a park and it attracts a lot of people in summer.]
Een onderaardse ruimte verkend door speleologen is een **grot** en kan soms bezocht worden.
[A subterranean space explored by speleologists is a cave and it can sometimes be visited.]

23. **peper [pepper] – lepel [spoon]**
Het eten zou nog beter smaken met een beetje zout en **peper** bij deze maaltijd.
[The food would taste even better if a little bit of salt and pepper would be added to the meal.]
Spaghetti dien je eigenlijk te eten met een vork en een **lepel** bij de maaltijd.
[Spaghetti actually needs to be eaten with a fork and a spoon.]

24. **piloot [pilot] – konijn [rabbit]**
De bestuurder van een vliegtuig is de **piloot** en heeft veel verantwoordelijkheid.
[The operator of a plane is a pilot and he has a lot of responsibilities.]
Het lief diertje met lange oren is een **konijn** en leeft hier in België.
[The sweet little animal with the long ears is called a rabbit and it lives here in Belgium.]

25. **plan [plan] – stad [city]**
De gevangenen willen ontsnappen en smeden een snood **plan** met enkele vrienden.
[The prisoners want to escape and therefore work out a cunning plan with some friends.]
Mijn vriendin studeert in New York en houdt van deze drukke **stad** in al zijn facetten.
[My friend studies in New York and loves this busy city in all aspects.]

26. **prins [prince] – straf [punishment]**
In het sprookje veranderde de kikker in een **prins** en ze leefden nog lang en gelukkig.
[In the fairy tale, the frog changed into a prince and they lived happily ever after.]
Voor zijn ongehoorzaamheid kreeg Jantje een zware **straf** en dit deed hem verdriet.
[Jantje was punished severely for his disobedience and felt distressed.]

27. **prinses [princess] – getuige [witness]**
De dochter van de koning en koningin is een **prinses** en wordt streng opgevoed.
[The daughter of the king and queen is a princess and she is brought up sternly.]
Als je een misdaad ziet gebeuren ben je een **getuige** en kan je informatie geven.
[If you have seen a crime happening, you are a witness and you can provide information.]

28. **ring [ring] – berg [mountain]**
Ze wachtte al jaren op zijn aanzoek en eindelijk gaf hij haar een gouden **ring** voor hun verloving.
[She had been waiting for years for his proposal and he finally gave her a golden engagement ring.]
De alpinist was al uren aan het klimmen en bereikte de top van de steile **berg** voor valavond.
[The alpinist had been climbing for hours and when he finally reached the top of the steep mountain before dusk.]

29. **schaap [sheep] – kapper [hairdresser]**
Om wol te verkrijgen scheerde hij het **schaap** dat in de stal stond.
[In order to get wool, he shaved the sheep that was standing in the fold.]
Om zijn haar te laten knippen ging hij naar de **kapper** die verderop woonde.
[In order to have a haircut, he went to the hairdresser's living down the street.]

30. **schoen [shoe] – herfst [autumn]**
Er plakte een kauwgum aan de zool van zijn **schoen** en die ging er niet makkelijk af.
[A chewing gum got stuck on the sole of his shoe and it was hard to get it off.]
Bladeren die van de bomen vallen is typisch voor de **herfst** en dat maakt veel mensen weemoedig.
[Leaves falling from the trees is a typical phenomenon in the autumn and it makes a lot of people melancholic.]

31. **schouder [shoulder] – rekening [bill]**
Hij wou de aandacht van de blinde man trekken en tikte op zijn **schouder** om hem te verwittigen.
[He wanted to attract the attention of the blind man and tapped on his shoulder to alert him.]
Hij wou het etentje afrekenen met de ober en vroeg hem de **rekening** om het totale bedrag te weten.
[He wanted to settle up with the waiter and asked him the bill to know the total amount.]

32. **sigaar [cigar] – deksel [lid]**
Fidel Castro let op zijn gezondheid, maar rookte een dikke Cubaanse **sigaar** deze middag.
[Fidel Castro minds his health, but he smoked a big Cuban cigar this afternoon.]
De vrouw wil de pot afsluiten, maar verloor het juiste **deksel** deze middag.
[The woman wants to close the jar, but she lost the lid this afternoon.]

33. **sneeuw [snow] – koorts [fever]**
Als het in een skigebied warmer is dan nul graden smelt de **sneeuw** en kan je niet skiën.
[If the temperature is above zero degrees in a skiing area, the snow will melt and you will not be able to ski.]
Als je lichaamstemperatuur hoger is dan 38 graden heb je **koorts** en kan je niet werken.
[If your body temperature is higher than 38 degrees, you have got a fever and you can not go to work.]

34. **sport [sport] – bloem [flower]**
Volleybal was altijd al mijn favoriete **sport** omdat het zo afwisselend is.
[Volleyball has always been my favorite sport because it is so varied.]
Een roos was altijd al mijn favoriete **bloem** omdat ze zo lekker ruikt.
[Roses have always been my favorite flowers because they have a lovely scent.]

35. **station [station] – sleutel [key]**
Deze trein komt altijd op tijd aan in het **station** van Brussel.
[This train always arrives on time at the station in Brussels.]
Een slot gaat enkel open met de juiste **sleutel** in het sleutelgat.
[A latch only opens with the right key in the keyhole.]

36. **storm [storm] – broek [trousers]**
Bij 10 beaufort spreekt men van een zware **storm** en die kan veel schade aanrichten.
[From 10 Beaufort on one speaks of a heavy storm and it can cause a lot of damage.]
Een kledingstuk met lange pijpen en rits is een **broek** en zit heel comfortabel.
[A garment with long legs and a zipper is a pair of trousers and it is very comfortable.]

37. **straat [street] – strand [beach]**
De arbeiders herstelden het voetpad in de doodlopende **straat** naast ons huis.
[The workmen repaired the footway in the dead end street next to our house.]
De kinderen bouwden een zandkasteel op het zonnige **strand** voor ons hotel.
[The children built a sandcastle on the sunny beach in front of our hotel.]

38. **telefoon [telephone] – schilder [painter]**
Naast een gsm heeft ze nog een gewone **telefoon** en een fax.
[In addition to a cellular phone, she also has a regular phone and a fax machine.]
Iemand die voor zijn beroep verft, is een **schilder** en heeft meestal veel werk.
[Someone who paints for a living is a painter and he usually has a lot of work.]

39. **tent [tent] – verf [paint]**
De circusartiesten geven een voorstelling in een grote **tent** op het marktplein.
[The circus performers put on a show in the big tent at the market square.]
De schilder bestelt een extra pot van deze rode **verf** voor de slaapkamer.
[The painter orders an extra pot of red paint for the bedroom.]

40. **trein [train] – vogel [bird]**
Een voertuig dat over sporen rijdt, is een **trein** met vaak vele wagons.
[A vehicle riding on rails is a train with usually a lot of wagons.]
Een dier dat in de lucht vliegt, is een **vogel** met zijn vleugels wijd open.
[An animal flying in the air is a bird with his wings wide open.]

41. **vlag [flag] – heks [witch]**
Rood, geel en zwart zijn de kleuren van de Belgische **vlag**, maar ook van de Duitse vlag.
[Red, yellow and black are the colours of the Belgian flag, but also of the German flag.]
Hans en Grietje werden gevangen genomen door de boze **heks**, maar konden nog ontsnappen.
[Hansel and Gretel were captured by the angry witch, but they managed to escape.]

42. **winter [winter] – ridder [knight]**
Het koudste seizoen van het jaar is de **winter** en duurt voor veel mensen te lang.
[The coldest season of the year is winter and it takes too long for a lot of people.]
Een geharnaste man op een paard is een **ridder** en doet denken aan de Middeleeuwen.
[A man in arms on a horse is a knight and he reminds people of the Middle Ages.]

CHAPTER 7
GENERAL DISCUSSION

The aim of the studies presented in this doctoral dissertation was to provide a general investigation of how the top-down influence of a sentence context modulates lexical access in bilinguals. In this final chapter, the main empirical findings of the thesis are summarized and discussed in light of the BIA+ model (Dijkstra & van Heuven, 2002) and a number of implications for the future modeling of the bilingual language system are outlined. The chapter is concluded with a brief discussion of some directions for future studies on bilingual word recognition and sentence processing.

RESEARCH OVERVIEW AND THEORETICAL IMPLICATIONS

SENTENCE CONTEXT EFFECTS ON LEXICAL ACCESS

In the first three empirical chapters of this dissertation (Chapters 2 - 4), we investigated whether the mere presentation of words in a sentence context, and the language cue it provides, modulate lexical access in bilinguals. Until recently, research on bilingualism has mainly focused on the processing of words out-of-context. These studies on isolated word processing have shown that lexical representations in the native language (L1) are activated when processing words in the second language (L2) (e.g., Dijkstra, Grainger, & van Heuven, 1999; Duyck, 2005; Lemhöfer & Dijkstra, 2004). Moreover, it has even been shown that knowledge of a second language influences processing in the mother tongue (e.g., van Hell & Dijkstra, 2002). This indicates that words from both languages are activated in parallel. However, these studies investigated word recognition out-of-context, whereas people rarely read lists of isolated words. Instead, words are encountered in meaningful sentences. It is therefore important to examine whether these findings on isolated word recognition can be generalized to word recognition in sentences. This way, a critical test of the empirical validity of the findings is provided. In order to provide a time-sensitive measurement of cross-lingual interaction effects, eye movements were monitored. Although the participants were unbalanced Dutch-English bilinguals, they were all relatively highly proficient in their L2.

In *Chapter 2* (Duyck, Van Assche, Drieghe, & Hartsuiker, 2007), we investigated whether the presentation of words in low-constraint sentences modulates lexical access during second-language reading. The cognate facilitation effect was used as a marker for the degree of cross-lingual activation spreading in the bilingual language system (e.g., Caramazza & Brones, 1979; Dijkstra et al., 1999; Schwartz, Kroll, & Diaz, 2007). Experiment 1 replicated the cognate facilitation effect for words out-of-context in an L2 lexical decision task (e.g., Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004). In Experiment 2, these stimuli were presented at the end of a low-constraint sentence (e.g., *Hilda was showing off her new RING / COAT*; *ring* is the cognate; *coat* the control word) as targets for lexical decision (e.g., Wright & Garrett, 1984). Clear cognate facilitation effects were obtained. Furthermore, facilitation was modulated by the degree of cross-lingual orthographic overlap because effects were stronger for identical cognates (e.g., *ring – ring*) than for nonidentical cognates (e.g., *schip – ship*). In Experiment 3, target words were presented in the middle of low-constraint sentences (e.g., *Hilda bought a new RING / COAT and showed it to everyone*) while monitoring eye movements. Significant cognate facilitation was obtained on early reading time measures (first fixations) of the target word for identical cognates, but not for nonidentical cognates. These results indicate that the sentence context may restrict L2 cognate effects when cross-lingual activation spreading is weaker (as for nonidentical cognates) but not when orthographic overlap is maximal (identical cognates).

The findings in this chapter are consistent with other recent studies on word recognition in second-language sentence reading. Schwartz and Kroll (2006) observed similar cognate facilitation effects in low-constraint sentences in a naming task. Van Hell and de Groot (2008) showed the same effects in a lexical decision task and in translation tasks. Our findings provide an important extension of these studies because we showed that the same effects are obtained for identical cognates in a more natural reading task. Similar findings were also obtained by Libben and Titone (in press) who showed cognate facilitation effects in low-constraint sentences for identical cognates. Furthermore, the results of this chapter focus attention upon the importance of cross-lingual overlap for cross-lingual interaction effects to occur in sentences.

What are the implications of these findings for theories on bilingual word recognition? First, the identical cognate effect in low-constraint sentences suggests that the language of the context itself does not seem to modulate lexical access. Indeed, the currently most elaborated model of bilingual word recognition, the BIA+ model (Dijkstra & van Heuven, 2002), predicts that the language information of the sentence does not provide strong selection constraints on bilingual word recognition. This implies a limited role for top-down lexical restrictions generated by sentences. Second, the fact that cognate facilitation disappeared for nonidentical cognates in the eyetracking experiment indicates that the presence of a sentence context may still influence lexical access. It seems that lexical access in sentence contexts interacts with task specific factors because nonidentical cognate effects were observed in the lexical decision task, but not in the eyetracking experiment. In the BIA+ model, a distinction is made between the word identification system (the integrated lexicon) and a task/decision system. The differential effects for nonidentical cognates depending on task characteristics need to be handled at the level of the task/decision system. Third, the fact that cognate facilitation emerged on first fixation durations (250 – 270 ms) is consistent with the theoretical view in the literature that cross-lingual interactions occur very early during visual word recognition (e.g., Dijkstra et al., 1999; Dijkstra & van Heuven, 2002). Finally, the stronger effects for identical than for nonidentical cognates are consistent with the BIA+ model in that it predicts cognate facilitation to depend on the degree of cross-linguistic overlap.

In *Chapter 3* (Van Assche, Duyck, Hartsuiker, & Diependaele, in press) we examined whether cross-lingual interaction effects occur during native-language sentence reading, which is a highly automated skill. Van Hell and Dijkstra (2002) already showed cognate facilitation for words out-of-context in the native language (for similar results, see Font, 2001). In a pretest, this cognate facilitation effect for words in isolation was replicated. Experiment 1 presented the stimuli in low-constraint sentences (e.g., *Bert heeft een oude OVEN / LADE gevonden tussen de rommel op zolder*. [Bert has found an old OVEN/ DRAWER among the rubbish in the attic.]) while measuring eye movements. We observed faster reading times for cognates than for controls on early reading time measures. Moreover, cognate facilitation was shown to be a continuous effect because reading time measures decreased with increasing orthographic overlap between the Dutch-English translation equivalents.

The same effects were observed in a replication experiment in *Chapter 4* with a different stimulus set. The finding of cognate facilitation in native-language sentence reading shows that representations of a second language are activated strongly enough to influence word recognition in the mother tongue.

The results of Chapters 3 and 4 provide strong evidence for the theoretical viewpoint that the bilingual language system is fundamentally language-nonselective. The fact that knowledge of a weaker language influenced native-language sentence reading has several important theoretical implications. First, similar to Chapter 2, the current results indicate that linguistic information of a sentence context does not modulate lexical access in bilinguals. This again points to a limited role for top-down influences of lexical constraints generated by a sentence context. Second, the fact that cross-lingual interaction effects were detected on early reading time measures (first fixation duration, gaze duration) indicates that L2 representations are activated very quickly. In the BIA+ model (Dijkstra & van Heuven, 2002), resting level activation of L2 representations is generally lower than L1 representations because of differences in proficiency and subjective frequency. As a result, they are activated more slowly than L1 representations. Activated orthographic representations activate corresponding phonological and semantic representations. This implies that L2 phonological and semantic codes are activated later than L1 representations (the *temporal delay assumption*). Thus, it might be possible that L2 representations are not activated strongly or quickly enough compared to L1 representations to exert an influence on reading (e.g., Duyck, 2005; Jared & Kroll, 2001). The finding of cognate facilitation *in sentences*, *in L1*, therefore provides very strong evidence for a bilingual language system in which representations from both the target and nontarget language are quickly activated in a language-nonselective way. Third and finally, the finding that cognate facilitation is a continuous function of cross-lingual orthographic overlap is in agreement with the BIA+ model in which cross-lingual activation spreading is a function of cross-lingual similarity between the input word and the lexical representations in the word identification system.

In general, the finding of cross-lingual interaction effects for word recognition in low-constraint sentences, both in L2 and in L1 reading, indicates that the language of the sentence context does not constrain nonselective activation. This supports the assumption of the BIA+ model that language membership only has a limited influence on the fundamentally nonselective word identification system. In the next section, we discuss whether the presence of semantic constraints might modulate this nonselective activation.

SEMANTIC CONSTRAINT EFFECTS ON LEXICAL ACCESS

In the next two empirical chapters of this dissertation (Chapters 5 and 6), we investigated whether semantic constraint of a sentence context modulates lexical access in bilingual visual word recognition. Monolingual studies have shown that semantic constraint provided by a sentence guides lexical access in L1. For instance, a predictive context can modulate activation of an ambiguous word's meanings (e.g., *bank* as a riverside or a financial institution) (e.g., Duffy, Kambe, & Rayner, 2001). A study of Altarriba, Kroll, Sholl, and Rayner (1996) on bilingual mixed-language sentence processing showed that the semantic constraint of the sentence can indeed be used as a cue for lexical access to the bilingual lexicon, by activating not only semantic restrictions, but also lexical restrictions for upcoming words. However, as they presented sentences in which words from both languages were presented, this may have fundamentally changed lexical access compared to unilingual sentence reading. Therefore, we examined whether semantic constraint also guides lexical access in natural, unilingual sentence reading, for L2 reading as well as for L1 reading.

In *Chapter 5* (Van Assche, Drieghe, Duyck, & Hartsuiker, submitted), we investigated whether cross-lingual interaction effects are modulated by semantic constraint during L2 sentence reading. In a pretest, we replicated the L2 cognate facilitation effect observed in earlier studies with a new set of stimuli (e.g., Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004; Schwartz et al., 2007). In Experiment 1, the cognates and controls were presented in low-constraint (e.g., *Kelly has never seen that type of SPORT in Canada; The group was surprised by a large SHARK in the sea*; *sport* is the cognate, *shark* is the control word) and high-constraint sentences (e.g., *Volleyball has always been the favorite SPORT of Sandra and her sister; The surfers were attacked by a dangerous SHARK in the sea*) while eye movements were monitored. Results yielded faster reading times for cognates than for controls in low-constraint sentences, but also in high-constraint sentences. Cognate facilitation again increased gradually with increasing cross-lingual overlap between translation equivalents. Experiment 2 ensured that these effects were not due to any confounds in stimulus selection because the same stimuli yielded no cognate effects in English monolingual controls.

The results of this study contrast with the results from earlier studies on cognate processing in high-constraint sentences (e.g., Schwartz & Kroll, 2006; van Hell & de Groot, 2008). For example, Schwartz and Kroll (2006) observed no cognate facilitation in high-constraint sentences. They used a naming task in which words were presented using rapid serial visual presentation. In the same way, van Hell and de Groot (2008) obtained no cognate effects in a lexical decision task for targets that were primed by a high-constraint sentence. In the General Discussion section of Chapter 5, we suggested that the differences between the current study and earlier studies might be a result of the different methodologies that were used. For instance, as in the earlier studies mentioned above, participants were obliged to read in a fixed time window (e.g., using rapid serial visual presentation), this might have allowed more time for the participant to anticipate the expected word compared to natural reading. This may therefore have masked cross-lingual interaction effects. Indeed, a recent eyetracking study of Libben and Titone (in press) obtained identical cognate facilitation effects on early reading time measures. These results are in accordance with the results in Chapter 5. In addition, our results showed cognate facilitation for a stimulus set that included both identical and nonidentical cognates. This cognate effect was shown to be a gradual and continuous effect as a function of cross-lingual overlap. In conclusion, it seems that the use of time-sensitive measurements is very important to uncover early cross-lingual activation spreading effects.

The finding of cognate effects in high-constraint sentences has important theoretical implications for the conceptualization of the top-down influence of semantic constraint on lexical access. Earlier studies (e.g., Altarriba et al., 1996; Schwartz & Kroll, 2006; van Hell & de Groot, 2008) indicate that the semantic restrictions imposed by the sentence may speed up lexical access so much that representations from the nontarget language have no chance to influence word recognition. These previous studies therefore suggest a significant influence of top-down semantic restrictions on lexical access. This viewpoint is largely consistent with the BIA+ model (Dijkstra & van Heuven, 2002) because it predicts that word recognition in sentence context is sensitive to syntactic and semantic context information, in a way that is similar to the context effects in monolingual studies. According to the BIA+ model, sentence context exerts an effect through boosted semantics that feed back to the orthographic level. The exact nature of this mechanism is not specified though. For instance, the model makes no distinction between lexical-level semantic information and message-level semantic information. Importantly, our results point to a different conceptualization of semantic sentence constraint effects on lexical access. We observed evidence for nonselective lexical access in semantically constraining sentences, although reading was facilitated for all targets (cognates and controls) in high-constraint sentences. This means that a high-constraint sentence restricts the activation of conceptual information of a target word but does not impose strong constraints on cross-lingual orthographic and phonological activation. The effect of semantic constraint on conceptual activation in the monolingual literature is explained by Schwanenflugel and LaCount (1988) in a feature restriction model. This model assumes that high-constraint sentences, but not low-constraint sentences, generate feature restrictions for upcoming words. Reading will only be facilitated for words that match the features that were generated. Our results on bilingual processing show that the semantic context can boost semantic activation for upcoming words, but cannot restrict lexical activation to words of only one language. Also, the finding of continuous cognate facilitation as a function of cross-lingual overlap is in agreement with the BIA+ model because it predicts that cognate facilitation arises from activation spreading between lexical representations.

In *Chapter 6*, we investigated whether cross-lingual interaction effects for L1 sentence reading are susceptible to semantic restrictions provided by the sentence. Experiment 1 was aimed at replicating the L1 cognate facilitation effect for words out-of-context in a lexical decision task (e.g., Van Assche et al., in press; van Hell & Dijkstra, 2002). However, although there was a trend toward faster reaction times for cognates than for controls, no clear cognate effects were obtained. As the lexical decision task may be susceptible to decision-making strategies or postlexical checking strategies, we decided to investigate L1 word recognition while using the time-sensitive eyetracking method. Therefore, in Experiment 2, cognates and controls were presented in low- and high-constraint sentences. In Chapters 3 and 4, we already showed that the mere presentation of words in an L1 sentence context does not modulate lexical access in the bilingual lexicon. However, in the present study, no cognate facilitation effects were obtained in either low- or high-constraint sentences, although we did obtain strong effects of sentence constraint for all word targets. In the General Discussion section of Chapter 6, we presented several possible explanations for this inconsistency in cognate facilitation effects across studies. Importantly, it turned out that the participants in the Chapter 6 experiment scored lower on some measures of L2 proficiency than the participants of Chapter 3.

In conclusion, the findings for L2 sentence processing indicate that, contrary to earlier studies, a limited influence should be assigned to top-down semantic constraints on lexical access in the bilingual lexicon. The findings for L1 sentence processing are less clear-cut and further studies are needed in order to provide clear results on this issue of semantic constraint effects during native-language reading, taking into account a more detailed assessment of the L2 proficiency of the participants.

FURTHER DISCUSSION AND DIRECTIONS FOR FUTURE RESEARCH

The empirical chapters of this dissertation provide new theoretical insights regarding the role of linguistic and semantic constraints on language-nonselective activation in bilinguals. More specifically, they point to a limited role for top-down effects originating from linguistic constraints on lexical access. This means that the language of the sentence context is not used as a restrictive language cue for lexical selection. In addition, the sentence constraint manipulation in Chapter 5 indicates that semantic constraint does not direct lexical access to words of only one language. It seems that a semantically constraining sentence restricts the activation of conceptual information, as shown by strong constraint effects on reading times, but does not restrict the degree of cross-lingual lexical activation in the bilingual lexicon, because cognates effects were obtained during L2 sentence reading.

The fact that the language information of a low-constraint sentence did not restrict lexical access is in agreement with the BIA+ model (Dijkstra & van Heuven, 2002). Indeed, the model predicts no significant influence of language membership on word recognition. The fact that a semantically constraining context did not limit the degree of language-nonselective access, however, is in contrast with the assumption of the BIA+ model that linguistic context information may exert constraints on nonselective activation. Our findings indicate that semantic restrictions on cross-lingual lexical activation must be rather low. As Dijkstra and van Heuven did not further specify or implement the exact mechanism through which sentence context affects word recognition, the present results provide the necessary empirical input for the future modeling of the bilingual language system.

The studies in this dissertation provide an important demonstration of a profoundly nonselective language system because we still observed language-nonselective activation in low-constraint sentences during L1 processing and even in high-constraint sentences during L2 processing. There are however several other research questions that need to be addressed in future research in order to achieve a complete understanding of the bilingual language processing system.

First, it should be investigated whether the bilingual language system is highly integrated with respect to all representational levels. The present dissertation focused on cognate processing and on how cross-lingual overlap in orthography, phonology and semantics facilitates word recognition in sentences. However, we did not manipulate phonological overlap directly and it is necessary to examine whether phonological representations are highly integrated as well. Earlier studies on phonological processing for words out-of-context have shown that L1 phonological representations are activated when processing words in L2 (e.g., Brysbaert, Van Dyck, & Van de Poel, 1999; Dijkstra et al., 1999; Duyck, 2005; Duyck, Diependaele, Drieghe, & Brysbaert, 2004; Gollan, Forster, & Frost, 1997). Gollan et al. (1997) even showed that cross-lingual phonological activation occurs for bilinguals whose two languages use different alphabets. Furthermore, other studies demonstrated that L2 phonological representations are also activated when words are processed in L1 (e.g., Duyck, 2005; Van Wijnendaele & Brysbaert, 2002), although these effects were not always found to be consistent (e.g., Duyck, 2005; Jared & Kroll, 2001; Haigh & Jared, 2007). Future studies will have to show whether the mere presentation of words in a sentence and the semantic constraint provided by the sentence modulates this nonselective activation of phonological representations.

Similarly, future studies should investigate whether syntactic representations are highly interconnected or shared between languages. Monolingual theories assume that words are connected to a syntactic category node (e.g., noun or verb, Levelt, Roelofs, & Meyer, 1999).

Research on bilingual sentence production has already shown that this node is shared between languages (e.g., Hartsuiker, Pickering, & Veltkamp, 2004), but it is not clear whether the same applies to sentence reading. Only by investigating all representational levels can one achieve a complete understanding of the bilingual language system.

Second, it is important to examine whether proficiency modulates the degree of integration and nonselective activation in bilinguals. For instance, van Hell and Dijkstra (2002) only observed L1-L3 cognate effects in native-language word recognition for trilinguals who were highly proficient in their L3, but not for trilinguals with a relatively low proficiency. Likewise, the failure to observe cognate facilitation effects in Chapter 6 is likely to be due to the lower proficiency level of the participants in those experiments. It may therefore be very interesting to study L1 cognate facilitation for balanced bilinguals having acquired two languages from birth but living in an L1 dominant environment. As this group is highly proficient in their L2, stronger cross-lingual activation spreading can be expected compared to bilinguals with a lower L2 proficiency. We should also note that in measuring proficiency in the studies of this dissertation, self ratings on reading, speaking, writing and general proficiency were used. These self ratings provide an important indication of the proficiency level, but in future studies investigating proficiency differences, it is advisable to also use more direct measures to determine the level of L2 proficiency such as measuring reaction times to words in both languages in lexical decision or naming tasks.

Third, as part of the further investigation of the integrated and language-nonselective lexical system, future studies should definitely investigate word recognition in trilingual subjects. For instance, in Belgium, every Dutch child learns at least two foreign languages at school in which they are relatively highly proficient (i.e., French and English). If the bilingual language system is highly integrated and truly nonselective with respect to all languages of an individual, one can expect that the additional activation of a third language results in stronger interaction effects for trilinguals than for bilinguals when both groups are equally proficient in their L1 and L2. To our knowledge, only one study has examined trilingual word recognition in the L3. Lemhöfer, Dijkstra, and Michel (2004) tested Dutch-English-German trilinguals while performing an L3 lexical decision task. They observed faster reaction times for L1-L2-L3 cognates than for L1-L3 cognates, indicating that the convergent activation from three languages speeds up recognition of cognates even more than that of two languages. In a similar way, L1-L2-L3 cognate facilitation effects can be investigated during native-language processing, both in isolation and in sentences. If the bilingual language system is profoundly nonselective and interactive, cross-lingual activation spreading should be stronger for trilinguals than for bilinguals when both groups are equally proficient in their L1 and L2. In addition, testing trilinguals may be useful for investigating the influence of semantic constraint on lexical access. For example, if future studies might show that semantic constraint modulates lexical access in native-language sentences in bilinguals, the stronger cross-lingual activation spreading in trilinguals might again show evidence for nonselective activation, even in a high-constraint sentence.

Fourth, the exact timecourse of nontarget language activation and cross-lingual interactions needs to be studied in detail. The results of the present dissertation on word recognition in sentences suggest that nontarget representations are activated very quickly because cross-lingual interaction effects were obtained on early reading time measures such as first fixation durations or gaze durations. However, it is unclear whether and when this nonselective activation decays. We still observed cognate effects on later stage measures such as regression path durations, but we should note that as participants made very few regressions from the target word, gaze durations and regression path durations were similar because gaze duration is included in the regression path duration. A study by Libben and Titone (in press) with French-English bilinguals showed that cross-lingual interaction effects did disappear on late comprehension eyetracking measures. This suggests that lexical access is nonselective during early phases of word recognition. However, in later stages of word recognition, only the lexical representation in the target language remained active. Future studies should investigate the timecourse of nontarget codes at several representational levels (phonological, semantic, orthographic, and syntactic).

Finally, the present dissertation investigated the effect of sentence context on lexical access, but it would also be interesting to test how the global language context might modulate lexical access. For instance, Elston-Güttler, Gunter and Kotz (2005) tested whether the L1 meaning of interlingual homographs is activated during L2 sentence processing. They observed semantic activation in the nontarget language but only during the first half of the experiment and only for participants who saw an L1 film prior to the experiment, boosting L1 activation. They argued that bilinguals gradually *zoomed into* L2. Similar results on phonological activation in L1 word recognition were obtained by Jared and Kroll (2001) in a word naming task. Nontarget phonological representations were only activated during L1 processing after participants had named a block of L2 words. These studies indicate that the pre-activation of a nontarget language may strongly influence processing in the target language. An interesting line of research would therefore be to investigate how word recognition in native-language sentences is influenced by pre-activation in the nontarget language (e.g., by watching an L2 film prior to the experiment). In addition, by analyzing separate parts of the experiment, one might get an indication of the speed of decay of the nontarget pre-activation.

IN CONCLUSION

The research reported in this dissertation provides important evidence for a bilingual language system that is fundamentally nonselective. By investigating cognate facilitation in sentences, we have shown that the language of the sentence does not provide strong selection constraints on lexical access, both for second-language and native-language reading. Moreover, the results indicate that even a semantically constraining sentence does not restrict language-nonselectivity for second-language reading. These results point to a profoundly nonselective bilingual language system with a limited role for top-down effects arising from language and semantic constraints.

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NEDERLANDSE SAMENVATTING

INLEIDING

Met ongeveer de helft van de wereldbevolking is een grote groep mensen tweetalig (Grosjean, 1982) en wordt onderzoek naar tweetaligheid steeds belangrijker binnen de psycholinguïstiek. Zo is in veel studies aangetoond dat er een invloed is van de ene taal tijdens het verwerken van woorden in de andere taal (o.a., Costa, Caramazza, & Sebastian-Galles, 2000; Dijkstra, Grainger, & van Heuven, 1999; Lemhöfer & Dijkstra, 2004). De meeste studies over tweetalige woordherkenning hebben echter enkel de verwerking van afzonderlijke woorden onderzocht, terwijl mensen zelden woorden in isolatie lezen, maar wel woorden in betekenisvolle zinnen. Dit roept de vraag op of woorden van beide talen ook parallel geactiveerd worden wanneer ze in een zinscontext gelezen worden. Het is mogelijk dat de presentatie van woorden in een zin de lexicale activatie beperkt tot woorden in de doeltaal. In het monolinguale domein is namelijk gevonden dat de semantische en syntactische restricties van een zinscontext kunnen gebruikt worden om de herkenning van woorden te versnellen. De vraag is nu of deze contexteffecten bij monolingualen veralgemeenbaar zijn naar tweetaligen. Deze onderzoeksvraag biedt eveneens een kritische test van de ecologische validiteit van de resultaten verkregen voor woorden in isolatie.

Om de parallelle activatie van lexicale representaties in beide talen te onderzoeken wordt de verwerking van *cognaten* vaak vergeleken met de verwerking van monolinguale controlewoorden (o.a. Caramazza & Brones, 1979; Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004). Cognaten worden gedefinieerd als vertalingsequivalenten met een gelijkende schrijfwijze en uitspraak in de twee talen (vb. Nederlands-Engels *schip – ship*). Wanneer tweetaligen woorden lezen in één taal en de verwerking van cognaten en noncognaten (vb. *stoel – chair*) verschilt van elkaar, wordt dit als evidentie aanzien voor de niet-taalselectieve activatie van representaties in het lexicaal systeem. Zo is in veel studies aangetoond dat cognaten sneller verwerkt worden dan controlewoorden (i.e. het *cognaat faciliatie effect*) (o.a. Costa et al., 2000; Lemhöfer & Dijkstra, 2004). Een theoretische verklaring voor dit cognaateffect kan gegeven worden binnen een toonaangevend model voor tweetalige visuele woordherkenning, het Bilingual Interactive Activation model (Dijkstra & van Heuven, 2002). Dit model veronderstelt dat de woorden van beide talen opgeslagen zijn in een gemeenschappelijk lexicon. Lexicale representaties van de eerste (L1) en de tweede taal (L2) worden geactiveerd in het lexicon op basis van de overlap met het doelwoord. Doordat cognaten een sterke orthografische, fonologische en semantische overlap hebben in de twee talen, zorgt de convergente activatie van deze representaties ervoor dat de activatie van cognaten versneld wordt vergeleken met noncognaten. Hoewel het BIA+ model vooral gericht is op de herkenning van afzonderlijke woorden, maakt het ook enkele voorspellingen rond woordverwerking binnen zinnen. Zo veronderstellen Dijkstra en van Heuven (2002) dat de taalcontext van de zin geen sterke selectiecriteria levert voor cross-linguale activatie in het lexicon. Ze stellen echter wel dat de semantische context van een zin rechtstreeks de activatie in het lexicon kan beïnvloeden.

In dit doctoraatsonderzoek werd de invloed van de taalcontext van de zin en van de semantische context van de zin onderzocht bij Nederlands-Engels tweetaligen, zowel voor het lezen in de tweede taal, als voor het lezen in de moedertaal. Als maat voor cross-linguale activatie maken we gebruik van het cognaatfacilitatie effect. In wat volgt worden de voornaamste bevindingen besproken.

TAALCONTEXTEFFECTEN OP LEXICALE TOEGANG

In de eerste drie hoofdstukken bestudeerden we in hoeverre de presentatie van woorden in een zinscontext de cross-linguale activatie in het lexicon moduleert. Slechts weinig studies hebben deze vraagstelling al onderzocht (e.g., Elston-Güttler, Gunter, & Kotz, 2005; Libben & Titone, in press; Schwartz & Kroll, 2006; van Hell & de Groot, 2008). De studies van Schwartz en Kroll (2006) en van Hell en de Groot (2008) toonden aan dat de presentatie van woorden in een zin de lexicale toegang niet moduleert, maar dat deze lexicale activatie wel gemoduleerd wordt door een semantisch voorspelbare zin. Zo vonden zij in een lexicale decisietaak en een woordbenoemingstaak dat het cognaateffect verdween binnen een hoog voorspelbare zin, maar niet binnen een laag voorspelbare zin tijdens het lezen in L2. Libben en Titone (in press) vonden echter wel effecten voor identieke cognaten (vb. *ring – ring*) in hoog voorspelbare zinnen op vroege oogbewegingsmaten. In het huidige doctoraatsonderzoek maakten we gebruik van de oogbewegingsmethode om de cross-linguale interacties te onderzoeken. Deze methode geeft een heel sensitieve meting en laat natuurlijk lezen toe.

In *Hoofdstuk 2* onderzochten we of de presentatie van woorden binnen een zin de lexicale toegang moduleert tijdens het lezen in L2. De resultaten tonen aan dat het cognaateffect blijft bestaan binnen laag voorspelbare zinnen (vb. *Hilda bought a new RING / COAT and showed it to everyone*) voor identieke cognaten (vb. *ring – ring*) maar niet voor niet-identieke cognaten (vb. *schip – ship*). Dit geeft aan dat de zinscontext de activaties in L1 kan beperken wanneer cross-linguale overlap niet volledig is (niet-identieke cognaten), maar niet wanneer de orthografische overlap maximaal is (identieke cognaten).

In *Hoofdstuk 3* bestudeerden we of cross-linguale interacties blijven bestaan tijdens het lezen van zinnen in de moedertaal. We presenteerden cognaten en controlewoorden in laag voorspelbare zinnen (vb. *Bert heeft een* *oude OVEN / LADE gevonden tussen de rommel op zolder*) terwijl oogbewegingen gemeten werden. De cognaten werden sneller gelezen dan de controlewoorden. Dit wijst erop dat de representaties van een tweede taal sterk genoeg geactiveerd worden om woordherkenning in de moedertaal te beïnvloeden. Daarenboven toonde deze studie aan dat cognaatfacilitatie een gradueel en continu effect is: leestijden werden korter naarmate de overlap tussen de cognaat en zijn vertaling in het Engels groter was (vb. vergelijk *ring – ring* en *schaap – sheep*).

In *Hoofdstuk 4* onderzochten we het cognaateffect uit Hoofdstuk 3 met een andere set stimuli. Uit de resultaten bleek dat het cognaateffect in L1 binnen laag voorspelbare zinnen kon gerepliceerd worden met een andere set van stimuli.

De bevindingen van deze drie hoofdstukken geven aan dat een zinscontext geen sterke beperkingen oplegt aan de mate van niet-taalselectieve activatie in het tweetalig lexicon. Dit resultaat werd gevonden voor het lezen in L2 én voor het lezen in L1. Deze studies bevestigen de assumptie van het BIA+ model (Dijkstra & van Heuven, 2002) dat de taal van de zin slechts een beperkte invloed heeft op lexicale activatie.

SEMANTISCHE EFFECTEN OP LEXICALE TOEGANG

In de volgende twee hoofdstukken bestudeerden we of de semantische context van een zin de lexicale activatie kan beperken bij tweetalige visuele woordherkenning. Monolinguale studies hebben al aangetoond dat de semantische context van een zin de lexicale toegang kan moduleren in L1. Een tweetalige studie van Altarriba, Kroll, Sholl, en Rayner (1996) heeft eveneens aangetoond dat de semantische context als een cue voor lexicale toegang kan gebruikt worden, omdat niet enkel semantische restricties, maar ook lexicale restricties voor woorden later in de zin gegenereerd werden.

Deze studie maakte echter gebruik van zinnen waarin woorden van beide talen gebruikt werden (vb. *He always placed all of his dinero* [money] *on a silver dish on his dresser*), waardoor geen conclusies kunnen getrokken worden over het lezen in meer natuurlijke, eentalige zinnen. Het is daarom belangrijk om te onderzoeken of semantische context ook lexicale toegang moduleert in gewone eentalige zinnen en dit zowel voor het lezen in L2 als het lezen in L1.

In *Hoofdstuk 5* onderzochten we of cross-linguale interacties gemoduleerd worden door de semantische context van een zin tijdens het lezen in L2. We presenteerden cognaten en controlewoorden in laag voorspelbare zinnen (vb. *Kelly has never seen that type of SPORT in Canada; The group was surprised by a large SHARK in the sea*; *sport* is de cognaat, *shark* is het controlewoord) en in hoog voorspelbare zinnen (vb. *Volleyball has always been the favorite SPORT of Sandra and her sister; The surfers were attacked by a dangerous SHARK in the sea*). De resultaten toonden dat cognaten sneller verwerkt werden in laag voorspelbare én in hoog voorspelbare zinnen. Dit cognaateffect versterkte gradueel met de mate van cross-linguale overlap tussen de vertalingsequivalenten. Een vervolgexperiment verzekerde dat de effecten zeker aan de cognaatstatus van de woorden te wijten waren en niet aan ongecontroleerde stimuluskenmerken omdat er geen cognaateffecten werden gevonden voor Engelse monolingualen. De resultaten van deze studie zijn niet in overeenstemming met vroegere studies die geen cognaateffecten vonden in hoog voorspelbare zinnen (vb. Schwartz & Kroll, 2006; van Hell & de Groot, 2008). Deze vroegere studies maakten echter gebruik van methoden zoals lexicale decisie en woordbenoeming waarbij de reactietijd mogelijks latere verwerkingsprocessen reflecteert. Libben en Titone (in press) vonden wel effecten voor identieke cognaten in hoog voorspelbare zinnen. De huidige studie toonde dat cognaatfacilitatie een gradueel effect is als functie van cross-linguale overlap en geeft aan dat het gebruik van een sensitieve meting heel belangrijk is om vroege cross-linguale activatie te detecteren.

De bevinding van cognaateffecten in hoog voorspelbare zinnen heeft belangrijke implicaties voor modellen van tweetaligheid. Het BIA+ model (Dijkstra & van Heuven, 2002) voorspelt namelijk dat een semantische context de lexicale activaties in beide talen kan beïnvloeden. De resultaten van Hoofdstuk 5 geven aan dat een semantische context de conceptuele representatie van woorden kan activeren omdat woorden sneller verwerkt werden in hoog dan in laag voorspelbare zinnen. De semantische context kan echter niet de cross-linguale interacties moduleren en lexicale toegang richten naar woorden van één taal. Dit suggereert een beperkte invloed voor semantische top-down processen op lexicale toegang over talen.

In *Hoofdstuk 6* bestudeerden we of cross-linguale interacties tijdens het lezen in de moedertaal gemoduleerd worden door de semantische context van een zin. Het doel van een eerste experiment was om het L1 cognaateffect voor afzonderlijke woorden te repliceren (van Hell & Dijkstra, 2002). We vonden hier echter enkel een trend naar snellere verwerking van cognaten dan controles. Om het cognaateffect te onderzoeken met een sensitievere maat beslisten we van de cognaten en controles te presenteren in laag en hoog voorspelbare zinnen terwijl oogbewegingen gemeten werden. In Hoofdstuk 3 en 4 toonden we al aan dat het cognaateffect blijft bestaan tijdens het lezen van laag voorspelbare zinnen in L1. In het Hoofdstuk 6 vonden we echter geen cognaateffecten in laag en hoog voorspelbare zinnen. Dit verschil in resultaten is vermoedelijk te wijten aan verschillen in bekwaamheid van de tweetaligen in hun L2.

In het algemeen geven de resultaten van Hoofdstuk 5 voor L2 zinsverwerking aan dat er een beperkte top-down invloed is van semantische context op de cross-linguale lexicale activaties in het tweetalig lexicon. De bevindingen voor L1 zinsverwerking zijn minder eenduidig en verder onderzoek is nodig om na te gaan hoe semantische context de verwerking in L1 moduleert.

BESLUIT

In dit doctoraatsonderzoek werd evidentie verkregen voor een tweetalig verwerkingssyteem dat fundamenteel niet-taalselectief is. Door het bestuderen van cognaatfacilitatie in zinnen toonden we aan dat de taal van de zinscontext geen sterke beperkingen oplegt aan de niet-selectieve lexicale activaties, zowel voor het lezen in de tweede taal, als voor het lezen in de moedertaal. Bovendien gaven de resultaten aan dat zelfs een semantische context de taal-selectiviteit van het tweetalig systeem niet kan beperken voor het lezen in de tweede taal. Deze studies geven sterke evidentie voor een fundamenteel niet-selectief taalsysteem met een beperkte invloed van top-down effecten op basis van taal en semantische beperkingen.

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