Sentence context modulates visual word recognition and translation in bilinguals

Janet G. van Hell [a,*], Annette M.B. de Groot [b]

[a] *Radboud University Nijmegen, Behavioral Science Institute, P.O. Box 9104, 6500 HE Nijmegen, The Netherlands*
[b] *University of Amsterdam, Department of Psychology, The Netherlands*

Abstract

The influence of sentence context constraint on subsequent processing of concrete and abstract cognates and noncognates was tested in three experiments. Target words were preceded by a predictive, high constraint sentence context, by a congruent, low constraint sentence context, or were presented in isolation. Dutch–English bilinguals performed lexical decision in their second language (L2), or translated target words in forward (from L1 to L2) or in backward (from L2 to L1) direction. After reading a high constraint sentence context, cognate and concreteness effects disappeared in lexical decision and strongly decreased in both translation tasks. In contrast, low constraint sentences did not influence cognate and concreteness effects. These results suggest that semantically rich sentences modulate cross-language interaction during word recognition and word translation.
© 2008 Elsevier B.V. All rights reserved.

1. Introduction

The world's language system is rapidly changing because of demographic trends, new technologies, and international communication (Graddol, 2004). One of the consequences is that the majority of present and future generations of people speak more than one language, and regularly switch between languages. Such an increasing number of bilingual and multilingual speakers across the world will not only affect written and spoken communication, but it will also affect theoretical perspectives in the linguistic and cognitive sciences. Accordingly, the study of language and cognition in bilingual and multilingual speakers has gained much interest in the past decades.

One of the areas in which considerable progress has been made, both in terms of empirical studies and theoretical models, is in understanding how bilinguals access words in their two languages and how word meanings become activated in bilingual memory (e.g., French & Jacquet, 2004; Kroll & de Groot, 2005). Research on bilingual word processing and models of the bilingual mental lexicon can be described along two important, and theoretically related and complementary, questions. One research line focuses on bilingual lexical access and the question of language selective versus language non-selective activation of words in bilingual memory. A second line focuses on the activation of word meaning after initial lexical access has taken place, and specifically examines how words in the bilinguals' two languages are connected to conceptual representations.

Both lines of research mainly focused on isolated word processing, in the absence of a meaningful linguistic context. Processing an isolated word is, obviously, not a common task in the everyday life of bilinguals who normally function in contextually rich situations. Moreover, the linguistic context surrounding the target word may influence its lexical activation process. Specifically, the sentence

---

* Corresponding author. Tel.: +31 243611619; fax: +31 243616211.
 E-mail address: J.vanHell@pwo.ru.nl (J.G. van Hell).

context in which a word is embedded may modulate the degree of co-activation of related words in bilingual memory. How words are recognized in natural sentence contexts may thus form a critical test of bilingual models on lexical access and concept activation, and critical to the development of the next generation of bilingual models (Kroll & Tokowicz, 2005; van Hell, 2002). We report three experiments in which we examined how a meaningful sentence context influences lexical access and concept activation. As we will see, manipulations of stimulus words' orthography, phonology, and meaning across languages formed critical tests of the bilingual models, and we followed this tradition in our experiments. Below we will discuss the two lines of research and theoretical models on lexical activation of words in bilingual memory.

1.1. Lexical access in bilingual memory

Two views have been proposed to describe lexical access to the bilingual mental lexicon. According to the language selective activation view, bilinguals activate only word candidates from the language that corresponds with the language of the incoming information. The language non-selective activation view holds that words from both languages are activated. The large majority of studies indicate that lexical access in bilingual memory operates in a parallel, language non-selective way (e.g., Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza, & Sebastián-Gallés, 2000; Costa, Miozzo, & Caramazza, 1999; Cristoffanini, Kirsner, & Milech, 1986; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Gollan, Forster, & Frost, 1997; Hermans, Bongaerts, de Bot, & Schreuder, 1998; Jared & Kroll, 2000; Marian, Spivey, & Hirsch, 2003; Nas, 1983; van Hell & Dijkstra, 2002; van Heuven, Dijkstra, & Grainger, 1998; Von Studnitz & Green, 2002).

Studies on bilingual lexical access often use visual word recognition tasks, like lexical decision, and often examine lexical access via manipulations of orthographic, phonological, or semantic similarity of words across the two languages. A frequently used comparison is that between cognates (words with similar or identical orthography, phonology, and semantics across languages, e.g., the Dutch–English translations 'lip–lip' or 'appel–apple') and noncognates. Typically, cognates are recognized and named faster than noncognates when presented in the weaker language (L2; e.g., Costa et al., 2000; de Groot & Nas, 1991; de Groot et al., 2000; Dijkstra et al., 1998; Dijkstra et al., 1999; Lemhöfer, Dijkstra, & Michel, 2004; Schwartz, Kroll, & Diaz, 2007). A cognate advantage was even found when the words were presented in the first, and dominant, language, L1 (van Hell & Dijkstra, 2002).

The faster recognition of cognates over noncognates is typically explained as evidence for a language non-selective activation process in which word candidates from both languages are activated in parallel. For example, the Bilingual Interactive Activation Plus model (BIA+; Dijkstra & van Heuven, 2002) postulates that the visual presentation of a word leads to parallel activation of orthographic codes in L1 and in L2, depending upon the similarity to the presented word and their resting level activation. The activated orthographic representations then activate associated semantic and phonological representations, and from the interactions (resonance) among the three types of codes the lexical code corresponding to the visual input emerges, and is recognized. Because word recognition is assumed to be affected by cross-language orthographic, phonological, and semantic overlap, the processing of cognates is faster and more accurate than that of noncognates. This explanation fits in with the explanation of cognate effects given by distributed models of bilingual memory (e.g., Thomas & van Heuven, 2005; van Hell & de Groot, 1998a).

Abundant evidence thus suggests that lexical activation of words, presented in isolation, is language non-selective. But how are words recognized in context? Does the presence of a sentence context, of the same language as the target word, modulate the co-activation of the related word in the non-target language? For example, does the English word 'apple' also co-activate its Dutch translation 'appel' when embedded in the English sentence 'She took a bite from the fresh green...'? The BIA+ model of Dijkstra and van Heuven (2002) proposes that linguistic context can influence word recognition. The model makes a distinction between a task/decision system and the word identification system (described earlier). The task/decision system is affected by non-linguistic effects, arising from instruction, task demands, or participant expectancies. Activity in the word identification system can be directly affected by linguistic context effects that arise from lexical, syntactic, and semantic sources. Dijkstra and van Heuven propose that sentence context may influence bilingual word recognition, irrespective of the language of the sentence context or of the target word, in a way functionally analogous to monolingual word recognition in context. They also propose that linguistic context may constrain the degree of language non-selective access, and the information that becomes activated in the target and non-target languages. As the authors point out, few empirical studies have examined how linguistic context influences bilingual word recognition. One of the questions to be answered is to what extent the mere presence of a sentence context, being a strong language cue, modulates the co-activation of target and non-target language information. Another question is to what extent non-selectivity and the co-activation of words in the target and non-target languages are modulated by variations in the semantic information in the linguistic context. We address these questions by examining how L2 word recognition (Experiment 1) is influenced by prior reading of sentence contexts that vary in semantic constraint.

In the monolingual literature on visual word recognition, many studies have examined how contextual information affects lexical access of words. These studies showed that contextual information modulates word frequency

effects (e.g., Kawamoto, 1993; Stanovich & West, 1983; Van Petten & Kutas, 1990), lexical ambiguity effects (e.g., Simpson & Krueger, 1991), and concreteness effects (see Schwanenflugel, 1991, for a review). The studies thus suggest that by providing contextual information, differences in the processing of words varying in frequency, lexical ambiguity, or concreteness are attenuated or even disappear. Few studies, however, examined how sentence context modulates cross-language activation in bilingual lexical processing (Altarriba, Kroll, Sholl, & Rayner, 1996; Elston-Güttler, Gunter, & Kotz, 2005; Li & Yip, 1998; Schwartz & Kroll, 2006). The available evidence suggests that, as with monolingual processing, top-down processes of sentence comprehension and bottom-up processes of lexical activation interact. It also shows that the degree of language non-selective activation is affected by variations in global language context and semantic characteristics of the sentence.

Elston-Güttler et al. (2005) studied the processing of German–English homographs (e.g., 'gift', meaning 'poison' in German) and controls presented in a (weakly) semantically related or unrelated sentence context. In an all L2 English experiment, German–English bilingual speakers were presented with a sentence context (e.g., 'The woman gave her friend a pretty'), followed by a homograph or control prime (e.g., 'gift'), and then followed by a target word (e.g., 'poison') for lexical decision. The global language context was manipulated by showing the bilinguals, prior to the experiment, a movie narrated in German or in English. Both reaction time and ERP measures showed a significant homograph priming effect in sentence context, but only when the experiment was preceded by the German movie, and only in the first experimental block. This finding suggests that the degree of language non-selective activation in homograph processing in sentences is sensitive to top-down influences like variations in the global language context.

In a cross-modal naming experiment with Chinese–English bilinguals, Li and Yip (1998), (Experiment 2) auditorily presented Cantonese sentences containing a critical interlingual homophone. Sentences were either strongly predictive or neutral with respect to the English meaning of the homophone. Shortly (150 ms) after the onset of the interlingual homophone, an English or Chinese target word that had or did not have a phonological overlap with the homophone was presented visually, and the participants were asked to name the word. Naming times on the English homophones were shorter than those on the non-homophone controls when embedded in the predictive sentence contexts, but not in the neutral sentence contexts. These results indicate that Chinese–English bilinguals can use prior sentence context early on to facilitate the naming of phonologically related words in the other language.

Li and Yip (1998) and Elston-Güttler et al. (2005) used one type of semantically related sentences (strongly predictive or weakly predictive, respectively). In a recent study, Schwartz and Kroll (2006) manipulated semantic constraint of sentences in a word naming study in Spanish–English bilinguals. They presented L2 interlingual homographs (as also studied by Elston-Güttler et al., 2005) and cognates inserted in L2 sentences. Schwartz and Kroll found that the cognate facilitation effect was eliminated when cognates and noncognates were embedded in a high constraint sentence context, but not in a low constraint sentence context. No such interaction between homograph status and sentence context was observed, suggesting that embedding homographs in a sentence context did not markedly affect homograph processing.

Together these studies show that lexical activation of words across languages can be modulated by embedding these words in a meaningful context. Importantly, Schwartz and Kroll (2006) found that cross-language activation was only modulated by a strongly semantically constraining sentence context and not by a low constraint sentence. This suggests that merely embedding words in a sentence, thereby providing a strong language cue for lexical activation, is not sufficient to eliminate non-selectivity and the co-activation of non-target language information. The study by Schwartz and Kroll (2006) further shows that the semantic constraint effect depends on cross-language meaning overlap of the target words embedded in the sentence: High constraint sentence context modulated the processing of words that share both form and meaning across languages (cognates) but not that of words that share only form (interlingual homographs).

In Experiment 1, we examined whether the presence of a sentence context, of the same language as the target word, modulates cross-language activation. Like Schwartz and Kroll, we embedded L2 cognates and noncognates in an L2 sentence context. Dutch–English bilinguals were visually presented with the sentence contexts and the target words were presented for lexical decision (rather than naming). Furthermore, we examined at a more fine-grained level whether sentence context effects depend on variations in target words' cross-language meaning overlap by comparing abstract and concrete cognates and noncognates. Note that this is a more fine-grained manipulation of cross-language semantic overlap than an absolute, all-or-none semantic overlap manipulation provided by the comparison of cognates and homographs. A cross-language word association study by van Hell and de Groot (1998a) suggests that cross-language overlap of orthographic, phonological, and semantic codes varies with cognate status and concreteness, and is relatively high for concrete cognates (like 'apple-appel') but lower for abstract cognates (like 'insight–inzicht') or abstract noncognates (like 'truth-waarheid'). When presented in isolation, L2 abstract cognates and noncognates may be less efficient in co-activating their translation in the non-target language than concrete cognates and noncognates. Under the assumption that contextual information facilitates lexical access, it can be expected that the recognition of L2 abstract words, and in particular abstract noncognates, will benefit more strongly from being embedded in a highly meaningful sentence context than the recognition of concrete words.

1.2. Representation and activation of word meaning

A second major line in bilingual research examines word processing after the initial phase of lexical access, and focuses on the activation of word meanings in bilingual memory (see Francis, 2005; Kroll & Tokowicz, 2005, for reviews). The question of how word meanings become activated in bilingual processing has mainly been studied, again, by presenting words in isolation. In this paper we will examine how sentence context affects the activation of word meaning.

An influential model that describes the activation of word meaning in bilingual memory is the Revised Hierarchical Model (RHM, Kroll & Stewart, 1994). The RHM focuses on the connections between word form representations (one system for each language) and the conceptual system (shared between the two languages). The RHM states that the strength of the links between the word form representations and the conceptual system differ as a function of fluency in L2 and the relative dominance of L1 to L2. Specifically, the RHM assumes that, in bilinguals who are more fluent in L1 than in L2, lexical level word-word connections from L2 to L1 are stronger than those from L1 to L2. Word-to-concept connections are stronger for L1 than for L2. Building on the latter idea, researchers emphasized that concept activation is more difficult for L2 words than for L1 words (La Heij, Hooglander, Kerling, & van der Velden, 1996) or, assuming that lexical nodes are connected with a set of distributed conceptual features, that L2 words are relatively weakly connected to distributed conceptual features (Kroll & de Groot 1997), or that L2 words are associated with fewer semantic senses than L1 words (Finkbeiner, Forster, Nicol, & Nakamura, 2004).

Differences in strength of word-to-concept mappings for L1 and L2 lead to clear predictions on translation performance, and the word translation task has been frequently used to test the RHM (Cheung & Chen, 1998; de Groot, Dannenburg, & van Hell, 1994; de Groot & Poot, 1997; Duyck & Brysbaert, 2004; Kroll, Michael, Tokowicz, & Dufour, 2002; Kroll & Stewart, 1994; La Heij et al., 1996; Miller & Kroll, 2002; Sholl, Sankaranarayanan, & Kroll, 1995; van Hell & de Groot, 1998b; van Hell, Oosterveld, & de Groot, 1996). In the translation task used in these studies, the bilingual is visually presented with a word in one language, and is asked to say out loud its translation in the other language. The RHM predicts that due to the strong connections from the L1 word to meaning, the translation of L1 into L2 (forward translation) is likely to be conceptually mediated. Due to the relatively strong lexical level connections between L2 and L1, the translation of L2 into L1 (backward translation) is more likely to occur at the lexical level, following the direct word-word connection. Backward translation should thus be faster and should be less sensitive to effects of semantic factors than forward translation.

To test these predictions, Kroll and Stewart (1994) presented words in semantically categorized lists (all words belonging to the same semantic category, e.g., garments) or in randomly mixed lists to Dutch–English bilinguals. In forward translation, the direction hypothesized to be conceptually mediated, words in the categorized list took longer to translate than words in the mixed list. In backward translation, the direction hypothesized to be lexically mediated, words of both lists were translated equally fast.

An alternative way to examine the activation of word meaning during forward and backward translation is via a manipulation of the semantic characteristics of words. De Groot et al. (1994) presented Dutch–English bilinguals words varying in concreteness, in the ease with which one can think of a context in which the word can be embedded ('context availability'), and in the ease with which a word can be defined. They found that the manipulation of semantic variables influenced backward and forward translation, although the semantic effects were slightly stronger in forward translation. Comparable findings are reported by van Hell and de Groot (1998b) and Tokowicz and Kroll (2007); but see Duyck and Brysbaert (2004) and La Heij et al. (1996). In the Introduction to Experiment 2, we will get back to the role of semantic variables in backward and forward translation.

In Experiment 2 in this paper, we provide a new test of the activation of word meaning in translation, in particular the RHM's asymmetry assumption that word-to-concept mappings are weaker in L2 than in L1, by embedding words in a meaningful sentence context (to our knowledge, this has not been done yet). The RHM, originally proposed to explain isolated word processing, predicts that when words are presented in isolation backward translation is faster and is less strongly influenced by semantic variables than forward translation. Assuming that prior presentation of a meaningful sentence context benefits the target word's conceptual access, an extension of the RHM to translation in context predicts that differences in the strength of word-to-concept mappings in L2 and L1 are attenuated (and may even disappear) when words are embedded in a meaningful sentence context.[1] In the Introduction to Experiment 2, we describe in more detail how sentence context may modulate the activation of word meaning in forward and backward

---

[1] It could be argued that the RHM predicts that embedding L2 words in a meaningful sentence context should have no effect on backward translation: weak L2 word form-to-concept mappings would imply that backward translation occurs entirely at the lexical level and no conceptual information is activated. However, a total absence of L2 word meaning activation seems unlikely, as the prior reading of a meaningful sentence context will emphasize the conceptual nature of the task. To anticipate the results, we found that L2 concrete words are recognized and translated faster than L2 abstract words, suggesting that in L2 word recognition and translation word meaning is involved. Moreover, the recognition and translation of L2 words were modulated by contextual constraint, indicating that L2 word recognition and translation are affected by semantic characteristics of the preceding sentence context. We therefore assume that the RHM's claim of weak L2 word form-to-concept mappings implies that L2 concept retrieval is more difficult than L1 concept retrieval, but certainly not impossible.

translation, and how this may vary as a function of the cognate status and concreteness of words.

1.3. The present study

Although the two lines of research described above emphasize different aspects of bilingual processing and bilingual memory, they are in fact related. Recent models of memory assume an integrated, highly interactive representation of orthographic, semantic, and phonological codes, both in monolingual (e.g., Van Orden, Pennington, & Stone, 1990) and bilingual (e.g., Dijkstra & van Heuven, 2002; Thomas & van Heuven, 2005; van Hell & de Groot, 1998a) speakers. The lines of research we discussed also have in common that they were developed to model isolated word processing. As noted by several researchers (e.g., Dijkstra & van Heuven, 2002; French & Jacquet, 2004; Kroll & Tokowicz, 2005; van Hell, 2002), little is known about the effects of semantic and syntactic information on cross-language activation in bilingual memory. We therefore examined the following questions. Can sentence context modulate the co-activation of related words in the non-target language during lexical access, and is the language of the sentence context a sufficient cue to modulate non-selective activation of words (Experiment 1)? Does sentence context affect the recognition and translation of words that vary in cross-language form and meaning overlap, and does the semantic constraint of the sentence context play a role? Are differences between the activation of meaning in forward and backward translation (as predicted by RHM) affected by contextual information?

2. Experiment 1: Lexical decision in the second language

2.1. Method

2.1.1. Design

A 2 (cognate status: cognate, noncognate) by 2 (concreteness: concrete, abstract) by 3 (context: high constraint, low constraint, no context) factorial design was used.

2.1.2. Participants

Sixty fairly fluent Dutch–English bilinguals, with Dutch as their native language and English as their second participated. All were first-year university students. After preparatory English lessons at elementary school (starting at around age 10), they had all attended English classes at secondary school for about 3–4 hours a week, starting at around age 12 and continuing until their enrollment in the university. Their schooling at the university required them to read mainly in English. The bilinguals were randomly allocated to one of the three context conditions. After finishing the experiment they were asked to rate their comprehension and production abilities in English on a 7-point scale (1 = very low, 7 = same as in Dutch). The mean ratings of comprehension and production abilities of participants in the three context conditions did not differ

significantly (see Table 1). All participants received course credit for participation.

2.1.3. Materials

The materials consisted of words and sentence contexts.

2.1.3.1. Words. Thirty cognates (half abstract, half concrete words) and 30 noncognates (half abstract, half concrete words), all English nouns, were selected from a corpus of 440 nouns rated for concreteness and cognate status by Dutch–English bilinguals drawn from the same population as those participating in the experiments (see De Groot et al., 1994, for a detailed description of the norming studies). Mean values and standard deviations of word properties are presented in Appendix A.

The word stimuli were matched on three word characteristics known to influence lexical processing: log word frequency, length, and context availability ('how easy it is to come up with a particular context or circumstance in which the word might appear'). Log word frequencies were derived from the CELEX frequency counts (Baayen, Piepenbrock, & van Rijn, 1993). Word length was expressed by counting letters. Context availability was derived from norms of the 440-words corpus of de Groot et al. (1994; see this study for details on norming). In Appendix A the corresponding means and standard deviations are listed. Across the two levels of concreteness and of cognate status, there were no significant differences in mean log word frequency or in mean length. Neither the concrete nor the abstract cognates and noncognates differed in context availability.

Forty pseudowords were constructed by changing one letter in each of 20 (newly selected) abstract and 20

Table 1

Self-assessed English proficiency ratings (scale 1 'very low' to 7 'same as in Dutch') of Dutch–English bilingual participants of Experiments 1–3

Context condition	Comprehension		Production	
	M	SD	M	SD
Experiment 1				
High constraint	5.40	0.75	4.85	0.88
Low constraint	5.10	0.79	4.75	0.91
No context	5.50	0.51	4.80	0.77
Experiment 2: backward translation				
High constraint	5.20	0.70	4.60	0.88
Low constraint	5.75	0.44	5.20	0.52
No context	5.10	0.97	4.90	0.72
Experiment 2: forward translation				
High constraint	5.35	0.88	4.65	0.93
Low constraint	5.60	0.75	4.75	0.91
No context	5.60	0.60	4.75	0.55
Experiment 3: backward translation				
High constraint	5.45	0.89	4.85	0.67
Low constraint	5.45	0.83	5.15	0.88
Experiment 3: forward translation				
High constraint	5.50	0.69	4.90	0.64
Low constraint	5.70	0.47	5.15	0.74

concrete English words (half cognates and half noncognates in both cases). Ten cognates and ten noncognates, half concrete and half abstract in both cases and all different from any of the test stimuli, were selected as practice stimuli. Ten of these words were converted into pseudowords by changing one letter.

2.1.3.2. Sentence contexts. Prior to the experiments, two rating studies were performed: sentence completion ratings and plausibility ratings.

To qualify sentences as high or low constraint, 240 participants, drawn from the same population as those of the actual experiments, were presented with sentences in which one word was omitted, and were asked to write down the first three reasonable completions that came into their mind (see also Schwanenflugel & Shoben, 1985). For each of the 60 English words (and their Dutch translations to be used in Experiments 2 and 3), eight sentence contexts were constructed: two English sentence contexts expected to be high constraint contexts and two English sentence contexts expected to be low constraint contexts, and the corresponding translations in Dutch. All English sentences had been checked by a native English speaker. In half the sentence contexts, for both constraint conditions, the omitted target word was the last word of the sentence. In the other half the target was located somewhere in the middle of the sentence, because it was not always possible to construct a syntactically regular, and semantically plausible, Dutch sentence with the target word in final position. These 480 sentence fragments were presented in eight different booklets containing one sentence for each of the 60 translation pairs.

The plausibility of the full sentences was rated by a new group of 240 participants, using Noble's (1953) word familiarity instructions but emphasizing that the plausibility of the situation as described by the sentence had to be judged. The eight booklets of the sentence completion study were adapted for the plausibility rating study, and were rated by 30 participants. Twenty sentences were added to each booklet to assess intergroup reliability of the ratings, which were high (*r*s ranging from .81 to .88 and from .91 to .95 for the English and Dutch sentences, respectively).

In the selected set of high constraint sentences, the mean production probabilities of the abstract and concrete noncognates and cognates ranged from .62 to .72, $p > .10$ for all differences between the four different groups of materials. In the selected set of low constraint sentences, the mean production probabilities of the target words ranged from .06 to .14, all ps $> .10$. Mean production probabilities are given in Appendix A. The sentences did not have an alternative completion with a high production probability. Appendix B lists a sample of the sentence contexts. The high and low constraint sentences for the four groups of target words were controlled for position of target word, plausibility, and length (see Appendix A, all ps $> .10$; see van Hell, 1998, for more details on the sentence norming studies).

Twenty high and 20 low constraint sentence contexts were constructed for the pseudowords, and 10 high and 10 low constraint sentence contexts were constructed for the practice stimuli. Across all conditions, sentence contexts for pseudowords and practice stimuli were comparable to those for the word stimuli in terms of target position and length.

2.1.4. Apparatus and procedure

The experiment was run on an Apple Macintosh computer in a normally lit room. All participants were tested individually. Stimuli were presented in black lower-case letters on a light-grey background. A two-button keyboard registered the responses of the participants.

The procedure for stimulus presentation was as follows. In the high and low constraint conditions, each trial began with a fixation stimulus (an asterisk) presented on the left-side of the screen for 1 s, at the position where the first letter of the sentence was to appear. Then, the sentence context was presented and remained on the screen for 4 s.[2] The location of the target word in the sentence was marked with three dashes (the target word itself was not included). Immediately after the sentence context disappeared from the screen, the target word appeared and remained on the screen until the participant responded by pressing one of two buttons. Response time (RT) was measured from the onset of the target word. One second after the participant pushed either response key, the fixation stimulus of the next trial appeared. In the control condition, target words were presented in isolation.[3] A fixation stimulus (an asterisk) appeared on the screen for 1 s, slightly to the left and above of where the target was to appear. Then, the target word was presented; the remainder of the procedure was identical to that of the sentence conditions.

Participants in the sentence context conditions were instructed to read the sentences attentively. To ensure that participants followed this instruction, they were told that the program would occasionally ask them, immediately after their response on the target word, to write down the sentence they had just seen. This request was made six times. It appeared that all participants read the sentences sufficiently well: The sentences noted down covered at least 75% of the information actually presented. After the

---

[2] In sentence priming studies, several sentence presentation procedures have been used (e.g., presenting sentences for a fixed amount of time, ending sentence presentation by the experimenter or by the reader). The procedure we used is comparable to that used in related monolingual (e.g., Schwanenflugel & Shoben, 1985) and bilingual (e.g., Proverbio, Leoni, & Zani, 2004) studies.

[3] The objective of our study is to examine whether the addition of contextual information eliminates the cognate and concreteness effects obtained when target words are presented in isolation. To obtain a genuine, unconfounded baseline effect of cognate status and concreteness, we decided to present these words in isolation (instead of using a 'neutral' sentence context like 'They said it was the ...', or one consisting of a series of xxx's.).

participants had written down the sentence, the experimenter initiated the next trial.

With regard to the target word, participants were instructed that after the sentence context a letter string would appear on the screen and they were asked to determine as quickly and as accurately as possible, whether or not this letter string was an English word. In case of a word, participants pushed the right-hand one of two push-buttons with their right forefinger. In case of a non-word, they pushed the left-hand button with their left forefinger.

For each context condition, trials were divided in five blocks of 20 stimuli (target words were mixed). After each block, the participant was allowed a brief rest of minimally 10 s. Trials were presented in random order with a different order for each participant.

2.2. Results and discussion

For each participant, mean RTs were calculated for each of the four cognate status (cognates vs. noncognates) by concreteness (concrete vs. abstract) conditions. Furthermore, mean RTs for the items within each cognate status by concreteness by context condition were calculated. RTs of incorrect responses and those shorter than 100 ms or longer than 2.5 SD above the participant's mean were eliminated (2.72% all data). Data on the pseudowords, requiring a 'no' response, were regarded as fillers and are not reported here. A 3 (context: high constraint, low constraint, no context) by 2 (cognate status: cognates, noncognates) by 2 (concreteness: concrete, abstract) ANOVA was performed on the mean subject RTs, treating context as a between-subjects variable, and cognate status and concreteness as within-subject variables.[4] The corresponding $3 \times 2 \times 2$ ANOVA was performed on the mean item RTs, treating context as a within-item variable, and the remaining variables as between-items variables. In this and subsequent analyses data were collapsed across target position (see, e.g., Sharkey & Sharkey, 1992). In order to gain insight into how context modulates effects of cognate status and concreteness, we performed a priori planned simple effects analyses within the three levels of the factor context; these analyses constitute the most critical tests of the theoretical questions of this study. The mean RTs and error rates are presented in Table 2.

Table 2

Mean reaction times (in ms) and error rates (in percentages) for lexical decision in the second language (English) (Experiment 1)

Concreteness	Noncognates		Cognates		Effect	
	RT	Error	RT	Error	RT	Error
High constraint						
Abstract	687 (115)	3.0 (5.9)	659 (97)	2.7 (4.0)	28	0.3
Concrete	664 (112)	3.0 (4.0)	647 (118)	1.3 (2.7)	17	1.7
Effect	23	0.0	12	1.4		
Low constraint						
Abstract	833 (152)	3.7 (5.9)	770 (126)	3.7 (5.9)	63	0.0
Concrete	775 (136)	3.3 (5.1)	744 (125)	0.3 (1.5)	31	3.0
Effect	58	0.4	26	3.4		
No context						
Abstract	720 (148)	4.7 (5.3)	652 (154)	0.7 (2.1)	68	4.0
Concrete	686 (169)	6.3 (4.6)	622 (96)	2.7 (3.4)	64	3.6
Effect	34	−1.6	30	−2.0		

Standard deviations in parentheses.

The ANOVA on the RT data yielded a marginally significant interaction between cognate status and context, $F_1(2,57) = 2.39$, $p = .10$; $F_2(2,112) = 2.68$, $.05 < p < .10$. A priori planned simple effects analyses indicated that the 66 ms effect of cognate status in the no context condition was significant, $F_1(1,57) = 21.43$, $p < .001$; $F_2(1,56) = 5.95$, $p < .05$. The effect of cognate status was also significant in the low constraint condition (47 ms), $F_1(1,57) = 11.04$, $p < .01$; $F_2(1,56) = 5.95$, $p < .05$, but was not significant in the high constraint condition (both ps > .10). The interaction between concreteness and context did not reach significance, $F_1(2,57) = 1.37$, $p > .10$; $F_2(2,112) = .94$, $p > .10$. However, a priori planned simple effects analyses showed a 32 ms concreteness effect in the no context condition, $F_1(1,57) = 9.27$, $p < .005$; $F_2(1,56) = 2.08$, $p = .15$. The effect of concreteness was also significant in the low constraint condition (43 ms), $F_1(1,57) = 15.86$, $p < .001$; $F_2(1,56) = 5.18$, $p < .05$, but was not significant in the high constraint condition (both ps > .10). Cognate status did not interact with concreteness, and the three-way interaction between cognate status, concreteness, and sentence context was not significant either.

Finally, the main effects of cognate status, $F_1(1,57) = 30.11$, $p < .0001$; $F_2(1,56) = 8.46$, $p < .01$, concreteness $F_1(1,57) = 25.14$, $p < .0001$; $F_2(1,56) = 3.14$, $.05 < p < .10$, and context, $F_1(2,57) = 5.72$, $p < .01$, $F_2(2,112) = 73.78$, $p < .0001$, were significant. Tukey HSD tests showed that the mean lexical decision times in the high constraint condition (664 ms) were shorter than in the low constraint condition (781 ms; ps < .05 or better), and that performance in the low constraint condition was slower than in the no context condition (670 ms; ps < .05 or better); RTs in the high constraint and no context conditions did not differ significantly.

Analyses on the error data will not be reported, since, as can be seen in Table 2, no speed/accuracy trade-off occurred.

---

[4] The stimulus materials in this and subsequent experiments were carefully controlled for word characteristics known to influence language processing, thereby controlling for error variance related to items. As item variability is controlled for by the experimental procedure, a control by means of a statistical procedure (here, in the form of an ANOVA with items as random factor, F_2) is not required, and the ANOVA with subjects as random factor (F_1) is considered the appropriate analysis (Raaijmakers, Schrijnemakers, & Gremmen, 1999). Because there is still discussion among researchers on the necessity of F_2 analyses in these situations, F_2 analyses are reported. In the few cases in which the F_2 analyses do not coincide with the F_1 analyses, our theoretical interpretation of the statistics is based on the F_1 analyses.

In sum, cognates were processed faster than noncognates when presented in isolation. The cognate advantage remained significant after reading a low constraint sentence context, but was no longer significant after reading a high constraint sentence context. This suggests that non-selectivity can be constrained by embedding words in a meaningful sentence context, but only when the sentence context provides semantically constraining information. This also implies that the language of the sentence context per se is not a sufficient cue to modulate the co-activation of words during lexical access. Schwartz and Kroll (2006) found that high constraint sentence contexts modulated the processing of cognates (sharing meaning and form) but not of homographs (sharing form only). By comparing abstract and concrete cognates and noncognates, we manipulated the degree of cross-language overlap at a more fine-grained level. We observed no significant three-way interaction between cognate status, concreteness, and sentence context, suggesting that the basic pattern is not qualified by subtle variations in word meaning overlap between cognates and noncognates. This observation adds to earlier findings (Elston-Güttler et al., 2005; Schwartz & Kroll, 2006) suggesting that the homograph effect is less sensitive to variations of semantic information in the preceding sentence context than the cognate effect.

Our findings are identical to the cognate findings of Schwartz and Kroll (2006), obtained with a different task (lexical decision rather than word naming), in bilingual speakers of different languages (Dutch–English bilinguals rather than Spanish-English bilinguals) and with a different language learning history (Dutch classroom learners of L2 English) rather than Spanish-English bilinguals living in a bilingual-bicultural community). So, the basic finding that high but not low constraint sentences modulate cross-language activation (when comparing cognate and noncognate word processing) appears a robust finding. This suggests that top-down processes of sentence comprehension and bottom-up processes of lexical activation interact, but that only a highly meaningful sentence context can constrain the co-activation of related information in the non-target language. Finally, this basic mechanism seems invariant to subtle manipulations of target word meaning overlap across languages.

Would the same pattern of sentence context effects in L2 visual word recognition be observed when bilinguals are asked to not only recognize the L2 words but also to translate them into L1? As discussed in the Introduction, the word translation task has been studied extensively to examine the nature of interlanguage connections in bilingual memory. After the initial recognition of the L2 word, a process shared with word recognition in the lexical decision task, the bilingual has to retrieve the L1 translation of the word. A critical question is whether this retrieval occurs at the word form level, or whether it is conceptually mediated. The Revised Hierarchical Model postulates that word-to-concept mappings are weaker in L2 than in L1. Therefore, translating isolated words from L2 into L1 (backward

translation) is more likely to occur at the lexical level, whereas translating words from L1 into L2 is more likely to be conceptually mediated. The RHM predicts that a manipulation of the semantic characteristics of words will affect backward translation less strongly than forward translation. In this study, we manipulated the concreteness of cognates and noncognates, in line with our earlier word translation studies (e.g., de Groot et al., 1994; van Hell & de Groot, 1998b). The RHM predicts that the concreteness effect will be relatively weak in backward translation.

As discussed in the Introduction, the large majority of studies examined the translation of words presented in isolation. Exceptions are the studies by La Heij, Bloem and colleagues who examined backward and forward translation of words accompanied by a semantically related picture (Bloem & La Heij, 2003; La Heij et al., 1996). Testing Dutch–English bilinguals, La Heij et al. (1996) observed that in both backward and forward translation, words are translated faster when accompanied by a semantically related picture than when accompanied by an unrelated picture. Moreover, the effect of picture context was identical (Experiment 3) or larger (Experiment 2) in backward translation than in forward translation. These results show that the translation of words, both in backward and forward direction, is affected (i.e., facilitated) by an accompanying picture.

A picture context is a non-verbal context, and different from a verbal, and linguistically richer, sentence context. To the best of our knowledge, as of yet no studies have examined how sentence context modulates the translation of target words, or, put differently, have used the translation task to elucidate the processes through which sentence context affects concept activation. Assuming that the prior presentation of a meaningful sentence context aids the target word's concept activation, the RHM would predict that embedding target words in a meaningful sentence context attenuates differences in cross-language processing caused by differences in the strength of L2 and L1 word-to-concept mappings. So, the asymmetry in backward and forward word translation (assuming such differences are present when target words are presented in isolation) will be reduced or may even disappear. Second, to gain more insight into how semantic constraint of the preceding sentence context may modulate translation performance, we embedded the target words in a high or a low constraint sentence context. Parallel to the finding in Experiment 1 that only a highly meaningful sentence context modulated non-selective access in L2 word recognition, it may be that only a high constraint, and not a low constraint, sentence context modulates translation performance.

Finally, we looked into more detail at the possible interaction between sentence context and word characteristics. In an earlier word translation study, we found that abstract words are translated slower and less accurately than concrete words. This relatively poor translation performance for abstract words was not present when abstract words were selected that were matched with concrete words on

the word characteristic context availability, the ease with which contextual information can be retrieved for a word (van Hell & de Groot, 1998b; note that in the typical case, abstract words have low context availability ratings). This suggests that words that are less efficient to activate their meanings when translated in isolation, like abstract words, and particularly abstract noncognates (see van Hell & de Groot, 1998a), will benefit more strongly from being embedded in a meaningful sentence context. Hence, we predict an interaction between context, concreteness and cognate status.

3. Experiment 2: Backward and forward translation

3.1. Method

3.1.1. Design

The design was similar to that of Experiment 1. Participants translated L2 target words into L1 (backward translation) or L1 target words into L2 (forward translation).

3.1.2. Participants

One hundred and twenty participants, drawn from the same population as those of Experiment 1, took part. They were randomly allocated to one of the six context by translation conditions. None of them participated in Experiment 1. After finishing the experiment they rated their comprehension and production abilities in English (See Experiment 1), see Table 1 for their mean ratings. Participants received course credit or money for participation.

3.1.2.1. Materials backward translation task. The 60 target words of Experiment 1, as well as the high and low constraint sentence contexts that preceded these target words, constituted the test materials. The language of the sentence contexts was the same as the language of the target words (both English).

The 20 practice words and sentence contexts of Experiment 1 were used. Of the 10 words converted to pseudowords in Experiment 1, the original word stimuli were used.

3.1.2.2. Materials forward translation task. The Dutch translations of the English stimuli of Experiment 1 and the backward translation task constituted the test materials (though Experiments 1 and 2 were run separately, the selection of stimulus words and sentences was performed in mutual attunement). As in Experiment 1, the words' concreteness and cognate status scores were derived from the de Groot et al. (1994) 440-word corpus; see lower part of Appendix A for mean values and standard deviations.

The word stimuli were matched on log word frequency (derived from the CELEX word frequency counts, Baayen et al., 1993), length, and context availability (derived from the de Groot et al., 1994, corpus); see lower part of Appendix A for mean values and standard deviations. All four groups of words were similar in log frequency

and in length (all *p*s > .10). Neither the concrete nor the abstract cognates and noncognates differed in context availability.

The Dutch translation of the English sentences of Experiment 1 and the backward translation task constituted the sentence context materials. In the selected set of high constraint sentences in Dutch, the mean production probabilities of the Dutch abstract and concrete noncognates and cognates ranged from .76 to .83, *p* > .10 for all differences between the four groups of materials. In the low constraint sentence contexts, target words' mean production probabilities ranged from .08 to .13, all *p*s > .10. Care was taken that sentences did not have an alternative completion with a high production probability. Mean production probabilities are given in Appendix A. A sample of the sentence contexts is presented in Appendix B. The mean plausibility and length of the Dutch high and low constraint sentences for the four groups of target words were equal (see Appendix A, all *p*s > .10).

As practice stimuli the Dutch translations of the practice stimuli of Experiment 1 were used. In all respects, these sentence contexts were comparable to those of the test stimuli.

3.1.3. Apparatus and procedure

The apparatus was identical to that of Experiment 1, except that responses were registered by a microphone that activated a voice-operated switch. Following the procedure of our previous translation experiments (e.g., de Groot et al., 1994; van Hell & de Groot, 1998b), the experimenter typed in the participant's response on the computer keyboard (this was not echoed on the screen), monitored the workings of the voice-key, and noted down failures of the voice-key to register the participant's response or triggering due to faltering of the participant's voice or ambient sounds.

The instruction for reading the sentence contexts was similar to that of Experiment 1. Because this experiment contained fewer trials than Experiment 1, the request for writing down the sentence was made four times throughout the task (rather than six times). All participants read the sentence contexts sufficiently well: the sentence frames noted down covered at least 75% of the information. With regard to the target word, participants were asked to speak out loud the Dutch translation of the English stimulus word (backward translation) or the English translation of the Dutch stimulus word (forward translation). They were instructed to respond as fast as they could while maintaining high accuracy. They were asked to remain silent when they could not come up with the translation of the stimulus.

The procedure in the translation experiment was similar to that of Experiment 1, up until response registration of the target word. The onset of the participant's response was registered by the voice-switch. RT was measured from the onset of the target word. Then the experimenter typed in the participant's response and hit the RETURN-key,

effectuating the presentation of the next stimulus one second afterwards. The maximum presentation duration for the target word was 5 s. Whenever this period expired, the experimenter typed the word 'none' and the next trial was called by pressing the RETURN-key.

Participants completed 60 test trials that were preceded by 20 practice trials. Test trials were divided in three blocks of 20 stimuli each (target words were mixed). After each block, the participant was permitted a brief rest of minimally 10 s, after which the experimenter initiated the presentation of the first trial of the next block.

3.2. Results and discussion

Following the procedures described in Experiment 1, mean subject and mean item RTs were calculated. RTs associated with translation errors or voice-switch registration failures were excluded. Failures of the voice-switch (including false starts of the participants) made up 6.89% and 6.30% of the backward and forward translation data, respectively. A response was considered an error when it was not listed as a possible translation of the stimulus in Dutch–English and English–Dutch dictionaries (Martin & Tops, 1984, 1986). An omission was scored if the participant had not initiated a response within 5 s after stimulus onset. For each participant and item, mean proportions of errors and omissions were calculated for each condition. The data were then analyzed as the analyses described in Experiment 1.

The organization of the results section is as follows. In Section 3.2.1, we first report analyses on the backward translation task to test whether sentence context modulates effects of cognate status and concreteness in translation, in order to gain more insight into how sentence context affects concept activation. In Section 3.2.2, the same series of analyses are reported for forward translation. These two series of analyses on the backward and forward translation data are comparable to those on the L2 word recognition data of Experiment 1. Finally, a third series of analyses specifically tests the predictions of the RHM (Section 3.2.3); the organization of these analyses is described at the beginning of that section.

3.2.1. Backward translation

Mean RTs, error rates, and omission scores are presented in Table 3.

Cognate status interacted with context, $F_1(2,57) = 4.87$, $p < .05$; $F_2(2,112) = 4.58$, $p < .05$. Simple effects analyses indicated that, similar to the findings of Experiment 1, strong effects of cognate status were obtained in the no context condition (275 ms), $F_1(1,57) = 79.70$, $p < .001$; $F_2(1,56) = 37.19$, $p < .001$, and in the low constraint condition (201 ms), $F_1(1,57) = 43.11$, $p < .001$; $F_2(1,56) = 15.73$, $p < .001$. In the high constraint condition, the effect of cognate status (139 ms) was notably smaller, yet remained significant, $F_1(1,57) = 20.42$, $p < .001$; $F_2(1,56) = 7.95$, $p < .01$.

Table 3
Mean reaction times (in ms) and error and omission rates (in percentages) for the backward translation task (Experiment 2)

Concreteness	Noncognates		Cognates		Effect	
	RT	Er-Om	RT	Er-Om	RT	Er-Om
High constraint						
Abstract	989 (246)	11.7 (8.3)	890 (151)	1.7 (3.0)	99	10.0
Concrete	911 (131)	4.3 (5.0)	732 (160)	0.0 (0.0)	179	4.3
Effect	78	7.4	158	1.7		
Low constraint						
Abstract	1359 (312)	10.7 (9.0)	1131 (174)	2.3 (3.9)	228	8.4
Concrete	1128 (153)	4.7 (6.5)	952 (94)	1.0 (2.4)	176	3.7
Effect	231	6.0	179	1.3		
No context						
Abstract	1354 (262)	21.0 (14.6)	993 (146)	2.3 (3.3)	361	18.7
Concrete	1032 (148)	8.0 (7.7)	844 (139)	0.3 (1.5)	188	7.7
Effect	322	13.0	149	2.0		

Standard deviations in parentheses. *Note.* Er-Om = error and omission rates.

Concreteness also interacted with context, $F_1(2,57) = 3.68$, $p < .05$; $F_2(2,112) = 3.44$, $p < .05$. Strong concreteness effects were observed in the no context condition (236 ms), $F_1(1,57) = 54.25$, $p < .001$; $F_2(1,56) = 22.78$, $p < .001$, and in the low constraint condition (205 ms), $F_1(1,57) = 40.87$, $p < .001$; $F_2(1,56) = 12.76$, $p < .01$. In the high constraint context condition, the advantage of concrete over abstract words was considerably smaller (117 ms), $F_1(1,57) = 13.45$, $p < .01$; $F_2(1,56) = 3.73$, $.05 < p < .10$.

Table 3 shows that the abstract noncognates in the high constraint condition (989 ms) were translated relatively fast, as compared to the same items in the low constraint (1359 ms) and no context (1354 ms) conditions. Indeed, the three-way interaction of context, cognate status, and concreteness was significant, $F_1(2,57) = 5.88$, $p < .01$; $F_2(1,56) = 3.48$, $p < .05$. Concreteness did not interact with cognate status. The main effects of cognate status, $F_1(1,57) = 133.50$, $p < .0001$; $F_2(1,56) = 27.26$, $p < .0001$, concreteness, $F_1(1,57) = 101.22$, $p < .0001$; $F_2(1,56) = 17.28$, $p < .001$, and context, $F_1(2,57) = 16.55$, $p < .0001$; $F_2(2,112) = 54.06$, $p < .0001$, were all significant. A Tukey HSD test confirmed that mean translation times in the high constraint condition (880 ms) were shorter than in the low constraint (1142 ms) and in the no context (1056 ms) conditions (all $ps < .01$ or better); the low constraint and no context conditions differed significantly only in the item analysis ($p < .01$).

These analyses show that the effects of cognate status and concreteness were considerably attenuated, but did not disappear fully, in the high constraint condition (as was observed in Experiment 1). Additional ANOVAs, however, on only the high constraint and the no context data revealed that the 139 ms cognate status effect in the high constraint condition was smaller than the 275 ms cognate effect in the no context condition, $F_1(1,38) = 9.55$,

$p < .005$; $F_2(1,56) = 10.26$, $p < .005$. Similarly, the 117 ms concreteness effect in the high constraint condition was smaller than the 236 ms concreteness effect in the no context condition, $F_1(1,38) = 8.08$, $p < .01$; $F_2(1,56) = 7.93$, $p < .01$. In contrast, ANOVAs on the low constraint and the no context data showed no difference in the magnitude of the concreteness effects. Likewise, the cognate effect in the low constraint condition was not significantly different from that in no context condition in the analysis by subjects, but it was different in the analysis by items, $F_2(1,56) = 4.65$, $p < .05$.

In short, the backward translation data show that in the high constraint condition, effects of concreteness and of cognate status were, as compared to words presented in isolation, considerably reduced. In the low constraint condition these effects remained substantial. Furthermore, the prior reading of a high constraint sentence context was particularly helpful in the translation of abstract noncognates.

3.2.2. Forward translation

Mean RTs, error rates, and omission scores are presented in Table 4.

Cognate status interacted with context, $F_1(2,57) = 6.76$, $p < .005$; $F_2(2,112) = 10.53$, $p < .001$. Strong cognate effects were obtained when cognates and noncognates were presented in isolation (346 ms), $F_1(1,57) = 52.52$, $p < .001$; $F_2(1,56) = 32.85$, $p < .001$, and in the low constraint sentence condition (288 ms), $F_1(1,57) = 36.38$, $p < .001$; $F_2(1,56) = 13.15$, $p < .005$. When cognates and noncognates were preceded by a high constraint sentence context, however, the effect of cognate status was strongly reduced (108 ms), $F_1(1,57) = 5.12$, $p < .05$; $F_2(1,56) = 1.80$, $p > .10$.

Concreteness also interacted with context, $F_1(2,57) = 4.86$, $p < .05$; $F_2(2,112) = 3.26$, $p < .05$. Strong concreteness effects were observed when concrete and abstract words were presented in isolation (313 ms), $F_1(1,57) = 58.12$, $p < .001$; $F_2(1,56) = 26.24$, $p < .001$, and

this effect remained about the same size when preceded by a low constraint sentence context (310 ms), $F_1(1,57) = 57.05$, $p < .001$; $F_2(1,56) = 17.37$, $p < .001$. In the high constraint condition, however, the concreteness effect was strongly attenuated (155 ms), yet remained significant, $F_1(1,57) = 14.23$, $p < .001$; $F_2(1,56) = 9.03$, $p < .005$.

As can be seen in Table 4, abstract noncognates in the high constraint condition (982 ms) were translated relatively fast, and much faster than in the low constraint (1585 ms) and no context (1523 ms) conditions. Indeed, as in backward translation, the three-way interaction between sentence context, cognate status, and concreteness was significant, $F_1(2,57) = 3.95$, $p < .05$; $F_2(2,112) = 3.58$, $p < .05$. Finally, the interaction between concreteness and cognate status was significant in the subject analysis only, $F_1(1,57) = 17.43$, $p < .001$; $F_2(1,56) = 1.61$, $p > .10$. The main effects of cognate status, $F_1(1,57) = 80.50$, $p < .0001$; $F_2(1,56) = 16.24$, $p < .001$, concreteness, $F_1(1,57) = 119.69$, $p < .0001$; $F_2(1,56) = 21.76$, $p < .0001$, and context, $F_1(2,57) = 16.38$, $p < .0001$; $F_2(2,112) = 104.28$, $p < .0001$ were significant. A Tukey HSD test showed that translation times were shorter in the high constraint condition (838 ms) than in the low constraint (1245 ms) and no context (1103) conditions (all ps $< .01$; RTs in the low constraint and no context conditions did not differ significantly).

As in backward translation, the effects of cognate status and concreteness strongly decreased in the high constraint condition, but were not fully eliminated. Additional ANOVAs on only the high constraint and no context data showed, however, that the 108 ms cognate status effect in the high constraint condition was significantly smaller than the 346 ms cognate advantage in the no context condition, $F_1(1,38) = 12.09$, $p < .005$; $F_2(1,56) = 17.55$, $p < .001$. Likewise, the 155 ms concreteness effect in the high constraint condition was significantly smaller than the 313 ms concreteness effect in the no context condition, $F_1(1,38) = 11.81$, $p < .005$; $F_2(1,56) = 3.44$, $p = .07$. In contrast, ANOVAs on only the low constraint and no context data revealed that sentence context did not interact with cognate status or with concreteness (all Fs < 1), indicating that the magnitude of the effects of cognate status and of concreteness in the low constraint condition was similar to those in the no context condition.

Summarizing, the forward translation data resembled the backward translation data: the effects of cognate status and concreteness were considerably larger in the no context condition than in the high constraint condition. The effects of concreteness and cognate status remained substantial, however, in the low constraint context condition. As in backward translation, the prior reading of a high constraint sentence context was particularly helpful in the translation of abstract noncognates. This suggests that embedding words in a meaningful sentence context particularly benefits concept retrieval of abstract noncognates. We will elaborate on this issue in the General Discussion.

Table 4
Mean reaction times (in ms) and error and omission rates (in percentages) for the forward translation task (Experiment 2)

Concreteness	Noncognates		Cognates		Effect	
	RT	Er-Om	RT	Er-Om	RT	Er-Om
High constraint						
Abstract	982 (276)	23.0 (14.4)	850 (134)	7.0 (7.6)	132	16.0
Concrete	803 (173)	1.3 (4.1)	719 (138)	1.0 (2.4)	84	0.3
Effect	179	21.7	131	6.0		
Low constraint						
Abstract	1585 (548)	26.3 (16.2)	1215 (294)	8.0 (10.5)	370	18.3
Concrete	1194 (266)	3.7 (5.5)	987 (178)	0.7 (2.0)	207	3.0
Effect	391	22.6	228	7.3		
No context						
Abstract	1523 (464)	21.7 (18.0)	996 (193)	4.0 (4.5)	527	17.7
Concrete	1030 (217)	1.7 (3.0)	864 (156)	0.7 (2.0)	166	1.0
Effect	493	20.0	132	3.3		

Standard deviations in parentheses. *Note*. Er-Om = error and omission rates.

3.2.3. Comparing backward and forward translation

In this section we focus on the predictions of the RHM. We first examined the translation of words presented in *isolation*, and tested whether forward translation is more strongly affected by manipulations of word meaning than backward translation (Section 3.2.3.1). We then examined whether any asymmetry in backward and forward word translation is affected by the prior reading of a sentence context (Section 3.2.3.2).

3.2.3.1. Forward and backward translations of isolated words.

A 2 (translation direction: backward, forward) by 2 (cognate status: cognates, noncognates) by 2 (concreteness: concrete, abstract) ANOVA was performed on the mean subject and item RTs. The ANOVA yielded a marginally significant three-way interaction between translation direction, concreteness and cognate status on the subject analysis only, $F_1(1,38) = 3.01$, $p = .09$. Abstract noncognates were translated 169 ms slower in forward than in backward direction; the corresponding translation asymmetry for abstract cognates, concrete noncognates, and concrete cognates was 3 ms, 2 ms, and 20 ms, respectively. The interaction between translation direction and concreteness was also marginally significant on the subject analysis only, $F_1(1,38) = 3.13$, $p = .08$. Furthermore, the interaction between concreteness and cognate status, $F_1(1,38) = 24.39$, $p < .0001$; $F_2(1,112) = 10.23$, $p < .005$, and the main effects of concreteness, $F_1(1,38) = 159.33$, $p < .0001$; $F_2(1,112) = 48.96$, $p < .0001$, and cognate status, $F_1(1,38) = 65.83$, $p < .0001$; $F_2(1,112) = 69.40$, $p < .0001$, were significant. The remaining effects were not significant.

This analysis shows evidence for a weak asymmetry effect as predicted by the RHM: Translating abstract noncognates in forward direction takes somewhat longer than translating abstract noncognates in backward direction. This corroborates the findings in the separate ANOVAs on the backward and forward translation data: the interaction between concreteness and cognate status was not significant in the backward translation data (see Section 3.2.1), but reached significance in the forward translation data (see Section 3.2.2).

3.2.3.2. Forward and backward translation of words embedded in context.

In a subsequent analysis we tested the prediction ensuing from the RHM that the asymmetry in backward and forward word translation will be reduced (or may even disappear) when these words are embedded in a meaningful sentence context. As a (weak) asymmetry effect was observed in the abstract noncognates only, the analysis focuses on the abstract noncognates. Tables 3 and 4 show that when presented in isolation, abstract noncognates are translated 169 ms slower in forward than in backward direction. Likewise, in the low constraint condition, abstract noncognates are translated 226 ms slower in forward direction than in backward direction. In the high constraint condition, this difference is reduced to 7 ms. The 2 (translation direction) by 3 (context) ANOVAs on the mean subject and item RTs on the abstract noncognates showed that the interaction between translation direction and context, however, failed to reach significance, $F_1(2,144) = 1.08$, $p = .34$; $F_2(2,56) = 2.91$, $p = .06$. The main effect of translation direction was not significant either, $F_1(1,114) = 3.68$, $p = .06$; $F_2(1,28) = 1.66$, $p = .21$, but the main effect of context was, $F_1(2,114) = 21.66$, $p < .0001$; $F_2(2,56) = 50.66$, $p < .0001$. So, although the interaction did not reach statistical significance, there is a suggestion in the data that, if anything, the difference in translating abstract noncognates in forward versus backward direction is affected by prior reading of a high constraint sentence context (but not by reading a low constraint sentence context).

To conclude, the comparison of forward and backward translations of words presented in isolation shows evidence of a weak asymmetry effect, confirming our earlier findings in Dutch–English bilinguals from the same population (de Groot et al., 1994; van Hell & de Groot, 1998b). The comparison of forward and backward translation times on words preceded by a low or a high constraint sentence shows that the interaction between the nature of the sentence context and lexical characteristics of words is largely similar in the two translation directions. Only in one specific type of words, abstract noncognates, there was a hint in the data that the translation asymmetry effect disappears in a high constraint sentence context.

It may be argued that the elimination (Experiment 1) and attenuation (Experiment 2) of the cognate status and concreteness effects in the high constraint condition, and the sustained significance of these effects in the low constraint condition, do not stem from differences in the degree of semantic constraint of the two types of sentences. That is, a high constraint context may merely enable the participant to predict the target word and prepare the subsequent response (but see, e.g., Fischler & Bloom, 1979). (This same argument pertains to the work of, e.g., Proverbio et al., 2004, and Schwanenflugel, Harnishfeger, & Stowe, 1988). We tested this possibility as follows: If participants indeed employed such a response preparation strategy, one would expect response preparation to be more successful the shorter the sentence context is, because a shorter context will give the reader more time to derive the response prematurely (remember the context was presented for a fixed amount of time). We therefore separated the longest sentence contexts from the shortest contexts within each of the cognate status by concreteness conditions, both for the high and the low constraint contexts. We then added the factor length to the earlier ANOVAs. If indeed response preparation underlies the elimination and attenuation of cognate status and concreteness effects in the high constraint context condition, the factor length should interact with sentence context, or three way interactions between length, sentence context and cognate status, or between length, sentence context and concreteness should be obtained. However, ANOVAs showed that none of these interactions were significant, in any of the three

tasks (lexical decision and forward and backward translations). The only effect of the factor length we found (in two of the three tasks) was, not surprisingly, its main effect. This effect reflects the importance of controlling the length of the sentences across the various conditions (as we did) in studies investigating sentence priming.

Although the analyses above argue against relegating the effects of sentence constraint to a deliberate response preparation strategy, we performed an additional experiment in which sentence contexts were presented via the technique of rapid serial visual presentation (RSVP; Potter, 1984). In this technique, each word of the sentence context is presented briefly (e.g., for 200 ms), in succession, and typically in the same location. A merit of this technique is that the fast word-by-word presentation of the sentence context should prevent any strategy of deliberate prediction of the target word.

4. Experiment 3: Backward and forward translation using RSVP

4.1. Method

4.1.1. Design
The design was similar to that of Experiment 2: high constraint, low constraint and no context. For the latter condition, the data of Experiment 2 were used.

4.1.2. Participants
Eighty participants, drawn from the same population as those of the preceding experiments, took part. None of the participants took part in Experiments 1 or 2. After finishing the experiment they were asked to rate their comprehension and production abilities in English, see Table 1. Participants received course credit for participation.

4.1.3. Materials
The stimulus materials were the same as in Experiment 2.

4.1.4. Apparatus and procedure
The apparatus and procedure were the same as in Experiment 2, with the exception of the sentence presentation procedure. The first word of the sentence context appeared at the centre of the screen. This word remained on the screen for 200 ms, and was then replaced by the next word of the sentence. In this way, the entire sentence context was presented. If the target word was located somewhere in the middle of the sentence, dashes were presented at its place, and the end of the sentence was marked by a full stop following the final word of the sentence context. If the target word was located at the end of the sentence, the last word of the sentence context was marked with dashes (following the procedures of, e.g., Duffy, Henderson, & Morris, 1989; Simpson, Peterson, Casteel, & Burgess, 1989). About 200 ms after the final word of the sentence context disappeared, the target word appeared and remained at the

centre of the screen until the participant responded. The procedure regarding the translation of the target word was as in Experiment 2.

The instructions for reading the sentence context and for translating the target words were similar to those of Experiment 2, with the exception that participants were now told that the words of the sentence would appear on the screen one by one. Participants were requested to write down the sentence four times throughout the task. All participants read the sentence contexts sufficiently well: In both conditions, the sentence frames noted down covered at least about 75% of the information provided.

4.2. Results and discussion

Mean subject and item RTs, error rates and omissions were calculated following the procedures described in Experiment 2. Voice-switch registration errors made up 7.30% and 7.38% of all data of the backward and forward translation conditions, respectively. The data were analyzed to conform the analyses described in Experiment 2.

4.2.1. Backward translation
Mean subject RTs, error rates, and omission scores are presented in Table 5 (the isolated word data of Experiment 2 are presented in the lower part).

The 186 ms cognate effect in the high constraint condition was smaller than the analogous effect in the no context (274 ms) and low constraint (251 ms) conditions, but the interaction between cognate status and sentence context just failed to reach significance in the subject analysis, $F_1(2,57) = 2.20$, $p = .12$, but was significant in the item analysis $F_2(2,112) = 3.05$, $p = .05$. Concreteness interacted with sentence context, $F_1(2,57) = 5.60$, $p < .01$; $F_2(2,112) = 2.46$, $p = .09$: concreteness effects in the high constraint, low constraint, and no context conditions were

Table 5
Mean reaction times (in ms) and error and omission rates (in percentages) for the backward translation task with sentence context presented via RSVP (Experiment 3)

Concreteness	Noncognates		Cognates		Effect	
	RT	Er-Om	RT	Er-Om	RT	Er-Om
High constraint						
Abstract	1133 (255)	10.7 (5.0)	906 (160)	1.0 (2.4)	227	9.7
Concrete	961 (203)	5.3 (5.1)	815 (165)	0.0 (0.0)	146	5.3
Effect	172	5.4	91	1.0		
Low constraint						
Abstract	1276 (184)	14.0 (13.5)	1007 (91)	2.0 (3.1)	269	12.0
Concrete	1106 (118)	6.3 (6.7)	872 (96)	0.3 (1.5)	234	6.0
Effect	170	7.7	135	1.7		
No context (Experiment 2)						
Abstract	1354 (262)	21.0 (14.6)	993 (146)	2.3 (3.3)	361	18.7
Concrete	1032 (148)	8.0 (7.7)	844 (139)	0.3 (1.5)	188	7.7
Effect	322	13.0	149	2.0		

Standard deviations in parentheses. *Note.* Er-Om = error and omission rates.

132 ms, 152 ms, and 236 ms, respectively. Cognate status interacted with concreteness in the subject analysis, $F_1(1,57) = 12.03$, $p = .001$, but the interaction between sentence context, cognate status and concreteness failed to reach significance, $F_1(2,57) = 2.20$, $p = .13$; $F_2(2,112) = 1.16$, $p > .10$. Finally, significant main effects were obtained for cognate status, $F_1(1,57) = 177.15$, $p < .0001$; $F_2(1,56) = 40.28$, $p < .0001$, concreteness, $F_1(1,57) = 166.52$, $p < .0001$; $F_2(1,56) = 19.82$, $p < .0001$, and sentence context, $F_1(2,57) = 3.96$, $p < .05$; $F_2(2,112) = 13.41$, $p < .0001$.

As in Experiment 2, we performed additional analyses comparing the high constraint with the no context condition and the low constraint with the no context condition. The ANOVA on the high constraint and no context data revealed that the 186 ms cognate effect in the high constraint condition was smaller than the 274 ms effect in the no context condition, $F_1(1,38) = 3.87$, $p = .057$; $F_2(1,56) = 4.34$, $p < .05$. Likewise, the 132 ms concreteness effect in the high constraint condition was smaller than the 236 ms concreteness effect of words presented in isolation, $F_1(1,38) = 7.57$, $p < .01$; $F_2(1,56) = 3.32$, $p = .07$. In contrast, ANOVAs on the low constraint and no context conditions yielded no significant interaction between cognate status and sentence context. The 152 ms concreteness effect in the low constraint condition was smaller than the 236 ms effect in the no context condition in the subject analysis, $F_1(1,38) = 6.43$, $p = .05$, but not in the item analysis.

4.2.2. Forward translation

The mean RTs, error rates, and omission scores are presented in Table 6 (the isolated word data of Experiment 2 are presented in the lower part).

As in Experiment 2, sentence context interacted with cognate status, $F_1(2,57) = 2.97$, $p = .06$; $F_2(2,112) = 3.52$, $p < .05$: the cognate effect in the high constraint, low

Table 6
Mean reaction times (in ms) and error and omission rates (in percentages) for the forward translation task with sentence context presented via RSVP (Experiment 3)

Concreteness	Noncognates		Cognates		Effect	
	RT	Er-Om	RT	Er-Om	RT	Er-Om
High constraint						
Abstract	1099 (366)	17.0 (10.2)	815 (164)	5.4 (4.1)	284	11.6
Concrete	780 (154)	1.7 (3.0)	704 (155)	0.0 (0.0)	76	1.7
Effect	319	15.3	111	5.4		
Low constraint						
Abstract	1407 (312)	22.7 (16.1)	1034 (161)	7.3 (8.1)	373	15.4
Concrete	1056 (160)	1.7 (3.7)	837 (125)	0.3 (1.5)	219	1.4
Effect	351	21.0	197	7.0		
No context (Experiment 2)						
Abstract	1523 (464)	21.7 (18.0)	996 (193)	4.0 (4.5)	527	17.7
Concrete	1030 (217)	1.7 (3.0)	864 (156)	0.7 (2.0)	166	1.0
Effect	493	20.0	132	3.3		

Standard deviations in parentheses. *Note.* Er-Om = error and omission rates.

constraint, and no context conditions was 180 ms, 296 ms, and 346 ms, respectively. The interaction between sentence context and concreteness was marginally significant in the subject analysis only, $F_1(2,57) = 2.49$, $p = .09$: the concreteness effect in the high constraint, low constraint, and no context conditions was 215 ms, 274 ms, and 313 ms, respectively. Cognate status interacted with concreteness, $F_1(1,57) = 29.48$, $p < .0001$; $F_2(1,56) = 4.05$, $p < .05$, but the three-way interaction between sentence context, cognate status and concreteness was not significant. Finally, significant main effects were obtained for context, $F_1(2,57) = 11.83$, $p < .0001$; $F_2(2,112) = 37.19$, $p < .0001$, cognate status, $F_1(1,57) = 92.44$, $p < .0001$; $F_2(1,56) = 22.78$, $p < .0001$, and concreteness, $F_1(1,57) = 222.42$, $p < .0001$; $F_2(1,56) = 25.71$, $p < .0001$.

As in the backward translation condition, we performed additional ANOVAs on the high constraint and no context conditions and on the low constraint and no context conditions. The ANOVA on the high constraint and no context conditions yielded a significant interaction between cognate status and context condition, $F_1(1,38) = 4.86$, $p < .05$; $F_2(1,56) = 5.93$, $p < .05$, indicating that the 180 ms cognate effect in the high constraint condition was smaller than the 346 ms effect in the no context condition. Likewise, the 215 ms concreteness effect in the high constraint condition was smaller than the 313 ms concreteness effect in the no context condition, $F_1(1,38) = 4.86$, $p < .05$, albeit not by items. In contrast, in the ANOVA comparing the low constraint and the no context conditions, the interaction between concreteness and sentence context was not significant, and the interaction between cognate status and sentence context reached significance only in the item analysis, $F_2(1,56) = 4.62$, $p < .05$.

4.2.3. Comparing forward and backward translation

As in Experiment 2, we performed a 2 (translation direction) by 3 (context) ANOVA to test whether forward and backward translation is different for abstract noncognates embedded in a meaningful sentence context. Remember that, when presented in isolation, only in the translation of abstract noncognates a weak asymmetry (as predicted by the RHM) was observed: abstract noncognates were translated 169 ms slower in forward than in backward direction. Parallel to Experiment 2, the RSVP data showed that in the low constraint condition, abstract noncognates were translated slower (i.e., 131 ms) in forward than in backward direction. In the high constraint condition, no such asymmetry occurred, and forward translation was even 34 ms faster than backward translation. Though the means are in the direction predicted by the RHM (and are comparable to those observed in Experiment 2), the interaction between translation direction and context was not significant (as was also the case in Experiment 2). The main effect of translation direction was not significant either, but the main effect of context was, $F_1(2,114) = 10.67$, $p < .0001$; $F_2(2,56) = 12.64$, $p < .0001$.

4.2.4. Overall analyses of Experiments 2 and 3

To see whether the pattern of results obtained with RSVP differed from that observed when sentence contexts were presented for a fixed amount of time, we performed overall ANOVAs on the RT data of the high and low constraint sentence context conditions of Experiments 2 and 3, adding the factor presentation as a between-experiments factor. These ANOVAs were performed on the backward and forward translation data separately. In the overall ANOVAs on the backward translation times, the main effect of presentation was not significant. The interaction between presentation and sentence context was significant, $F_1(1,76) = 4.98$, $p < .05$; $F_2(1,112) = 15.86$, $p < .005$: the difference between high and low constraint sentence contexts observed with fixed presentations (880 ms versus 1142 ms) was reduced when these contexts were presented via RSVP (954 ms versus 1065 ms). The four way interaction was significant on the subject analysis only, $F_1(1,76) = 4.48$, $p < .05$, and reflects the fact that the interaction between sentence context, cognate status, and concreteness was significant in Experiment 2, but just failed to reach significance in Experiment 3. None of the remaining interactions reached significance. ANOVAs on the forward translation times yielded no main effect of the factor presentation. Presentation interacted with sentence context $F_1(1,76) = 3.57$, $p = .06$; $F_2(1,112) = 15.13$, $p < .005$: the difference between high and low constraint sentence contexts with fixed presentation time (838 ms versus 1245 ms) again decreased when contexts were presented via RSVP (849 ms versus 1083 ms). None of the remaining interactions with the factor presentation were significant.

Importantly, the relevant interactions between sentence context and cognate status were significant, both in backward translation $F_1(1,76) = 6.35$, $p < .05$; $F_2(1,112) = 3.17$, $p < .08$ and in forward translation, $F_1(1,76) = 15.72$, $p < .001$; $F_2(1,112) = 15.26$, $p < .005$. Similarly, the interaction between sentence context and concreteness was generally significant, in backward translation, $F_1(1,76) = 3.96$, $p = .05$; $F_2(1,112) = 1.91$, $p = .17$, and in forward translation, $F_1(1,76) = 7.67$, $p < .01$; $F_2(1,112) = 5.67$, $p < .05$.

In conclusion, the overall analyses generally show that the difference between performance in the high and low constraint context conditions was smaller when sentences were presented rapidly word-by-word than when these sentences were presented for a fixed amount of time. This is not an isolated result. Though studies that used either a reader-paced or a fixed presentation procedure typically observe a substantial advantage of high over low constraint sentences (see Section 1), Masson (1986), using an RSVP procedure, obtained a considerably smaller advantage of high over low constraint sentence contexts (see also Forster, 1981). More importantly, however, the overall analyses revealed no other marked effects of presentation mode. These findings indicate that the effects of sentence context constraint on the advantage of concrete over abstract words and of cognates over noncognates observed when sentences were presented for a fixed amount of time were comparable to the effects obtained with the RSVP procedure.

However, closer inspection of the results of Experiments 2 and 3 reveals a subtle difference we should comment on. The interaction between sentence context, cognate status, and concreteness (indicating that a high constraint sentence context is particularly helpful in the translation of abstract noncognates) was significant with the fixed presentation procedure of Experiment 2 (cf. the ANOVAs on the high and low constraint data only), but failed to reach significance with the RSVP procedure (though the means were in the same direction). A plausible explanation for this finding is that the overall difference in RTs between high and low constraint contexts tends to be smaller with the RSVP procedure than with the fixed presentation procedure (see above).

5. General discussion

In three experiments, we examined how context modulates lexical access and concept activation in bilingual memory. In the past decades, considerable progress has been made in understanding how bilingual speakers access words in their two languages and how word meanings become activated after initial lexical access has taken place. In all but a very few cases, the empirical findings and the theoretical models that seek to explain these findings are based on processing words in isolation. We studied how words are recognized (Experiment 1) and translated (Experiments 2 and 3) when embedded in a meaningful sentence context to gain more insight into how contextual information may modulate lexical access and concept activation in bilingual memory.

Studies on bilingual word recognition, often employing manipulations of orthographic, phonological and semantic overlap, overwhelmingly show that lexical access in bilingual memory operates in a parallel, language non-selective way. In line with these studies, we observed in a lexical decision study in Dutch–English bilinguals' L2 English (Experiment 1), that cognates are processed faster than noncognates. We then wondered whether sentence context might modulate a word's lexical access, in particular whether sentence context modulates the co-activation of information in the non-target language. We found that the cognate facilitation effect disappeared when words were presented after a semantically highly constraining sentence context, but not after a low constraint sentence context. This suggests that only sentences that are semantically highly constraining towards a particular target word can modulate lexical access in bilingual memory, and constrain the co-activation of related information in the non-target language. These findings also suggest that the language of the sentence context itself is not a sufficient cue to restrict lexical access to the target language and to bias the bottom-up process of lexical activation (e.g., by activating the lexical items of the language of the context only or by inhibiting items from the non-target language). Had this

been the case, then both low and high constraint sentences should have modulated the cognate facilitation effect.

Our findings in Experiment 1 are identical to those of Schwartz and Kroll (2006), whose Spanish–English bilingual speakers named cognates and noncognates presented after a high or low constraint sentence context. In a recent study with Dutch–English bilinguals, but using low constraint sentences only, Duyck, van Assche, Drieghe, and Hartsuiker (2007) also observed that the cognate facilitation effect in lexical decision and reading in L2 remained substantial. Again, this study shows that the language of the context per se is not a sufficient cue to bias bilingual lexical access and confine it to the language of the sentence context.

Although our study and those of Schwartz and Kroll (2006) and Duyck et al. (2007) used different sentence presentation procedures, different tasks, and/or different bilinguals, the combined findings converge at the conclusion that high constraint but not low constraint sentence contexts affect lexical access in bilingual memory. This suggests that the bilingual word identification system is open to contextual influences: Top-down processes of sentence comprehension and bottom-up processes of lexical activation interact, but only a semantically highly constraining sentence context has the effect of constraining the lexical selection process to one language, namely the language of the context. A recent eye tracking study by Libben and Titone (2007) provides more insight into the time course of contextual influence and lexical selection. Libben and Titone presented French-English bilinguals with high and low constraint sentences containing a cognate or noncognate target word. They observed a cognate effect in the initial stage of reading high constraint sentences (i.e., first fixation duration, first pass gaze duration) that was no longer significant in the later stage of sentence processing (go-past time, the sum of every fixation before going past the target word). In the low constraint sentences, the cognate effect remained significant across all fixation duration measurements. This suggests that even in high constraint sentences, non-selective activation occurs initially which is followed by lexical selection. It also indicates that bottom-up processes of lexical activation interact with top-down processes of sentence comprehension.

Schwartz and Kroll (2006) observed that high constraint sentences eliminated the faster naming times of cognates (sharing both meaning and form across languages) over noncognates, whereas no such effects were observed for the homographs (sharing only form across languages; see also Elston-Güttler et al., 2005). Rather than comparing an all-or-none semantic overlap of words across languages, we examined context effects in relation to more fine-grained variations in cross-language semantic overlap, and compared abstract and concrete cognates and noncognates. It appeared that the basic pattern of contextual effects was not different for abstract versus concrete cognates and noncognates. So, the basic pattern of sentence contextual influences on lexical access in bilingual memory seems immune to subtle (but not to all-or-none) variations in cross-language semantic overlap.

Do the results of Experiment 1 also inform theoretical views on the representation of cognates and noncognates in bilingual memory? Models that have been proposed to explain the cognate facilitation effect in visual word recognition can be divided into two broad categories. According to one line of models, cognates and noncognates are represented in a similar way, but vary in the degree of overlap in orthographic, phonological, and semantic information (see, e.g., Dijkstra & van Heuven, 2002; Thomas & van Heuven, 2005; van Hell & de Groot, 1998a). These models emphasize the co-activation of orthographic, phonological and semantic information across languages during word recognition, and the cognate facilitation effect is attributed to differences in overlap among the three codes, with the effect that cognates reach a stable state earlier than noncognates. A second broad group of models emphasize qualitative differences in the representation of cognates and noncognates (e.g., de Groot & Nas, 1991; Kirsner, Lalor, & Hird, 1993; Sánchez-Casas, Davis, & García-Albea, 1992; Sánchez-Casas & García-Albea, 2005). For example, de Groot and Nas propose that at the lexical level the representations of both cognate and noncognate translations are connected. At the conceptual level, cognates and noncognates are represented in a qualitatively different way: Cognate translations share a representation, but noncognate translations are represented in separate conceptual nodes. In the models of Kirsner, Sánchez-Casas and colleagues, morphology determines how cognates and noncognates are represented. These researchers propose that cognate translations share a morphological representation whereas the two members of a noncognate translation pair have a separate morphological representation in bilingual memory. The finding that the cognate facilitation effect remains substantial in one of two context conditions (the low constraint condition) but not in the other (the high constraint condition) is easier to reconcile with theories that emphasize the co-activation of shared information across the two languages than with models that emphasize structural differences in the representation of cognates and noncognates. More specifically, if cognate facilitation effects emerge from the special representational status of cognates in memory, the cognate effect should be immune to variations in semantic constraint of the sentences the target words are embedded in.

In Experiments 2 and 3, we examined how contextual information influences the translation of words. As discussed in the Introduction, the word translation task has been used extensively to study concept activation and the nature of interlanguage connections in bilingual memory. According to the Revised Hierarchical Model (RHM; e.g., Kroll & Stewart, 1994), word-to-concept mappings are weaker in L2 than in L1, and therefore translating isolated words from L2 to L1 (backward translation) is more likely to occur at the lexical level, whereas translating words from L1 into L2 (forward translation) is more likely to be conceptually mediated. Hence, a manipulation of semantic characteristics should affect forward translation

more strongly than backward translation. When presented in isolation, we found that concrete words were translated faster than abstract words, not only in forward but also in backward direction, suggesting that also translation from L2 into L1 is conceptually mediated. We did, however, find evidence for a weak translation asymmetry effect, in line with the RHM's prediction, for one specific type of words: The translation of abstract noncognates took somewhat longer in forward direction than in backward direction.

The next question we addressed was how contextual information, and variations in semantic constraint therein, modulates word translation. The pattern of results obtained in the translation tasks appeared highly similar to that in the lexical decision task. Effects of cognate status and concreteness observed in isolated word translation were strongly reduced when the words were presented after a high constraint sentence context, but remained substantial when presented after a low constraint sentence context. Moreover, prior presentation of a high constraint sentence context appeared particularly helpful in translating abstract noncognates. These results were obtained in forward as well as in backward translation, and both when sentences were presented for a fixed amount of time (Experiment 2) and when presented word-by-word (Experiment 3).

In overall analyses, we compared the forward and backward translation data to test the prediction based on the RHM that differences in the strength of word-to-concept mappings in L2 and in L1 are attenuated by embedding words in a meaningful sentence context. The overall analyses showed that the basic context effects on translation were similar in backward and in forward translation. A more specific analysis on the abstract noncognates only (the word class for which a weak asymmetry effect was found) showed that the 169 ms translation asymmetry effect, when the stimulus words were presented in isolation, remained substantial in the low constraint condition (226 ms), but was reduced to 7 ms in the high constraint condition. Although the effect was too weak to reach statistical significance, these findings show that, if anything, the translation asymmetry observed for isolated words was attenuated when the abstract noncognates were embedded in a highly meaningful sentence context, but not in a low constraint sentence context. It should be noted that our bilinguals were fairly fluent, and that these effects were observed in the type of words that were most difficult for them to translate: the abstract noncognates. This suggests that the translation asymmetry and the influence of sentence context on word translation are possibly more pronounced in bilingual speakers who are less proficient in their L2. This is an issue to be considered in future research.

What do these translation data tell us about the word-to-concept mappings in L2 and L1? Our data suggest that for the fairly fluent Dutch–English bilinguals tested in this study, there are no qualitative differences in the nature of connections between words and concepts in L2 and in L1, and that backward and forward translation are both conceptually mediated. We propose that the basic mechanism involved in conceptual activation of L2 words is comparable to that of L1 words, although words may differ in relative ease with which they can activate their concepts. This is further supported by the finding that effects of semantic constraint of sentences are comparable across the two translation directions: Prior presentation of a high constraint sentence context, but not of a low constraint sentence context, affected translation performance. This suggests that only semantically highly constraining contextual information benefits the target word's concept activation, but the underlying mechanism works similarly for words in L2 and in L1.

For one type of words, abstract noncognates, concept retrieval was (still) rather difficult for the bilinguals we tested. This may be due to relatively weak L2 word-to-concept mappings for the abstract noncognates (e.g., Kroll & de Groot, 1997; La Heij et al., 1996; van Hell & de Groot, 1998a) or because L2 abstract noncognates are associated with relatively few semantic senses (Finkbeiner et al., 2004). The strong influence of high constraint sentence contexts on the translation of the abstract noncognates suggests that concept retrieval of these words in particular benefits from prior presentation of the semantically rich sentence context.

Additional evidence for the interpretation of the findings regarding abstract noncognates in terms of relative difficulty of L2 concept activation (and not in terms of qualitatively different connections) comes from analyses of translation errors and omissions on these words. These analyses are motivated by the theoretical view advanced by La Heij et al. (1996), who also proposed that backward and forward translations are conceptually mediated. La Heij et al. hypothesized that word translation can be decomposed into two main processes: determining the meaning of the word to be translated (concept activation) and the subsequent retrieval of the response word (word retrieval). If indeed backward and forward translations are conceptually mediated, the main problem in backward translation will be concept activation and not the subsequent retrieval of the L1 word form. In contrast, the main problem in forward translation will not be concept activation (well-practiced when reading in L1), but the subsequent retrieval of the L2 word. Problems in concept activation during backward translation would lead to errors in translation (resulting from the activation of an incorrect concept), whereas problems in L2 word retrieval in forward translation should lead to failures to come up with the translation (i.e., response omissions). We tested these predictions in additional ANOVAs on the error and omission data regarding isolated abstract noncognates translated in forward and in backward direction. Indeed, more errors were made in backward (11.0%) than in forward (5.3%) translation (a difference that reached significance in the subject analysis, $F_1(1, 38) = 5.31$, $p < .05$; $F_2(1,28) = 1.73$, $p = .20$), whereas slightly more omissions occurred in forward (16.3%) than in backward (10.0%) translation (but this difference is weak and did not reach statistical significance, $F_1(1, 38) = 2.56$, $p = .12$; $F_2(1,28) = 2.18$, $p = .15$).

Our sentence context data (Experiment 2) enable a further test of this interpretation, and indeed confirm it. If a meaningful sentence context aids concept activation, it can be expected that sentence context will be particularly helpful in reducing the errors made in backward translation. In contrast, contextual information will not strongly reduce the omissions made in forward translation, if indeed response omissions mainly stem from difficulty in L2 word retrieval. Indeed, the ANOVA on the error data of the abstract noncognates yielded an interaction between sentence context and translation direction in the subject analysis, $F_1(2,114) = 3.12$, $p < .05$; $F_2(2,56) = 2.05$, $p = .14$; the relatively high percentage of errors in backward translation (11.0%) was significantly reduced when words were presented in sentence context (high constraint: 6.5%, low constraint: 4.7%), whereas the percentage errors were comparable across the three forward translation conditions (no context: 5.3%; high constraint: 6.3%; low constraint: 6.0%). No significant interaction was obtained in the omission data ANOVAs; mean forward translation omissions were 16.3%, 16.7%, and 20.3% in the no context, high constraint and low constraint conditions, respectively; mean backward translation omissions were 10%, 5.3%, and 6.0% in the no context, high constraint and low constraint conditions, respectively.

A final question to be addressed is how contextual information may affect lexical access and concept retrieval in bilingual memory. The different effects of high and low constraint sentences obtained in the three experiments reported in this paper, as well as in the eye tracking and naming studies by Altarriba et al. (1996) and Schwartz and Kroll (2006), convincingly show that semantic constraint in the sentence modifies lexical access and concept activation. Discerning high constraint and low constraint sentence contexts is thus important for understanding the mechanisms with which sentence context operates on upcoming words. Via which mechanism may the semantic constraint effect come about? The differential effects obtained with semantically high and low constraint sentences can be understood by assuming that a high constraint sentence, but not a low constraint sentence, delineates the lexical and conceptual information of a word that is activated on the basis of feature restrictions imposed by the sentence context. According to the feature restrictions hypothesis, proposed by, e.g., Schwanenflugel and LaCount (1988) and Kellas, Paul, Martin, and Simpson (1991) in the monolingual literature, readers use sentence context to generate semantic, syntactic, and lexical feature restrictions to facilitate the processing of upcoming words. These feature restrictions are compared to the conceptual features of upcoming words. Readers will generate more feature restrictions for high constraint sentences than for low constraint sentences. For example, in case of the high constraint sentence context 'She took a bite of the fresh green...' for the target word 'apple', readers may generate the feature restrictions [can be bitten], [fresh], and [green]. In the low constraint sentence context 'My sister was hungry and took the last...' for the target word 'apple', readers may generate the single feature restriction [taken when hungry].

Many upcoming words accommodate this single feature restriction [taken when hungry], whereas a few words accommodate all three feature restrictions in the high constraint example. High, but not low, constraint sentences thus delineate the activation of semantic, orthographic and phonological elements of words in bilingual memory (we assume here that semantic, orthographic and phonological information are highly interconnected, as is assumed in many current models, including the BIA+ model).

How does this affect the cognate facilitation effect in lexical decision in the second language? Assuming that top-down processes of sentence comprehension and bottom-up processes of lexical activation interact, the semantic feature restrictions generated by a high constraint sentence will reduce the number of lexical entries that compete for selection, in both cognates and noncognates alike. This reduces, or may even eliminate, the cognate advantage in the bottom-up lexical activation process due to the co-activation of orthographic, phonological, and semantic information across languages. In contrast, the feature restrictions activated when reading a low constraint sentence context are not specific enough to modulate effects emanating from bottom-up activation processes. So, compared to low constraint sentences, high constraint sentences move the time window of lexical selection and help the lexical activation process to reach a stable state at an earlier time. Likewise, in translation, high constraint sentences may delineate the conceptual elements that become activated (e.g., van Hell & de Groot, 1998a), or demarcate a subset of a word's senses (Finkbeiner et al., 2004), which will facilitate concept retrieval (in line with RHM; La Heij et al., 1996). The benefits of this process will be particularly strong for words whose concepts are relatively difficult to retrieve, like the abstract noncognates in our bilinguals.

To conclude, although considerable progress has been made in understanding how bilinguals recognize and translate words presented in isolation, relatively little is known on how sentence context affects lexical access and concept activation in bilingual memory. The present study shows that semantically highly constraining sentence contexts, but not low constraint sentence contexts, can restrict lexical access to the target language in visual word recognition, and can benefit a target word's concept activation in translation (and similarly so in forward and backward translation).

Acknowledgements

Appendix A

Mean values (and standard deviations) of the properties of word sets and sentence contexts used in Experiments 1–3

	Cognates		Noncognates	
	Concrete	Abstract	Concrete	Abstract
English				
Word property				
Cognate status	5.89 (.52)	5.89 (.73)	1.23 (.08)	1.23 (.09)
Concreteness	6.43 (.49)	3.95 (1.42)	6.58 (.47)	2.92 (.39)
Context availability	5.74 (.36)	4.18 (.73)	5.71 (.58)	4.06 (.33)
Log frequency	3.50 (.34)	3.53 (.34)	3.39 (.36)	3.56 (.42)
Length	5.87 (1.19)	6.13 (1.85)	5.27 (1.39)	6.60 (2.35)
Context property				
Production probability HC	.72 (.22)	.62 (.24)	.71 (.25)	.65 (.25)
Production probability LC	.09 (.08)	.09 (.19)	.14 (.15)	.06 (.05)
Plausibility HC	4.20 (.66)	4.26 (.74)	3.90 (.96)	4.02 (.67)
Plausibility LC	4.48 (.85)	4.28 (.93)	4.23 (.79)	4.20 (.60)
Length HC	46.93 (8.93)	46.27 (6.41)	48.07 (8.62)	47.67 (7.87)
Length LC	46.07 (6.71)	47.33 (7.11)	46.07 (7.87)	48.60 (8.24)
Dutch				
Word property				
Cognate status	5.89 (.52)	5.89 (.73)	1.23 (.08)	1.23 (.09)
Concreteness	6.09 (.63)	3.44 (1.44)	6.44 (.26)	2.46 (.49)
Context availability	5.66 (.34)	3.72 (.37)	5.67 (.23)	3.62 (.32)
Log frequency	3.43 (.35)	3.38 (.36)	3.39 (.21)	3.40 (.27)
Length	6.07 (1.16)	6.27 (1.98)	6.07 (2.40)	6.27 (1.98)
Context property				
Production probability HC	.83 (.16)	.76 (.21)	.79 (.22)	.83 (.15)
Production probability LC	.13 (.12)	.08 (.11)	.09 (.10)	.12 (.10)
Plausibility HC	4.27 (.85)	4.60 (.84)	4.16 (.93)	4.25 (1.03)
Plausibility LC	4.28 (1.08)	4.22 (.98)	4.10 (.77)	4.37 (.81)
Length HC	48.53 (6.88)	47.07 (5.46)	46.40 (8.79)	47.73 (8.65)
Length LC	45.93 (6.14)	46.93 (7.68)	45.13 (7.52)	48.67 (8.69)

Note. HC, high constraint; LC, low constraint.

Appendix B

A sample of high and low constraint sentence contexts and target words used in Experiments 1–3

Abstract noncognates

HC Dutch: Na enige aarzeling vertelde mijn vader de *waarheid*.
English: After some hesitation my father told the *truth*.

LC Dutch: Veel onderzoekers zoeken nog steeds naar de *waarheid*.
English: Many researchers are still looking for the *truth*.

Appendix B (*continued*)

Concrete noncognates

HC Dutch: Op de eerste lentedag draagt zij graag een *rok*.
English: On the first day of spring she likes to wear a *skirt*.

LC Dutch: De rijke vrouw kocht een dure *rok*.
English: The rich woman bought an expensive *skirt*.

Abstract cognates

HC Dutch: De vragen bij het tentamen vereisten kennis en *inzicht*.
English: The questions at the exam required knowledge and *insight*.

Appendix B (*continued*)

LC　　Dutch: Dit moeilijke tentamen vereiste veel *inzicht*.
　　　　English: This difficult examination required much *insight*.

Concrete cognates
HC　　Dutch: De mooiste hut op het schip is van de *kapitein*.
　　　　English: The best cabin of the ship belongs to the *captain*.

LC　　Dutch: De knappe man in het witte pak is de *kapitein*.
　　　　English: The handsome man in the white suit is the *captain*.

HC, high constraint; LC, low constraint.

References

Altarriba, J., Kroll, J. F., Sholl, A., & Rayner, K. (1996). The influence of lexical and conceptual constraints on reading mixed-language sentences: Evidence from eye fixations and naming times. *Memory and Cognition, 24*, 477–492.

Baayen, H., Piepenbrock, R., & van Rijn, H. (1993). *The CELEX lexical database (CD-ROM)*. Philadelphia, PA: University of Pennsylvania, Linguistic Data Consortium.

Bloem, I., & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language, 48*, 468–488.

Brysbaert, M., van Dyck, G., & van de Poel, M. (1999). Visual word recognition in bilinguals: Evidence from masked phonological priming. *Journal of Experimental Psychology: Human Perception and Performance, 25*, 137–148.

Cheung, H., & Chen, H.-C. (1998). Lexical and conceptual processing in Chinese–English bilinguals: Further evidence for asymmetry. *Memory and Cognition, 26*, 1002–1013.

Costa, A., Caramazza, A., & Sebastián-Gallés, N. (2000). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1283–1296.

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language, 41*, 365–397.

Cristoffanini, P., Kirsner, K., & Milech, D. (1986). Bilingual lexical representation: The status of Spanish–English cognates. *Quarterly Journal of Experimental Psychology, 38A*, 367–393.

de Groot, A. M. B., Dannenburg, L., & van Hell, J. G. (1994). Forward and backward word translation by bilinguals. *Journal of Memory and Language, 33*, 600–629.

de Groot, A. M. B., Delmaar, P., & Lupker, S. J. (2000). The processing of interlexical homographs in translation recognition and lexical decision: Support for nonselective access to bilingual memory. *Quarterly Journal of Experimental Psychology, 53A*, 397–428.

de Groot, A. M. B., & Nas, G. L. J. (1991). Lexical representation of cognates and noncognates in compound bilinguals. *Journal of Memory and Language, 30*, 90–123.

de Groot, A. M. B., & Poot, R. (1997). Word translation at three levels of proficiency in a second language: The ubiquitous involvement of conceptual memory. *Language Learning, 47*, 215–264.

Dijkstra, A., Grainger, J., & van Heuven, W. J. B. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language, 41*, 496–518.

Dijkstra, A., & van Heuven, W. J. B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition, 5*, 175–197.

Dijkstra, A., van Jaarsveld, H., & ten Brinke, S. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism: Language and Cognition, 1*, 51–66.

Duffy, S. A., Henderson, J. M., & Morris, R. K. (1989). Semantic facilitation of lexical access during sentence processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 791–801.

Duyck, W., & Brysbaert, M. (2004). Forward and backward number translation requires conceptual mediation in both balanced and unbalanced bilinguals. *Journal of Experimental Psychology: Human Perception and Performance, 30*, 889–906.

Duyck, W., van Assche, E., Drieghe, D., & Hartsuiker, R. (2007). Visual word recognition by bilinguals in a sentence context: Evidence for nonselective lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 663–679.

Elston-Güttler, K. E., Gunter, T. C., & Kotz, S. A. (2005). Zooming into L2: Global language context and adjustment affect processing of interlingual homographs in sentences. *Cognitive Brain Research, 25*, 57–70.

Finkbeiner, M., Forster, K., Nicol, J., & Nakamura, K. (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory and Language, 51*, 1–22.

Fischler, I., & Bloom, P. A. (1979). Automatic and attentional processes in the effects of sentence contexts on word recognition. *Journal of Verbal Learning and Verbal Behavior, 18*, 1–20.

Forster, K. I. (1981). Priming and the effects of sentence and lexical contexts on naming time: Evidence for autonomous lexical processing. *Quarterly Journal of Experimental Psychology, 33A*, 465–495.

Francis, W. S. (2005). Bilingual semantic and conceptual representation. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 251–267). New York, NY: Oxford University Press.

French, R. M., & Jacquet, M. (2004). Understanding bilingual memory: Models and data. *Trends in Cognitive Sciences, 8*, 87–93.

Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew–English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 1122–1139.

Graddol, D. (2004). The future of language. *Science, 303*, 1329–1331.

Hermans, D., Bongaerts, T., de Bot, K., & Schreuder, R. (1998). Producing words in a foreign language: Can speakers prevent interference from their first language? *Bilingualism: Language and Cognition, 1*, 213–230.

Jared, D., & Kroll, J. F. (2000). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language, 44*, 2–31.

Kawamoto, A. H. (1993). Nonlinear dynamics in the resolution of lexical ambiguity: A parallel distributed processing account. *Journal of Memory and Language, 32*, 474–516.

Kirsner, K., Lalor, E., & Hird, K. (1993). The bilingual lexicon: Exercise, meaning and morphology. In R. Schreuder & B. Weltens (Eds.), *The bilingual lexicon* (pp. 215–248). Amsterdam: John Benjamins.

Kroll, J. F., & de Groot, A. M. B. (1997). Lexical and conceptual memory in the bilingual: Mapping Form to Meaning in Two Languages. In A. M. B. De Groot & J. F. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 169–199). Mahwah, NJ: Lawrence Erlbaum Publishers.

Kroll, J. F., & de Groot, A. M. B. (2005). *Handbook of bilingualism: Psycholinguistic approaches*. New York, NY: Oxford University Press.

Kroll, J. F., Michael, E., Tokowicz, N., & Dufour, R. (2002). The development of lexical fluency in a second language. *Second Language Research, 18*, 137–171.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language, 33*, 149–174.

Kroll, J. F., & Tokowicz, N. (2005). Models of bilingual representation and processing: Looking back and to the future. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 531–553). New York, NY: Oxford University Press.

La Heij, W., Hooglander, A., Kerling, R., & van der Velden, E. (1996). Nonverbal context effects in forward and backward word translation: Evidence for concept mediation. *Journal of Memory and Language, 35*, 648–665.

Lemhöfer, K., Dijkstra, T., & Michel, M. C. (2004). Three languages, one ECHO: Cognate effects in trilingual word recognition. *Language and Cognitive Processes, 19*, 585–611.

Li, P., & Yip, M. C. (1998). Context effects and the processing of spoken homophones. *Reading and Writing, 10*, 223–243.

Libben, M., & Titone, D. A. (2007). Bilingual lexical access in context: Evidence from eye movements during reading. In *Paper presented at the 48th annual meeting of the psychonomic society*, Long Beach, November 15–18.

Marian, V., Spivey, M., & Hirsch, J. (2003). Shared and separate systems in bilingual language processing: Converging evidence from eyetracking and brain imaging. *Brain and Language, 86*, 70–82.

Martin, W., & Tops, G. A. J. (1984). *Van Dale Groot Woordenboek Engels-Nederlands (Van Dale large English-Dutch dictionary)*. Utrecht, The Netherlands/Antwerpen, Belgium: Van Dale Lexicografie.

Martin, W., & Tops, G. A. J. (1986). *Van Dale Groot Woordenboek Nederlands-Engels (Van Dale large Dutch-English dictionary)*. Utrecht, The Netherlands/Antwerpen, Belgium: Van Dale Lexicografie.

Masson, M. E. J. (1986). Comprehension of rapidly presented sentences: The mind is quicker than the eye. *Journal of Memory and Language, 25*, 588–604.

Miller, N. A., & Kroll, J. F. (2002). Stroop effects in bilingual translation. *Memory and Cognition, 30*, 614–628.

Nas, G. (1983). Visual recognition in bilinguals: Evidence for a cooperation between visual and sound based codes during access to a common lexical store. *Journal of Verbal Learning and Verbal Behavior, 22*, 526–534.

Noble, C. E. (1953). The meaning–familiarity relationship. *Psychological Review, 60*, 89–98.

Potter, M. C. (1984). Rapid serial visual presentation (RSVP): A method for studying language processing. In D. Kieras & M. A. Just (Eds.), *New methods in reading comprehension research* (pp. 91–118). Hillsdale, NJ: Lawrence Erlbaum Associates.

Proverbio, A. M., Leoni, G., & Zani, A. (2004). Language switching mechanisms in simultaneous interpreters: An ERP study. *Neuropsychologia, 42*, 1636–1656.

Raaijmakers, J. G. W., Schrijnemakers, J. M. C., & Gremmen, F. (1999). How to deal with 'The language-as-fixed-effect fallacy'?: Common misconceptions and alternative solutions. *Journal of Memory and Language, 41*, 416–426.

Sánchez-Casas, R. M., Davis, C. W., & García-Albea, J. E. (1992). Bilingual lexical processing: Exploring the cognate/noncognate distinction. *European Journal of Cognitive Psychology, 4*, 293–310.

Sánchez-Casas, R. M., & García-Albea, J. E. (2005). The representation of cognate and noncognate words in bilingual memory: Can cognate status be characterized as a special kind of morphological relation? In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 226–250). New York: OUP.

Schwanenflugel, P. J. (1991). Why are abstract concepts hard to understand? In P. J. Schwanenflugel (Ed.), *The psychology of word meanings* (pp. 223–250). Hillsdale, NJ: Lawrence Erlbaum.

Schwanenflugel, P. J., Harnishfeger, K. K., & Stowe, R. W. (1988). Context availability and lexical decisions for abstract and concrete words. *Journal of Memory and Language, 27*, 499–520.

Schwanenflugel, P. J., & LaCount, K. (1988). Semantic relatedness and the scope of facilitation for upcoming words in sentences. *Journal of Experimental Research: Learning, Memory, and Cognition, 14*, 344–354.

Schwanenflugel, P. J., & Shoben, E. J. (1985). The influence of sentence constraint on the scope of facilitation for upcoming words. *Journal of Memory and Language, 24*, 232–252.

Schwartz, A. I., & Kroll, J. F. (2006). Bilingual lexical activation in sentence context. *Journal of Memory and Language, 55*, 197–212.

Schwartz, A. I., Kroll, J. F., & Diaz, M. (2007). Reading words in Spanish and English: Mapping orthography to phonology in two languages. *Language and Cognitive Processes, 22*, 106–129.

Sharkey, A. J. C., & Sharkey, N. E. (1992). Weak contextual constraints in text and word priming. *Journal of Memory and Language, 31*, 543–572.

Simpson, G. B., & Krueger, M. A. (1991). Selective access of homograph meanings in sentence contexts. *Journal of Memory and Language, 30*, 627–643.

Simpson, G. B., Peterson, R. R., Casteel, M. A., & Burgess, C. (1989). Lexical and sentence context effects in word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 88–97.

Sholl, A., Sankaranarayanan, A., & Kroll, J. F. (1995). Transfer between picture naming and translation: A test of asymmetries in bilingual memory. *Psychological Science, 6*, 45–49.

Stanovich, K. E., & West, R. F. (1983). On priming by a sentence context. *Journal of Experimental Psychology: General, 112*, 1–36.

Thomas, M. S. C., & van Heuven, W. J. B. (2005). Computational models of bilingual comprehension. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 202–225). New York, NY: Oxford University Press.

Tokowicz, N., & Kroll, J. F. (2007). Number of meanings and concreteness: Consequences of ambiguity within and across languages. *Language and Cognitive Processes, 22*, 727–779.

van Hell, J. G. (1998). *Cross-language processing and bilingual memory organization*. Unpublished Doctoral Dissertation, University of Amsterdam, the Netherlands.

van Hell, J. G. (2002). Bilingual word recognition beyond orthography: On meaning, linguistic context and individual differences. *Bilingualism: Language and Cognition, 5*, 209–212.

van Hell, J. G., & de Groot, A. M. B. (1998a). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition, 1*, 193–211.

van Hell, J. G., & de Groot, A. M. B. (1998b). Disentangling context availability and concreteness in lexical decision and word translation. *Quarterly Journal of Experimental Psychology, 51A*, 41–63.

van Hell, J. G., & Dijkstra, A. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin and Review, 9*, 780–789.

van Hell, J. G., Oosterveld, P., & de Groot, A. M. B. (1996). Covariance structure analysis in experimental research: Comparing two word translation models. *Behavior Research Methods, Instruments, and Computers, 28*, 491–503.

Van Heuven, W. J. B., Dijkstra, A., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language, 39*, 458–483.

Van Orden, G. C., Pennington, B. F., & Stone, G. O. (1990). Word identification in reading and the promise of subsymbolic psycholinguistics. *Psychological Review, 97*, 448–522.

Van Petten, C., & Kutas, M. (1990). Interactions between sentence context and word frequency in event-related brain potentials. *Memory and Cognition, 18*, 380–393.

Von Studnitz, R., & Green, D. W. (2002). Interlingual homograph interference in German-English bilinguals: Its modulation and locus of control. *Bilingualism: Language and Cognition, 5*, 1–23.