Do semantic sentence constraint and L2 proficiency influence language selectivity of lexical access in native language listening?

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Running Head: Native-language auditory word recognition in a sentence context

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Abstract

We investigated whether language nonselective lexical access in bilingual auditory word recognition when listening in the native language (L1) is modulated by (a) the semantic constraint of the sentence and (b) the second-language (L2) proficiency level. We report two experiments in which Dutch-English bilinguals with different proficiency levels completed an L1 auditory lexical decision task on the last word of low- and high-constraining sentences. The critical stimuli were interlingual homophones (e.g., *lief* (sweet) – *leaf* /li:f/). Participants recognized homophones significantly slower than matched control words. Importantly, neither the semantic constraint of the sentence, nor the proficiency level of the bilinguals interacted with this interlingual homophone effect. However, when we compared the slow and fast reaction times, we observed a reduction in the homophone interference effect when listening to high-constraining sentences in L1 for the slow RTs, but not for the fast RTs. Taken together, this provides strong evidence for a language-nonselective account of lexical access when listening in the native language, and suggests that even when low proficient bilinguals are listening to high-constraint sentences in L1, both languages of a bilingual are still activated.

Much research on bilingualism has asked whether lexical access in word recognition is language selective or not. According to one point of view, bilinguals have two separate lexicons (e.g., Gerard & Scarborough, 1989). So, when reading or listening in one language, only words from this lexicon are activated. However, by now there is much evidence for another viewpoint according to which bilinguals have one lexicon that integrates words from both the native (L1) and nonnative (L2) language. Evidence in favor of this account has especially been reported in the domain of visual word recognition (e.g., de Groot, Delmaar, & Lupker, 2000; Dijkstra & Van Heuven, 1998; Duyck, 2005; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Van Assche, Duyck, Hartsuiker, & Diependaele, 2009), but there are also several studies in the auditory domain (e.g., Ju & Luce, 2004; Lagrou, Hartsuiker, & Duyck, 2011; Marian & Spivey, 2003; Schulpen, Dijkstra, Schriefers, & Hasper, 2003; Spivey & Marian, 1999; Weber & Cutler, 2004).

More recent research has started to investigate whether there are factors that can constrain this language nonselectivity (e.g., context, lexical, or language history/proficiency variables). Here, we investigated three such factors. In particular, we tested whether lexical access remains language nonselective when listening to sentences in the native language (L1). Additionally, we investigated the influence of the semantic constraint of the sentence and the L2 proficiency level of the bilinguals. Although previous studies mostly agree that lexical access is language nonselective when reading or listening in L2, the evidence for language nonselectivity in L1 is not always consistent (see below), and the relevant studies are mostly restricted to recognition of isolated speech/words (e.g., Spivey & Marian, 1999; Weber & Cutler, 2004). One explanation of this inconsistency may be that L2 representations are too weak to compete with L1 representations. Moreover, Lagrou, Hartsuiker, and Duyck (2013) demonstrated that when listening in L2, the activation of lexical representations of the non-target language (i.e., L1) is

modulated, but not eliminated, by the semantic constraint of the sentence. Hence, it could be the case that the joint influence of the semantic constraint of the sentence and the weaker interference from L2 to L1 recognition completely annul cross-lingual interference. Similarly, with respect to the influence of L2 proficiency, a limited number of studies have demonstrated less cross-lingual interference with low-proficient L2 speakers, but the evidence in favor of this conclusion is mixed. Therefore, in this study we investigated the compound influence of these three variables. It might be that several factors conspire to render lexical access language-selective. Do sentences that generate strong lexical restrictions towards a specific word in the native language completely eliminate interlingual effects? And is this the case for low and high proficient bilinguals?

Below, we will first discuss the literature on bilingual visual and auditory word recognition in L2 and in L1. Then, we will zoom in on studies on bilingual word recognition that investigated the influence of semantic constraint and L2 proficiency respectively.

Bilingual word recognition

Until now, the issue of language nonselectivity has been studied in several ways. In many occasions, researchers have used stimuli that overlap across languages with respect to phonology (e.g. homophones), orthographic word form (e.g. homographs) or both (and if meaning also overlaps, cognates). For example in the visual domain, the homograph interference effect (e.g., de Groot et al., 2000; Gerard and Scarborough, 1989) and the cognate facilitation effect (e.g., Libben & Titone, 2009; Peeters, Dijkstra, & Grainger, 2013) have been considered as reliable markers of cross-lingual interactions in the bilingual lexicon. For example, Dijkstra,

Timmermans, and Schriefers (2000) observed slower recognition of homographs relative to controls in a language decision task (i.e., participants decided whether a presented word was an English or a Dutch word) and in a go/no-go task (i.e., participants needed to respond only when an English or a Dutch word were presented). Duyck et al. (2007), instructed participants to read words in L2 while eye movements were registered. Reading times were faster for cognates than for matched control words, which demonstrates a clear cognate facilitation effect.

Although research on bilingual auditory word recognition remains more scarce than research in the visual domain, there is now converging evidence from several studies, especially for L2 listening, that lexical access to spoken words is also language nonselective. For example, pioneering studies by Marian and colleagues (Marian & Spivey, 2003; Spivey and Marian, 1999), and subsequent work by Weber and Cutler (2004) and Lagrou et al. (2011) all found that listening in a second language is influenced by knowledge of the native language. Marian and colleagues conducted a visual world study with late Russian-English bilinguals who were strongly immersed in English. Participants were instructed in their L2 to pick up a real-life object (e.g., "*Pick up the marker*"). There were more fixations on competitor objects with a name in the irrelevant L1 that was phonologically similar to the target (e.g., a stamp; *marka* in Russian) than on distracter objects with a name in L1 that was phonologically unrelated to the L2 target. This effect was replicated with a group of Dutch-English bilinguals, in a comparable eyetracking study by Weber and Cutler. The results of an auditory lexical decision study by Lagrou et al. are consistent with these eyetracking results. In the latter study, bilinguals (but not monolinguals) showed slower L2 lexical decisions on interlingual homophones (e.g., *lief* (sweet) – *leaf* /li:f/) than on matched control words, suggesting that when listening in L2, L1 representations become active and compete for recognition, implying that lexical access is language nonselective.

The evidence for language nonselectivity in bilingual auditory word recognition is less consistent for listening in the native language. Spivey and Marian (1999) instructed Russian-English bilinguals also in their L1 (e.g., *"Podnimi marku"* meaning "Pick up the stamp"), and found that they also fixated more on competitor items with a name in the irrelevant L2 that was phonologically similar to the target (e.g., *marker*). However, this was not the case in the study by Weber and Cutler (2004). In this study, Dutch-English bilinguals who were instructed in their L1 did not fixate more on the irrelevant L2 competitor that was phonologically similar to the target. A clear difference between studies that could account for this inconsistency is that the bilinguals of Marian and colleagues were L2 immersed and, consequently, probably much more proficient. Using a different paradigm, Lagrou et al. (2011) did however reach similar conclusions as Spivey and Marian. They found that lexical decision times were slower for interlingual homophones than for controls when listening in L1, even though the participants in this study were non-immersed and (presumably) less proficient in their L2 than the bilinguals in the study by Spivey and Marian, and thus comparable to the group op bilinguals that participated in the Weber and Cutler study. Although L2 proficiency might have an effect on some levels of L2 word recognition, these findings suggest that proficiency is not the crucial variable in explaining why some studies observed cross-lingual interference and other studies have not. More evidence for language nonselective lexical access in L1 comes from a visual world eye-tracking study by Ju and Luce (2004). In this study, Spanish-English bilinguals fixated pictures of interlingual competitors (nontarget pictures whose English names (e.g., *pliers*) shared a phonological similarity with the Spanish targets (e.g., *playa*, "beach")) more frequently than control distracters. However, this effect was only found when the Spanish target words were altered to contain English-appropriate voice onset times. When the Spanish targets had Spanish VOTs, no

L1 interference was found. In sum, whereas there is convergent evidence for language nonselective lexical access when listening in L2, the evidence for cross-lingual interference when listening in L1 is more mixed. In the present study we therefore tested which additional variables might play a role and under which circumstances cross-lingual interactions when listening in L1 can be observed.

The influence of semantic constraint

In the literature on monolingual word recognition, several studies have demonstrated that readers automatically use contextual information to facilitate word recognition. Studies by Binder and Rayner (1998), Onifer and Swinney (1981), and Rayner and Frazier (1989) showed that ambiguous words are easier to interpret when there is a context to facilitate the recognition process. In the literature on bilingual auditory word recognition, the number of studies testing such effects are very scarce, although some bilingual studies in the visual domain have investigated semantic constraint effects. Schwartz and Kroll (2006) and Van Hell and de Groot (2008) showed that cross-lingual interactions were annulled or strongly diminished when responding to words (e.g., in naming or translating) that were embedded in high-constraint sentences. However, eyetracking studies by Libben and Titone (2009), Titone, Libben, Mercier, Whitford, and Pivneva (2011), and Van Assche, Drieghe, Duyck, Welvaert, and Hartsuiker (2011) demonstrated that cross-lingual interactions remained significant, even when reading sentences that were highly constraining towards the lexical representation in the target language.

Only few studies investigated the influence of semantic constraints when listening to sentences in L2. Chambers and Cooke (2009) conducted a visual world study in which English-

French bilinguals were instructed to listen to sentences in L2 and click on the image that represented the last word of the spoken sentence. Each display contained an image of the final noun target (e.g., *poule*, meaning *chicken*), an interlingual near-homophone whose name in English is phonologically similar to the French target (e.g., *pool*), and two unrelated distracter items. When the sentence information was compatible (i.e., both the French target and the interlingual near-homophone are plausible in the sentence context) (e.g., *Marie va décrire la poule* [Marie will describe the chicken]) with the competitor, interlingual competitors were fixated more than unrelated distracter images. However, this was not the case when sentence information was incompatible with the competitor (i.e., only the French target, but not the interlingual near-homophone is plausible in the sentence context) (e.g., *Marie va nourrir la poule* [Marie will feed the chicken]). This shows that sentence context may strongly constrain cross-lingual interactions in L2 recognition.

FitzPatrick and Indefrey (2010) also demonstrated that the semantic constraint of a sentence may influence cross-lingual interactions in the bilingual lexicon. In their study, EEGs were recorded from Dutch-English bilinguals who were listening to L2 sentences with a semantic incongruity that typically elicit a N400 component. When listening to incongruities in L2, this N400 is delayed compared with the N400 when listening to an incongruity in L1. When the last word of the sentence was a word with initial overlap with an L1 translation equivalent of the most probable sentence completion (e.g., "My Christmas present came in a bright-orange *doughnut"* (initial overlap with "doos" where *doos* is Dutch for *box*) the observed N400 had the same timing as the N400 that is elicited by a semantic incongruity whose translation equivalent did not have initial congruence. Thus, when listening to sentences that are quite semantically

constraining in L2, L1 competitors were not activated (or these L1 competitors are at least not considered for semantic integration).

However, although the sentences that were used in these two studies were plausible, they were low-constraining, and thus not very strongly restrictive towards the L2 representation of the interlingual target. In contrast, Lagrou et al. (2013) conducted a study that did not only present low-constraining, but also high-constraining sentences, and thus manipulated the semantic constraint of the sentence directly. Three possible constraining factors were tested, namely the presentation of target words in a sentence (rather than isolation), the native accent of the speaker, and the semantic constraint of the sentence. With this aim, Dutch-English bilinguals completed an L2 auditory lexical decision task on interlingual homophones (e.g., *lief* (sweet) – *leaf* /li:f/) and control words that were presented at the end of a sentence in L2. The results demonstrated that lexical access in an L2 sentence context was modulated by the semantic constraint of the sentence (and also by the native accent of the speaker). Nevertheless, although the presentation of a highly constraining sentence context significantly reduced cross-lingual interactions in the bilingual lexicon, the effect remained significant in the high-constraint sentences. The results so far thus suggest that a semantically constraining sentence can reduce cross-lingual interactions when (a) reading sentences in L2 and in L1, and (b) listening to sentences in L2. However, until now it is not clear whether cross-lingual interactions can be reduced or even annulled when listening to high-constraining sentences in L1. This is one of the questions that will be answered in the present study.

The influence of L2 proficiency

Especially in the literature on bilingual visual word recognition, the influence of language proficiency on the degree of language nonselectivity has often been investigated. Van Hell and Dijkstra (2002) tested Dutch-English-French trilinguals in a Dutch lexical decision task. Both L1-L2 cognates and L1-L3 cognates yielded faster reaction times than control words. However, the L1-L3 cognate facilitation effect was only observed with high proficient L3 speakers. These results are in line with an account of language nonselective lexical access, but highlight the importance of language proficiency before cognate effects can be detected in L1 processing. This is confirmed by studies of Bultena, Dijkstra, and Van Hell (2014), Brenders, Van Hell, and Dijkstra (2011) and Titone et al. (2011) who also demonstrated that the magnitude of the cognate facilitation effect is smaller for low proficient bilinguals than high proficient bilinguals.

In the auditory domain, the influence of L2 proficiency was investigated by Blumenfeld and Marian (2007). In a visual world paradigm, they compared German-English and English-German bilinguals' eye movements. Participants heard object names in English (e.g., "Click on the *coral*") and had to identify them from a display with four pictures that included the target, a similar-sounding German competitor (e.g., "Korb", meaning "basket" in English), and two unrelated distractor pictures. Crucially, the cognate status of the English targets was manipulated (i.e., half of the targets were English-German cognates, and half were noncognates). When cognates were presented, both German-English and English-German bilinguals looked more frequently at the German competitor that at the unrelated distractors. However, only German-English bilinguals co-activated the German distractors when processing noncognates. This implies that L1 German speakers always co-activated German during English word recognition, whereas L2 German speakers only did thus during the recognition of cognates, These results are in line with studies by Ju and Luce (2004), Marian and Spivey (2003), and Weber and Cutler

(2004), and suggest that L2 proficiency influences the degree of language nonselectivity of lexical access. However, the influence of proficiency does not cover the whole story. The work of Spivey and Marian (1999) and Weber and Cutler suggests that cross-lingual interference is only present with high-proficient bilinguals (cfr., Spivey & Marian), and not with low-proficient bilinguals (cfr., Weber & Cutler). Nevertheless, the latter was not confirmed by Lagrou et al. (2011), as the results of this study with a similar group of Dutch-English bilinguals with a similar level of L2 proficiency as in the Weber and Cutler study demonstrated that cross-lingual interactions are still present when listening in L1. The present study was set up to determine the joint influence of semantic constraint and L2 proficiency.

The present study

The aim of this study was to investigate whether lexical access in bilingual auditory word recognition is language nonselective when listening to sentences in L1. Importantly, we also tested whether this effect is modulated by the semantic constraint of the sentence and by the L2 proficiency level of our Dutch-English bilinguals. In the study by Lagrou et al. (2013) we already found evidence that cross-lingual interactions when listening to sentences in L2 were modulated by the semantic constraint of the sentence. More specifically, we observed that the homophone effect (i.e., slower RTs on homophones than on control words) was reduced, but not eliminated when listening to high-constraint sentences. Because there is evidence from previous studies that effects from L2 on native language listening might be less robust, it could be that the presentation of a highly constraining sentence context when listening in L1 results in a situation where multiple factors interact and render lexical access functionally language-selective. This

would imply that when listening to high-constraint L1 sentences the interlingual homophone effect would be annuled.

To test this hypothesis, Dutch-English bilinguals completed an L1 auditory lexical decision task on the last target word of low- and high-constraint sentences in L1. This last word could be either an interlingual homophone or a matched control word. The homophones were also used in Lagrou et al. (2011) and caused interference in bilingual auditory word recognition but no effect at all when the subjects were monolingual English speakers[1]. If lexical access in L1 sentence listening is not language selective, we expect to find a slower RT for homophones than for control words in the low constraining sentences. This would imply that (sub)-phonemic cues, inherent to the speech signal are not used to restrict lexical access to the currently relevant lexicon, even though sentences contain more of these cues than isolated words. If the semantic constraint of the sentences and the level of L2 proficiency influence lexical activation so strongly that non-target language representations may not longer compete with target recognition, we expect to find a reduced, and maybe even completely annulled homophone effect in the high constraining sentences and with low-proficient bilinguals. If a joint influence of these variables is needed to reduce or eliminate the cross-lingual interference effect, we expect to find this only when low-proficient bilinguals are listening to high-constraint sentences in L1.

Experiment 1

Method

Participants

Seventy-eight students from Ghent University participated in Experiment 1 for course credits or a monetary fee. All were native Dutch speakers and reported English as their L2. They started to learn English around age 14 at secondary school, and because they were regularly exposed to their L2 through popular media, entertainment, and English university textbooks, they were all quite proficient in their L2, even though they live in a clearly L1-dominant environment (using L1 about 95% of the time). After the experiment, participants completed the LexTALE language proficiency test (Lemhöfer & Broersma, 2012) to determine their L2 proficiency level. In the study by Lemhöfer and Broersma, the validity of this proficiency test is demonstrated by its good correlations with other objective proficiency measures such as error rates and RTs in an English lexical decision task. By means of the median-split procedure (*MEDIAN* = 72.5, *SD* = 5.44, *RANGE* = 60-92.5), we categorized 39 participants as low-proficient bilinguals and 39 other participants as high-proficient bilinguals. Participants were also asked to self-rate their L1 (Dutch) and L2 (English) proficiency with respect to several skills (reading, writing, speaking, understanding, general proficiency) on a 7-point Likert scale ranging from "very bad" to "very good". We also assessed general L3 (French) proficiency. Mean self-reported L1 (*M* = 6.25, *SD* = 0.81), L2 (*M* = 5.14, *SD* = 0.96), and L3 (*M* = 4.30, *SD* = 1.16) general proficiency differed significantly (dependent samples t-tests yielded *p*s < .001). Participants were not informed that their L2 knowledge would be of any relevance to the experiment.

Stimulus materials

Target stimuli consisted of 144 items: 24 interlingual Dutch-English homophones (e.g., *lief* (sweet) – *leaf* /li:f/), 24 matched Dutch control words, 24 Dutch filler words, and 72

nonwords. All targets were selected from the stimulus list of Lagrou et al. (2011), in order to ensure comparability across studies, and therefore make it possible to assess the context effects while keeping the stimuli constant. Interlingual homophones and control words were matched item by item for number of phonemes, L1 word frequency, neighborhood size, bigram frequency, number of syllables, and pronunciation duration (see Table 1). None of the target stimuli were homophones or cognates in the L3 (i.e., French).

INSERT TABLE 1 ABOUT HERE

Filler words and nonwords were created with the WordGen stimulus software (Duyck, Desmet, Verbeke, & Brysbaert, 2004). Filler words did not differ from homophones and controls with respect to the matching criteria mentioned above. Nonwords were phoneme strings with no Dutch or English meaning, but with a legal Dutch phonology, and they were matched with interlingual homophones and control words with respect to number of phonemes and bigram frequency. For each target, a low- and high- constraining sentence was constructed, resulting in 288 sentences. Sentences were matched in terms of number of words and syntactic structure. For the low-constraining sentences, the preceding sentence context was identical for targets and control words, but this was by definition impossible for the high-constraint sentences[2]. In this case, the preceding sentence context was highly constraining towards either the target or the control word. Targets were always in the final position of the sentence. To ensure that participants would not see the same target twice, sentences were divided across two lists. The low- and high constraint sentences for each homophone-control pair are included in the

Appendix. Sentences were pronounced by a native Dutch speaker who was also a very high-proficient English speaker. Using WaveLab software, stimulus materials were recorded in a sound-attenuated booth by means of a SE Electronics USB1000A microphone with a sampling rate of 44.1 kHz and a 16-bit sample size. Sentence- and target durations were measured with WaveLab software.

Sentence completion

To verify the constraint manipulation of the sentences containing an interlingual homophone or control word, a sentence completion study was conducted with twenty further participants. Participants saw each sentence without the interlingual homophone/control word, and they were instructed to complete the sentence with the first word that came to mind when reading the sentence. Production probabilities for interlingual homophones (e.g., *bos*, meaning "forest" but sounding like "*boss*" /bOs/) and control words (e.g., *tak*, meaning "branch") were extremely low for low-constraining sentences, and were very high for high-constraining sentences (see Table 2). Production probabilities for the irrelevant L1 translation equivalents of the L2 reading of the homophone (e.g., *blad*, meaning "leaf") were extremely low for low- and high- constraining sentences (see Table 2). A paired t-test demonstrated that for the low-constraint sentences, there were no differences in production probabilities between homophones, control words and L1 translation equivalents ($p > 0.93$). For the high-constraint sentences, production probabilities were similar for homophones and control words ($p > 0.85$), and different for L1 translation equivalents ($p < .001$).

INSERT TABLE 2 ABOUT HERE

Additionally, another fifteen participants were asked to rate the plausibility of the low constraint sentences on a scale from 1 (not at all plausible) to 9 (very plausible)[3]. A paired t-test demonstrated that plausibility ratings for homophone sentences (M = 7.14, SD = 2.30) did not differ from ratings for control word sentences (M = 6.17, SD = 2.38), $t(23) = 1.13$, $p = .27$.

Procedure

Participants received written instructions in Dutch (their L1) to perform a Dutch lexical decision task on the last word of each sentence. They were instructed to put on a headphone through which sentences would be presented auditorily. Before the experiment, a practice session of twelve trials was completed. Each trial started with a 500 ms presentation of a fixation cross in the center of the screen. After another 200 ms the sentence was presented. Then, participants had to decide whether the last word was a Dutch word or a nonword. When a word (nonword) was presented, participants used their right (left) index finger to press the right (left) button of a response box. Visual feedback (i.e., when an error was made the screen turned red, when the response was correct, "OK!" appeared on the screen) was presented on the screen during 200 ms. The next trial started 500 ms later. After the experiment, participants self-rated their L1, L2, and L3 proficiency. They also completed the LexTALE language proficiency test in L2, and a backward translation test on the interlingual homophones to verify whether they knew the English meaning of the homophones (which they did: accuracy was above 90% correct for each participant).

Results

On average, participants made 3.61 % errors (*SD* = 1.18). Errors, trials with RTs faster than 300 ms after target onset, and trials with RTs more than 2.5 standard deviations above the participant's mean RT after target onset for word targets were excluded from the analyses. As a result, 4.59 % of the data were excluded from the analyses. Reported latency analyses are based on RTs measured from (auditory) target onset. When latency analyses were based on reaction times measured from (auditory) target offset, the same pattern of results was obtained.

An ANOVA on the reaction times (see Figure 1 and Table 3) with target type (interlingual homophone vs. control) and sentence constraint (low vs. high) as the independent within-subjects variables, and L2 proficiency level (low vs. high) as the independent between-subjects variable, revealed a main effect of target type, $F1(1,76) = 8.71$, $p < .01$, $\eta^2_p = .10$; $F2(1,23) = 10.17$, $p < .01$, $\eta^2_p = .31$, indicating that reaction times were significantly slower for interlingual homophones than for control words. The main effect of sentence constraint was also significant, $F1(1,76) = 206.71$, $p < .001$, $\eta^2_p = .73$; $F2(1,23) = 46.01$, $p < .001$, $\eta^2_p = .67$, indicating that participants responded significantly faster on targets that were preceded by a high-constraining sentence context than on targets that were preceded by a low-constraining sentence context. The main effect of proficiency was not significant, $F1 < 1$; $F2 < 1$, which indicates that reaction times were not different for low- and high-proficient bilinguals. Importantly, none of the two- or three-way interactions between target type, sentence constraint, and proficiency were significant, all $F1 < 1$ and $F2 < 1$, indicating that the homophone interference effect was neither modulated by the semantic constraint of the sentence, nor by the L2 proficiency level of the participants, nor by the interaction of the semantic constraint and the L2 proficiency level of the participants[4].

INSERT FIGURE 1 ABOUT HERE

INSERT TABLE 3 ABOUT HERE

To investigate the influence of L2 proficiency operationalized as a continuous variable, we calculated the correlation between the L2 proficiency scores on the LexTALE language proficiency test and the homophone effect. There was no significant correlation between these variables, r = -.06, p = .61, which is consistent with the results above taking proficiency as a discrete variable and which further indicates that proficiency does not modulate cross-lingual interactions in the bilingual lexicon (see Figure 2).

INSERT FIGURE 2 ABOUT HERE

Discussion

The goal of Experiment 1 was to test whether lexical access is language nonselective when Dutch-English bilinguals listen to meaningful sentences in L1. We also investigated whether this degree of language nonselectivity is modulated by the semantic constraint of the sentence and by the L2 proficiency level of our bilinguals. Therefore, participants completed a L1 lexical decision task on the last word of low and high constraining sentences. We divided the participants in groups of relatively low and high proficient bilinguals on the basis of a median

split. First, there was a clear homophone effect, which provides evidence for the language nonselective nature of lexical access when listening to sentences in L1. Second, there was a main effect of semantic constraint (i.e., participants responded faster to high-constraint sentences than to low-constraint sentences), but there was no interaction between the homophone effect and the semantic constraint of the sentence. This suggests that bilinguals activate their second language, even when they are listening to sentences in their native language, and even when these sentences are highly constraining towards the L1 representation of the interlingual homophone presented at the end of the sentence. Third, the results demonstrated that the L2 proficiency level of the bilinguals did not influence the degree of language nonselectivity, as there was no significant interaction or correlation between the homophone effect and the L2 proficiency level. However, we noted that there was little variation in the LexTALE proficiency scores, with almost all participants having intermediate scores (i.e., most participants scored around 75; range is 60 – 92.5). It is possible that there was too little variation in proficiency to affect the homophone effect. Experiment 2 therefore tested a new group of participants with a more variable proficiency level.

Experiment 2

Method

Participants

One hundred sixteen students from Ghent University participated in the experiment for course credits or a monetary fee. They were all native Dutch speakers and reported English as their L2, which they started to learn around age 14 at secondary school. Two weeks before the

actual experiment, participants completed the LexTALE language proficiency questionnaire (Lemhöfer & Broersma, 2012) to determine their L2 proficiency level. Based on these scores, the 116 participants were categorized as high-proficient Dutch-English bilinguals (n = 36; LexTALE scores > 85, M = 91.18, SD = 3.33), as intermediate-proficient (n = 40; LexTALE scores between 65 and 85, M = 72.94, SD = 6021), or as low-proficient Dutch-English bilinguals (n = 40; LexTALE scores < 65, M = 60.19, SD = 3.50).

Stimulus materials and procedure

The stimulus materials in this experiment were identical to the materials we used in Experiment 1. The procedure was also very similar, except that participants now completed the LexTALE proficiency questionnaire two weeks before the experiment took place, in order to assign equal numbers of participants to each proficiency condition (low, intermediate, and high).

Results

On average, participants made 6.54 % errors (SD = 5.06). Errors, trials with RTs faster than 300 ms after target onset, and trials with RTs more than 2.5 standard deviations above the participant's mean RT after target onset for word targets were excluded from the analyses (6.75%). Reported latency analyses are based on RTs measured from (auditory) target onset. When latency analyses were based on reaction times measured from (auditory) target offset, the same pattern of results was obtained.

An ANOVA on the reaction times (see Figure 3 and Table 4) with target type (interlingual homophone vs. control) and sentence constraint (low vs. high) as the independent within-subjects variables, and English proficiency level of the participants (low vs. intermediate vs. high) as the independent between-subjects variable revealed a main effect of target type,

$F1(1,113) = 18.46$, $p < .001$, $\eta^2_p = .14$; $F2(1,57) = 12.74$, $p < .01$, $\eta^2_p = .06$, indicating that reaction times were significantly slower for interlingual homophones than for control words. The main effect of sentence constraint was also significant, $F1(1,113) = 409.86$, $p < .001$, $\eta^2_p = .78$; $F2(1,57) = 55.29$, $p < .001$, $\eta^2_p = .55$, indicating that participants responded significantly faster on targets that were preceded by a high-constraining sentence context than on targets that were preceded by a low-constraining sentence context. The main effect of proficiency was also significant, $F1(2, 113) = 429.38$, $p < .001$, $\eta^2_p = .06$; $F2(1,57) = 12.61$, $p < .01$, $\eta^2_p = .22$. Planned comparisons demonstrated that high-proficient bilinguals were significantly faster than intermediate-proficient bilinguals, $F1(1,113) = 4.44$, $p < .05$, $\eta^2_p = .12$; $F2(1,57) = 6.28$; $p < .05$, $\eta^2_p = 16$. Reaction times were not different for intermediate-proficient and low-proficient bilinguals, $F1 < 1$, $F2 < 1$. Importantly, the interaction between target type and sentence constraint was not significant, $F1 < 1$; $F2 < 1$. The interaction between target type and proficiency was not significant either, $F1 < 1$; $F2 < 1$, as was the triple interaction between target type, sentence constraint and proficiency, $F1 < 1$, $F2 < 1$.

INSERT FIGURE 3 ABOUT HERE

INSERT TABLE 4 ABOUT HERE

To investigate the influence of L2 proficiency as a continuous variable, we calculated the correlation between the L2 proficiency scores on the LexTALE language proficiency questionnaire and the homophone effect. There was again no significant correlation between

these variables, $r = .10$, $p = .29$, which further indicates that proficiency does not modulate cross-lingual interactions in the bilingual lexicon (see Figure 4).

INSERT FIGURE 4 ABOUT HERE

Discussion

Because there was not much variability in the L2 proficiency level of the Dutch-English bilinguals who participated in Experiment 1, we decided to replicate this experiment with a new group of Dutch-English bilinguals with a broader range of L2 proficiency. However, this did not change the overall pattern of results we observed in the first experiment. In Experiment 2 we could replicate our initial homophone effect, which confirms the language nonselective nature of lexical access when listening to sentences in L1. We also found a main effect of semantic constraint, but there was again no interaction between the homophone effect and the semantic constraint of the sentence. In contrast with Experiment 1, we now observed a main effect of L2 proficiency level: highly proficient bilinguals were faster than intermediate or low proficient bilinguals. However, even with this more variable group of Dutch-English bilinguals, there was no trace of an interaction or correlation between the homophone effect and the L2 proficiency level.

In the L2 study of Lagrou et al. (2013) on the influence of semantic constraint on language nonselectivity, overall reaction times were significantly slower than the overall RTs in the present study. This can be explained by the fact that in L2 listening proficiency is lower,

which makes recognition slower. Therefore, manipulations (such as semantic constraint) that strongly influence (speed up) this slow target activation, might overrule the weaker spreading activation effect arising from non-target language representations. In L1 listening, word recognition is much faster, so that a semantic constraint manipulation effect has a smaller impact on target activation. Given this smaller effect, it is plausible that also the interaction of the semantic effect with the homophone interference effect is more limited. This could explain why we observed no such interaction in the present study. Additionally, it is also possible that sentence wrap-up effects come more into play, as participants had to respond to the last word of a sentence in their native language. To investigate whether it is possible that the reaction times in the present study are just too fast to reveal possible interactions between the homophone effect and any other variable, we decided to use a median-split procedure on the data of Experiment 2 to make a distinction between "slow" and "fast" reaction times. In line with our prediction, we now observed a triple interaction between the homophone effect, the semantic constraint of the sentence, and the speed of response, $F1(2,113) = 22.13$, $p < .05$, $\eta^2_p = .38$; $F2(2,57) = 5.38$, $p < .01$, $\eta^2_p = .48$. This interaction indicates that the homophone effect is modulated by the semantic constraint of the sentence, but only when taking into account the "slow" reaction times. In this case, the homophone effect was reduced, but not annulled, when participants were listening to sentences that were highly constraining. However, when we had a look at the "fast" reaction times, there was no trace of an interaction between the homophone effect and the semantic constraint of the sentence. In sum, this additional analysis confirms the findings of Lagrou et al. by demonstrating a reduction in the degree of language nonselectivity of lexical access when listening to high-constraint sentences, but also stresses the importance of response speed.

General Discussion

The goal of this study was to investigate whether cross-lingual interactions are modulated by a sentence context when listening in the native language. Importantly, we also tested whether this effect was influenced by the semantic constraint of the sentence and by the L2 proficiency level of Dutch-English bilinguals. With this aim, a group of Dutch-English bilinguals completed a Dutch auditory lexical decision task on the last word of auditorily presented sentences. To examine the influence of semantic constraint, target words that overlapped with a non-target language were presented at the end of both low- and high constraining sentences. The participants responded significantly slower on interlingual homophones (e.g., *lief* (sweet) – *leaf* /li:f/) than on matched control words. Importantly, there was (a) no interaction between the homophone effect and the semantic constraint of the sentence, (b) no modulation of the homophone effect by the L2 proficiency level of the bilinguals, and (c) no triple interaction between the homophone effect, the semantic constraint of the sentence, and the L2 proficiency level of the participants. So, the semantic and lexical restrictions imposed by the sentence context are not sufficient to override competition from a lexical representation in a non-target language, even if this is the non-dominant, least proficient language, and even not when the L2 proficiency level of the bilinguals is relatively low. We will elaborate further on these results in the next paragraphs.

The fact that we observed a homophone effect when listening to sentences in L1 extends the results from isolated (i.e., not in a sentence context) bilingual word recognition in L2 and in L1 (e.g., Ju & Luce, 2004; Lagrou et al., 2011; Marian & Spivey, 2003; Spivey & Marian, 1999; Weber & Cutler, 2004). Taken together, this is the first study that has investigated the influence of semantic constraint and L2 proficiency level on L1 auditory word recognition, and the results

indicate that the mere presentation of a sentence context, even when listening in L1, is not sufficient to modulate cross-lingual interactions in the bilingual lexicon. Hence, the (sub)-phonemic cues, inherent to the speech signal, are not used to restrict lexical access to the currently relevant lexicon even though sentences contain much more of these cues than isolated words.

Our results demonstrated a main effect of semantic constraint, indicating that participants responded faster to targets in high-constraint sentences than to targets low-constraint sentences. This replicates many findings from the monolingual domain (e.g., Frazier & Rayner, 1990; Schwanenflugel & LaCount, 1988; Schwanenflugel & Shoben, 1985; Stanovich & West, 1983), in which faster reaction times were observed for targets in highly predictable sentences compared to RTs for targets in nonpredictable sentences. For this study, this constitutes an important check of the constraint manipulation. The main effect of constraint is also in agreement with the results from bilingual visual word recognition by for example Van Assche et al. (2011) in which faster reading times were observed for targets in high-constraint sentences compared to targets in low-constraint sentences.

We also investigated whether the homophone effect is modulated by the semantic constraint of the sentence. Because there was no trace of an interaction between the interlingual homophone effect and the constraint manipulation, we can conclude that cross-lingual interactions are not strongly influenced by this specific manipulation when listening in L1. This is a surprising and remarkable finding, because this suggests that even when bilinguals have conversations in their native language, and when the content of the interlocutor's speech is highly predictable, one is still influenced by knowledge of a second language.

This finding extends the results from sentence studies in the bilingual visual domain (e.g., Libben & Titone, 2009; Schwartz & Kroll, 2006; Titone et al., 2011; Van Assche et al., 2011; Van Hell & de Groot, 2008). In these studies, the results concerning the observation of cross-lingual interactions when reading high-constraint sentences were somewhat mixed: Schwartz & Kroll (2006) and Van Hell & de Groot (2008) demonstrated that cross-lingual interactions were actually reduced or diminished in a high-constraint context, but Van Assche et al. (2011) found evidence for language nonselectivity both when reading low- and high constraining sentences. Libben and Titone (2009) also found evidence for cross-lingual interactions when reading low- and high-constraint sentences, but for the high-constraint sentences, cross-lingual interactions were only observed in early (and not in late) eye-tracking measures of reading. Hence, the results from the present study are most in line with the Van Assche et al. (2011) study, in which evidence for language nonselectivity in L1was found both when processing low- and high-constraint sentences. Given that this study draws on the same bilingual population as tested here, one possibility is that the inconsistencies across studies are related to the language profile of the participants (but see below).

These results are not in complete agreement with studies on nonnative spoken word recognition (e.g., Chambers & Cooke, 2009, FitzPatrick & Indefrey, 2010; also our own study, Lagrou et al., 2013), in which cross-lingual interactions were modulated by the semantic constraint of the sentence. For example, Lagrou et al. found evidence for the fact that cross-lingual interactions are reduced (but not eliminated) when listening to a high constraining sentence context in L2, and Ju and Luce (2004) found that language-specific (sub)-phonemic cues can restrict the activation of the nontarget language. As a consequence, we were rather surprised that the homophone effect in L1 was not influenced by the semantic constraint of the

sentence. We expected that L2 representations would be too weak to interfere with L1 representations. We also predicted that several factors would interact and as such could eliminate language-nonselective access. Specifically, we expected that the combined effect of several constraints (i.e., when low-proficient L2 speakers listen to interlingual homophones in high-constraint sentences in L1) would strongly influence activation in lexical target representations, so that the homophone interference effect could be eliminated or at least reduced. This was not the case, so the present data constitute evidence for a language nonselective account of lexical access when listening to sentences in L1 in which cross-lingual interactions are not eliminated or even reduced by the semantic constraint of the sentence or by the L2 proficiency level of the participants.

Interestingly, because reaction times were faster in this study in L1 compared to the study of Lagrou et al. 2013 in L2, an analysis in which we divided the present RTs into fast and slow RTs demonstrated that for the slow RTs, the cross-lingual interference effect was in fact reduced when listening to the high-constraint sentences, whereas this was not the case for the fast RTs. This finding is actually very similar to what Libben and Titone (2009) observed in an eyetracking study. In this study, for high-constraint sentences the authors only found evidence for language nonselective lexical access with early-stage comprehension measures, whereas there was no cross-lingual interference for late-stage comprehension measures.

We also tested whether the homophone effect is influenced by the L2 proficiency level of our Dutch-English bilinguals. In Experiment 1, participants were assigned afterwards to a low-proficiency or a high-proficiency group, based on their LexTALE scores. The results of this study showed that there was neither a main effect of L2 proficiency, nor an interaction or correlation between the homophone effect and the L2 proficiency level of the bilinguals. Because

the assignment of participants to a low or high proficient group was done post-hoc, we had no control on the proficiency level of the participants in the experiment. More specifically, when we had a closer look at their proficiency scores, we noticed that these were all quite intermediate and without extremely low or high proficiency scores. Therefore we decided to run a second experiment, in which we tested participants' L2 proficiency level before they took part in the experiment. This allowed us to create three different, large, groups of participants with low, intermediate, and high proficient Dutch-English bilinguals. Although we now found a main effect of proficiency (i.e., high-proficient bilinguals responded faster than intermediate or low-proficient bilinguals), there was again no interaction or correlation between the homophone effect and the L2 proficiency level of our bilinguals. The lack of such a correlation is consistent with work by Pivneva, Mercier, and Titone (2014). In this study, the authors also demonstrated that L2 proficiency does not reduce cross-language activation.

Although previous studies have mostly found an effect of L2 proficiency on the degree of cross-lingual interactions, the present results are not necessarily in contradiction with those findings. We propose three possible explanations. First, it would for example be possible that it is not L2 proficiency per se, but rather L2 experience that modulates the language nonselective nature of lexical access. Although the Dutch-English bilinguals from our study differed on their L2 proficiency level as measured by the LexTALE, this does not imply that they would also differ on the amount of L2 experience. Whitford and Titone (2012) for example demonstrated that it is the relative amount of bilinguals' L2 and L1 experience which determines the degree of lexical activation. So although there are objective differences in the L2 proficiency level of our bilinguals, this does not imply that there are substantial differences in the relative amount of L2 and L1 experience. Second, although there are differences in the LexTALE scores of our

participants, it is still possible that the bilinguals with the lowest LexTALE scores are still quite proficient, and hence still allow cross-lingual interactions to occur. Therefore it would be interesting to test a group of bilinguals that is even less proficient (e.g., monolinguals, or bilinguals who have just started to learn English as a second language). However, because this group might also differ on several other variables (e.g., age, socio-economic status, intelligence), we decided not to include this in the present study. Third, although this is quite unlikely, it might be the case that language nonselective lexical access is simply not influenced by the L2 proficiency level of bilinguals, and that cross-lingual interactions are so strong that they overrule proficiency differences.

These results also have theoretical implications. and constraint further bilingual extensions of monolingual models of auditory word recognition such as the Distributed Model of Speech Perception (Gaskell & Marslen-Wilson, 1997), NAM (Luce & Pisoni, 1998), Shortlist (Norris, 1994; Norris, McQueen, Cutler, & Butterfield, 1997), and TRACE (Elman & McClelland, 1988; McClelland & Elman, 1986). To account for our findings, these models would need to be extended with the assumption that L2 representations are part of the same system as, and interact with, L1 representations. These models would then predict cross-lingual interactions between the native and the nonnative lexicon (which was demonstrated in the present study by the observation of slower RTs on interlingual homophones than on matched control words). However, the role of top-down factors such as the semantic constraint of the sentence is very limited, as we did not observe an interaction between the homophone effect and the semantic constraint of the sentence. Thus, the findings are most compatible with models that assume only a restricted role for such top-down effects.

The results of this study can also help to further constrain the Bilingual Language Interaction Network for Comprehension of Speech (BLINCS) that was introduced recently by Shook and Marian (2013). According to BLINCS, the two languages of a bilingual are separated, but integrated. This allows cross-lingual interactions because there are lateral links between translation equivalents. Moreover, because items that map together are simultaneously active, they inhibit one another. Although this model can account for many phenomena in bilingual language processing, it still has to be expanded to capture for example the effects of linguistic context. Hence, at this point the model does not make concrete predictions on the influence of semantic constraints.

To summarize, this study provides evidence for an account of lexical access that is language nonselective even when listening in L1. Moreover, the presence of cross-language interactions when the preceding sentence context was highly constraining towards the representation in the target language indicates that this language nonselectivity is not annuled by the semantic constraint of the sentence.

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Footnotes

1. In that study and here we did not test monolingual Dutch speakers, because such speakers are very hard to find, and also would differ on a number of other variables such as socio-economic status).
2. Whereas the sentences preceding the homophone/control word are identical in the low-constraint condition, this is not the case in the high-constraint condition. In order to keep this comparable across conditions, we ran an extra experiment which addresses this issue. Because it is not feasible to present identical sentences preceding the homophone and the control word in the high-constraint condition, we decided to present non-identical sentences preceding the homophone and the control word in the low-constraint condition. However, the results of this additional experiment lead us to the same conclusion as the present results do. The participants responded significantly slower on interlingual homophones (e.g., *lief* (sweet) – *leaf* /li:f/) than on matched control words. Importantly, there was (a) no interaction between the homophone effect and the semantic constraint of the sentence, (b) no modulation of the homophone effect by the L2 proficiency level of the bilinguals, and (c) no triple interaction between the homophone effect, the semantic constraint of the sentence, and the L2 proficiency level of the participants.
3. An additional analysis of the main experiment was completed in which we excluded the low-constraining sentences and their high-constraining counterpart of which the homophone or control word had a plausibility score lower than 4 on this scale. As a consequence, four sentences were excluded from this analysis. Importantly, the exclusion of these sentences did not change the overall pattern of results.
4. We want to thank an anonymous reviewer for pointing out that there were a few near-cognates and a homograph present in our control stimuli (in the Appendix, they are marked

with an asterisk). Therefore we ran an additional analysis after we removed these stimuli, which demonstrated that the overall pattern of results was not affected by the exclusion of these stimuli. An ANOVA on the reaction times with target type (interlingual homophone vs. control) and sentence constraint (low vs. high) as the independent within-subjects variables, and L2 proficiency level (low vs. high) as the independent between-subjects variable, revealed a main effect of target type, $F1(1,76) = 7.69$, $p < .01$, $\eta^2_p = .09$; $F2(1,19) = 8.34$, $p < .01$, $\eta^2_p = .27$, indicating that reaction times were significantly slower for interlingual homophones than for control words. The main effect of sentence constraint was also significant, $F1(1,76) = 198.54$, $p < .001$, $\eta^2_p = .66$; $F2(1,19) = 43.51$, $p < .001$, $\eta^2_p = .43$, indicating that participants responded significantly faster on targets that were preceded by a high-constraining sentence context than on targets that were preceded by a low-constraining sentence context. The main effect of proficiency and the two- and three way interacions between target type, sentence constraint and proficiency were not significant, $F1 < 1$; $F2 < 1$,

Appendix. Experimental stimuli.

Low-constraint / Interlingual homophones	Low-constraint / Control words
1. Luc ging naar de winkel en kocht daar een **biet**. (beat) [Luc went to the store and bought a beet.]	1. Luc ging naar de winkel en kocht daar een **rits**. [Luc went to the store and bought a zipper.]
2. Tijdens hun wandeling werden ze lastig gevallen door een **bij**. (bay) [During there walk they were attacked by a bee.]	2. Tijdens hun wandeling werden ze lastig gevallen door een **gek**. [During there walk they were attacked by a fool.]
3. De dokter bekeek heel aandachtig haar **bil**. (bill) [The doctor took a good look at her buttock.]	3. De dokter bekeek heel aandachtig haar **jas**. [The doctor took a good look at her coat.]
4. De man besefte opeens dat hij te maken had met een gevaarlijke **boel**. (bull) [The man suddenly realized that he had to deal with a dangerous business.]	4. De man besefte opeens dat hij te maken had met een gevaarlijke **boer**. [The man suddenly realized that he had to deal with a dangerous farmer.]
5. In de tuin van mijn vader vond ik een **boon**. (bone) [In my father's garden I found a bean.]	5. In de tuin van mijn vader vond ik een **peer**. [In my father's garden I found a pear.] *
6. De kunstenaar maakte een schilderij van een **bos**. (boss) [The artist made a painting of a forest.]	6. De kunstenaar maakte een schilderij van een **tak**. [The artist made a painting of a branch.]
7. Toen ze jarig was, kreeg ze als geschenk een **brief**. (brief) [When it was her birthday, the present she received was a letter.]	7. Toen ze jarig was, kreeg ze als geschenk een **paard**. [When it was her birthday, the present she received was a horse.]
8. Omdat ze zo geschrokken was, gaf ze een trap tegen haar **dij**. (day) [Because	8. Omdat ze zo geschrokken was, gaf zee en trap tegen haar **zus**. [Because she

she was so frightened, she gave a kick against her thigh.]

9. Tijdens die avontuurlijke tocht bleef Els haperen met haar **hiel**. (heal) [During that adventurous journey Els got stuck with her heel.]
10. Hij kwam binnen en zag haar staan in de **hoek**. (hook) [He came in and saw her in the corner.]
11. Eva vroeg haar moeder om een nieuwe **koek**. (cook) [Eva asked her mother for a new biscuit.]
12. De moeder van dat meisje stond me op te wachten in de **kou**. (cow) [The mother of that girl was waiting for me in the cold.]
13. De leerlingen luisterden aandachtig naar haar **lied**. (lead) [The pupils listened attentively to her song.]
14. De nieuwe bewoners van dat appartement waren erg **lief**. (leaf) [The new inhabitants of that appartment were very sweet.]
15. Op hun wandeltocht vonden de leidsters van de jeugdbeweging een **lijk**. (lake) [During their walk the leaders of that youth movement found a corpse.]
16. Thijs bekeek samen met zijn vader een afbeelding van een **mes**. (mess) [Thijs was looking with his father to an image

was so frightened, she gave a kick against her sister.]

9. Tijdens die avontuurlijke tocht bleef Els haperen met haar **kous**. [During that adventurous journey Els got stuck with her stocking.]
10. Hij kwam binnen en zag haar staan in de **rook**. [He came in and saw her in the smoke.]
11. Eva vroeg haar moeder om een nieuwe **zeep**. [Eva asked her mother for a new soap.]
12. De moeder van dat meisje stond me op te wachten in de **bus**. [The mother of that girl was waiting for me in the coach.] *
13. De leerlingen luisterden aandachtig naar haar **lach**. [The pupils listened attentively to her laugh.]
14. De nieuwe bewoners van dat appartement waren erg **bang**.) [The new inhabitants of that appartment were very scared.] *
15. Op hun wandeltocht vonden de leidsters van de jeugdbeweging een **touw**. [During their walk the leaders of that youth movement found a rope.]
16. Thijs bekeek samen met zijn vader een afbeelding van een **koe**. [Thijs was looking with his father to an image of a

of a knife.]	cow.]
17. Ze vonden de ring van die vrouw onder een **pet**. (pet) [They found the ring of that woman under a cap.]	17. Ze vonden de ring van die vrouw onder een **das**. [They found the ring of that woman under a tie.]
18. Hij genoot ervan om de avond door te brengen op een **plein**. (plane) [He enjoyed spending the evening at the square.]	18. Hij genoot ervan om de avond door te brengen op een **troon**. [He enjoyed spending the evening at the throne.] *
19. Ruben had heel wat veranderd, en daarom kreeg hij een **prijs**. (praise) [Ruben had changed a lot, and that's why he received a reward.]	19. Ruben had heel wat veranderd, en daarom kreeg hij een **straf**. [Ruben had changed a lot, and that's why he received a punishment.]
20. Jammergenoeg eindigde die dag met een **proef**. (proof) [Unfortunately that day was closed with a test.]	20. Jammergenoeg eindigde die dag met een **traan**. [Unfortunately that day was closed with a tear.]
21. Mijn vriendin Sanne kon blijven vertellen over die **reis**. (raise) [My friend Sanne could keep telling about that trip.]	21. Mijn vriendin Sanne kon blijven vertellen over die **tuin**. [My friend Sanne could keep telling about that garden.]
22. Tine vond de nieuwe leerkracht in die school heel erg **slim**. (slim) [Tine found the new teacher in the school very smart.]	22. Tine vond de nieuwe leerkracht in die school heel erg **saai**. [Tine found the new teacher in the school very boring.]
23. Die zwarte kater van de buren was echt **vet**. (vet) [That cat of the neigbours was very fat.]	23. Die zwarte kater van de buren was echt **lui**. [That cat of the neigbours was very lazy.]
24. Hij verstopte de schatkist van de zeerover in een **wei**. (way) [He hide the treasure-chest of the pirate in a meadow.]	24. Hij verstopte de schatkist van de zeerover in een **hok**. [He hide the treasure-chest of the pirate in a shed.]

High-constraint / Interlingual homophones	High-constraint / Control words
1. De jongen at graag rode kool, maar ook rode **biet**. (beat) [The boy loved to eat red cabbage, but also red beet.]	1. Hij kon zijn jas dichtmaken met knopen, maar ook met een **rits**. [He could close coat with buttons, but also with a zipper.]
2. De imker vertelde ons dat honing afkomstig is van de **bij**. (bay) [The bee-keeper told us that honey comes from the bee.]	2. Hij verbleef in de psychiatrie, want de dokter noemde hem een **gek**. [He lived in a psychiatric centre, because the doctor said he was crazy.]
3. Op het einde van de avond kneep de man stiekem in haar linker **bil**. (bill) [At the end of the evening the man secretly squized her left buttock.]	3. In de winter draagt hij een muts, een sjaal en een warme **jas**. [During winter he wears a hat, a scarf and a warm coat.]
4. De jongen kreeg meer dan één geschenk, in feite kreeg hij er zelfs een hele **boel**. (bull) [The boy received more than one present, in fact he even received many.]	4. De koeien zaten ’s winters in de stal die eigendom was van de **boer**. [During winter the cows were in the stable of the farmer.]
5. In de trein zei ze dat ze hem leuk vond, dus ze had voor hem een **boon**. (bone) [In the train she told that she liked him, so she had a preference for him. (saying)]	5. De bekendste fruitsoorten zijn wellicht de appel en de **peer**. [The most common fruits are probable the apple and the pear.] *
6. Toen Roodkapje haar grootmoeder ging bezoeken, moest ze de weg volgen door het donkere **bos**. (boss) [When Little Red Riding Hood visited her grandmother, she had to follow the road through the dark forest.]	6. Terwijl hij dat verhaal vertelde sprong hij van de hak op de **tak**. [While he told that story he skipped from one subject to another. (saying)]

7. Toen hij op reis was, schreef hij zijn ouders af en toe een **brief**. (brief) [When he was on a trip, from time to time he wrote his parents a letter.]
8. Het lichaamsdeel tussen heup en knie noemen we een **dij**. (day) [The part of the body between hip and knee is what we call a thigh.]
9. Omdat ze zo dicht voor me wandelde, trapte ik per ongeluk op haar **hiel**. (heal) [Because she walked so close before me I accidently stepped on her heel.]
10. Omdat het kleine meisje stout was geweest zette haar moeder haar in de **hoek**. (hook) [Because the little girl had been bad, her mother put her in the corner.]
11. Uiteindelijk bakte hij een taart en ook een trommel vol met **koek**. (cook) [Eventually he baked a cake and also a tin of biscuits.]
12. Er was geen sprake van warmte tijdens de winter, maar eerder van **kou**. (cow) [It was not warm during winter, but rather cold.]
13. Terwijl we rond het kampvuur zaten, zongen we samen een mooi **lied**. (lead) [While we were sitting around the campfire, we were singing a beautiful song.]

7. Die ruiter was de beste in het berijden van een **paard**. [That horseman was the best in riding a horse.]
8. Af en toe gaan we een weekendje weg samen met mijn broer en **zus**. [From time to time we go a weekend away with my brother and sister.]
9. Net wanneer ze wilden vertrekken naar het feest, ontdekte Mieke een ladder in haar **kous**. [Just when they wanted to set off for the party, Mieke discovered a run in her stocking.]
10. Zij stak haar sigaret binnen op, en nu zagen we bijna niets meer door de **rook**. [She lit her cigarette indoors, and now we almost couldn't see a thing because of the smoke.]
11. Vooraleer Marie ging slapen, waste ze zich met water en **zeep**. [Before Marie went to bed, she washed herself with water and soap.]
12. Wie gebruik maakt van het openbaar vervoer, neemt vaak de trein, de tram of de **bus**. [People using public transport often take the train, tram or coach.] *
13. Hij keek niet kwaad, want op zijn gezicht zag ik een **lach**.[He wasn't angry, because on his face there was a laugh.]

14. Ik wilde die kinderen graag helpen want ze waren zo **lief**. (leaf) [I wanted to help those children because they were so sweet.]
15. Toen hij zo geschrokken was, zag hij zo bleek als een **lijk**. (lake) [When he was frightened, he was as pale as a corpse.]
16. De vrouw waste de tomaten en sneed ze in stukken met een **mes**. (mess) [The woman washed the tomatoes and cut them into pieces with a knife.]
17. Wanneer de zon schijnt bedekt hij zijn hoofd met een hoed of een **pet**. (pet) [When the sun is shining he covers his head with a hat or a cap.]
18. De kinderen en jongeren kwamen op woensdagmiddag samen op het **plein**. (plane) [The children and youngsters gathered on Wednesday afternoon at the square.]
19. Hij zei dat hij het winnende lot in de tombola had, en kreeg daarom een mooie **prijs**. (praise) [He told that he had the winning ticket in the tombola, and that's why he received a beautiful reward.]
20. Vooraleer ze zich kon inschrijven doorstond ze een mondelinge test en een fysieke **proef**. (proof) [Before she

14. Terwijl ze naar die griezelige film keken, waren de kinderen erg **bang**. [While they were looking at that scare movie, the children were very frightened.] _
15. De indianen bonden de gevangenen vast met een **touw**. [The indians tied up the prisoners with a rope.]
16. De boer vertelde de kinderen dat melk afkomstig was van de **koe**. [The farmer told the children that milk is produced by the cow.]
17. Wanneer Peter naar een feestje gaat, draagt hij altijd een strik of een **das**. [When Peter goes to a party, he always wears a bow or a tie.]
18. De koning regeerde over het land al zittend op zijn **troon**. [The king governed his country sitting on his throne.] *
19. Omdat de kleuter ruzie gemaakt had op school, kreeg hij van de juf een **straf**. [Because the infant had a fight at school, the teacher gave him a punishment.]
20. Ik denk nog vaak terug aan die dag met een lach, maar ook met een **traan**. [I often think back to that day with a

could subscribe she passed an oral and a physical test.]	laugh, but also with a tear.]
21. De man boekte voor de verjaardag van zijn vrouw een verre en exotische **reis**. (raise) [For the birthday of his wife the man booked a far and exotic trip.]	21. Kris verzorgde de planten en reed het gras af in zijn prachtige **tuin**. [Kris was taking care of the plants and was cutting the grass in his wonderful garden.]
22. Jan heeft de beste resultaten van de klas, want hij is heel **slim**. (slim) [Jan has the best grades of the class, because he is very smart.]	22. Hij interesseerde zich niet voor dat vak, en vond de lessen erg **saai**. [He wasn't interested in that subject and found the lessons very boring.]
23. Omdat ze op haar voeding lette at ze geen frieten, want die waren te **vet**. (vet) [Because she payed attention to her diet she didn't eat fries, because they were too fat.]	23. Hij doet geen moeite om een nieuwe job te zoeken, want hij is erg **lui**. [He didn't put a lot of effort on finding a new job, because he is very lazy.]
24. Je zult de koeien zien die de hele dag grazen in die **wei**. (way) [You will see the cows grazing the whole day in that meadow.]	24. De kippen slapen 's nachts buiten in het **hok**. [The chickens sleep at night outside in the shed.]

Figure Captions

Figure 1. Graphical presentation of RTs on homophones and matched control words as a function of sentence constraint (low vs. high) and L2 proficiency level of the participants (low vs. high) in Experiment 1. The vertical bars represent the 95 % confidence interval.

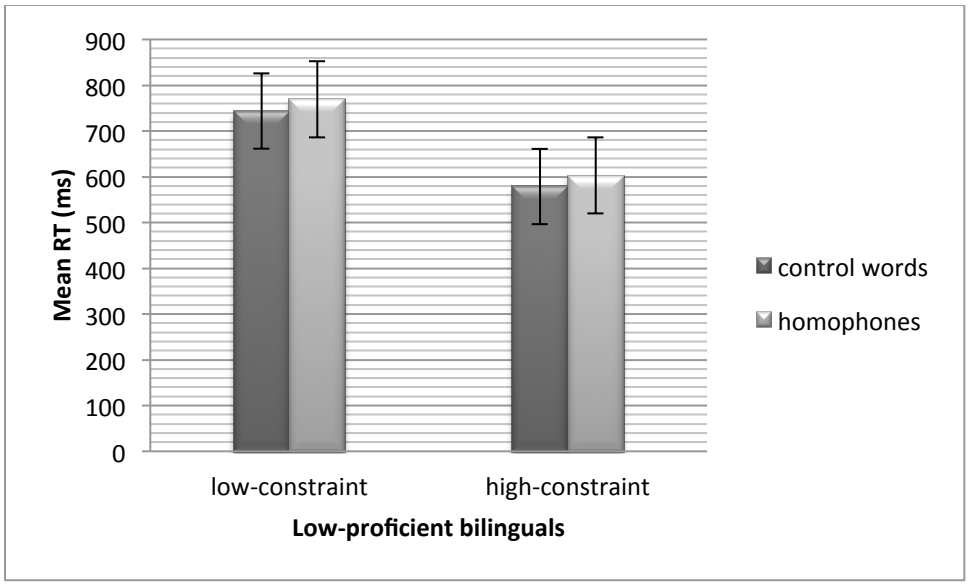
Figure 2. Scatterplot representing the homophone effect as a function of the L2 proficiency level of the participants in Experiment 1.

Figure 3. Graphical presentation of RTs on homophones and matched control words as a function of sentence constraint (low vs. high) and L2 proficiency level of the participants (low vs. intermediate vs. high) in Experiment 2. The vertical bars represent the 95 % confidence interval.

Figure 4. Scatterplot representing the homophone effect as a function of the L2 proficiency level of the participants in Experiment 2.

Figure 1

Graphical presentation of RTs on homophones and matched control words as a function of sentence constraint (low vs. high) and L2 proficiency level of the participants (low vs. high) in Experiment 1. The vertical bars represent the 95 % confidence interval.



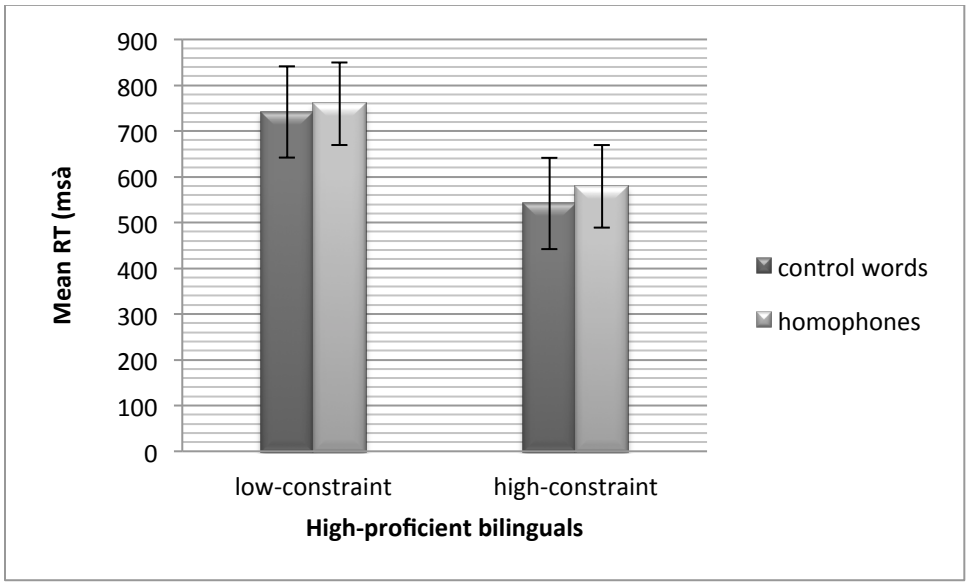


Figure 2

Scatterplot representing the homophone effect as a function of the L2 proficiency level of the participants in Experiment 1.

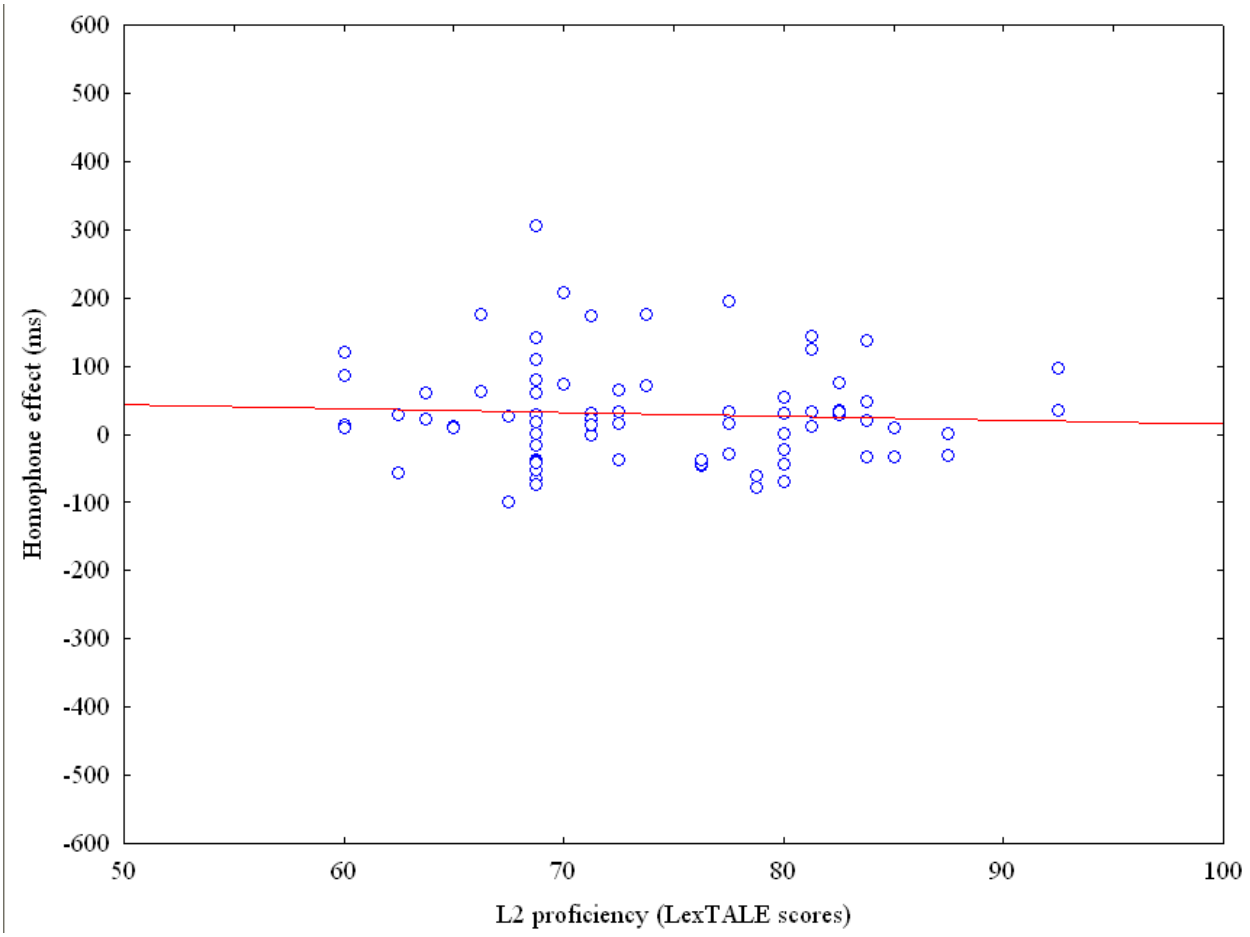
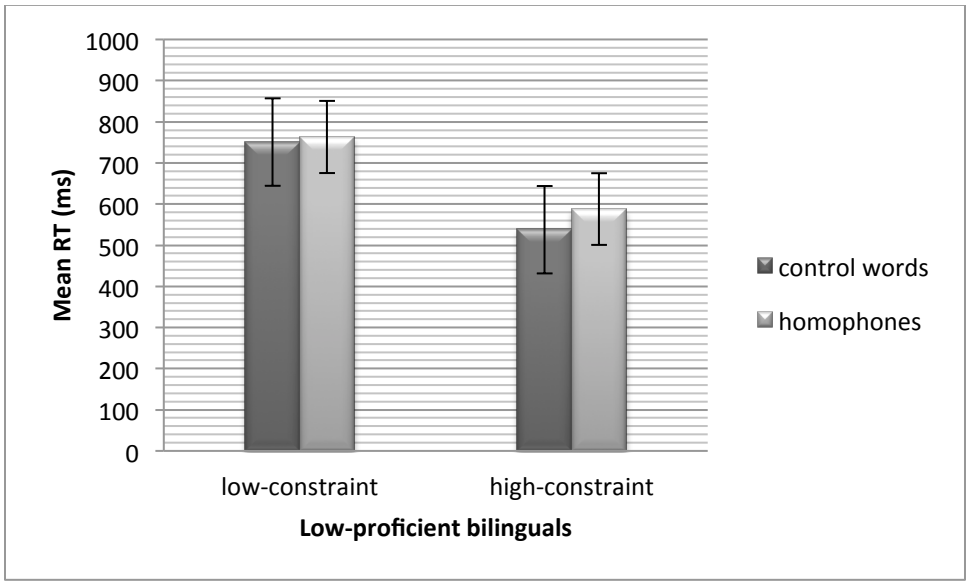
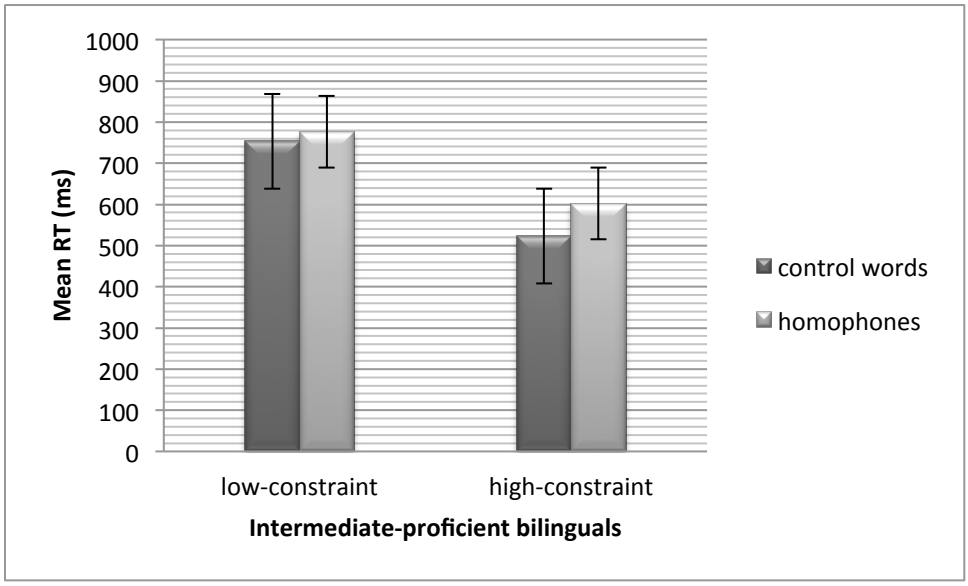


Figure 3

Graphical presentation of RTs on homophones and matched control words as a function of sentence constraint (low vs. high) and L2 proficiency level of the participants (low vs. intermediate vs. high) in Experiment 2. The vertical bars represent the 95 % confidence interval.





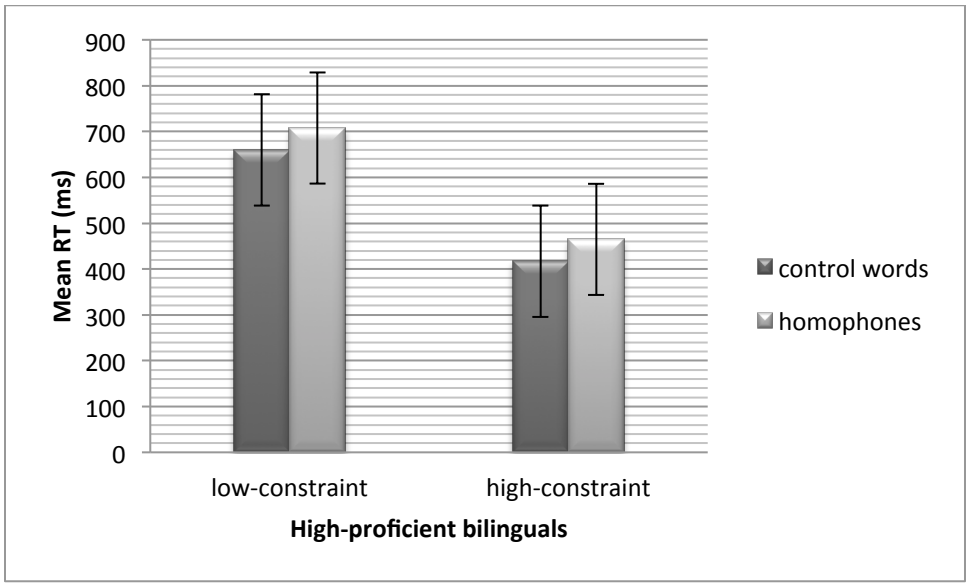

900
800
700
600
500
400
300
200
100
0
Mean RT (ms)
low-constraint
high-constraint
High-proficient bilinguals
control words
homophones

Figure 4

Scatterplot representing the homophone effect as a function of the L2 proficiency level of the participants in Experiment 2.

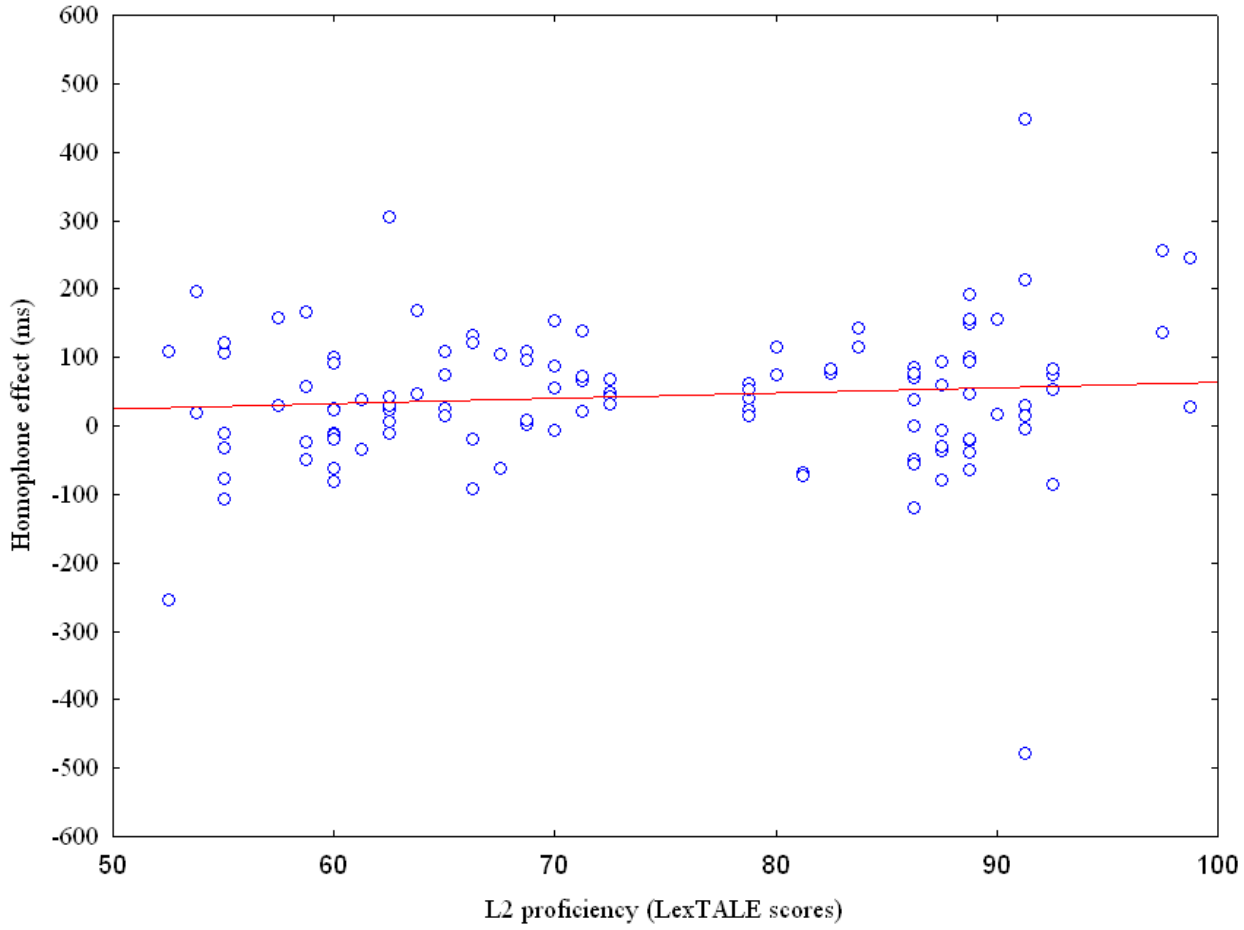


Table 1

Mean lexical characteristics of homophones and control words.

Condition	Number of phonemes	Word frequency [a]	Neighborhoodsize [b]	Bigram frequency [c]	Number of syllables	Duration [d]
Homophones	3.04 (0.62)	1.57 (0.61)	13.21 (6.60)	22627 (10284)	1 (0)	357.50 (74.32)
Control words	3.13 (0.54)	1.50 (0.47)	13.50 (6.64)	23137 (16969)	1 (0)	376.52 (80.88)
p	> .49	> .37	> .67	> .85	identical	> .14

Note. Standard deviations are indicated in parentheses. Reported p-values indicate significance levels of dependent samples t-tests between targets and competitors. [a] Mean log frequency per million words, according to the CELEX lemma database (Baayen, Piepenbrock, & Van Rijn, 1993). [b] Neighborhoodsize (Coltheart, Davelaar, Jonasson, & Besner, 1977) calculated using the WordGen program (Duyck, Desmet, Verbeke, & Brysbaert, 2004) on the basis of the CELEX lemma database (Baayen et al., 1993). [c] Mean summated bigram frequency (calculated using WordGen, Duyck et al., 2004). [d] Pronunciation duration in ms.

Table 2

Production probabilities for interlingual homophones, control words, and L1 translation equivalents of the L2 reading of the homophone in low- and high-constraint sentences.

	Sentence constraint	
Word type	Low	High
Interlingual homophone	0.02 (0.02)	0.88 (0.08)
Control word	0.03 (0.05)	0.82 (0.17)
L1 translation equivalent	0.01 (0.09)	0.0006 (0.004)

Note. Standard deviations are indicated in parentheses.

Table 3

Mean RTs (in Milliseconds) as a function of word type (control word vs. homophone), semantic constraint (low vs. high), and L2 proficiency level of the participants (low vs. high) in Experiment 1. Standard deviations are presented between brackets.

		Control words	Homophones
Low-proficient bilinguals			
	Low-constraint	744 (25)	769 (25)
	High-constraint	579 (32)	603 (25)
High-proficient bilinguals			
	Low-constraint	742 (25)	760 (25)
	High-constraint	542 (32)	579 (26)

Table 4

Mean RTs (in Milliseconds) as a function of word type (control words vs. homophone), semantic constraint (low vs. high), and L2 proficiency level of the participants (low vs. intermediate vs. high) in Experiment 2. Standard deviations are presented between brackets.

		Control words	Homophones
High-proficient bilinguals			
	Low-constraint	660 (30)	708 (29)
	High-constraint	417 (43)	465 (36)
Intermediate-proficient bilinguals			
	Low-constraint	753 (30)	776 (29)
	High-constraint	523 (43)	602 (36)
Low-proficient bilinguals			
	Low-constraint	751 (32)	763 (31)
	High-constraint	538 (45)	588 (38)