PSYCHOLOGICAL SCIENCE

A JOURNAL OF THE ASSOCIATION FOR PSYCHOLOGICAL SCIENCE
aps

Research Report

Does Bilingualism Change Native-Language Reading?

Cognate Effects in a Sentence Context

Eva Van Assche, Wouter Duyck, Robert J. Hartsuiker, and Kevin Diependaele

Ghent University

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

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

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

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

Address correspondence to Eva Van Assche, Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B-9000 Ghent, Belgium, e-mail: eva.vanassche@ugent.be.

Psychological Science
RESEARCH, THEORY, & APPLICATION IN PSYCHOLOGY AND RELATED SCIENCES

recognition, because this would limit lexical search to lexical entries of only one language.

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

In a pretest, we replicated the native-language cognate-facilitation effect for words presented in isolation (Van Hell & Dijkstra, 2002) with a set of 40 cognates and control words that were matched on word class (all words were nouns), word length (identical), number of syllables, word frequency, neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977), and bigram frequency. Forty-two Dutch-English bilinguals performed a Dutch (native-language) lexical decision task (word/nonword decision) on these words, Dutch filler words, and nonwords. Linear mixed-effects model analyses in which frequency was included as a control variable showed significantly faster reaction times for cognates (M = 493 ms) than for controls (M = 507 ms), $F(1, 3067) = 7.70, p < .01$. We also used a continuous measure of cognate status by defining cross-lingual overlap between each word and its translation (e.g., *piloot-pilot*: .95; *schaap-sheep*: .52; *eend-duck*: .08) using the word similarity metric developed by Van Orden (1987). This analysis showed a gradual effect of cross-lingual overlap on word processing: Recognition of Dutch words was facilitated when words had higher degrees of orthographic similarity with English, $F(1, 3067) = 4.45, p < .05$. This pretest demonstrated that second-language lexical representations become active when bilinguals read native-language words in isolation, and constitutes a validation of these materials for the actual sentence study.

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

METHOD

Participants

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

Stimulus Materials

The 40 cognate-control pairs of the pretest were inserted in a native-language sentence context that could contain both the cognate and a control word (e.g., "Ben heeft een oude OVEN/LADE gevonden tussen de rommel op zolder" ["Ben found an old OVEN/DRAWER among the rubbish in the attic"]; for the complete set of stimuli of the experiment and the replication, see Main Stimulus Details in the Supporting Information available on-line; see p. 927). By presenting the cognate and its control word in the same low-constraint sentence context, we avoided confounding effects of preceding words across conditions (see also Duyck et al., 2007). Predictability of the sentences was assessed in a sentence-completion study with a separate sample of 30 participants. Mean production probabilities for cognates and control words showed that the sentences were indeed of low constraint (cognates: .024; controls: .029). Participants saw each sentence only once, with either the cognate or the control word. The same 40 filler sentences were presented to each participant.

Apparatus

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

Procedure

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

RESULTS

We fitted linear mixed-effect models, as implemented in the *lme4* library (Bates, 2007) in *R* (R Development Core Team, 2009), to the first-fixation durations (i.e., the duration of the first fixation on the target word during the first passage over that region), log-transformed gaze durations (i.e., the sum of the fixation durations from the moment the eyes land on the word of interest until the moment they move off again), and log-transformed regression-path durations (i.e., the time from the first encounter with the target word until a subsequent word is fixated). Fixation times that were 2 standard deviations above each participant's condition mean were removed from analyses (3.1% of the data for first-fixation durations, 3.7% of the data for gaze durations, and 4.3% of the data for regression-path durations). Additionally, 25.2% of the data was removed from analyses because the word was skipped or the sentence was not read in a beginning-to-end way (5.7%). There were no significant differences in data removal across conditions. Mean first-fixation, gaze, and regression-path durations are shown in Table 1.

Each analysis included crossed random effects for participants and sentence frames (see Baayen, Davidson, & Bates, 2008).[1] To control for effects of parafoveal preview, we included the distance between the prior fixation and the target word as a control variable. This resulted in significant nonlinear effects of this variable; this result is consistent with monolingual eye-tracking studies (e.g., Vitu, McConkie, Kerr, & O'Regan, 2001). If this control variable was removed from analyses, effects of cross-lingual overlap became somewhat weaker, but the pattern of results did not change.

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

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

TABLE 1

Mean First-Fixation, Gaze, and Regression-Path Durations for Cognate and Control Words

	Duration (ms)		
Word type	First fixation	Gaze	Regression path
Cognate	196 (49)	205 (63)	239 (108)
Control	201 (53)	213 (66)	249 (111)

Note. Standard deviations are given in parentheses. The first-fixation duration is the duration of the first fixation on the target word during the first passage over that region. The gaze duration is the sum of the fixation durations from the moment the eyes land on the word of interest until the moment they move off again. The regression-path duration is the time from the first encounter with the target word until a subsequent word is fixated.

REPLICATION

To ensure the reliability of our findings, we carried out a replication of this experiment with a different set of stimuli, namely the 30 cognates used in the second-language reading study of Duyck et al. (2007), and 30 new matched Dutch (native-language) control words (for the complete set of stimuli of the experiment and the replication, see Replication Stimulus Details in the Supporting Information available on-line; see p. 927). Only one of these 30 cognates was also used in the previous experiment. The participants were 64 further students with the same language background. The obtained results were very similar: Again, we observed faster first-fixation durations for cognates ($M = 210$ ms) than for control words ($M = 216$ ms), $F(1, 1087) = 3.32$, $p < .05$. Similarly, the continuous analyses showed shorter reading times for Dutch words with higher degrees of cross-lingual orthographic similarity with English in first-fixation duration, $F(1, 1087) = 5.02$, $p < .05$. This effect was marginally significant for gaze duration, $F(1, 1077) = 2.50$, $p = .07$, and not significant for regression-path duration, $F < 1$. Most importantly, this replication again yielded a significant cognate-facilitation effect on an early reading-time measure, using a different set of stimuli (for a detailed description of the method and results of the replication experiment, see Replication in the Supporting Information available on-line; see p. 927).

DISCUSSION

We found that knowledge of a second language changes native-language reading. Early reading-time measures (first-fixation duration and gaze duration) were shorter for cognates than for

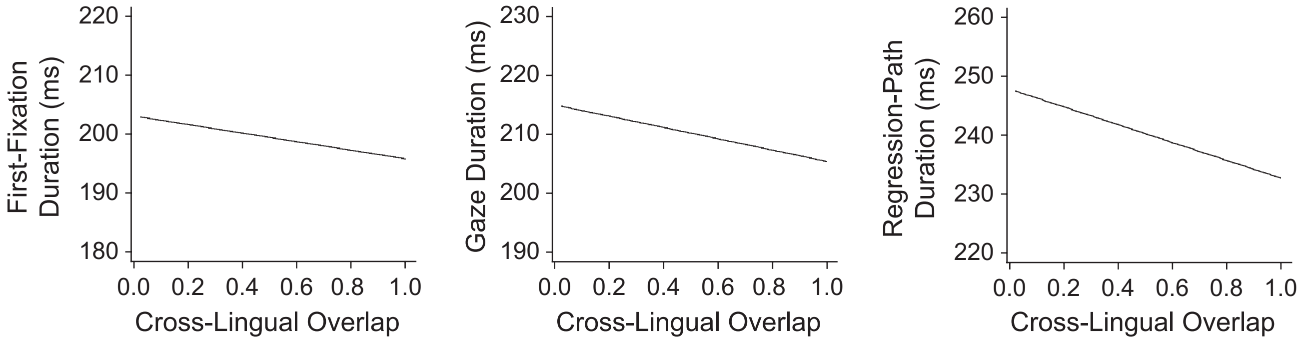

Fig. 1. Regression results from the main experiment: first-fixation duration, gaze duration, and regression-path duration as a function of cross-lingual overlap.

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

These results have several important theoretical implications. First, they provide strong evidence for the theoretical viewpoint that the bilingual language system is profoundly nonselective, even during native-language processing. Reading a word in one language automatically activates word representations from the target and nontarget languages. The obtained continuous effects of overlap indicate that this spreading of activation is a function of cross-lingual similarity between lexical representations, not restricted within the language to which these belong (as interactive activation models of bilingual word reading, such as the Bilingual Interactive Activation Plus model, would predict; Dijkstra & Van Heuven, 2002).

Second, our results indicate that linguistic information given in a sentence context does not modulate lexical access in bilinguals. The presentation of words in a sentence context did not nullify cross-lingual lexical activations, even though restricting lexical search to entries from the target language would constitute an efficient lexical-search strategy. Third, the results go beyond bilingual word recognition in that they show that comprehension of a sentence in a native language is influenced by knowledge of the second language. Taken together with recent studies on bilingual sentence parsing (e.g., Dussias & Cramer Scaltz, 2008) and bilingual sentence production (e.g., Hartsuiker, Pickering, & Veltkamp, 2004), this finding argues for a bilingual sentence-processing system that is highly integrated across languages.

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

Acknowledgments—This research was made possible by the Research Foundation-Flanders, of which Eva Van Assche is a research fellow and of which Wouter Duyck is a postdoctoral research fellow. We thank Judith Kroll, Simon Liversedge, and an anonymous reviewer for their helpful comments on an earlier version of this manuscript.

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 & Cognition*, *24*, 477–492.

Ameel, E., Storms, G., Malt, B., & Sloman, S. (2005). How bilinguals solve the naming problem. *Journal of Memory and Language*, *53*, 60–80.

Baayen, R.H., Davidson, D.J., & Bates, D.M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *4*, 390–412.

Bates, D.M. (2007). *Linear mixed model implementation in lme4*. Unpublished manuscript, University of Wisconsin, Madison.

Bialystok, E., Craik, F.I.M., & Ryan, J. (2006). Executive control in a modified antisaccade task: Effect of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*, 1341–1354.

Coltheart, M., Davelaar, E., Jonasson, J.T., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and performance* (Vol. 6, pp. 535–555). New York: Academic Press.

Dijkstra, T., 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, T., & 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.

Dussias, P.E., & Cramer Scaltz, T.R. (2008). Spanish-English L2 speakers' use of subcategorization bias information in the resolution of temporary ambiguity during second language reading. *Acta Psychologica*, *128*, 501–513.

Duyck, W. (2005). Translation and associative priming with cross-lingual pseudohomophones: Evidence for nonselective phonological activation in bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 1340–1359.

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

Gollan, T.H., Montoya, R.I., Cera, C., & Sandoval, T.C. (2008). More use almost always means a smaller frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of Memory and Language*, *58*, 787–814.

Hartsuiker, R.J., Pickering, M.J., & Veltkamp, E. (2004). Is syntax separate or shared between languages? Cross-linguistic syntactic priming in Spanish-English bilinguals. *Psychological Science*, *15*, 409–414.

Hohenstein, J., Eisenberg, A., & Naigles, L. (2006). Is he floating across or crossing afloat? Cross-influence of L1 and L2 in Spanish-English bilingual adults. *Bilingualism: Language and Cognition*, *9*, 249–261.

Ivanova, I., & Costa, A. (2008). Does bilingualism hamper lexical access in speech production? *Acta Psychologica*, *127*, 277–288.

Jared, D., & Kroll, J.F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, *44*, 2–31.

Laufer, B. (2003). The influence of L2 on L1 collocational knowledge and on L1 lexical diversity in free written expression. In V.J. Cook (Ed.), *L2 effects on the L1* (pp. 9–31). Clevedon, England: Multilingual Matters.

R Development Core Team. (2009). *R: A language and environment for statistical computing*. Available from the R Foundation for Statistical Computing Web site: http://www.R-project.org

Reichle, E.D., Pollatsek, A., Fisher, D.L., & Rayner, K. (1998). Toward a model of eye movement control in reading. *Psychological Review*, *105*, 125–157.

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

Van Hell, J.G., & de Groot, A.M.B. (2008). Sentence context modulates visual word recognition and translation in bilinguals. *Acta Psychologica*, *128*, 431–451.

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

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

Van Orden, G.C. (1987). A rows is a rose: Spelling, sound, and reading. *Memory & Cognition*, *15*, 181–198.

Vitu, F., McConkie, G.W., Kerr, P., & O'Regan, J.K. (2001). Fixation location effects on fixation durations during reading: An inverted optimal viewing position effect. *Vision Research*, *41*, 3513–3533.

(Received 11/11/08; Revision accepted 1/30/09)

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Main Stimulus Details
Replication Stimulus Details
Replication

Please note: Wiley-Blackwell is not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.