

WORD RECOGNITION IN BILINGUALS: EVIDENCE AGAINST THE EXISTENCE OF TWO SEPARATE LEXICONS

Marc BRYLSBAERT
University of Ghent

Evidence is increasing that the first stages of word processing in bilinguals are language-independent. Early findings that seemed to point to the existence of independent lexicons and a language selective access mechanism, can be explained either because participants were able to use low-level orthographic and phonotactic cues about the language of the stimulus, or because the dependent variable was not sensitive enough to reveal the interactions. Recent research based on lexical decision and masked priming indicates that, in the very first stages of word recognition, the words of the different languages mastered by a bilingual, behave as if they were words of the same language.

Up to recently, models of bilingual word processing have been dominated by the idea that words of different languages are stored in separate lexicons (e.g., de Groot, 1993; Kroll, 1993; Snodgrass, 1993). Researchers have assumed that the systems underlying word recognition in the different languages mastered by a multilingual, function independently during the first stages, and are interconnected only at a very late, conceptual, level. In the last few years, however, evidence has accumulated that the initial phases of word recognition may be largely language independent (and hence processed by a unitary structure). I will first review the evidence for separate representations and then describe the evidence in favour of a unitary lexicon.

Evidence for Language-Specific Lexicons

The idea of a bilingual equipped with two independent language processing devices is intuitively appealing, because it easily explains why language interference is rare in situations without uncertainty about the target language (e.g., while reading an English article). The only thing that needs to be postulated is the possibility of inhibiting the nontarget language system and conveying the sensory information to the correct input lexicon. This requires nothing more than a selective access control mechanism, as proposed by MacNamara and Kushnir (1971). According to them, bilinguals have an input

Correspondence concerning this article should be addressed to Marc Brysbaert, Department of Experimental Psychology, Henri Dunantlaan 2, 9000 Ghent. Electronic mail may be sent to marc.brysbaert@rug.ac.be.

switch mechanism that guides the incoming sensory information to the appropriate lexical system.

Empirical evidence for the selective access hypothesis was found in the detrimental effects of code switching on language comprehension (e.g., Kolers, 1966; MacNamara & Kushnir, 1971). Bilinguals take longer to read sentences composed of words from both languages they master, than they take to read normal, single-language sentences. Soares and Grosjean (1984) demonstrated that the processing cost due to language mixing arises immediately during the recognition of the word following the code switch.

Other, more direct, evidence for the language selective access hypothesis was provided by Scarborough, Gerard, and Cortese (1984) and Gerard and Scarborough (1989). Scarborough et al. used a monolingual lexical decision task, in which the participant had to indicate whether a visually presented string of letters formed a word in a particular language or not. Using Spanish-English bilinguals, Scarborough et al. reported that participants rejected words of the nontarget language with the same speed as nonwords. This was true both when the target language was the participants' first language, and when it was their second language. Scarborough et al. argued that this finding implied that bilinguals were selectively accessing the lexicon required for the experimental task and processing the nontarget language words as nonwords. The fact that the rejection latencies to the nontarget language words did not show a word frequency effect added further support to this conclusion.

Gerard and Scarborough (1989) made use of unbalanced non-cognate Spanish-English homographs to support the hypothesis that lexical information is represented in language-specific lexicons and that word recognition requires searching the language-appropriate lexicon. Non-cognate interlexical homographs are words that have the same spelling but different meanings in two languages. For instance, the word "red" in Spanish means "net". Unbalanced homographs are words that have a high frequency of occurrence in one language and a low frequency in the other language (e.g., "red" is a low frequency word in Spanish). Gerard and Scarborough asked Spanish-English bilinguals to run a monolingual word/nonword decision task. Mixed into the single language list of words were unbalanced English-Spanish non-cognate interlexical homographs. The results showed that only word frequency in the currently active language -and not the summed frequency in both languages- predicted homograph recognition time. So, although "red" is a high frequency word in English, Spanish-English bilinguals were no faster in the Spanish only condition than Spanish monolinguals in recognizing it, thus lending support to the language-specific dual-lexicon hypothesis.

Very similar results have been reported by Dijkstra, Van Jaarsveld, and Ten Brinke (1998, Experiment 1). They made Dutch-English bilinguals perform an English lexical decision task that included English/Dutch non-cognate

homographs, cognates, and English control words. Non-cognate homographs are words that exist in both languages, but have a different meaning (e.g., list, boom), cognates are words that exist in both languages with the same meaning (e.g., bus, rib), and English control words are words that only exist in English (e.g., bag, ape). Just like Gerard and Scarborough (1989), Dijkstra et al. found no difference in reaction times to non-cognate homographs and English control words. In contrast, cognates were recognized faster than controls. Dijkstra et al.'s findings are important because English and Dutch words are much more alike than English and Spanish words, so that participants could not make use of low-level, orthographic cues, as suggested by Grainger (1993; see below).

Finally, in the last two years some intriguing findings have been reported with brain imaging techniques. Kim, Relkin, Lee, and Hirsch (1997) applied functional magnetic resonance imaging (fMRI) to determine the spatial relationship between native and second languages in the human cortex, and showed that within the language sensitive regions of the frontal lobe (Broca's area), second languages acquired in adulthood ("late" bilinguals) were spatially separated from native languages. However, when acquired during the early language acquisition stage of development ("early" bilinguals), native and second languages tended to be represented in common frontal cortical areas. In both late and early bilingual individuals, the temporal lobe language sensitive regions (Wernicke's area) showed effectively little or no separation of activity based on the age of language acquisition. Perani et al. (1996) used positron emission tomography to study brain activity in adults while the participants were listening to stories in their native language, in a second language acquired after the age of seven, and in a third unknown language. Several areas, similar to those previously observed in monolinguals, were activated by the native but not by the second language. Both the second and the unknown language yielded distinct left hemispheric activations in areas specialized for phonological processing. These results indicate that some brain areas are shaped by early exposure to the maternal language and are not necessarily activated by the processing of a second language to which individuals have been exposed for a limited time later in life. However, these results do not specify at which point the languages start to diverge. In addition, a subsequent study (Perani et al., 1998) showed that the differences in cortical responses had more to do with the proficiency level of the participants than with the age of second language acquisition.

Evidence Against Language Selective Access

In contrast with the previous findings, a number of studies have been published in which participants were unable to suppress their knowledge of

nontarget languages while performing a monolingual task. Some of the early evidence in visual word recognition comes from Altenberg and Cairns (1983), and Nas (1983). Altenberg and Cairns (1983) showed that English monolinguals took less time to reject nonwords in a lexical decision task when the nonwords contained an illegal sequence of letters in English (e.g., PFLOK) than when they did not (e.g., TWOUL). In contrast, the rejection time of English-German bilingual participants depended additionally on whether or not the letter string was illegal in German (e.g., PFLOK is a legal sequence of letters in German), even though the task only involved decisions about English words.

In a first experiment, Nas (1983) looked at how Dutch-English bilinguals process Dutch words in an English lexical decision task. He found that these Dutch words took considerably longer to reject than control nonwords. In a second experiment, Nas showed that nonwords written according to the English orthography but resulting in homophones of existing Dutch words (e.g., SNAY which according to the English letter-to-sound correspondences sounds like the Dutch word "snee" [cut]) resulted in longer rejection times than control nonwords. Nas interpreted these results as evidence for the existence of a common store for Dutch and English words.

Grainger (1993) tried to reconcile the contradictory findings of Nas (1983) and Scarborough et al. (1983; see above) by pointing to the fact that in the study of Scarborough et al. participants may have used nonlexical characteristics of words (such as orthographic cues) to reject the nontarget words in the lexical decision task. Indeed, the orthographic similarity between English and Dutch is considerably greater than the orthographic similarity between English and Spanish.

Evidence for the use of language-specific orthographic cues by bilinguals has been reported by Grainger and Beauvillain (1987). These authors had French-English bilinguals decide whether or not a visually presented stimulus was a word in either of their two languages. The main research interest was a comparison between decision latencies in pure lists containing words from one language only, and mixed lists containing words from both languages (together with the same legal nonwords). The results showed that latencies to words in the mixed lists were slower than to the same words in the pure language lists, but that this increased difficulty in word recognition only occurred directly after a language switch. Moreover, the disruptive effects of switching language were absent for target words containing language-specific orthographic cues (e.g., the beginning letters "wh", which mark a word as English and not as French). Apparently the participants were able to use certain orthographic cues present in the target language to offset the negative effects of a switch in language.

Language-specific orthographic cues may also explain a finding reported by French and Ohnesorge (1996). Using French-English bilinguals and the same

task as Grainger and Beauvillain (1987), these authors found that nonwords with few neighbours in French were rejected faster than nonwords with many neighbours in French, when all words were French words. However, when half of the words were English words and half French words, both types of nonwords yielded equal reaction times. Important for the interpretation of the results was that the nonwords with few neighbours in French had many neighbours in English (and thus probably contained many English-specific orthographic cues).

The importance of language-specific cues in stimulus materials has also been demonstrated for auditory word recognition (Grosjean, 1988; Li, 1996). Grosjean (1988) examined two major psycholinguistic factors in French-English bilinguals' recognition of code-switched words in the auditory modality. The first factor was the phonotactic structure of the code-switched word. Some phonotactic structures are quite typical for a particular language. For example, initial consonant clusters are more frequent in English than in French, while initial consonant plus vowel combinations are more frequent in French than in English. Therefore, a word with a consonant cluster configuration would prompt the bilingual listener to identify it as an English word and that of a consonant-vowel configuration as a French word. The second factor Grosjean examined were the phonetics of the language that was used to produce the code-switched word. Grosjean distinguished true code-switches from borrowings: True code-switches are pronounced as in the guest language and thus retain phonetic cues of the guest language (e.g., an English word pronounced in English phonetics), while borrowings are phonetically adapted to the speaker's base language and thus have lost phonetic cues from the guest language (e.g., an English word pronounced using French phonetics with a French accent). Grosjean's results indicated that both phonotactic structure and language phonetics played an important role in French-English bilingual code-switch recognition. When words were phonotactically marked as belonging to the guest language, they were recognized sooner and with more ease than words not marked in this way. Also, when words were pronounced in the guest-language phonetics, they were easier to identify than words that were integrated phonetically into the base language.

Li (1996) repeated and extended Grosjean's study with Chinese-English bilinguals. In Experiment 1, listeners were asked to identify a code-switched word in a sentence on the basis of increasing fragments of the word (i.e., the word-gating paradigm). Three factors were manipulated. The first two were the same as in Grosjean (1988): the phonotactic structure of the code-switched word and the phonetics of the pronunciation. The third factor concerned the prior context of the sentence in which code-switching occurred. Previous research of monolingual word recognition had indicated that when spoken word recognition takes place in a constraining context, only half of the acoustic

information of a word is needed for correct identification. In isolation, much more information is needed, and often a word may not be recognized even after its acoustic offset. Li's results showed clear effects of language phonetics and context. With code-switched words pronounced as in the guest language (English), only 58% of the word was needed for correct identification, whereas 72% was needed for words pronounced in the base-language phonetics (Chinese). As for the context, only 59% of the word was needed for correct identification if there was a constraining context, compared to 72% if there was not. Li noted that these last results match very well with the recognition times found in monolingual English speakers, and concluded that (p. 764): "... the results suggest that when a code-switched word occurs in a natural sentential context, bilingual Chinese-English listeners need no more time to identify the word than do English listeners in a unilingual situation." The effect of the phonotactic structure was less straightforward and depended on interactions with language phonetics and prior context: Only in the condition of guest-language phonetics and no constraining context was the effect of the phonotactic structure in line with Grosjean's findings. In Experiment 2, Li repeated this basic pattern using a word-shadowing task in which listeners repeated the code-switched word following a predesignated point upon hearing the sentence.

Although low-level (orthographic and phonotactic) factors seem to account for a number of findings that have been interpreted as evidence for language selective access, this explanation may be hard to maintain given the Dijkstra et al. (1998) data. These authors worked with Dutch-English bilinguals and found that lexical decision times to non-cognate homographs did not differ from those to English control words, although the orthographic constraints are very similar in English and Dutch. Dijkstra et al.'s study was repeated by De Moor (1998) who basically obtained the same results. Dutch-English bilinguals were asked to indicate whether a letter string formed an English word or not. Some of the words were non-cognate homographs (e.g., *brand*, meaning *fire* in Dutch); other were English control words of the same frequency (*dwarf*). Just like Dijkstra et al., De Moor found no reliable difference in reaction latencies to these two types of words (homographs: RT = 678 ms; controls: RT = 687 ms). This seemed to indicate that the Dutch word representation of the homographs had not been activated. However, if on the subsequent trial, the English translation of the Dutch word was presented (i.e., *fire*), there was a reliable translation priming effect of 11 ms (*fire* after *brand*: RT = 623 ms; *fire* after an unrelated word: RT = 634 ms). The translation priming effect suggests that although it did not affect the lexical decision time to the homograph, the Dutch word form still had been activated. This is not what one would expect on the basis of two independent lexicons and language selective access. Also, it should be noted that Dijkstra et al. (1998) did not interpret their finding as evidence for independent lexicons. This is because they obtained a significant

facilitation effect with cognates in the English lexical decision experiment; and in two subsequent experiments, they first replicated Nas's (1983) finding that Dutch words take longer to reject in an English lexical decision task (Experiment 2), and then showed frequency-dependent interlingual facilitation effects when participants performed a lexical decision task in which they had to respond "yes" to stimuli that formed a word in either English or Dutch (Experiment 3). According to Dijkstra et al., this pattern of results due to task demands and stimulus list composition is best explained by the Bilingual Interactive Activation model (see also Dijkstra et al., this issue).

Other tasks have also shown that language interactions are readily obtained when language-specific cues cannot be used to perform the experimental task (and to short-cut the normal word processing). Grainger and Dijkstra (1992) demonstrated that, when bilinguals are performing a monolingual lexical decision task, activation of the lexical representations of the other language cannot be prevented (see also Dijkstra et al., this issue). They did so by looking at the impact of neighbors (i.e., words that can be formed by changing one letter of the target word). Words that had more neighbors in the irrelevant language than in the target language ("traitors") took longer to accept than words that had an equivalent number of neighbors in both languages ("neutrals"), and these in turn led to longer latencies than words that had more neighbors in their own language ("patriots"). In the same vein, Beauvillain (1992) found, in French-English bilinguals but not in monolinguals, shorter response latencies for the acceptance of language-specific words than for the acceptance of language-nonspecific words (language-specific words were words with bigram frequencies higher in the target language than in the nontarget language; e.g., CREAM is specific for English, whereas TRADE is not).

Language interactions have also been observed in priming paradigms. Beauvillain and Grainger (1987) reported that priming FIVE with FOUR facilitated lexical decision regardless of whether the prime was presented in a block of French (FOUR in French means OVEN) or English primes. French and Ohnesorge (1996), however, criticized this study because the primes were presented for a shorter period of time (100 ms) than the targets (around 600 ms), so that the context manipulation of changing the filler primes may not have been strong enough. In a subsequent experiment (French & Ohnesorge, 1997), they showed that a reliable priming effect of non-cognate English-French primes (e.g., "fin") on English target words ("shark") in a condition with all-English targets, was cancelled when half of the target words were French words.

Making use of the masked priming procedure, Bijeljac-Babic, Biardeau, and Grainger (1997) reported other evidence of interlingual interactions at the first stages of visual word recognition. They relied on Segui and Grainger's (1990) finding that processing of a low frequency target word (e.g., "BLUR") is hampered more when the word is preceded by a tachistoscopically presented

high frequency orthographic neighbor ("blue") than when it is preceded by an orthographically dissimilar control word. Segui and Grainger expected this orthographic inhibition effect on the basis of McClelland and Rumelhart's (1981) Interactive Activation model. Testing highly proficient bilinguals, Bijeljac-Babic et al. obtained the orthographic inhibition effect in a cross-language condition with primes from the participants' second language and targets from the participants' first language. So, highly proficient French-English bilinguals experienced more problems deciding that "AMONT" was a French word when immediately before the English word "among" had been presented for 57 ms than when the control word "drive" had been presented. No effect was found with monolinguals and beginning bilinguals. This finding is particularly interesting because in the masked priming paradigm participants are unaware of the tachistoscopically presented primes. Still, the primes had an effect in the Bijeljac-Babic et al. study, even though they belonged to a language that was not part of the experimental task.

Brysbaert, Van Dyck, and Van de Poel (in press) also used the masked priming procedure, but looked at cross-language facilitation instead of inhibition. They started from the finding (Grainger & Ferrand, 1996; Humphreys, Evett, & Taylor, 1982; Perfetti & Bell, 1991) that the probability of recognizing a tachistoscopically presented target word is greater when the target is preceded by a tachistoscopically presented homophonic prime (e.g., "creap-CREEP") than when it is preceded by a graphemic control prime that shares the same graphemes with the target word but does not sound the same (e.g., "crelp-CREEP"). The homophonic priming effect is usually interpreted as evidence for the idea that visual word recognition involves phonological recoding of the input before lexical access occurs. Brysbaert et al. wondered whether this effect could be extended to a cross-language situation and, thus, whether a target word from a person's second language could be primed by a homophonic word from the first language. So, in Experiment 1, they presented stimulus pairs "wie-OUI" and "jij-OUI" to Dutch-French bilinguals and to French monolinguals ("oui" is a French word and means "yes"; "wie" is a Dutch word and means "who", its Dutch pronunciation is the same as the French pronunciation of "oui"; "jij" is a Dutch word, means "you", and sounds completely different from "oui"). Brysbaert et al. found that the bilinguals, but not the monolinguals, performed better on the first type of stimuli than on the second type of stimuli. In addition, the cross-language homophonic priming effect was of the same magnitude as the intra-language homophonic priming effect measured within the same experiment (by comparing stimulus pairs like "fain-FAIM" and "faic-FAIM"). In Experiment 2, Brysbaert et al. replicated the effect with Dutch homophonic and graphemic control nonwords as primes (a Dutch homophonic nonword is a sequence of letters that is not a word in Dutch or in French and that according to the Dutch grapheme-phoneme correspondences, but not according

to the French grapheme-phoneme correspondences, sounds like a French target word; e.g. "soer-SOURD" vs. "siard-SOURD"). Again, these results were obtained despite the fact that the participants were unable to identify the prime stimuli and were unaware of the bilingual nature of the task (for them, the task was to recognize shortly presented French words). Van Wijnendaele and Brysbaert (1998) replicated Brysbaert et al.'s findings with proficient French-Dutch bilinguals; this indicates that the interlingual phonological priming effect is not restricted to influences from the first language on the second, but also works from a reasonably well-mastered second language on the mother tongue.

Based on (some of) the above evidence, Grainger (1993; Grainger & Dijkstra, 1992) proposed two alternative models to the idea that bilingualism is characterized by two distinct lexicons and that prior to lexical access one of the lexicons is selected for input. First, in the Bilingual Activation Verification model, incoming orthographic information initially activates lexical representations in both languages independent of the language context. It is only in later selection/verification processes that language context information can come into play. For instance, this information can guide the verification process to the appropriate lexical system and thus effectively diminish the total number of possible candidates by about half. Second, in the Bilingual Interactive Activation model, letter representations activated by sensory input from the printed word send activation on to lexical representations in both languages. These lexical representations then send activation on to supralexical "language nodes", activated word nodes from each language providing excitatory input to the corresponding language node. The model is interactive in the sense that higher level nodes can feed back information to lower level units. In other words, an activated language node will send back excitatory input to all the word nodes in that language, and these word nodes will, in turn, inhibit the word nodes of the other language. For further information on the Bilingual Interactive Activation model, see Dijkstra et al. (this issue), and French and Ohnesorge (1996, 1997).

Beyond the First Access Stage

In the previous section, we have reviewed evidence that the very first stages of word recognition (i.e., the activation of lexical representations matching the sensory input) may be language-independent. Of course, this does not preclude that at a certain moment in processing, language-inappropriate word candidates must be suppressed in order to avoid cross-language confusion, but the evidence so far suggests that this stage happens later than usually assumed. For instance, following the Bilingual Interactive Activation model, Bijeljac-Babic

et al. (1997) hypothesized that cross-language inhibition does not start before some word representations have been activated in the lexicon. These word representations send information to the higher-level language nodes, which influence the on-going competition among activated word candidates via top-down connections that inhibit language-inappropriate candidates. The most recent version of the Bilingual Interactive Activation model (Dijkstra et al., this issue) also includes the possibility of asymmetric cross-language inhibition from language node to word level, so that the system can be tuned to the task at hand (i.e., there will be more inhibition from the nontarget language node in a monolingual situation than in a bilingual situation; for a similar reasoning, see French & Ohnesorge, 1996, 1997).

Brysbaert (in preparation) also obtained empirical evidence for nontarget language inhibition shortly after the activation of lexical candidates. Starting point was a study of Ziegler and Jacobs (1995) who showed that homophonic nonwords of existing words activate the orthography of these words. Participants were presented with a target letter (e.g., "i") and had to indicate whether this letter was present in a subsequently shown letter string. The critical conditions consisted of homophonic nonwords that either contained the target letter in contrast to the corresponding real word (e.g., "taip" vs. "tape"), or homophonic nonwords that did not contain the target letter in contrast to the word (e.g., "brane" vs. "brain"). Ziegler and Jacobs found that decision times and error rates were higher for these homophonic nonwords than for graphemic control nonwords. Their interpretation was that the nonwords were recoded into a phonological representation before activating the corresponding word representation in the auditory lexicon. They further assumed that in the auditory lexicon, lexical representations contain information about the correct spelling of the word, which is triggered when the auditory representation is selected. So, the nonword "brane" activates the phonological word representation /breIn/, which includes the spelling pattern "brain", making it more difficult to indicate that the letter "i" is not part of the stimulus "brane". Brysbaert (in preparation) extended the paradigm to a cross-language situation and examined whether for Dutch-French bilinguals it would be more difficult to indicate that there is no letter "o" in "baume" than in "paume" (the French word "baume" -meaning balm - is a homophone of the Dutch word "boom" -tree; "paume" is a French control word of the same frequency but without Dutch homophonic counterpart). The results were the opposite of Ziegler and Jacob's: Participants were significantly faster to indicate that the letter "o" was not part of "baume" than to indicate that the letter "o" was not part of "paume". This seems to indicate that the spelling of the nontarget language is not only inactive (which would have led to no difference between conditions), but effectively suppressed.

Finally, it goes without saying that bilingual word recognition involves more than the activation of the correct representation in the mental lexicon.

Letter strings not only have to be identified as representing a known word in one or the other language, it is also important to retrieve the meaning of the word, and -often- the translation. Concerning the latter, there are two possible ways in which a word could be translated: either through direct links between the corresponding lexical representations, or via a common meaning system to which all lexical representations have access. With the exception of cognates, evidence is strong for obligatory semantic mediation in translation (e.g., La Heij, Hooglander, Kerling, & Van der Velden, 1996; Van Hell, Oosterveld, & de Groot, 1996), although there have been claims that semantic mediation may be involved to a larger extent in the translation from the first to the second language than in the opposite direction (where there would be more direct lexical links; e.g., Kroll & Stewart, 1994).

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