Can bilinguals use language cues to restrict lexical access to the target language?

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There is considerable evidence that bilingual readers activate lexical candidates from both their languages (language non-selective lexical access), even when the language context does not require this. But most of these studies investigated word recognition in isolation (e.g., in lexical decision experiments). This chapter asks whether language non-selective access generalizes to more contextualized language use, for example when words are part of meaningful sentences, or when words are spoken aloud and so reveal information about the word's language. We discuss four sets of studies that have addressed this issue. The perhaps surprising conclusion that emerges from this work is that bilinguals do *not* seem to exploit potentially useful cues that could strongly restrict the number of lexical candidates. Lexical access, it seems, is profoundly language non-selective. We will discuss the implications for theories of bilingual word recognition, in particular Dijkstra and Van Heuven's (2002) BIA+ model.

Introduction

Imagine you are a Dutch-English bilingual and you read the word *leek*. One possibility is that you will get the English reading – a type of vegetable. But it is also possible that you get one or both of the Dutch readings – a "layman" in the noun reading, and "resembled" in the verb reading. Now imagine that this word is placed somewhere in a Dutch or English sentence. Research on monolingual language processing (e.g., Duffy, Kambe, & Rayner, 2001) suggests that the semantic and syntactic constraints of the sentence will affect the degree of activation of the within-language homonyms (*leek*-resembled, and *leek*-layman). The issue addressed in this chapter is whether cues such as the language of the sentence affect the degree to which the bilingual reader will restrict lexical access to words of only a single language.

The theory that bilingual readers will initially activate lexical candidates in both of their languages (or in even more than two languages in the case of multilinguals) is usually referred to as *language non-selective* lexical access. Conversely, the theory that bilinguals keep lexical representations of the two languages separate and will only activate lexical candidates from the currently relevant language is referred to as *language selective* lexical access. There is a considerable amount of evidence in research on visual word recognition in support of language non-selective access. Thus, studies using lexical decision (in which participants decide whether a string of letters is a word or a non-word) have demonstrated

that interlingual homographs (like *leek*) are responded to more slowly than matched control words, at least under some task-conditions (e.g., Dijkstra, Timmermans, & Schriefers, 2000). This is suggestive that bilingual readers activated both the English lexical representation (which, in an English lexical decision task, requires a yes-response) and the Dutch lexical representation (which requires a no-response). The resulting competition then slows down response latencies.

Another line of research considered effects of cognate status. Cognates are words with identical or similar orthographic/phonological form and meaning in the two languages, such as *tomaat – tomato* in Dutch and English. If cognates have a processing advantage over words occurring in only one language, this is highly suggestive that both lexical representations become co-active, speeding up word recognition. Indeed, several studies have shown that cognates are responded to more quickly in a second language (L2) lexical decision task, compared to matched non-cognate control words (e.g., Caramazza & Brones, 1979). Lemhöfer et al. (2004) showed that cognate effects even accumulate across languages: Dutch-English-German trilinguals performing an L3 lexical decision task responded fastest when the word was a cognate in all three languages (e.g., *echo-echo-Echo*), slower when the word was a cognate between Dutch and German but not English (e.g., *kunst-art-Kunst*) and slowest for German control words (e.g., *Zelt – tent* in both Dutch and English). Interestingly, Van Hell and Dijkstra (2002) showed that cognate status even affects lexical decision in subjects' *first* language (L1). Thus, Dutch-English-French trilinguals responded faster to L1/L2 cognates (e.g., *droom*, meaning *dream*) than to L1 control words (*tuin*, meaning *garden*). There was also an effect for L1/L3 cognates (e.g., *muur, mur* in French, meaning *wall*) but only in a group that was highly proficient in L3.

Summarizing, studies using homographs and cognates in the domain of visual word recognition strongly support the theory of language non-selective access. Note that there is converging evidence for language non-selective access from other domains such as auditory word recognition (e.g., Weber & Cutler, 2004; Spivey & Marian, 1999) and word production (e.g., Costa et al., 1999; Hermans et al., 1998).

However, the large majority of studies on bilingual word recognition only studied word recognition out of context, typically using lexical decisions about individual words. In actual life, bilinguals will of course most often read words embedded in meaningful sentences, which in turn are part of meaningful discourse (e.g., a newspaper article). A Dutch-English bilingual might for example read the Dutch sentence "*Door spot leek die brave arts rover met pet*" (Because of mockery that good doctor resembled robber with hat). In this example, taken

from De Bruijn, Dijkstra, Chwilla, and Schriefers (2001), every single word is also a word in English; but interestingly most Dutch-English bilinguals do not appear to notice this and report that it is a Dutch sentence, presumably because the mutual semantic and syntactic constraints of the Dutch readings of these words allow for a interpretable (though unusual) reading whereas the English readings lead to a random word list. The question thus arises whether it is still the case that lexical access is language non-selective when words are embedded in a sentences. One possibility is that the language of the sentence is already such a strong cue towards language membership, that lexical access in sentence context becomes functionally language selective. That is, if I am reading a newspaper article in Dutch, it would seem highly inefficient to consider, for each and every new word I read, whether the visual input my brain gets constitutes an existing word in English.

It is also possible that language non-selective access is not modulated by the global language context, but that the (more local) semantic and syntactic constraints of the sentence can sometimes restrict the number of activated lexical candidates to one language, similar to the way sentences may influence activation *within* a single language, for instance for homonyms. This would fit with the idea that sentence processing is a highly predictive process (e.g., Altmann & Kamide, 1999; Pickering & Garrod, 2007; Van Berkum, Brown, Zwiterslood, Kooijman, & Hagoort, 2005). For instance, Wright and Garrett (1984) showed that readers predict the syntactic categories of upcoming words: readers made faster lexical decisions to the final words in a (meaningless) sentence, when that word was syntactically congruent (e.g., if your bicycle is stolen you must *formulate;* for now, the happy family lives with *batteries*) than when it was incongruent (e.g., if you bicycle is stolen you must *batteries;* for now, the happy family lives with *formulate*). Schwanenflugel and LaCount (1988) demonstrated that readers use sentence context to predict the *meaning* of upcoming words. Given a context like "the tired mother gave her dirty child…" readers respond fastest to the word with the highest cloze probability (*bath*), somewhat slower to words that are semantically related to the expected word (*shower*), and slowest to words that are semantically felicitous in the sentence context, but are unrelated to the expected word (*scolding*).

Dijkstra and Van Heuven (2002) were the first to make some claims, albeit at a very general level, about the effect of sentence context on the degree to which lexical acces is language non-selective. These authors presented the Bilingual Interactive Activation plus (BIA+) model, a proposal for an architecture of bilingual word recognition. This model extends the earlier BIA computer model, which was based on McClelland and Rumelhart's (1981)

interactive activation model. Unlike its predecessor, BIA+ distinguishes between a word identification system (containing orthographic, phonological, and semantic representations, as well as "language nodes") and a task/decision system which implements control procedures that are affected by the task and the non-linguistic context (e.g., instructions, list composition). An important property of the model is that it is highly interactive, and that there is both interaction *within* the word identification system (e.g., semantic codes can send feedback to orthographic codes) but also *between* the word identification system and higher-order systems such as the sentence parsing system. Dijkstra and Van Heuven therefore argued that "in fact, such linguistic context information may exert serious constraints on the degree of language selective access that may be observed" (p. 187). However, because the task schema system has not been computationally implemented, unlike the word identification system which *was* implemented during the development of BIA, the model's predictions about such top-down influences are not very explicit. The remainder of this chapter discusses recent studies, from our lab and from other labs, that have addressed this general claim, therefore providing the necessary empirical input for future model development. Specifically, we address the following questions: (1) is the language of the sentence in itself sufficient to restrict lexical activation to only the target language?; (2) does the answer to (1) depend on whether the target language is L1 or L2?; (3) does a strong semantic constraint restrict lexical activation to only the target language? (4) can listeners use non-lexical (e.g., phonetic) cues in auditory word recognition to restrict lexical activation?

Is the language of the sentence sufficient to restrict lexical access?

One of the first studies that addressed the question of whether the language of the sentence can restrict lexical access was Elston-Güttler, Gunter, and Kotz (2005). These authors presented German-English bilinguals with English sentences that ended with an interlingual homograph, such as *gift* (German *Gift* means *poison*) or *tag* (German *Tag* means *day*). These sentences were then followed by a target word for lexical decision, which either did (*poison*) or did not (*boss*) correspond to the German meaning of the sentence-final word. Earlier work by Elston-Güttler (2000) had shown that in an out-of-context task, *gift* primed *poison* in this population of bilinguals, but that there was no priming when *gift* was embedded in a sentence context. The experiment therefore included a further context manipulation: half of the participants saw a German-language movie prior to the experiment and the other half saw the same movie, but now in English. Both reaction times and Event-Related Potentials (ERPs), time-locked to the target word, were measured. The authors found a priming effect in

reaction times and in both the N200 and N400 components of the ERP-signal, but these effects were restricted to only the first block of the experiment for only those subjects who saw the German-language movie. These findings thus suggest that sentence context can indeed restrict lexical access, but also that this depends on global language context and that it takes some time before a language-selective setting is effective (which Elston-Güttler et al. referred to as *zooming into* the language).

As noted by Duyck, Van Assche, Drieghe, and Hartsuiker (2007), however, this study used interlingual homographs. Although there are several reports that interlingual form overlap affect response latencies in isolation (e.g., Dijkstra et al., 2000, as mentioned above) the results are not always consistent and effects seem to be highly sensitive to specific characteristics of the task. This is why Duyck et al. evaluated the effects of sentence context using a more reliable marker of language non-selective access, namely cognate facilitation. They conducted three experiments with Dutch-English bilinguals. Experiment 1 was an (L2) English lexical decision task with single presentations of words. This experiment clearly replicated earlier reports of cognate facilitation out of context (e.g., Caramazza & Brones, 1979): identical cognates (e.g., *ring-ring*, n = 8) were responded to faster than control words (e.g., *pig, varken* in Dutch). Non-identical cognates (e.g., *ship – schip*, n = 22) were also responded to faster than control words, although descriptively the effect was somewhat smaller. Most importantly, this validated the materials for the next two experiments, which tested for effects of sentence context.

Experiment 2 presented these cognates and controls as the final words of sentences. Sentences were coherent and plausible, but not semantically constraining towards the target, as determined by a pretest with 50 further participants (there were no differences in predictability between the cognate and control conditions). An example sentence is *Hilda was showing off her new RING/COAT.* The sentences were presented word-by-word and participants made a lexical decision on the sentence-final words. Similar to Experiment 1, there was a significant cognate facilitation effect, for both identical and non-identical cognates. Again, the effect was descriptively larger for identical cognates.

Experiment 3 then measured reader's eye-movements while they were reading the sentences with embedded cognates or control words. Arguably, eye-tracking allows for the study of reading processes in a much more naturalistic way than paradigms such as lexical decision. A further advantage is that eye-tracking has a very accurate temporal and spatial resolution, and that it allows for the computation of several measures related to relatively early and late processes. In particular, two early measures were computed (*first fixation duration* – duration

of the first fixation on the critical word) and *gaze duration* – sum of durations of all fixations on the critical word before the eyes move out of this region for the first time). Furthermore, one later measure was computed, namely *regression path duration*: the sum of durations of all fixations before the eyes move to a region to the right of the critical region. Thus, as opposed to gaze duration, this measure includes regressions originating from the critical word. To avoid sentence wrap-up effects in criticial reading times (e.g., Just & Carpenter, 1980), the sentences of Experiment 2 were adapted slightly, so that the critical word was never the last word of the sentence. This experiment showed cognate facilitation effects, but only for identical cognates. For these stimuli, there was an effect on first fixation duration, gaze duration, and on regression path duration. Summarizing, the studies of Duyck et al. (2007) and Elston-Güttler et al. (2005) strongly suggest that the language of the sentence is not by itself sufficient to restrict lexical access to the target language. However, the degree to which markers of language non-selective access show up seems to depend on variables such as global context and degree of orthographic overlap.

Does the cognate-effect survive a sentence context in L1?

One might argue that the results of the studies of Duyck et al. and Elston-Güttler et al. are not very surprising, as the direction of cross-linguistic influences was always from the first and dominant language to a second language. It may be difficult to "turn off" the L1 when reading in L2. Indeed, there is considerable evidence for asymmetries in cross-linguistic influences. Translation priming for example (e.g., priming the English word "BOY" with its French translation equivalent "garçon") tends to be stronger, and more often reliable, in the direction L1->L2 than in the direction L2->L1 (e.g., Gollan, Forster, & Frost, 1997; but see Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009).

Thus, probably the strongest test case for language non-selective access in a sentence context is reading in the first language. This is precisely what Van Assche, Duyck, Hartsuiker, and Diependaele (2009) did. First, they presented 40 Dutch/English cognates in a Dutch lexical decision test (in isolation). They replicated the cognate facilitation effect in L1 reported by Van Hell and Dijkstra (2002). Importantly, there was also an effect when cross-linguistic orthographic overlap between translation equivalents was defined as a continuous variable rather than a dichotomous one, which is in accordance with connectionist models of word recognition such as BIA. Next, the cognates and control words were embedded in Dutch sentences, and eye-movements were registered. When cognate status was treated as a dichotomous variable, there was a marginal effect of cognate status on first fixation durations

and significant effects on gaze durations and regression path durations. When cognate status was treated as a continuous variable, there were significant effects on all three measures. Thus, cognates are read faster than control words, even in bilinguals' first and dominant language. A final experiment replicated these findings using the "old" set of stimuli used by Duyck et al. (2007) (but now embedded in a Dutch sentences). Again, an L1 cognate advantage was observed.

Summarizing, cognate facilitation remains when one is reading in L1, even in a sentence context. This supports the claim that lexical access in bilingual readers is profoundly language non-selective. It appears that learning a second language fundamentally changes processing of the *first* language.

Does the cognate-effect survive a highly constraining sentence context?

Dijkstra and Van Heuven (2002) argued that there is interactivity between processes involved in sentence comprehension (such as parsing) and the bilingual visual word recognition system. They therefore argued that syntactic and semantic context information from different languages can influence word recognition so that lexical access might become more language-selective.

As noted by Dijkstra and Van Heuven (2002), this suggestion seems to be consistent with a set of findings reported by Altarriba, Kroll, Sholl, and Rayner (1996). Altarriba et al. presented Spanish-English bilinguals with English sentences containing a Spanish or an English target word and monitored eye-movements. The words varied in lexical frequency, and the sentences varied in semantic constraint. For example, a low-constraint sentence was "They chose a *calle [street]* that could be easily closed off for the parade" and the high-constraint counterpart was "You need to look both ways before crossing a *calle [street]* as busy as that one". As is to be expected, first fixations on the English control words (e.g., "street") were shorter in the high-constraint than the low-constraint conditions. Thus, the constraint manipulation was successful in building up a expectation about the meaning and lexical identity of the upcoming word. In contrast, first fixations on the Spanish words (e.g., "calle") were *longer* in the high- than the low-constraint conditions (although only with high-frequency words). This finding suggests that sentence constraint not only leads to a prediction at the semantic level, but also at the lexical level – the word "street" is predicted and pre-activated, but not its translation equivalent in Spanish.

One problem with Altarriba et al.'s study is that the critical stimuli, English sentences containing code-switched Spanish words, are rather unnatural. However, studies that

presented cognates or interlingual homographs in sentence context also observed effects of sentence constraint. Schwartz and Kroll (2006) had Spanish-English bilinguals name out loud target words embedded in L2 sentences. Two group of participants were tested, that differed in their proficiency in L2 English. In both groups, there was cognate facilitation in low-constraint sentences, but no cognate effect in high-constraint sentences. For interlingual homographs, results were not as clear-cut. Van Hell and De Groot (2008) asked Dutch-English bilinguals to make lexical decisions on words embedded in English sentences, or to translate such words either from L2 to L1 or vice versa. An example of a low-constraint sentence is "The handsome man in the white suit is the _____ captain" (the Dutch translation is "kapitein"). The high-constraint counterpart of the example is "The best cabin in the ship belongs to the _____ captain". Van Hell and De Groot found cognate effects in the low-constraint condition in all experiments, but these effects were reduced, or even non-significant (lexical decision) in the high-constraint condition. Summarizing, data from paradigms such as naming, lexical decision, or translation suggest that sentence context affects bilingual lexical access, reducing or nullifying effects that appear to indicate language non-selective access.

One potential problem with these studies, however, is that they tap into processes like response selection and word production, that are *subsequent* to word recognition and may take place quite long after recognition has been completed. It is therefore important to consider the results of experiments using eye-movements, which arguably provide more accurate insights into the time-course of recognition. One such study was recently reported by Libben and Titone (2009). French-English bilinguals read sentences in L2 English with embedded cognates and interlingual homographs. In addition to the early measures (first fixation duration, gaze duration) and late measures (regression path duration) that Duyck et al. (2007) computed, these authors also reported skipping rate (the probability that the word was not fixated) as an early measure and total reading time (the sum of all fixations on the word, be it in the first pass or in a later pass) as a late measure. In the low-constraint condition, there was cognate facilitation and interlingual homograph inhibition on all early and late measures. But in the high-constraint condition, these effects were restricted to the early measures only (i.e., first fixation duration, gaze duration, and skipping rates for cognates; gaze durations for homographs) with no trace of an effect for the late measures. The authors therefore concluded that bilingual language processing is language nonselective at initial processing stages, but that semantic constraints kick in later, and reduce the amount of non-selectivity.

This conclusion may be premature, however. A recent study of Van Assche, Drieghe, Duyck, and Hartsuiker (submitted) tested Dutch-English bilinguals reading cognates in English sentences of low and high semantic constraint. A lexical decision task in isolation first replicated the cognate facilitation effect, thus validating the stimuli. The eye-tracking experiment then showed cognate effects in both the low-constraint and the high-constraint conditions for all measures (early *and* late). There were main effects of constraint on all measures, but constraint did *not* interact with cognate status. This was the case both when cognate status was taken as a dichotomous variable or a continuous variable. The cognate effects disappeared in a control experiment with monolingual English speakers, demonstrating that these effects were genuinely due to overlap with Dutch. Thus, this study finds clear evidence for the cognate effect surviving the semantic restrictions exerted by a highly constraining sentence, even in late measures. This contrasts with the results of Libben and Titone (2009) who only found cognate effects in high-constraint sentences on early measures.

What can explain these differences? It is not the case that Libben and Titone's sentences exerted a stronger semantic constraint than Van Assche et al.'s; in fact, the opposite is true, with cloze values of .86-.89 in Van Assche et al., and values of .48-.49 in Libben and Titone. There are several further differences between the studies in terms of the population (Libben and Titone's participants acquired English much earlier than Van Assche et al.'s, and were balanced in their percentage of daily use of L1 and L2, unike those of Van Assche), the stimuli (Libben and Titone used only form-identical cognates, whereas Van Assche et al. also used non-identical ones), and the stimulus list composition (with a much higher percentage of language-ambiguous stimuli in Libben and Titone). It is not yet clear how such differences can account for the differences in findings, but it is important to note that Van Assche et al. conducted a more conservative test (less proficient bilinguals, less opportunity to "boost" the non-target language, stronger semantic constraint) and still found that the cognate effect is not affected by sentence constraint.[1]

Summarizing, there is some evidence that a highly semantically constraining context can render lexical access somewhat less language non-selective. However, this is based on experiments using relatively unnatural stimuli (sentences containing a language-switched word, Altarrriba et al., 1996) or tasks (e.g., Van Hell & De Groot, 2008). Studies using eye-

[1] Note that late eye-movement measures typically include earlier ones. It is thus possible that effects on "late" measures are not genuinely late effects, but rather reflect early effects.

tracking (Libben & Titone, 2009; Van Assche et al., submitted) demonstrated that cognate (and homograph) effects can survive a strong manipulation of sentence constraint, but it is not yet clear whether this is true for only early stages of word recognition.

What about speech cues in *spoken* comprehension?

The studies reviewed in the previous sections found little evidence that bilinguals can restrict lexical access to only the target language by using cues inherent in the input signal (i.e., the language of the preceding context and semantic restrictions on upcoming words). These studies all tested written comprehension in bilinguals speaking Dutch, German, French, or English. It is important to note that in such languages written words (e.g., LEEK) can be truly language-ambiguous, because these language use the same basic script (the Roman alphabet) and a highly overlapping set of letters (with a few exceptions, mainly with respect to use of diacritics: <ç> occurs in French but not in Dutch, English, or German, <ü> occurs in German, but not in Dutch, English, or French – note that such characters are typically not used in the studies described above). In contrast, in spoken languages there are many sublexical cues that can reveal the language of the utterance. Thus, there a many phonemes that occur in English but not Dutch (e.g., /ae/) or vice versa (/y/); and while some phonemes overlap between the two languages (e.g., /r/), many of them sound different because of allophonic variation. Additionally, Grosjean (1988) showed that bilinguals are able to judge language membership of so-called guest words pronounced as either code-switches or borrowings, solely on the basis of the words' initial phonemes. The question then arises whether listeners can use the language-cues that are inherent in the speech signal to restrict lexical access to a single language.

Note that speech is an extremely rich signal indeed. Acoustic aspects of the speech signal provides information about a person's gender, age, and social background, the region the person comes from – and in the case of a bilingual speaker – the person's native language. Van Berkum, Van den Brink, Tesink, Kos, and Hagoort (2008) demonstrated that the brain processes some of these cues extremely rapidly. They measured ERPs while the subjects listened to sentences spoken by several individuals. The crucial manipulation concerned the match or mismatch between the content of what the person was saying and the information about that person that could be extracted from speech cues. For example, a child would say a sentence with an adult content (e.g., about drinking beer), or a man with a posh accent would state that he had decided to get a large tattoo on his back. Compared to a control condition were the content was consistent with the inferred properties of the speaker, sentences with a

clash between content and speaker elicited a difference in the ERP-signal after about 200-300 ms. In other words, listeners use cues in speech to make predictions about upcoming meaning. It is therefore conceivable that they likewise use speech cues to make predictions about the language of upcoming words, so that lexical access in spoken word recognition would become language selective.

Compared to the large number of studies that have asked whether lexical access in visual word recognition is language selective or non-selective, only a handful of studies asked the analogous question in the auditory domain. To do so, Spivey and Marian (1999) and Weber and Cutler (2004) used the "visual-world paradigm": participants viewed a scene consisting of several objects and simultaneously heard a spoken instruction (e.g., "pick up the desk and place it below the diamond"). Eye-movements were monitored while participants listened to the instruction and executed the task (i.e., of dragging and dropping a picture using the computer mouse). Such studies found that bilinguals, while hearing the target word (e.g., desk in this example), looked more at competitor pictures that had a phonologically similar name *in the other language* than at control pictures. Thus, Dutch-English bilinguals would more often look at a picture of a *lid* (of a pan) than at a control picture, because the Dutch word for *lid* is "deksel" which sounds similar to "desk". However, although several studies found evidence for influences of L1 when listening to L2, only one study (Spivey and Marian, 1999) found evidence for L2-influences when listening to L1; and this was for a population of bilinguals who were extremely fluent in L2 and were immersed in a L2-dominant environment (Russian-English bilingual students who were studying at a top-tier university in the United States).

Recently, Lagrou, Hartsuiker, and Duyck (submitted) re-examined this issue using a lexical decision task with interlingual homophones (e.g., boss [bOs]), meaning "forest" in Dutch. Dutch-English bilinguals executed the auditory lexical decision task in L1 (Dutch) or L2 (English). The stimuli were spoken by two different speakers: a native speaker of Dutch with English as L2 and a native speaker of English with L2 Dutch. Thus, the Dutch word "bos" was spoken once by a person speaking in her native language and once by a person speaking with an English accent, and analogously the English word "boss" was spoken once by a person speaking in her native language and once by someone with a Dutch accent. The results were very clear: in the English lexical decision task, interlingual homophones were responded to more slowly than control stimuli. This was independent on whether the native language of the *speaker* was Dutch or English. A control experiment with monolingual English native speakers ruled out that this effect was spuriously due to some uncontrolled

lexical differences between homophones and controls: the English native speakers showed no trace of homophone inhibition. Importantly, a further experiment with Dutch/English bilinguals showed homophone inhibition in L1 Dutch, thus demonstrating an influence of L2 on L1. Summarizing, this study provides clear evidence for language non-selective access in listening to speech, both in L2 and in L1, and independently of the speaker's accent. Even though speech provides many cues about the language that is spoken and the person speaking that language, and even though bilinguals are able to accurately interpret these cues (Grosjean, 1988), listeners do *not* seem to exploit such cues to restrict lexical access.

Discussion

Summary of findings and theoretical implications

This chapter reviewed four sets of studies that asked whether bilinguals can limit lexical access to only the currently relevant language by exploiting various cues. Results showed that markers of language non-selective access (cognate facilitation, homograph and homophone interference) remained in the presence of such cues. The language of the preceding words of a written sentence is an insufficient cue to make lexical access language-selective (e.g., Duyck et al., 2007) even when reading in the native language (Van Assche et al., 2009). Eye-tracking studies show that lexical access remains language non-selective, even when there is high semantic constraint (Libben & Titone, 2009; Van Assche et al., submitted) – although it remains possible that sentence constraint does exert a relatively late effect (Libben & Titone). Finally, even though speech is a very rich signal and so could give highly reliable cues about the language of unfolding words, lexical decision data indicate that listeners do not exploit such cues (Lagrou et al., submitted).

Such findings have important implications for the further development of models of word recognition in bilinguals. The BIA+ model (Dijkstra & Van Heuven, 2002) for example, is currently rather underspecified with respect to effects of linguistic context. On the one hand, Dijkstra and Van Heuven repeatedly argue that the bilingual word recognition system is in constant interaction with higher levels of linguistic processing, with the possible implication that such interactions might affect the degree of language (non-) selectivity. On the other hand, BIA+ lacks an explicit mechanism for top-down interactions; it solely point out the possibility. Thus, it is not clear how exactly preceding linguistic context might modulate lexical access in this model – that is, the model has "language nodes" but importantly, these nodes do not affect the activation level of lexical nodes through top-down connections (in contrast to the model's predecessor, BIA, Dijkstra & Van Heuven, 1998). Similarly, as also

pointed out by Libben and Titone, 2009 and Schwartz and Kroll, 2006, it is unclear how in BIA+ semantic or syntactic constraints might limit lexical activation to only a few lexical candidates (in the correct language). All in all, at this point we argue that the data indicate only a very limited role for top-down modulation, at the very least for initial stages of word recognition. Our suggestion would therefore be that future developments of BIA+ should concentrate on making the model less, rather than more, interactive.

Role of stimuli, task, and population

At this point, only a handful of studies have considered effects of context on the degree of language (non-) selectivity. Future studies will have to establish whether the findings generalize across different sets of stimuli, tasks, and populations. With respect to the stimuli, most studies used language-ambiguous words like cognates and homographs (as is also the case in studies on bilingual word recognition in general). Studies differ, however, in whether they use only form-identical stimuli (Libben & Titone, 2009) or a mixture of form-identical and form-similar stimuli (e.g., Duyck et al., 2007; Van Assche et al., 2009; Van Hell & De Groot, 2008). The studies also differ in whether form-identity is considered a variable in the analysis (Duyck et al.) or not (Van Hell & De Groot) and whether this variable is taken to be dichotomous (Duyck et al.) or continuous (Van Assche et al.). These differences are relevant with respect to two issues. First, the proportion of language-ambiguous words relative to all words in the experimental list might be used as a further (global) contextual cue towards language. Thus, the most conservative test of language non-selective access is one that minimizes this proportion (e.g., Duyck et al., 2007). Second, analyses that treated language overlap as a continuous variable (Van Assche et al., 2009; submitted) show graded effects: the more orthographically similar two translation equivalents are, the shorter the reading times. This finding has theoretical repercussions for the representation and processing of cognates: it fits the account of BIA+ according to which orthographic, phonological, and semantic representations in the two languages "resonate". In contrast, it is not consistent with theories that assume cognates are represented in a qualitatively different way from non-cognates (Sánchez-Casas, Davis, & Garcia-Albea, 1992).

Regarding effects of the *task*, there seem to be important differences between results obtained with paradigms like lexical decision, naming, and translation (Schwartz & Kroll, 2006; Van Hell & De Groot, 2008) and those obtained with eye-tracking (Libben & Titone, 2009; Van Assche et al., submitted). Specifically, only studies with eye-tracking could find evidence for cognate facilitation effects in highly constraining sentences. It is likely that this

is because eye-tracking in reading is a more sensitive paradigm. Another possibility, suggested by Libben and Titone, is that only eye-tracking picks up on the earliest stages of word recognition (during which lexical access is language non-selective), while these other paradigm tap into later stages (during which interactions with the sentence processor have made lexical access language selective). Future studies will of course need to clarify this issue.

Finally, it is important to ask whether the findings discussed here generalize to other bilingual populations. The studies discussed here differed in the language pairs (Dutch-English, French-English, German-English, or Spanish-English), L2 proficiency, and L2 age of acquisition. For example, Libben and Titone's (2009) participants had higher L2-proficiency and acquired L2 earlier than Van Assche et al.'s (submitted) participants. Schwartz and Kroll (2006) found an identical pattern of cognate facilitation (in low-constraint sentences only) in both high- and intermediate proficient group of bilinguals. In contrast, Libben and Titone reported that more proficient participants seemed to have a somewhat smaller cognate effect. Thus, the issue of how proficiency and learning history affects bilingual lexical access in context is far from resolved.

Further issues

There are three further issues that merit some discussion. One has to do with the question of whether bilingual lexical access in language *production* is similar to that in comprehension. There is little doubt that lexical access in production is language non-selective too (e.g., Costa, Miozzo, & Caramazza, 1999; Colome, 2001), at least in the situation when speakers produce isolated words. Costa et al. for example used the picture-word interference paradigm where people name pictures and ignore distractor words. What remains to be seen, however, is whether bilingual lexical access in language production is influenced by sentence context or other language cues. The simplest theory is probably that production and comprehension use similar processing principles, which would predict that language cues cannot alter non-selective access in production. However, there are important differences in the tasks required of the production and comprehension systems. In production, there must be considerable control so as to ensure that speakers choose words from the correct language. In fact, in Poulisse and Bongaert's (1994) analysis of a corpus of L2-productions, involuntary switches to L1 occurred very infrequently. In contrast, the language comprehension system does not *necessarily* have to choose the language of input (although bilingual readers usually can tell the language of the text they are reading, of course); the

most important thing is surely to grasp the meaning of the text that is being read or the speech that is heard. This allows for the reader to rely on information flowing bottom-up from visual input to lexical representations (and to meaning), without necessarily making a language selection. It is conceivable, therefore, that the stronger degree of control that is needed in language production leads to a much stronger reliance on contextual information to restrict lexical access to only the target language.

The next issue is the severe limitation of the language pairs that have been studied so far. All of the relevant studies conducted were restricted to Romance and/or Germanic languages using the Roman alphabet. An obvious question is whether the script in which a word is written (a completely valid language cue in the case of, say, Arabic-French, Chinese-Russian, or Hindi-English bilinguals) can restrict lexical access. If it does not, then one might expect a processing advantage for written words that share meaning and phonology between a bilingual's two languages although (obviously) not orthography. A precondition is, of course, that 'resonance' at only the levels of meaning and sound is sufficient to obtain cross-linguistic effects.

It is finally worth noting that the field of psycholinguistics tends to categorize words as cognates or as interlingual homographs in quite a quick and dirty way. Thus, the criterion for a cognate is 'same or similar meaning and form'.[2] But without a good theory of semantic representations, it is difficult to say what is similar in meaning and what is different. Many words do not uniquely refer to one concept, but have many related, but different senses. The word's translation in another language might share some, but not all of these senses. This is nicely illustrated by an anecdote Peter Hagoort once told during a dinner: Moshe was an immigrant in the United States. When somebody asked him "are you happy here?" he answered "yes, sure"; but then he continued with "aber *glücklich* bin ich nicht" [but happy I am not]. The anecdote illustrates that German 'glücklich' and English 'happy' are translation equivalents but, in subtle ways, don't fully share meaning.

Another example is the case of the words *stokbrood* (Dutch) and *Stockbrot* (German) (literally: stickbread). Both words refer to a type of bread. But whereas the Dutch word refers to a bread that has the shape of a stick (i.e., a baguette), the German word refers to a bread that is baked on a stick. It is not clear whether such items should be considered true cognates (both meanings fall within the rather small semantic field of types of bread) or false friends (there are fundamental differences in the meaning, especially with respect to how one goes

[2] This is obviously quite different from the typical definition in linguistics, where cognates are words that, historically, derive from a common root, even if they nowadays have little orthographic overlap.

about to prepare a stokbrood vs. Stockbrot). Additionally, not only do translations differ in senses, sometimes they also differ in meanings. English “fire” and Dutch “vuur” differ for example, in that English “fire” has a subordinate meaning (to end someone’s employment) that Dutch does not. What do such differences in meaning imply for cognate effects in word recognition? One possibility is that there are graded meaning effects, just as there are graded orthographic effects (Van Assche et al., 2009). The difficult challenge for testing this is of course to develop a metric of semantic overlap across languages (see Finkbeiner, Forster, Nicol, & Nakumura, 2004; Van Hell and De Groot, 1998 for important steps in this direction).

Conclusion

In conclusion, the available evidence at this point strongly pleads for a bilingual lexical access system that is profoundly language non-selective and that is therefore insensitive to language cues. This conclusion is somewhat surprising – after all, by exploiting cues towards the language, the reader or listener could reduce the number of lexical candidates by a highly significant amount, running only the (very limited) risk of missing the very occassional code-switched word. So, even though word recognition is a very efficient cognitive process, this process does not seem to be optimized in bilingualism.

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