Bilingual lexical access

Eva Van Assche[1], Marc Brysbaert[2], and Wouter Duyck[2]

[1] Department of Applied Psychology, Thomas More University of Applied Sciences, Belgium

[2] Department of Experimental Psychology, Ghent University, Belgium

Abstract

Bilingual ambiguity can arise when a word form is shared across languages but the meanings are different in each language (e.g., the word *pie* means *foot* in Spanish). The way bilinguals process this ambiguity informs us about general bilingual language processing. Do bilinguals activate both meanings of an ambiguous word or is only the meaning in the contextually relevant language activated? The current review presents studies that have explored cross-language ambiguity and the factors influencing bilingual ambiguity resolution. It examines how interactions of language context, frequency, task demands, and/or individual differences such as proficiency and executive control influence cross-language ambiguity effects. The review concludes that the bilingual language system is organized in an integrated lexicon that is accessed language-nonselectively but that it is important to take into account all of the possibly interacting factors.

Introduction

Bilinguals differ from monolinguals in that they constantly have to manage two languages to produce and comprehend words in the appropriate language. A central question in bilingualism research is how bilinguals access words in their two languages. Two opposing views have been formulated to address this issue. According to the *language-selective access hypothesis,* bilinguals only activate representations from the contextually relevant language (e.g., Gerard & Scarborough, 1989). Another account, the *language-nonselective access hypothesis,* assumes that bilinguals always activate words from both of their languages. This processing issue has been debated for a long time along with the question of whether bilinguals have an integrated lexicon for their two languages or two separate lexicons (e.g., for reviews, see, e.g., De Groot, 2011; Kroll & De Groot, 2005).

In recent years, much evidence has accumulated in favor of the language-nonselective access and integrated lexicon account (e.g., De Groot, 2011; Van Assche, Duyck, & Hartsuiker, 2012). In this respect, language ambiguous words have been studied extensively because how people process these words can shed light on the language-nonselective activation issue in bilinguals. The research centers on three types of words: interlingual homographs, homophones, and cognates. Interlingual homographs have the same orthographic word form but a different meaning in both languages (e.g., *pan* meaning *bread* in Spanish). They resemble intralingual homographs, which are words with more than one unrelated meaning in a language (e.g., *second* in English, which has different meanings when used as a noun, a verb, or an adjective).

The second type of ambiguous words are interlingual homophones, which share the same phonology across languages but differ in meaning (e.g., the French word *faire,* meaning *make* sounds the same as *fare* in English). Again, these words resemble intralingual homophones, such as *mail* and *male*.

The final type of ambiguous words consists of cognates. These are words that have the same or similar spellings and/or pronunciations in both languages and have the same meaning (e.g., the Dutch word *bakker* meaning *baker* in English). Cognates do not have an intralingual counterpart, although they come close to polysemous words. Polysemous words are words in one language with several, related meanings (e.g., *chicken* referring to an animal and to the meat of the animal that is consumed). Contrary to homographs (also called homonyms), polysemous words are usually easier to process (Rodd, Gaskell, & Marslen-Wilson, 2002).

The interlingual ambiguous words are compared to control words that exist only in one language and that are matched on lexical factors including frequency, length, and word neighbors (e.g., the English control word *daisy* has no overlap with the Dutch translation *madeliefje*). If processing of the ambiguous words is different from that of the control words, this is considered as evidence for the co-activation of the various meanings of the ambiguous word in the different languages.

In the present chapter, we review studies investigating this ambiguity processing across languages with a focus on ambiguity resolution in interlingual homographs and homophones. We come to the conclusion that upon encountering an ambiguous word, all known meanings (and pronunciations) of the word are initially activated, independent of the context in which the word occurs. Inappropriate meanings are subsequently inhibited on the basis of the ongoing language processing. Top-down context expectations have no effect on the initial activation of meanings and limited effect on the subsequent meaning inhibition.

Homographs within languages

The monolingual literature on lexical ambiguity has been an important starting point for studies in the bilingual field (e.g., Degani & Tokowicz, 2010). As we indicated above, lexical ambiguity not only exists between languages but also within languages (e.g., the word *bank* may mean a financial institution or a riverside). The central question in monolingual research is whether all meanings of a homograph are initially activated or whether only the contextually relevant meaning is activated. Many studies have addressed this question and it seems that the answer is slightly more complicated than initially thought (e,g., Duffy, Morris, & Rayner, 1988).

For a start, there is evidence that all meanings of homographs are initially activated, with the speed and strength of the activation depending on the relative frequencies of the meanings (e.g., Hogaboam & Perfetti, 1975). For instance, the word *port* is used much more often to refer to a place where ships anchor than to a type of drink. So, the ship-related meaning will be activated and rise more rapidly than the drink-related meaning. When the word is presented in a sentence context, the inappropriate meaning is inhibited after the initial activation. This will be easier for the less frequent, subordinate meaning than for the frequent, dominant meaning.

A sentence constraining the meaning of a homograph before it is presented, can to some extent influence the activation of the different meanings (e.g., Duffy et al., 1988). So, the ship-related meaning of *port* will be boosted in a sentence like *The ship sailed to the port*, whereas it will be reduced in a sentence like *The man eagerly drank the port*. However, it is not the case that the meaning activation can be completely prevented by the context, particularly not when the meaning is familiar (i.e., when it is the most frequent, dominant meaning).

The disambiguation of homographs seems to differ between individuals. Proficient readers tend to be more efficient at resolving the competition between the different meanings of homographs (e.g., Gernsbacher & Robertson, 1995). At the same time, they are familiar with more meanings of homographs, so that they more often come across ambiguities.

Homographs between languages

For bilinguals, interlingual homographs (e.g., *pie* ~ desert in English and *foot* in Spanish) are the equivalent of the semantically ambiguous homonyms in monolinguals (e.g., *bank*). This type of words have been tested very often to investigate ambiguity resolution in bilinguals. In contrast to monolingual studies where the focus was on investigating whether lexical access of ambiguous words is affected by the sententialcontext, the focus in bilingual studies has been on investigating language-nonselective activation. As a consequence, monolingual studies have presented critical words in context, whereas bilingual studies have mainly examined words presented in isolation (e.g., Beauvillain & Grainger, 1987; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Dijkstra, Grainger, & Van Heuven, 1999; Dijkstra, Timmermans, & Schriefers, 2000a) and only later took into account the influence of context (e.g., Libben & Titone, 2009; Schwartz & Kroll, 2006; Van Hell & De Groot, 2008). Homographs have been studied using several general approaches such as comparing high-frequency and low-frequency readings of homographs (e.g., De Groot, Delmaar, & Lupker, 2000; Dijkstra et al., 2000a; Kerkhofs, Dijkstra, Chwilla, & de Bruijn, 2006) or comparing the processing time and accuracy of interlingual homographs to monolingual control words (Dijkstra et al., 1998; 1999).

In one of the earlier studies on bilingual ambiguity resolution, Beauvillain and Grainger (1987) used the approach of semantic priming in which participants are presented with a prime word before they respond to the target word. The prime words are either semantically related or unrelated to the target words and this relation influences target word processing times. Related prime words tend to speed up target word processing. Beauvillain and Grainger used a bilingual semantic priming task to see whether the non-target meaning of the homograph is activated while reading in the target language. English-French bilinguals read interlingual homographs as primes (e.g., *pain* meaning *bread* in French) in French or English and then were presented with targets which could be related or unrelated to either the English or French meaning of the homograph (*pain – ache*). Participants were asked to perform a lexical decision task on these target words. In the lexical decision task, participants have to decide whether the presented target is a legitimate word or a non-wordot. Semantic priming was observed when targets were presented 150 ms after the onset of the primes, but not when the interval was longer (750 ms). Briefly, priming was taken as a measure of lexical activation. The priming effects depended on the homograph's relative frequency. Only target words related to the higher frequency reading of the homographs were facilitated (e.g., the French *bread* meaning of the homograph *pain*). These results suggested that the irrelevant homograph meaning was activated at first and inhibited only later with the more frequent meaning having an advantage.

Dijkstra et al. (1998) did not find evidence for homograph interference when Dutch-English bilinguals performed a lexical decision task in their second language (L2). In this study, processing times of homographs were compared to monolingual control words. In the first experiment, Dutch-English bilinguals were presented with interlingual homographs, English control words, and nonwords in an English lexical decision task. No difference in reaction times (RTs) was found between English control words and interlingual homographs, suggesting that the Dutch reading of the homograph did not influence English word recognition. However, when pure Dutch words which required a no-response were included in the stimulus list of the second experiment, RTs were longer for interlingual homographs than for English controls. The presence of non-target Dutch words might have boosted activation of Dutch leading to stronger interference effects for homographs. Finally, the third experiment was a generalized lexical decision task in which participants responded ‘yes’ if a word of either language was presented. Here, facilitation was found for interlingual homographs compared to control words. It seems that bilinguals were able to respond as soon as either reading of the homograph was available. These results showed that the task demands (e.g., language-specific vs. generalized lexical decision task and the presence of non-target language words requiring a no-response) influenced the reading of interlingual homographs. They can be recognized faster than, slower than, or equally fast as monolingual control words depending on the task demands of the lexical decision experiments (see also Dijkstra, De Bruijn, & Schriefers, & Ten Brinke, 2000b; Lemhöfer & Dijkstra, 2004).

In another study, Dijkstra et al. (1999) showed that the absence of homograph effects in Dijkstra et al.’s (1998) first experiment could be clarified by distinguishing the orthographic and phonological overlap components of the homographs. Homographs can have the same pronunciation (e.g., English *pet* meaning *cap* in Dutch) or have a different pronunciation across languages (e.g., *stage* meaning *internship* in Dutch). Dijkstra et al. (1999) found that Dutch-English bilinguals performing an English L2 lexical decision task responded more quickly and more accurately to homographs with different pronunciations in both languages than to control words. This illustrates the importance of controlling for phonological similarity across languages and suggests that the null results for interlingual homographs in Experiment 1 of Dijkstra et al. (1998) may have resulted from the positive influence of orthographic overlap and the negative influence of phonological overlap.

Homophones within languages

Homophones are words that sound the same but have different meanings (e.g., *allowed* – *aloud*). Monolingual research has focused on the question of whether both readings of such words are activated during reading, which would suggest that visual word recognition depends on the phonological code in addition to the orthographic input.

Two of the most informative studies were published by Lukatela and Turvey (1994a, 1994b). In a first study, they usedshort prime durations (30-57 ms) and masked priming. In this priming paradigm, the prime is masked by symbols (e.g., #######) before (forward mask) or after prime presentation (backward mask) to diminish the visibility of the prime. Lukatela and Turvey showed that homophonic primes facilitated the naming of target words more than orthographic controls. So, the naming of the target word *toad* was faster after the prime *towed* than after the prime *told*. In a second study, Lukatela and Turvey showed that phonologically mediated priming was also possible with associated words. So, the target *frog* was named faster if the homophonic prime *towed* (the mediator) was presented briefly relative to an orthographic control prime *tolled*.

Drieghe and Brysbaert (2002) replicated the latter effect in a lexical decision experiment and in addition found that the effect disappeared when the prime was presented for 250 ms rather than 57 ms. In the former case, the prime was clearly visible, whereas this was not true in the 57 ms presentation condition. Drieghe and Brysbaert intepreted their findings as evidence for a view in which the phonology of visually presented words initially activated all known compatible meanings, but in which the orthographically unlicensed meaning was subsequently deactivated.

Homophones between languages

Whereas research on the monolingual homophone effect centered on the question of whether both meanings of homophones are activated, research on the bilingual homophone effect has focused on the question of whether the phonology of the non-target language is activated as well. The Dutch word *beek* [*ditch*] sounds like the English word *bake* for a Dutch-English bilingual but not for an English monolingual (for whom the stimulus is a nonword sounding like the word *beak*).

Brysbaert, Van Dyck, and Van de Poel (1999) examined whether a target L2 word could be primed with a homophonic word of the L1 (e.g., prime *wiel* [wheel] for the L2 target word *huile* [oil] in Dutch-French bilinguals). An equivalent example for Dutch-English bilinguals would be to test whether the briefly presented English target word *bake* would be more likely recognized after the masked Dutch homophonic prime word *beek*, than after the orthographic Dutch control prime *beuk* (meaning *beech* in English). They indeed found such an effect. To make sure that the effect was not due to a confound in the stimulus materials, they replicated the study with French monolinguals and observed that these participants did not show the cross-lingual phonological priming effect. Van Wijnendaele and Brysbaert (2002) subsequently showed that the cross-lingual phonological priming effect was also observed in English-Dutch bilinguals when the primes are part of the participants' L2 and the targets part of the L1.

Brysbaert and colleagues interpreted the above findings as evidence that, when a bilingual is reading a text, not only are the spelling-sound correspondences of the text language automatically activated but also the other spelling-sound correspondences the bilingual knows. After the initial, ballistic activation, the inadequate interpretations are pruned by a process of lexical inhibition (see also Carrasco-Ortiz, Midgley, & Frenck-Mester, 2012).

In another study, Duyck (2005) also found evidence for the activation of all meanings of interlingual homophones in an exclusively L2 task with Dutch-English bilinguals. The presentations of English L2 homophone primes (e.g., *hook*) of the L1 translation equivalents (*hoek*) of the target word (*corner*) facilitated lexical decision responses. It is important to note here that the prime only influenced target word processing when it was more frequent than the target. The homophone facilitation effect was not observed in the other language priming direction: L1 targets (e.g., *weg* [way]) were not processed faster if they were primed by interlingual homophones (*wei* [meadow] of their L2 translations (*way*). It seems that the mapping of the ambiguous phonological code of the word *wei* on the L2 meaning was much weaker than the mapping on the L1 meaning and not strong enough to influence word recognition in this case.

The interlingual homophonic priming effect has also been shown for languages that do not share the same script. Nakayama, Sears, Hino, and Lupker (2012) showed phonological priming of Japanese Katakana words on English target words in Japanese-English bilinguals. Lee, Nam, and Katz (2005) reported phonological priming between Korean and English words, both in the L1-L2 and the L2-L1 direction.

Interestingly, the cross-language phonological priming effect, in which a word in one language activates phonologically similar or phonologically identical words in the other language, is also observed for languages that do not share an alphabetic script (which allows the prelexical conversion of letters into sounds). Zhou et al. (2010) investigated Chinese-English bilinguals. A word-naming task (i.e., see target *door* and name it aloud) was used in Experiments 1 and 2, and a lexical decision task in Experiments 3 and 4. English targets (e.g., *door*) were preceded by phonologically related single character Chinese primes (e.g., “道” /dao/ meaning *road*) or by unrelated Chinese words. Cross-language phonological priming was observed in both word-naming and lexical decision and in both priming directions (L1-L2 and L2-L1). These results of phonological priming with two languages that do not share script strongly support the view that bilinguals have integrated phonological representations for both languages (e.g., Dijkstra & Van Heuven, 2002). Zhou et al. further claimed that the phonological priming effect was due to phonological similarity at the lexical level and not at the sublexical level because the pronunciation of Chinese character cannot be determined using sublexical spelling-sound correspondences.

These findings of Zhou et al. (2010) were extended to Japanese Kanji and English by Ando, Jared, Nakayama, and Hino (2014). These authors showed that Kanji primes facilitated lexical decisions to phonologically similar English words. Again, this finding shows that the interlingual facilitatory phonological priming effect not only arises for prime words in scripts that encode phonemes and syllables but also for logographic prime words.

Interlingual homophones have also been used as word stimuli in a lexical decision task and compared to monolingual control words (e.g., Dijkstra et al., 1999; Haigh & Jared, 2007; Jared & Kroll, 2001; Lemhöfer & Dijkstra, 2004; Pexman, Lupker, & Jared, 2001). Dijkstra et al. (1999) selected English words that varied in their degree of orthographic, phonological, and semantic overlap with Dutch words as targets in an English L2 lexical decision task (Experiment 2). They found facilitatory effects of orthograpic overlap, but inhibitory effects of phonological overlap. Homophones such as the English word *cow* (sounds like the Dutch word *kou* meaning *cold*) were responded to more slowly than control words (cf. Doctor & Klein, 1992). Dijkstra et al. argued that the inhibitory effect arose because phonological representations from both languages were activated upon presentation of a homophone. This resulted in competition between the target phonological representation and the non-target phonological representation, leading to a delay in processing.

However, this pattern of inhibition has not consistently been found in other studies (e.g., Haigh & Jared, 2007; Lemhöfer & Dijkstra, 2004). Haigh and Jared (2007) presented interlingual homophones and controls to English-French and French-English bilinguals to investigate whether phonological representations in both languages are activated when reading in one language. All stimuli were English and were presented in an English lexical decision task. The English-French bilinguals performing the task in their native L1 did not show a homophone effect, whereas the French-English bilinguals performing the task in their L2 showed a homophone facilitation effect. Responses to homophones were faster and more accurate than for monolingual control words. This suggests that the bilinguals activated phonological representations from their L1 when reading in the second but the reverse was not true. It seems that a specific level of L2 proficiency is necessary to obtain cross-language interference effects when processing words in L1 (e.g., Duyck, 2005; Jared & Szucs, 2002). The effect reported by Haigh and Jared was also subject to task demands because it was not replicated in subsequent experiments when cognates and interlingual homographs were added to the stimulus list.

Interim summary

For ambiguous stimuli such as homographs and homophones, we have seen that bilinguals initially activate the lexical representations associated with all possible readings of the word. This seems to happen in an automatic way. Upon presentation of a word, all related orthographic, phonological and semantic codes are activated in a language-nonselective way (e.g., Dijkstra & Van Heuven, 2002). Subsequently, the non-appropriate information is suppressed to come to the desired interpretation (e.g., through lateral inhibition mechanisms in the *bilingual interactive activation plus model* [BIA+]; Dijkstra & Van Heuven, 2002).

The clearest method to show the initial activation of multiple interpretations is the masked priming procedure, in which a prime word is shown for such a brief period of time that the inhibition process cannot intervene. When the stimuli are presented for a longer time (e.g., as targets in a lexical decision task), time costs can be demonstrated when the various readings of the word conflict with each other, and time savings when the various readings are in agreement.

Although the general framework is straightforward, the specific dynamics are likely to depend on a number of factors. First, the speed of information activation depends on the activation level of the items and, therefore, is likely to be affected by factors such as frequency, recency of use and language proficiency. For instance, high-frequency words have higher resting level activation levels and reach the threshold for activation more quickly than low-frequency words. Similarly, it can be assumed that in non-balanced bilinguals words from the dominant language will show a stronger and faster activation than equally frequent words from the non-dominant language.

Second, it can be hypothesized to what extent the initial activation of information and the subsequent resolution of competition between representations are affected by the context in which the word recognition takes place. The context consists of two factors. First, there are bottom-up factors, such as the words previously processed or language-specific letter strings present in the target word. Second, there are top-down factors related to task instructions or the language environment (e.g., being in a country where L1 or L2 is spoken).

Finally, the effect of the multiple activation of information is likely to depend on the task demands and may also differ across individuals. The various influences will be discussed in more detail in the following sections.

Frequency

In general, homograph effects are larger when the homograph is more frequent in the non-target language than in the target language (e.g., Beauvillain & Grainger, 1987; De Groot et al., 2000; Dijkstra et al., 2000a; Kerkhofs et al., 2006). For instance, Dijkstra et al. (2000) selected a set of Dutch-English homographs of three types: homographs with a high-frequent reading in English and low-frequent in Dutch, homographs with a low-frequent reading in English and high-frequent in Dutch, and homographs with low-frequent readings in both languages. These homographs together with monolingual control words were presented to Dutch-English bilinguals in three experiments. In the first experiment, a language decision was made pressing one button for an English word and another button for a Dutch word. In the second experiment, participants responded only when they identified an English word (i.e., English go/no-go task). In the third experiment, this same task was done in Dutch.

Homograph ambiguity effects were dependent on the frequency of the homograph's readings in each task. Language decision was slower when the homograph reading was high-frequent in the non-target language. In the go/no-go tasks, participants often failed to respond to a target word if its word form had a high-frequent reading in the non-target language. These results indicate the importance of the relative frequency of the homograph's readings. In addition, they show that participant's strategies depending on task demands and/or instructions are insufficient to suppress the non-target language. Bilinguals would have benefitted from suppressing the non-target language in the go/no-go tasks but even here homograph effects were present, also when the participants responded to words from their own L1.

In another study of Kerkhofs et al. (2006), Dutch-English bilinguals performed an English lexical decision task in which interlingual homographs were preceded by semantically related or unrelated English words (e.g., *heaven – angel* vs. *bush – angel*; *angel* means *sting* in Dutch). RTs to the homographs were faster when a related word was presented as prime compared to an unrelated word. This effect was modulated by the relative frequencies of the readings of the homographs: responses were faster when the English frequency was high and when the Dutch frequency was low. The same effects were reflected in the brain responses measured by event related potentials (ERPs). Of particular interest was the N400 component which is sensitive to the congruity of a stimulus with the previous semantic context. Kerkhofs et al. showed that the N400 amplitude was modulated by word frequency in both L1 and L2.

These results show that the relative frequency of the two readings of the homograph is very important. Indeed, frequency is an important predictor of language processing in general (e.g., Brysbaert & New, 2009; Keuleers, Lacey, Rastle, & Brysbaert, 2012) and controlling for frequency when selecting stimulus materials is the norm in psycholinguistic research.

Language proficiency

Information can only be activated when it is known to the participants. Most of the effects reported above were obtained with proficient bilinguals, although most of the time the participants were unbalanced bilinguals. That is, they used their native language more often and more fluently than their L2.

In general, the effects would be more pronounced when participants are processing ambiguous L2 target words and the researcher examines influence from L1 (e.g., Duyck, 2005; Haigh & Jared, 2007). As a result, when investigating a new topic, researchers will look for L1 influences on L2 task performance, as these are easier to obtain. Only in a later phase will they look for L2 influences on L1 performance. These are smaller, but theoretically more important, because they indicate that the first learned, dominant language is not impervious to a later acquired language. Above, we discussed the phonological priming effect from L2 on L1 (e.g., Van Wijnendaele & Brysbaert, 2002). We also referred to the finding of Dijkstra et al. (2000) that participants often failed to respond to interlingual homographs in their L1 when the L2 reading was more frequent (e.g., Dutch-English bilinguals failed to recognize *room* [cream] in their L1 because of the higher frequency of the word in English).

Another interesting series of studies investigated spoken word recognition (e.g., Lagrou, Hartsuiker, & Duyck, 2011; 2013; Spivey & Marian, 1999; Weber & Cutler, 2004).

Previous research had shown that when participants hear a word, initially all words starting with the same sounds are activated (e.g., Marslen-Wilson, 1987). This was shown with a visual world paradigm. In this paradigm, participants see four pictures on a screen and are asked to look at the picture of which they hear the name. Participants have no problems doing so. However, if one of the the distractor pictures starts with the same sounds as the spoken word, they often mistakenly look at the distractor picture before looking at the target picture. So, if participants are asked to look at the *flower*, they will occassionaly move their eyes to the distractor picture representing a *flame*, which starts with the same phonemes.

Spivey and Marian (1999) reported that the same effect is found across languages when bilinguals are given instructions in L1. Russian-English bilinguals were instructed in Russian to look at a particular figure (e.g., at the *marku* [stamp]), while one of the distractor pictures showed a *marker*. In this condition too, participants often mistakenly looked at the distractor with the overlapping beginning before looking at the proper target. This made Spivey and Marian conclude that in auditory word recognition bilinguals not only activate all words of the target language starting with the same sounds, but also all known words of the other language.

Weber and Cutler (2004) replicated the cross-language finding of Spivey and Marian (1999), but only when instructions were given in L2 and the distractors started with the same sounds in L1. No effects were found of distractors in L2 on targets in L1. Importantly, Spivey and Marian had tested their participants in a L2 environment (Russian students studying at an American university), whereas Weber and Cutler studied their participants in a L1 environment (Dutch students studying at a Dutch university), which Weber and Cutler thought might be the reason for the deviating findings.

Lagrou et al. (2013) criticized Weber and Cutler (2004) because the phoneme overlap between the targets and the distractors was very small (often only a single phoneme). When they repeated the study with stimuli having a larger overlap they found influences both of L1 on L2 and the other way around, replicating the initial study of Spivey and Marian (1999).

In another study, Lagrou et al. (2011) used a lexical decision with interlingual homophones to investigate language-nonselective activation in auditory word recognition. Dutch-English bilingual completed an English L2 and a Dutch L1 auditory lexical decision task. In both tasks, interlingual homophones such as *lief* [sweet] and *leaf* that are pronounced the same in both languages [/li:f/) were recognized more slowly than matched control words. So, not only was there are homophone effect when individuals were listening in L2, the effect was also present during listening in L1. It seems that activation in L2 was strong enough in this case to influence word recognition in L1. This homophone effect disappeared in a control experiment with English monolinguals providing evidence for the true bilingual nature of the effect.

Importantly, one must keep in mind that it is easier to obtain influences from the stronger L1 on the generally weaker L2, and that one must run careful and powerful experiments before deciding that influences from L2 on L1 are non-existent or limited to certain contexts.

Context

The series of studies starting with Spivey and Marian (1999) also illustrate that researchers are biased to explain divergent findings (between research laboratories and conditions) to context effects, being interpreted as the participant’s language mode. For a long time it was indeed thought that bilinguals functioned differently in a fully monolingual environment than in a bilingual environment (Grosjean, 2001). It was also thought that bilinguals could top-down activate or inhibit one of their languages as a function of the context in which they were operating (e.g., while reading a text in L1 or L2).

Research has been unable to confirm the existence of language modes (see Garcìa et al., this volume). In fact, most of the findings against language-selective activation discussed above have been obtained in contexts that could be described as monolingual situations (participants responding to words entirely in their L2 or even to L1 words in an L1 context). The cross-language priming effects from L2 on L1 in which L2 words can prime L1 word processing, for instance, were mostly obtained without the participants being aware of the existence of L2 primes (which were presented too briefly to be noticed). As far as the participants were concerned, they were simply processing words in their native language. The same was true for the participants listening to L1 target words in the study of Lagrou et al. (2011).

Language context can be defined at different levels. In addition to the general language mode, context can also consist of more local elements, such as the language of the word before the target word, the composition of the stimulus list, the sentence context in which the target word appears, the task that must be performed, and even specific characteristics of the target word. These various types of context may influence bilingual ambiguity resolution in different ways (e.g., Dijkstra et al. 1998; Elston-Güttler, Gunter, & Kotz, 2005).

For instance, the local context of the stimulus list in Dijkstra et al. (1998) influenced the time needed to process homographs. Homograph interference was only present when non-target Dutch words were included in the list and required a no-response. This effect of stimulus list composition was considerably stronger than that of explicit instructions about the task. Dijkstra et al. (2000b) explicity instructed the Dutch-English participants at the beginning of the experiment to give a no-answer when Dutch words were encountered in the stimulus list. Dutch words were only included in the second part of the experiment. Interestingly, no homograph effect was found in the first half of the experiment. Only after the first Dutch word was encountered did the homograph effect emerge. This points to a strong bottom-up influence of the language context that cannot be overruled by top-down instructions.

Elston-Güttler et al. (2005) also examined the impact of previous language processing on word recognition. They examined both behavioral responses (RTs) and brain responses (ERPs) to the critical stimuli. German-English bilinguals were presented with sentences that ended with a prime word that was either an interlingual homograph (e.g., *The woman gave her friend a pretty GIFT*; *gift* means *poison* in German) or a matched control word (e.g., *The woman gave her friend a pretty SHELL*). The target that followed the sentence was the English L2 translation of the German L1 meaning of the homograph (*poison*). Participants had to respond to the L2 target word. In addition, the participants watched a film before the experiment, either in L1 or L2. Elston-Güttler et al. observed that the cross-lingual activation of the homographs was sensitive to the film seen before the experiment. Targets were recognized faster after the related homograph sentence than after the unrelated control sentence, but only for participants who had viewed a film in their L1 prior to the experiment and only in the first block of the experiment. So, the effect quickly disappeared.

In addition to these reaction time data, ERPs were measured. Elston-Güttler et al. looked at the N400 component in the ERP signal because this is an indicator of semantic integration (Kutas & Hillyard, 1980). It has been shown to be less negative to targets preceded by semantically related primes than to targets preceded by unrelated primes. A modulation of the N400 effect was obtained: the N400 was less negative to targets after the related homograph sentence than after the unrelated control sentence, but only after viewing the

German film and only in the first block of the experiment. So, it looks as if watching a German L1 film can briefly boost the L1 activation of words, even in the presence of L2 sentences. However, by the second block of the experiment, participants had adjusted to the English L2 language input of the experiment, so that the L1 meaning of the homograph was no longer able to influence response times. For the interpretation of the finding, it is important to know that the target following the prime was processed consciously. So, it may be possible that the effect was situated at the level of lexical inhibition rather than the initial meaning activation.

Furthermore, in another study, Paulmann, Elston-Güttler, and Kotz (2006) did not find an effect of the language of the movie prior to the experiment. They used the same prime and target materials of Elston-Güttler et al. (2005) but not preceded by a sentence context. In this experiment, Paulmann et al. reported cross-language priming throughout the experiment, independent of whether the participants before the experiment had watched a German L1 movie or an English L2 movie. On the basis of this finding, the authors concluded (p. 730): *The present results suggest that L2 learners are not able to consciously or subconsciously suppress L1 influence even in an all-L2 task preceded by a global L2 language setting*.

Other studies have looked at the extent to which the meaning activation of interlingual homographs can be attenuated by the preceding sentence context in ways similar to the intralingual effects reported by Duffy et al. (1988; see above). It was shown that the presentation of words in a sentence context and the semantic constraint of the sentence can influence bilingual ambiguity resolution (e.g., Hoversten & Traxler, 2016; Libben & Titone, 2009; 2006; Titone et al., 2011; Van Hell & De Groot, 2008).

Libben and Titone (2009), for instance, recorded eye movements while French-English bilinguals were reading low- and high-constraint sentences containing homographs and controls (e.g., *Since they liked to gossip, they had an extended CHAT that lasted all night*; *chat* means *cat* in French). Homograph interference was present on early (e.g., the first fixation on the target word) and late comprehension measures (e.g., the total reading time on the target) in low-constraint sentences but only on late comprehension measures in high-constraint sentences. Libben and Titone interpreted these findings as evidence for a view according to which the sentence context doesn not affect the initial activation of meaning but the subsequent inhibition of inappropriate meanings. Most other studies can also be interpreted within this framework. Interlingual homograph interference effects are observed most of the time but can be modulated by sentence constraint, L2 proficiency, frequency of the homograph readings, and/or individual differences in domain-general executive control (e.g., Jouravlev & Jared, 2014; Libben & Titone, 2009; Pivneva, Mercier, & Titone, 2014; Schwartz & Kroll, 2006; Titone et al., 2011).

Another study by De Bruijn, Dijkstra, Chwilla, and Schriefers (2001) examined whether local language context can influence activation of the different readings of an interlingual homograph. In their ERP study, local context was defined as the language of the word preceding the homograph. They presented Dutch-English bilinguals with word triplets and the participants had to decide whether all three items were correct Dutch and/or English words. Sometimes, the second item was an interlingual homograph whose English meaning was semantically related to the third item of the triplet (e.g., *house* – *angel* – *heaven*; *angel* means *sting* in Dutch). The first item of the triplet could then be a purely English (*house*) or a Dutch word (*zaak*) to vary the local language context. The authors hypothesized that presenting a Dutch word first might bias the reading of the interlingual homograph to Dutch, hereby reducing semantic priming effects between the English reading of the homograph (*angel*) and the third word (*heaven*). However, semantic priming effects were found in the behavioral data irrespective of the language of the first item of the triplets. Similarly, the

ERPs showed that the N400 priming effect was not influenced by the language of the first item of the triplets. Thus, local language context in the form of the language of the item preceding the homograph does not seem to influence activation of the different readings of the homograph.

Finally, Poort, Warren, and Rodd (2016) showed that reading a homograph in one language can affect subsequent processing in the other language, even after a delay of more than ten minutes. In their study, Dutch-English bilingual read Dutch sentences containing homographs. After a filler task of ten minutes the impact of this priming task in Dutch was measured in an English lexical decision task. Homographs were processed more slowly than control words (but see Gerard & Scarborough, 1989; Lalor & Kirsner, 2001). The results show that the interpretation of ambiguous words is influenced by recent experience.

In sum, there is evidence to suggest that language context helps to some extent to disambiguate homographs and homophones. However, it is not the case that instructions and even local sentence contexts can overrule the automatic activation of multiple meanings, certainly not the activation of highly familiar meanings. A more defendable interpretation is that they help – to some extent – in the subsequent inhibition of the unneeded, inappropriate meanings. This is a conclusion that agrees very much with the conclusion reached about the processing of intralingual homographs and homophones.

Task demands

The effects of bilingual ambiguity are different in different tasks (see also García et al., and Heredia & Cieślicka, this volume. The study of Dijkstra et al. (1998) illustrated this by showing null effects for homographs in a L2 lexical decision task but facilitation effects in a generalized lexical decision task. This suggests that in the latter task, responses were based on the fastest available reading (L1 or L2) of the homograph which was probably the stronger

L1 orthographic representation (see also Lemhöfer & Dijkstra, 2004). This process is easier than the process in a language-specific lexical decision task where bilinguals first have to recognize a letter string as a word and then have to identify the language of the word.

Similarly, in the go/no-go tasks of Dijkstra et al. (2000a) participant only pressed a button when a letter string belonged to the target language. This task required participants to check the language membership of the words so that inhibitory homograph effects were observed, especially when the non-target language reading of the homograph was high-frequent. Dijkstra et al. also included a language decision task. In this task, language membership had to be checked as well and the activation of both readings of the homograph again resulted in slower reaction times for homographs than for controls.

Importantly, the task effects are easiest to understand when one assumes they originate from the translation of input into output. Ambiguous words tend to be processed more slowly than control words when the various readings of the word conflict with each other (e.g., are associated with different responses). When the various meanings of homographs and homophones are associated with the same response, they result in facilitation. Once, the stimulus-response aspect is taken into account, very little evidence remains for language-specific processing of words that are ambiguous with respect to their language status.

Individual differences

Individual differences such as L2 proficiency influence the processing of ambiguous words (for a review, see Van Hell & Tanner, 2012; see also Palma & Titone, this volume). The dominant language (typically L1) has a stronger effect on the non-dominant language (typically L2) (e.g., Duyck, 2005; Jared & Szucs, 2002). Also, bilinguals have to be relatively proficient in the weaker language for it to have an effect on word recognition in the dominant language (e.g., Grainger, Midgley, & Holcomb, 2010; Kroll & Stewart, 1994; Van Hell & Dijkstra, 2002).

In addition to L2 proficiency, other factors such as domain-general executive control may modulate cross-lingual activation in bilinguals (e.g., Mercier, Pivneva, & Titone, 2013; Pivneva et al., 2014). For instance, Pivneva et al. (2014) recorded eye movements while French-English bilinguals varying in L2 proficiency were reading L2-English sentences containing interlingual homographs, cognates (e.g., *piano* in English and French) and control words. Sentences could either be low- or high semantically constraining (e.g., *Because it was completely worthless, the brown colored COIN was thrown out* vs. *Because she knew the change was counterfeit, the brow colored COIN was thrown out*; *coin* is a French-English homograph meaning *corner* in French). The bilinguals also completed a battery of executive control task to examine their executive control skills. The results showed that greater executive control but not L2 proficiency reduced cross-language activation during early reading stages, in terms of less interlingual homograph interference in low-constraint sentences. The reverse was true for cognates: increased L2 proficiency but not executive control reduced cognate facilitation effects. Pivneva et al. proposed that homograph processing required more domain-general executive control than cognate processing because of the cross-language semantic conflict (i.e., the different meanings of the homograph in each language).

The factors influencing bilingual ambiguity processing discussed in this section, L2 proficiency and executive functioning, do not operate in isolation. They interact with each other and they interact with other factors such context, frequency, and task demands. Moreover, bilinguals may differ in sensitivity to each of these factors. Frequency effects for instance have been shown to be stronger in L2 than in L1 (e.g., Brysbaert, Lagrou, & Stevens, in press; Duyck, Vanderelst, Desmet, & Hartsuiker, 2008). Arguably, this is related to the learning process of words, which sees the word frequency effect first increase as a new language is learned (because the most frequent words are the first to be learned) and subsequently decrease (because a ceiling level is reached for the high-frequency words). It is important to take this into account because L1 word frequencies (CELEX, SUBTLEX) do not take into account that in general the experience with words is considerably lower in L2 than in L1. For instance, bilinguals may perceive a high-frequency word in L2 as only a medium familiar word because they have not come across this word more often than across medium-frequency L1 words. When investigating bilingual ambiguities it is important to think about these issues and to search for solutions. For instance, better information may be obtained from familiarity ratings in L1 and L2 (Kuperman & Van Dycke, 2013) or from mathematical equations linking L1 frequency measures to L2 proficiency levels.

Meaning selection

How do bilinguals select the correct meaning of an interlingual homograph in a specific language context if all of its meanings are always activated irrespective of the target language? It is still unclear what processes underlie the selection of the target language in bilinguals and what processes underlie the selection of the target meaning of an interlingual homograph (e.g., Durlik, Szewczyk, Muszynski, & Wodniecka, 2016; Green, 1998; Macizo, Bajo, & Martín, 2010). There is a continuing debate on whether bilinguals inhibit the non-target homograph meaning or whether the activation of this meaning decays over time (e.g., Altarriba & Gianico, 2003; Beauvillain & Grainger, 1987).

Macizo et al. (2010) used a negative priming paradigm to address this issue. In this paradigm, it is investigated whether a to-be-ignored stimulus still influences target word processing. Their results support the *inhibitory hypothesis* according to which an inhibitory mechanism can suppress non-target word presentations. Spanish-English bilinguals had to decide whether pairs of English words were related in meaning. They responded more slowly to homographs presented with words related to the Spanish meaning of the homograph (e.g., *pie* – *toe*; *pie* meaning *foot* in Spanish) than to control words (*log* – *toe*). Bilinguals experienced a conflict raised by the parallel activation of the two meanings of the homograph. They had to ignore the Spanish meaning which was irrelevant for the English task and this delayed their response. More importantly, they were slower to respond when the English translation of the Spanish homograph meaning was presented later in the experiment (*foot* - *hand*). This suggests that bilinguals activated both meanings of the homograph initially and then inhibited the non-target meaning to select the target meaning. However, this non-target meaning had to be reactivated later in the experiment and this caused a delay.

Other studies have also found evidence for inhibitory processes at work in bilingual ambiguity resolution (e.g., Mercier et al., 2013; Pivneva et al., 2014). For instance, Pivneva et al. (2014) showed that bilinguals reading homographs in L2 sentences experienced less interference from the non-target meaning of the interlingual homograph when they had higher levels of executive control. This again suggests an important role for inhibitory processes in meaning selection of language ambiguous words (cf. Green, 1998; e.g., Durlik et al., 2016).

Conclusion

The evidence reviewed in this chapter suggests that lexical access in bilinguals is fundamentally language-nonselective in an integrated bilingual language system. In most of the studies reviewed in this chapter, there was evidence for activation of the non-target meanings of ambiguous words such as interlingual homographs and homophones. This supports non-selective access models of bilingual word recognition (e.g., BIA+ model, Dijkstra & Van Heuven, 2002) and is in agreement with other findings from cognate studies (e.g., Dijkstra et al., 1999; Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011) and cross-language neighborhood studies (e.g., Van Heuven, Dijkstra, & Grainger, 1998). However, this does not mean that bilingual lexical access cannot be modulated at all. Language context can affect ambiguity resolution, especially if it interacts with other factors such as frequency and semantic context. There thus seems to be a stronger influence from bottom-up factors such as language context (e.g., Libben & Titone, 2009) and stimulus set composition than from top-down factors such as participant expectations (e.g., Dijkstra et al., 2000b).

Keywords

Bilingual ambiguity resolution, Bilingual interactive activation plus model (BIA+), Co-activation, Cognates, Cross-language ambiguity effects, Cross-language interference effects, Cross-language phonological priming effect, Cross-language priming effect, Cross-lingual activation, Cross-lingual phonological effect, Domain-general executive control, Dominant language, English lexical decision task (ELD), General lexical decision task (GLD), Go/no-go task, High-frequency words, Homonyms, homophone, Homophone effect, Homophone facilitation effect, Homophones, Individual differences, Inhibitory effects, Inhibitory hypothesis, Interlingual homographs, Interlingual homophonic priming effect, Language mode, Language proficiency, Language-nonselective access hypothesis, Language-selective access hypothesis, Lexical ambiguity, Lexical inhibition, Low-frequency words, Masked priming, Meaning selection, N400, Negative priming paradigm, Non-balanced bilinguals, Phonological overlap, Phonological priming effect, Phonologically mediated priming, Polysemous, Prime,

Thought questions

1. The studies reviewed in this chapter primarily studied bilinguals who speak languages with the same scripts. There is also little variability in the languages that have been studied in the

domain of lexical ambiguity resolution. Most of the experiments were conducted with Dutch-English, French-English or English-French, German-English, and Spanish-English bilinguals. However, there are also languages with completely different scripts such as Chinese, Japanese or Hebrew (e.g., Zhou et al., 2010). How do you think lexical ambiguity may arise when testing for instance Hebrew-English bilinguals? How do you think language context or proficiency may influence lexical ambiguity resolution in bilinguals who speak languages with different scripts?

2. Think about your own bilingualism. Can you think of a homograph that is high-frequent in your L2 and only low-frequent in your L1? Can you imagine that when you are reading or hearing this word in an L1 context, you also think of the L2 meaning of this word and that this may confuse you? What factors do you think can influence this process? Do you think that bilinguals who frequently switch languages in daily life (e.g., someone who speaks Spanish with his/her parents, English at school and both Spanish and English with his/her friends) might experience less or more interference from the language not in use?

3. This review is focused on tasks that tap visual word recognition, rather than production. In recognition, a word is presented and the recognition process goes from processing the visual features and letters of the word to meaning activation. In production on the other hand, the process is reversed. When producing a word, the starting point is the meaning and then phonological representations are activated and the word is pronounced. Bilingual word processing has also been shown to be language-nonselective in production (e.g., Costa, 2005; De Groot, 2011). How do you think bilinguals will resolve ambiguity when they have to pronounce a word that sounds the same in both languages?

Internet sites

LexicALL: Data-Sets: http://lexicall.widged.com/repository/listing.php

Software and Data-Sets: http://crr.ugent.be/

SUBTLEX-UK: Word Frequency British English: http://crr.ugent.be/archives/1423

SUBTLEX-US: Word Frequency American English: http://expsy.ugent.be/subtlexus/

Word Generator: WordGEn: http://www.wouterduyck.be/?page_id=29

Wuggy: Multilingual Pseudoword Generator: http://crr.ugent.be/programs-data/wuggy

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