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Semantic ambiguity within and across languages: An integrative review

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Semantic ambiguity often occurs within a language (e.g., the word "organ" in English means both a body part and a musical instrument), but it can also cross a language boundary, such that a given word form is shared in two languages, but its meanings are different (e.g., the word "angel" means "sting" in Dutch). Bilingual individuals are therefore faced not only with ambiguity in each of their languages, but also with ambiguity across languages. The current review focuses on studies that explored such cross-language ambiguity and examines how the results from these studies can be integrated with what we have learned about within-language ambiguity resolution. In particular, this review examines how interactions of frequency and context manifest themselves in ambiguity that crosses a language boundary and call for the inclusion of language context as a contributing factor. An extension of the monolingual reordered access model (Duffy, Morris, & Rayner, 1988) is outlined to discuss the interactions between these factors. Furthermore, the effects of the similarity between the two meanings, task differences, and individual differences are explored. This review highlights the need for studies that test within- and cross-language ambiguity in the same individuals before strong conclusions can be made about the nature of interactions between frequency, semantic context, and language context.

Keywords: Semantic ambiguity; Interlingual homographs.

Semantic ambiguity exists when a word form corresponds to more than one meaning, as in the English word "organ", which denotes both a body part and a musical instrument. For bilingual speakers, additional ambiguity may arise when a word form is shared across languages, but the meanings are different. For instance, the word "fin" means "end" in Spanish. Such words are called *interlingual homographs* or *false friends*. The current review builds on the rich monolingual literature on semantic ambiguity resolution and explores how bilingual speakers process semantic ambiguities within and between their languages.

Models of within-language ambiguity

Within-language semantic ambiguity processing has been studied extensively, mostly centring on whether one or both meanings of an ambiguous word are considered for selection during language

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comprehension. Several models have been proposed to address this issue. *Context-dependent models* assume that context predetermines access such that only the appropriate meaning is activated (e.g., Schvaneveldt, Meyer, & Becker, 1976). For example, Schvaneveldt et al. found that when context biases one meaning of an ambiguous word (e.g., with a prime word like "money" preceding the ambiguous word "bank"), a target related to the same meaning (e.g., "save") will be processed more quickly than a control sequence of unrelated words, but a target related to the other meaning (e.g., "river") will not be facilitated. *Exhaustive-access models* (e.g., Onifer & Swinney, 1981), in contrast, postulate that all meanings of an ambiguous word are initially accessed in parallel with context affecting only later selection processes. In support of this view, Onifer and Swinney observed that even when an ambiguous word was presented in a biased context, lexical decisions to targets related to both of its meanings were facilitated when they were presented immediately following the sentence, suggesting that both the appropriate and the inappropriate meanings of the ambiguous word were initially activated. Following a delay, however, only targets related to the appropriate meaning were facilitated relative to matched controls.

The *ordered-access model* (Hogaboam & Perfetti, 1975) similarly assumes that context does not determine which meanings are accessed and further suggests that the initial activation of the two meanings is serially determined by their frequency. In their study, Hogaboam and Perfetti asked participants to indicate whether a word at the end of a sentence was ambiguous (i.e., had two unrelated meanings) or not. They found that participants were faster to say that a word was ambiguous when the sentence biased its less frequent meaning, suggesting that the more frequent meaning was already active.

These models assume that only one factor can affect initial activation. The empirical findings have painted a more complex picture, however, lending support to more interactive models that assume that both frequency and context influence initial access of the two meanings (Simpson, 1984; Tabossi & Sbisá, 2001). One such hybrid model is the *reordered-access model* (Duffy, Morris, & Rayner, 1988), which postulates that both meaning frequency and the preceding context can influence initial meaning activation. Further, the model assumes that processing time is lengthened when two meanings are activated in parallel, which can occur either for words with two meanings of roughly the same frequency (i.e., *balanced ambiguous words*) in a context that is neutral with respect to which meaning is appropriate, or for words with one meaning that is more common than the other (i.e., *biased ambiguous words*) in a context that strongly biases the less common meaning. In both of these cases, the two meanings are activated in the same time window, which slows processing. In support of this hypothesis, in an eye movement paradigm Duffy et al. showed that gaze durations on balanced ambiguous words presented in a neutral context and on biased ambiguous words presented in a context biasing the less common meaning were longer than gaze durations on control words.

At present, the within-language ambiguity literature is less concerned with *whether* frequency or context affects meaning activation and more concerned with *how* these factors interact. There is a focus on the relative strength of these factors (e.g., Duffy, Kambe, & Rayner, 2001), their manifestation in different tasks (e.g., Armstrong & Plaut, 2008) and at different time points (e.g., van Petten & Kutas, 1987), and whether there are individual differences in the ability to use frequency and context to resolve ambiguity (e.g., Andrews & Bond, 2009; Gernsbacher & Faust, 1991; Perfetti & Hart, 2002). We address these issues in more detail in the context of cross-language ambiguity. First, we introduce the findings related to ambiguity that crosses the language boundary and consider how the models proposed to explain within-language ambiguity can be extended to accommodate these findings.

Cross-language ambiguity

As mentioned above, in the case of bilinguals, the mapping of the two languages can create ambiguity that crosses the language boundary. In particular, *interlingual homographs* (IHs), which are words that share lexical form but not meaning across languages (e.g., "fin", which means "end" in Spanish), may create additional ambiguity for bilinguals, even when they are using only one of their languages. As is described throughout this paper, the processing of these words has been studied extensively, because it pertains to the issue of whether language access is selective or nonselective.

Selective-access accounts assume that bilinguals can "turn off" the nontarget language, such that when they try to process one of their languages, only words from that target language are considered (e.g., Gerard & Scarborough, 1989). In contrast, *nonselective-access accounts* postulate that words from the nontarget language are nonetheless active and compete for selection (e.g., de Groot, Delmaar, & Lupker, 2000; Dijkstra & van Heuven, 1998; van Hell & Dijkstra, 2002). Therefore, when studying IHs, evidence for nontarget-language activation supports nonselective-access accounts, whereas the absence of such evidence lends support to selective-access accounts. The Appendix presents a summary of 35 experiments that directly examined processing of IHs in an attempt to elucidate this issue.

Three general approaches have been used to address this issue. The first approach uniquely applies to the question of selective versus nonselective access in bilinguals and involves the examination of how disparate lexical characteristics in two languages affect processing of IHs. Consider, for example, an IH that is of low frequency in English, but of high frequency in Dutch; one can examine whether it behaves more like a high-frequency word or a low-frequency word when bilinguals process this word in one of the languages (e.g., Dijkstra, van Jaarsveld, & ten Brinke, 1998; Gerard & Scarborough, 1989). In addition to differences in frequency in the two languages, researchers have also investigated the ramifications of differences in morphological family size (Dijkstra, del Prado Martín, Schulpen, Schreuder, & Baayen, 2005) and in syntactic role (e.g., Greenberg & Saint-Aubin, 2004, 2008).

The second approach is to compare the overall processing of IHs relative to matched single-language control words. A difference between IHs and matched controls is taken to indicate the activation of the nontarget-language reading, much like what has been done in the monolingual domain with ambiguous words (e.g., "processing complexity tasks", Simpson, 1984, p. 318). If ambiguous words take more/less time to process than words that are matched on important characteristics such as frequency and length, then presumably it is the additional meaning of the ambiguous word that influences processing. A total of 23 experiments have adopted this approach in the bilingual domain (e.g., Dijkstra, Grainger, & van Heuven, 1999; see Appendix).

The final approach, which parallels what has been done in monolingual research using semantic priming tasks, is to examine whether the nontarget reading is activated on a word-by-word basis. That is, by probing the nontarget-language meaning of the IH (e.g., the meaning "end" in an English task containing the IH "fin"), one can infer whether both the target and the nontarget meanings were initially activated. If the nontarget meaning were primed, then one could assume it was activated (but see van Petten & Kutas, 1987, suggesting that such effects could be due to backward priming from the probe word). Six experiments have employed this approach with cross-language ambiguity (e.g., Beauvillain & Grainger, 1987; see Appendix). In summary, all three approaches provide evidence for the debate between selective- and nonselective-access accounts, and these can be used to investigate ambiguity both within and across languages.

To preview, the evidence reviewed in this paper, along with other findings such as cross-language orthographic neighbourhood effects (e.g., van Heuven, Dijkstra, & Grainger, 1998) and cognate effects (e.g., van Assche, Duyck, Hartsuiker, & Diependaele, 2009), suggests that bilingual lexical access is fundamentally nonselective. There is ample evidence to suggest that the nontarget language is active and that top-down instructions or participant expectations are insufficient to eliminate this activation.

Extension of models to cross-language ambiguity

Within-language ambiguity models potentially can be extended to capture how bilinguals process cross-language ambiguity (e.g., Altarriba & Gianico, 2003). Monolingual context-dependent models, which assume that context predetermines which meaning(s) become activated (e.g., Schvaneveldt et al., 1976), can be extended to predict that bilinguals activate only the target-language meaning of IH. Thus, when processing IHs, such as the word "fin", in an English context, only the meaning in English (the target language) becomes activated. In contrast, the exhaustive-access model (Onifer & Swinney, 1981) and the ordered-access model (Hogaboam & Perfetti, 1975) assume that context cannot restrict initial activation, and therefore all meanings (or at least the more frequent meaning) will become activated regardless of context. One can consider the bilingual nonselective-access accounts mentioned above (e.g., de Groot et al., 2000) to be consistent with these monolingual models. All meanings of an IH, regardless of language, become activated based on their frequency. Even when the word "fin" is encountered in an English setting, its Spanish meaning ("end") will nonetheless become activated for Spanish–English bilinguals.

Note, however, that the notion of context is underspecified in this formulation for bilinguals. In particular, semantic context and language context may be in conflict under some circumstances. For instance, in the sentence "We knew the play had reached its *fin* when we saw the curtain fall" the target language is English, but the meaning of the sentence biases the Spanish reading of the IH "fin" (which means "end"; Altarriba, Carlo, & Kroll, 1992). Reliance on semantic context or on language context may thus lead to different outcomes, and it is therefore useful to separately examine how semantic context and language context influence cross-language ambiguity processing and how these factors may interact.

Furthermore, research on within-language ambiguity suggests that neither the context-dependent nor the context-independent models in their purest form capture the entire set of findings. Rather, it appears that interactive models that consider the relative role of frequency and context better fit the data (e.g., Simpson, 1984; Tabossi & Sbisá, 2001). It is therefore argued in this review that a transition toward more interactive accounts is needed to account for the data from the bilingual domain. And, in particular, rather than asking whether language membership can *determine* lexical access, one should consider the *relative* role of language context in relation to the other factors (i.e., frequency and semantic context).

To discuss the possible interactions between frequency, semantic context, and language context, an extension of the monolingual reordered-access model (Duffy et al., 1988) is proposed. Specifically, this monolingual model asserts that each meaning of an ambiguous word is weighted according to the evidence available to support it, and that the selection process is based on these weights. Further, the model suggests that frequency and context (both semantic and syntactic) operate by affecting the amount of evidence supporting each meaning. This conceptualization allows for the inclusion of other factors, such as language membership context, in the same interactive system. Indeed, Schwartz and colleagues have similarly called for the extension of this model to the bilingual case (Arêas Da Luz Fontes & Schwartz, in press; Schwartz, Yeh, & Arêas Da Luz Fontes, 2009).

The *three-factor framework* proposed here suggests that in addition to frequency and semantic/syntactic context, language context may influence the evidence accumulated for each meaning. All three factors can potentially provide support for the different meanings of ambiguous words and should therefore be considered jointly.

As is described in more detail below, the three-factor framework is undoubtedly an oversimplification of many important issues. Most prominently, there is clear evidence that not all types of language context are used in the same way by the word recognition system (e.g., the distinction between stimulus set composition and explicit instructions; Dijkstra, de Bruijn, Schriefers, & ten Brinke, 2000a). Further, as is true for all of the models discussed above, several issues need to be considered when one determines the frequency of the two meanings of IHs.

Nonetheless, the three-factor framework may provide a useful approach to evaluate the data on IH processing reviewed below. In particular, evidence for activation of only the target-language meaning of the IH (which has been taken to support selective-access accounts; e.g., Gerard & Scarborough, 1989) implies that language context is the most influential, or the first factor, to come into play. Such evidence implies that none of the meanings of the IHs in the nontarget language become activated because the language context determines early on that they are inappropriate. The two other factors (i.e., semantic context and frequency) can operate on meanings in the target language only, if more than one meaning exists in that language. As mentioned above, the available evidence suggests that language access is fundamentally nonselective in nature. This suggests that language membership information is not the first factor to come into play in bilingual word recognition. However, this does not rule out the possibility that language membership information biases lexical access, and/or that it interacts with other factors such as frequency and semantic/syntactic context to determine comprehension.

To examine these issues, we first extend findings about frequency and context from research on within-language ambiguity to cross-language ambiguity. Then, we examine how ambiguity resolution varies as a function of meaning similarity, task demands, and individual differences. These central issues are examined in the context of cross-language ambiguity processing. We then discuss a central and unique issue in cross-language processing, which is the asymmetry in the effects of the first language (L1) on the second language (L2) and vice versa. The paper concludes with important ways in which research on within-language and cross-language ambiguity can be integrated to inform ambiguity research in general.

Frequency

Role of frequency in within-language ambiguity

Effects of meaning dominance. The two meanings of an ambiguous word often differ in their relative frequency. The more common meaning is referred to as the *dominant meaning*, and the less common meaning is referred to as the *subordinate meaning*. In the absence of context, it appears that the dominant meaning is accessed first, in accordance with the ordered-access model (Hogaboam & Perfetti, 1975). For instance, Simpson (1981) found facilitation in a lexical decision task to targets related to the dominant but not to the subordinate meaning of ambiguous word primes (for similar findings, see Simpson & Burgess, 1985). Meaning dominance also plays a role in context, in that when the context supports the dominant meaning, the activation of the subordinate meaning is not always detectable (Simpson, 1981; Tabossi & Zardon, 1993). Because frequency is such an important predictor of language processing in general, it is not surprising that controlling for frequency is essential, and that this has become the norm in both within- and cross-language research.

Effects of relative meaning dominance (polarization). Most ambiguous words are unbalanced/biased, such that one of their meanings is much more frequent than the other (e.g., "ball") whereas other ambiguous words are balanced, with the frequency of their two meanings being roughly equal (e.g., "date"). Whether ambiguous words are biased or balanced is especially important when one considers the influence of context. In particular, the circumstances under which biased and balanced ambiguous words differ from unambiguous words vary. Balanced ambiguous words are generally processed more slowly than unambiguous words in neutral context, whereas biased ambiguous words are processed more slowly than unambiguous words when the context supports the subordinate meaning, but not when context supports the dominant meaning or when it is neutral (e.g., Binder, 2003; Duffy et al., 1988).

Notably, however, it may be more informative to think about meaning frequency as a continuum, rather than simply distinguishing balanced from biased ambiguous words. Indeed, Kawamoto (1993) treats such *polarization* as a continuum, and proposes that unambiguous words can be viewed as one extreme on the polarization continuum, with balanced ambiguous words at the other extreme. Similarly, Duffy et al. (2001) emphasize the importance of the particular degree of polarization. They focus on the subordinate bias effect (SBE; Rayner, Pacht, & Duffy, 1994), which is the lengthened processing time observed when a biased ambiguous word is presented in a context that biases its subordinate meaning, presumably because of the inevitable activation of the dominant meaning. Duffy et al. note that although it may be possible to eliminate the competition from the dominant meaning for moderately biased ambiguous words by strengthening the context, it seems unfeasible to eliminate the SBE for highly biased words (for which the subordinate meaning is extremely rare). It therefore appears that the particular ratio of meaning frequency is important, especially when the ambiguous words are presented in context. The more frequent meaning enjoys an advantage in processing, and this advantage is more prominent as the degree of polarization increases.

Role of frequency in cross-language ambiguity

When one considers IHs like the word "angel" (which means "sting" in Dutch), the ratio of meaning frequency crosses the language boundary, because these words have one meaning in each language. There are therefore several ways to think about the relative frequency of these two meanings.

Frequency by language dominance. The first approach assumes that for bilinguals who are more proficient in their L1, all words in L2 are less frequent than all words in L1, and therefore for any given IH the dominant meaning is the L1 meaning, and the subordinate meaning is the L2 meaning. For instance, because a Dutch–English bilingual is more proficient in Dutch, the word form "angel" is more commonly associated with its Dutch ("sting") meaning than it is with the meaning "seraph". It follows that when the context supports the L2 meaning it is assumed to support the subordinate meaning (discussed by Altarriba & Gianico, 2003).

Frequency irrespective of language. Alternatively, the relative frequency of the IH in the two languages may vary, and the absolute frequency in each language could be considered separately. For instance, the word "angel" may be more frequent in English than it is in Dutch. Several studies have indeed taken advantage of differences in the absolute frequency of IHs in two languages. In an early study, Beauvillain and Grainger (1987, Experiment 2) selected biased French/English IHs, for which the reading in one language was very frequent but the reading in the other language was less frequent, based on mean frequency ranks in each language. For example, the word "pain" is not as frequent in English as it is in French (meaning "bread"). Beauvillain and Grainger presented participants with IHs followed by target words that could be related to their meaning in French or in English (e.g., "butter" or "ache" for "pain"). Participants were instructed to read the IHs in either French or English and to make a lexical decision to the test words in French or in English (language was manipulated within participants). Regardless of instructed language, priming was observed only for the high-frequency reading of the IHs (e.g., the bread meaning of "pain"). Thus, when meaning frequency was determined based on separate frequency ranks in English and in French, it appears that IHs are processed like single-language ambiguous words with the more frequent meaning enjoying an advantage in the absence of context (e.g., Simpson, 1981).

A similar conclusion can be reached based on more recent studies that have used other objective within-language measures. For instance, de Groot et al. (2000) presented participants with Dutch/English IHs, half of which had a higher frequency reading in Dutch, and half of which had a higher frequency reading in English, based on the CELEX corpus (Baayen, Piepenbrock, & van Rijn, 1993). Relevant to the current discussion, these frequency counts are based on separate text corpora for English and Dutch and therefore reflect a "within-language" measure of frequency and not necessarily the actual frequency with which the Dutch−English bilinguals who participated in that study encountered the words throughout their lives. In a translation recognition task (Experiment 1) and in a lexical decision task that used words from the nontarget language as "nonwords" (Experiment 3), large frequency-dependent inhibitory effects were found for IHs relative to matched controls (see also Dijkstra et al., 1998, Experiment 2). Thus, a low frequency English word like "vet" was responded to more slowly than a matched low-frequency English word like "fog", because "vet" is an IH with high frequency in Dutch (meaning "fat"). A similar pattern of results was found by Dijkstra, Timmermans, and Schriefers (2000b) in a go/no-go lexical decision paradigm in English (Experiment 2) and in Dutch (Experiment 3). These results suggest that the relative frequency of the two readings of an IH is important, and that here too the more frequent reading appears to be activated first, consistent with the monolingual ordered-access model (Hogaboam & Perfetti, 1975)

Subjective frequency (combining both). Using an objective frequency count in the two languages is only an approximation, however, to the actual frequency of the two readings for bilingual individuals. In particular, models of bilingual word recognition, such as the bilingual interactive activation (BIA) and BIA+ models (Dijkstra & van Heuven, 1998, 2002) to be described in more detail later, emphasize subjective frequency as the underlying important factor in word recognition, and yet the majority of studies did not make an attempt to obtain this subjective measure (but see Gerard & Scarborough, 1989; von Studnitz & Green, 2002). Subjective frequency reflects both the relative dominance of the participants in the two languages and the objective (within-language) frequency count in each language. To obtain a more accurate measure of this complex construct one would need to norm the words by asking bilingual participants to rate the words' frequency in each of their languages (e.g., von Studnitz & Green, 2002), which will take into account their relative proficiency in the two languages.

Gerard and Scarborough (1989) in fact selected biased Spanish/English IHs based on frequency norms obtained from bilingual speakers. Using this subjective measure they did not observe a significant influence of the nontarget readings of IHs on lexical decision latencies, supporting a selective-access account. Note, however, that the authors assumed that the summed frequencies from the two languages should facilitate processing for both IHs and cognates (which share meaning in both languages), relative to a control word with the same frequency in only the target language. They did not consider the possibility that there could be interference for IHs because of conflicting semantics. The general pattern of means in their study could in fact be consistent with IH interference relative to matched controls.

Determining whether IHs have a higher frequency in one language than the other, even based on subjective frequency measures, may not be sufficient. Rather, as suggested by monolingual research (e.g., Duffy et al., 2001), the degree of polarization, or the particular subjective frequency ratio, should be examined. For example, two IHs may be more frequent in Spanish than in English (e.g., "fin", which means end, and "pan", which means bread), and yet one may be more polarized than the other. As evident in studies examining the SBE, more polarized ambiguous words are more resistant to the influence of context, in that strengthening the context to support the subordinate meaning is not enough to eliminate the competition from the dominant meaning (Duffy et al., 2001). More polarized IHs similarly may be more resistant to the influence of context.

To conclude, it is essential to better specify meaning frequency of IHs using a measure that reflects both the participants' proficiency in the two languages and the objective within-language frequency count in each language. This would allow one to identify the dominant and subordinate meanings of the IHs and to compare their processing to that of within-language ambiguous words. Further, once this is done, it would be possible to examine how this factor interacts with both semantic information and language membership information provided by the context.

Context

It is evident that meaning frequency has a critical role in determining how ambiguous words are processed in isolation; however, word recognition rarely occurs without context. This context ultimately determines which meaning is appropriate, but there is less agreement about its influence on initial lexical access. As mentioned above, context-dependent theories assume that initial lexical access depends entirely or at least partially on the preceding context, whereas context-independent accounts (such as the ordered-access model and the exhaustive-access model) assume that context bears no influence on initial lexical activation.

As pointed out by Tabossi and others (e.g., Tabossi & Zardon, 1993), context is not an undifferentiated notion. Rather, context of various types and strengths may influence ambiguity processing in different ways. This observation is especially relevant for cross-language ambiguity because context may provide not only semantic and syntactic information, but also language membership information. When an IH is embedded in an English sentence, for instance, the sentence provides a clear English language context in addition to the semantic and syntactic frame it provides. In the following sections, we review how different types of context were used to study both within- and cross-language ambiguity. We highlight the distinction between semantic and language context for cross-language ambiguity and examine how the findings can be understood in the three-factor framework, which allows for interactions between frequency, semantic context, and language context.

Within-language ambiguity in context

The appropriate meaning of an ambiguous word depends on the semantic context in which it appears. Semantic context can be provided on different scales, ranging from a single-word prime (e.g., Nievas & Marí-Beffa, 2002) to a whole paragraph preceding the ambiguous word (e.g., Binder, 2003). Often, researchers manipulate the semantic content of a sentence to bias the subordinate or the dominant meaning of an ambiguous word, or avoid any bias by introducing a semantically neutral sentence (Duffy et al., 1988; Elston-Güttler, Paulmann, & Kotz, 2005b). Researchers have examined the effect of context on ambiguous word processing using several approaches. One set of approaches are similar to those used to examine ambiguous word processing in isolation (e.g., by presenting a target word related to one of the meanings at various time points after the presentation of the ambiguous word, e.g., Elston-Güttler et al., 2005b). Another approach is to record reading times (e.g., with eye-tracking) while participants read for comprehension. Using this method, fixation time and gaze duration on the target word and on posttarget regions can be used to infer whether context changes the difficulty of processing the ambiguous word (e.g., Binder, 2003; Duffy et al., 1988).

In addition to semantic content, sentences can also provide a syntactic frame for the upcoming words. This type of information may be especially useful when processing ambiguous words whose meanings differ in their part of speech (POS; e.g., "punch"). When a word like "punch" is embedded in context, the syntactic frame can potentially constrain which meaning is appropriate, as in the sentence "He wanted to take a sip of the *punch*". Interestingly, Elston-Güttler and Friederici (2005, 2007) did not observe a difference between homonyms whose meanings differ in POS and homonyms whose meanings belong to the same POS when presented at the end of a sentence context. This suggests that the contribution of the syntactic constraint provided by the sentence was minimal. Similarly, in a computational model, Kawamoto (1993) examined the influence of semantic and syntactic contexts on processing of ambiguous words whose meanings differed in their POS and suggested that syntactic context is less influential than semantic context because it biases more alternatives (e.g., all nouns are appropriate). Semantic context, in contrast, biases a smaller set of alternatives (e.g., a beverage) and is therefore more constraining. The number of lexical alternatives that are biased or constrained by a context is important when we consider the effect of language membership context (to be discussed below), because language context likely biases an even larger set of alternatives (i.e., all words in a given language), and its effect may therefore be reduced compared to semantic or syntactic context.

Cross-language ambiguity in context

In the case of bilinguals, context can provide not only a semantic/syntactic bias but also information about the appropriate target language. Although the environment within which IHs are presented (e.g., stimulus set composition, instructions to participants) has been experimentally manipulated, it is only recently that researchers have started to examine how bilinguals process these words in natural sentential context (e.g., Libben & Titone, 2009; Schwartz & Kroll, 2006). In what follows, we review these findings by first considering the separate effects of language context and semantic context on processing of cross-language ambiguity and then discussing how they may be contrasted.

Language context. In cross-language ambiguity research, a distinction traditionally has been made between bottom-up sources of language context (e.g., sentence, stimulus set composition) and top-down sources such as instructions or participants' communicative goals (see Dijkstra & van Hell, 2003). This distinction has proven useful because the two types of information appear to be used differently in bilingual word recognition. As is described below, there is evidence to suggest that top-down sources of information are not used by bilinguals to restrict activation to the target language (e.g., Dijkstra et al., 2000a).

In a series of lexical decision experiments, Dijkstra and colleagues examined how IH processing is affected by stimulus set composition and task demands. For instance, Dijkstra et al. (1998) observed no reliable difference in reaction times (RTs) to Dutch/English IHs compared to matched English controls in an English lexical decision task (Experiment 1), despite reliable facilitation for cognates in that study. However, in a second English lexical decision task, the stimulus set included pure Dutch words that required a "no" response because they were non-English words. Interestingly, the inclusion of these Dutch filler words changed the pattern of results, such that significant inhibition was now observed for IHs compared to matched English controls, especially when the IHs had a high-frequency reading in Dutch. Thus, although it would have been beneficial for participants to base their responses solely on English, and to suppress any activation of Dutch words, the bottom-up activation of the Dutch reading could not be suppressed, supporting a nonselective account. It appears that language membership information provided by the instructions (i.e., only English is relevant) was not sufficient to override the language membership information provided by the stimulus set (i.e., both English and Dutch are relevant). In a third experiment, participants were instructed to respond "yes" to words in either Dutch or English (i.e., perform a generalized lexical decision task). In this condition, the task and stimuli provided consistent language membership information (i.e., both English and Dutch are relevant), and significant facilitation was observed for IHs over matched English controls. Thus, whether a difference relative to controls is shown for IHs seems to depend on the stimulus set composition and the task.

To directly contrast the effect of stimulus set composition, or language intermixing, with that of explicit instructions, Dijkstra et al. (2000a) instructed participants to perform an English lexical decision task and specifically informed them that pure Dutch words would be included and that these items should be given a "no" response. Although the participants were not aware of it, the experiment was divided into two phases. In the first phase, no pure Dutch words were actually included, and no RT difference was found for Dutch/English IHs relative to English controls. In the second phase, however, Dutch filler words were included, and significant IH inhibition was immediately observed. These data again suggest that the language membership information provided by the instructions is not as effective at influencing activation as the bottom-up language context of the stimulus set composition.

The global language context in which a task is performed appears to behave like other top-down sources of information, in that it is insufficient to restrict the activation of the nontarget language. In particular, Paulmann, Elston-Güttler, Gunter, and Kotz (2006) presented German–English bilinguals with a film narrated in one of their languages at the beginning of the experimental session. In a semantic priming study using event-related potentials (ERPs), participants were presented with IHs followed by English target words for lexical decision. The target word could reflect the German meaning of the IH or be unrelated. The results showed significant priming, in both RTs and the N400, for target words depicting the L1 meanings of the IHs. Interestingly, this priming was evident regardless of which version of the film (L1 or L2) was presented, suggesting that such global context was insufficient to restrict the activation of the nontarget-language (L1) reading.

These studies suggest that language context is not a uniform notion, and that there is a qualitative difference between language membership information that is provided in a bottom-up fashion by the stimuli and language context information that is provided by the instructions or the communicative setting. Sentential context can provide not only language context but also semantic constraint to the different meanings of the word (e.g., Libben & Titone, 2009). However, when sentences are neutral with respect to which meaning is appropriate, they presumably provide language context without semantic context. In one study, Nakayama and Archibald (2005) presented Dutch/English interlingual homographs and interlingual homophones (which overlap in phonology but not in orthography across languages) embedded in English sentences, while participants' eye movements were recorded. Importantly, the sentences were constructed to be neutral such that the target (English) reading of an IH and an English control word fit the sentences equally well. The results showed decreased first fixation and gaze durations on the interlingual homographs relative to matched controls and the reverse pattern for interlingual homophones (implying an inhibitory role for phonological overlap). These findings suggest that in the absence of semantic bias, the language context provided by the sentences did not eliminate the activation of the nontarget reading of the IHs.

If one considers a sentence to be a bottom-up source of information, this finding is somewhat contradictory to the effects observed from other bottom-up sources of information such as stimulus set composition reviewed above, because it suggests that in an all-English sentence context IHs still differed from controls, whereas in the studies reported above (e.g., Dijkstra et al., 2000a), IHs did not differ from controls in an all-English stimulus set composition. This discrepancy could be explained by considering the contribution of semantic context. In particular, the sentences in the Nakayama and Archibald (2005) study were neutral with respect to the control words. That is, they were normed to fit the target reading of the IHs and the control words equally well, but it is not clear that the sentences were neutral with respect to the two meanings of the IHs. To illustrate, the nontarget reading of the IH "roof" (which is "robbery") could potentially be integrated in the sentence "The *roof* was more impressive than I thought", but it is likely that the sentences provided more bias toward one meaning of the IH than the other. Because this aspect of the materials was not examined, it is difficult to disentangle the effect of language context from that of semantic context in this study. Furthermore, the relative dominance of the IHs may affect the pattern of results. The IHs used by Nakayama and Archibald were chosen to be biased with a higher frequency in English than in Dutch, but because the bilinguals were more proficient in Dutch it is possible that the IHs were relatively balanced for these participants. Based on the literature on within-language ambiguity, biased and balanced ambiguous words behave differently in context, and it is therefore important for future research to determine the subjective relative dominance of the words.

With this in mind, future studies could examine the influence of language context without semantic context by constructing sentences that are neutral with respect to the two meanings of the IHs.

Semantic context. More often than not, semantic context is provided by the sentences in which ambiguous words are embedded. As has been done in the within-language domain, sentences can be manipulated to provide a bias toward the subordinate or the dominant meanings of IHs or to be neutral with respect to which meaning is appropriate. These semantic manipulations change the amount of semantic bias provided by the sentence, but keep the language membership information constant. We examine how IHs are processed in such sentences in an attempt to isolate the effect of semantic context from that of language context.

Schwartz and Kroll (2006) manipulated the degree of semantic constraint of the sentences while keeping language context constant. Higher and lower proficiency Spanish–English bilinguals named targets embedded in English sentences using a rapid serial visual presentation (RSVP) paradigm. Crucially, the targets (IHs, cognates, or controls) could be more or less biased by the sentence frame as determined by a separate cloze norming experiment. IHs suffered an accuracy decrement relative to English controls for the low-proficiency group only, regardless of sentence constraint, although the degree of constraint was effective in modifying the processing of cognates. Note that participants were performing the task in L2 (English), and it is therefore their ability to negotiate the activation of the L2 (target) reading with that of the L1 (nontarget) reading that is in question. Apparently, more proficient bilinguals were able to use the combination of language context and semantic context provided by the sentences to restrict the competition from the nontarget reading of the IHs, whereas less proficient bilinguals were not able to do so.

Although the constraint manipulation was not effective in this particular study for IHs, it is interesting to consider how it may have affected the nontarget reading of the IHs. In particular, sentences were normed to have a high or a low cloze probability for the target-language meaning of the IH (and matched control), but the degree to which the nontarget meaning could be integrated in the sentence was not examined. The low- and high-constraint sentences may in fact differ in that respect. For example, in the high-constraint sentence "From the beach we could see the shark's *fin* pass through the water", the Spanish meaning of the IH "fin" (which means "end") is inappropriate. This is not necessarily the case for the low-constraint sentence "We felt a bit nervous when we saw the *fin* of the shark in the distance", in which the Spanish reading could perhaps have been integrated, because the disambiguating information is presented after the target to be named in the RSVP paradigm. Thus, it is important to consider not only the bias created by the sentence to the target meaning, but also whether it deems the other meaning inappropriate.

The constraint manipulation employed in a recent eye-tracking study was found to influence processing of IHs (and cognates). In particular, Libben and Titone (2009) observed that in low-constraint sentences, French/English IHs were processed more slowly than matched English controls, as indicated by both early-stage comprehension measures (e.g., first-fixation duration) and late-stage comprehension measures (e.g., total reading time). In high-constraint sentences, in contrast, IH interference was evident only in early-stage measures, suggesting that the initial nonselective access was quickly resolved. This study suggests that language membership information, in combination with minimal semantic constraint, does not eliminate the nontarget-language activation. Further, even in a highly constraining sentence, there is evidence for initial nontarget-meaning activation. However, similar to the studies mentioned above (Nakayama & Archibald, 2005; Schwartz & Kroll, 2006), the degree to which the nontarget meaning could be integrated in these sentences was not explored.

Contrasting semantic and language context. One way to examine the separate effects of language context and semantic context is to try to put these two types of context into conflict. For example, in an

RSVP study by Altarriba et al. (1992), semantic context and language context were directly contrasted. In that study, Spanish–English bilinguals named IHs embedded in sentences. Sentences were in Spanish (L1) or in English (L2) and were congruent with either the target or the nontarget meaning of the IH. For example, the English sentence "We knew it was a shark because we saw its *fin* as it approached the boat" was an L2 sentence congruent with the L2 meaning (L2 language context, L2 semantic context), but the sentence "We knew the play had reached its *fin* when we saw the curtain fall" was an L2 sentence congruent with the L1 meaning of the IH (L2 language context, L1 semantic context). The results showed that processing of IHs was slower and less accurate than that of controls in L2, regardless of semantic context (L2 language L2 semantic and L2 language L1 semantic). That is, whether the sentence meaning was congruent with the L1 meaning or the L2 meaning, bilinguals took more time and were less accurate to name IHs relative to English controls in L2, perhaps reflecting simultaneous activation of both meanings. However, in L1, interference for the IHs relative to Spanish controls was observed only when the context was congruent with the L2 meaning (L1 language L2 semantic).

These findings could be interpreted within the three-factor framework as reflecting an interaction among frequency, semantic context, and language context. In particular, increased processing time of IHs relative to controls suggest that the two meanings of the IHs were activated in the same time window, and the competition between them presumably lengthened processing. If we assume that the L1 meaning is more frequent than the L2 meaning, it is reasonable to assume that the dominant meaning (L1) is always active, and its activation is evident even when the semantic context and the language context support L2 (L2 language L2 semantic condition). The activation of the subordinate meaning (L2) is evident when the language context supports it (sentences in L2), or when the semantic context supports it (L1 language L2 semantic condition). Therefore, all three factors (frequency, semantic context, and language context) contribute to the different meanings of the IHs and influence the time-course of their activation.

One can think of the sentences of Altarriba et al. (1992) as highly constraining, in that either the L2 or the L1 meanings of the IHs were appropriate, but not both. In that respect, the manipulation was symmetrical in its effect on the target and nontarget readings, in that it either biased the target reading and ruled the nontarget reading inappropriate, or vice versa. It still remains to be examined how these different factors interact when the sentences provide a bias but do not deem the other meaning inappropriate (e.g., "we waited till the *fin* of the shark was completely visible").

To more accurately characterize the pattern of interactions between semantic and language context, it is essential to disentangle their effects experimentally. To achieve this goal, one can keep language context constant and manipulate whether the sentence provides a bias to the target or nontarget reading of the IH. Alternatively, one can keep the semantic bias to a minimum, such that both meanings of the IH can be successfully integrated, but change the language of the sentence to manipulate language context. Moreover, it may be possible to eliminate the semantic and syntactic context of the sentence but keep the language context by embedding IHs in scrambled sentences (e.g., Greenberg & Saint-Aubin, 2004).

Before we conclude, it is important to reiterate that the distinction between language context and semantic context is an oversimplification. First, language context can be provided locally or globally. For instance, Elston-Güttler, Gunter, and Kotz (2005a) focused on global language context and contrasted it with a combination of semantic context and local language context provided by sentences. Similar to the study by Paulmann et al. (2006), a film narrated in either English or German was presented at the beginning of an experimental session to provide a global language context for the task. Following the film, German–English bilinguals performed a semantic priming task while ERPs were recorded. IHs were presented at the end of sentences that biased their English meaning (e.g., "Joan used scissors to remove the *tag*"). Then, an English word was presented for lexical decision; this English word either denoted the German meaning of the IH (e.g., day) or was unrelated. Thus, the semantic and local contexts of the sentence always biased the English reading of the IH, but the global context (i.e., film) biased either the target or the nontarget language. The results indicated that when all types of context (i.e., semantic, local language, and global language context) supported the target language, no significant priming was observed in the RTs or ERPs for target words depicting the L1 meaning of the IHs. However, when the German film was viewed, significant priming was initially observed in both RTs and ERPs. With time, the semantic context, in combination with the local language context of the upcoming sentences, allowed participants to "zoom in" to their L2, such that by the second block of trials there was no evidence of nontarget-language activation. This suggests that global language context can interact with local (semantic and language) context and stresses the need to clearly define the type and level of context used.

Even when one considers the use of sentences, the distinction between semantic context and language context is not simple. For instance, it is possible to provide a mix of semantic and language context by incorporating "socio-contextual triggers" (van Hell & Witteman, 2009). These trigger words could be related to the target- or nontarget-language socio-context. For instance, "Wall-Mart" is a trigger highly related to an English environment, but "Albert-Heijn" is a name of a grocery store chain in the Netherlands. Sentences could be presented in English or in Dutch, could bias the Dutch or the English meaning of the IHs, and could include any of these triggers. Incorporating such socio-contextual triggers in sentences containing IHs would allow us to examine whether such triggers are effective above and beyond the effects of semantic and language contexts of the sentence. In summary, both semantic/syntactic information and language membership information can potentially affect how cross-language ambiguity is processed. The evidence reviewed above suggests that top-down language context such as explicit instructions or global communicative goals are limited in their ability to affect processing, but that bottom-up language membership information, such as stimulus set composition, enhances the activation of the nontarget reading of IHs.

When we focus on language context information provided by a sentence, only tentative conclusions can be drawn because there is relatively little research contrasting semantic context and language context. Nonetheless, when sentences provide both language context and semantic context, bilinguals can focus on the target (L1) reading of IHs (Altarriba et al., 1992), or can focus on the target (L2) reading of IHs when they are proficient enough in L2 (Elston-Güttler et al., 2005a; Schwartz & Kroll, 2006). Thus, proficiency in the target language serves as a mediating factor, perhaps reflecting the role of meaning frequency in this complex interaction.

Specifically, when the nontarget reading of the IHs is more dominant than the target reading, there is evidence for competition from the nontarget meaning even when the IH is embedded in sentence context (e.g., Altarriba et al., 1992, when participants perform the task in L1; Libben & Titone, 2009, and Nakayama & Archibald, 2005, when the subjective frequency of the IHs is higher in the L1; and Schwartz & Kroll, 2006, for less proficient bilinguals). The competition from the dominant meaning even when the sentence biases the subordinate (target) meaning is consistent with the SBE (e.g., Duffy et al., 2001) found in within-language ambiguity research. To conclude, this complex pattern of results is best understood within a framework that allows for interactions between semantic context, language context, and frequency, such as the three-factor framework.

Similarity of the alternatives

The contribution of each of these factors may vary as a function of the particular words in question.

In particular, the similarity of the two meanings of the ambiguous words should be considered. As is described below, in within-language research, the semantic similarity of the two meanings has been emphasized. In the case of cross-language ambiguity, the two readings of an IH may be more or less similar not only in meaning but also in form. These issues are discussed in more detail below.

Semantic similarity

Research on within-language ambiguity has often combined homonyms (words that have two unrelated meanings, such as "bank") and polysemous words (words that have two or more related senses, such as "paper"). However, recent research has suggested that not all ambiguous words are equivalent. Klein and Murphy (2001) examined whether the meanings/senses of ambiguous words are represented together or separately by asking participants to make sensicality judgements to phrases containing a polysemous word (e.g., the word "paper" in "wrapping paper"). Upon repeated presentation of the same polysemous word, significant priming was obtained when the word was used to indicate the same sense (e.g., "shredded paper"), but inhibition occurred when the polysemous word was repeated with a different sense (e.g., "daily paper"). Moreover, the pattern observed for polysemous words did not differ from that obtained for homonyms with multiple unrelated meanings (Experiment 3; but see Klepousniotou, Titone, & Romero, 2008, who suggest that there is a difference between homonyms and polysemous words with highly overlapping senses).

Nonetheless, it has been suggested that the degree of semantic relatedness between the two meanings of an ambiguous word is a crucial factor in its processing. Rodd, Gaskell, and Marslen-Wilson (2002) contrasted the effects of multiple related senses with that of unrelated meanings, for which separate meanings correspond to different dictionary entries. Words with multiple unrelated meanings were at a disadvantage relative to matched controls, whereas words with multiple related senses were at an advantage relative to matched controls. Interestingly, they also collected semantic similarity ratings on the meanings and showed that even for ambiguous words with multiple meanings, meaning relatedness negatively correlated with latencies.

This suggests that rather than focusing on the distinction between homonyms and polysemous words, it is perhaps more informative to consider semantic relatedness between meanings on a continuum, because it appears to affect processing of both polysemous words and homonyms. To obtain a continuous measure of semantic similarity for ambiguous words, one can present the ambiguous words with short definitions of their different nuances of meaning and ask participants to rate their similarity (e.g., Rodd et al., 2002). Alternatively, one can embed the words in different sentential contexts and ask participants to base their relatedness judgement on these different uses of the word (e.g., Elston-Güttler & Williams, 2008). Note, however, that there may be differences in how bilinguals and monolinguals perceive the semantic similarity of the different nuances of meanings of an ambiguous word because of indirect mapping between translations (e.g., Degani, Prior, & Tokowicz, in press; Elston-Güttler & Williams, 2008).

In particular, an ambiguous word with two meanings is rarely translated as a single ambiguous word in the other language (Frenck-Mestre & Prince, 1997). Rather, two separate words usually correspond to these two meanings. For example, the English word "change" is translated into Dutch as "wisselgeld" to denote its monetary meaning and as "verandering" to denote alteration. Degani et al. (in press) recently had monolingual English speakers and Hebrew–English and English–Hebrew bilinguals rate the semantic similarity of pairs of English words. Some of these word pairs shared a label in Hebrew (e.g., both "tool" and "dish" translate into Hebrew as "kli"), and some corresponded to different labels in Hebrew (e.g., "ability" and "diary" translate into Hebrew as "yexolet" and "yoman", respectively). Interestingly, pairs that shared a Hebrew translation (which was itself a Hebrew homonym or polysemous word) were rated by the two bilingual groups as more similar in meaning than pairs that did not share a label in Hebrew, whereas the monolinguals showed no such difference. In addition to the clear differences between bilinguals and monolinguals, the results may further suggest that the two meanings of the ambiguous words were perceived as more similar than they would have been if they did not share a label. In this study, monolingual Hebrew speakers did not rate the two meanings of the Hebrew ambiguous words, but it may be the case that by virtue of having two different translations in English, bilinguals would perceive the two meanings as less similar than Hebrew monolinguals would. This interesting influence of cross-language ambiguity on within-language ambiguity remains to be explored.

Similarity between languages (system level)
The two meanings of IHs cross the language boundary. The overall similarity of the two languages is therefore important. For example, languages that share a script afford the opportunity for cross-language pairs to share both orthography and phonology, but languages that differ in script constrain the cross-language form similarity of cross-language pairs to phonology. Similarity in orthography and similarity in phonology have been shown to affect processing in different ways. Whereas orthographic overlap typically leads to an advantage in processing (e.g., Dijkstra et al., 1999; Nakayama & Archibald, 2005), phonological overlap sometimes leads to a disadvantage (e.g., Dijkstra et al., 1999; but see, Haigh & Jared, 2007, for contrasting findings). However, the effects depend on a complex set of factors, and there is some evidence that in the absence of shared script, effects of phonological overlap are exaggerated (Gollan, Forster, & Frost, 1997). Thus, whether the two languages share a script is likely to influence how cross-language ambiguity is processed.

In addition, similarity in form between the two languages is likely to affect the degree to which the word or the preceding context provide cues to language membership. If diacritic marks, for instance, vary across languages, individuals may be able to use this information early in processing to bias the meaning activation to the appropriate language, and the interplay between frequency, semantic context, and language context may be somewhat different. Unfortunately, however, there is very little variability in the languages that have been used to study cross-language ambiguity. As can be seen in the Appendix, a total of 23 experiments were conducted with Dutch and English, 6 with French and English, 3 with Spanish and English, and 3 with German and English. Clearly, there is a need to examine the generality of the effects in other language pairs.

Similarity between translations (item level)
Even when the pair of languages is kept constant, one can examine the degree of semantic and form similarity across the two languages for each word individually. Dijkstra et al. (1999) focused on Dutch/English pairs that vary in orthographic, phonological, and semantic overlap and pointed out that the traditional distinction between cognates, which share lexical form and meaning across languages, and IHs, which share form but not meaning, neglects the role of phonology. In English progressive demasking and lexical decision tasks, Dijkstra et al. observed facilitation for overlap in orthography and semantics but inhibition for overlap in phonology between the two readings of IHs (for a similar finding in a reading task, see Nakayama & Archibald, 2005; for evidence that interlingual homophones are not necessarily inhibited in lexical decision, see Lemhöfer & Dijkstra, 2004).

Even if one considers orthography, phonology, and semantics, the overlap on any of these dimensions is not always complete (e.g., the translation pair university–universidad for English and Spanish) and should therefore be examined as a continuous measure. Dijkstra et al. (1999) indeed examined the effect of phonological and orthographic overlap as a continuous measure and found orthographic overlap to be positively correlated with performance and phonological overlap to be negatively correlated with performance. Notably, however, semantic overlap was not treated in the same way. Although ratings of semantic similarity of the two meanings of the cross-language pair were collected in that study, this factor was dichotomized (see also Lemhöfer & Dijkstra, 2004). If semantic overlap were treated as a continuous variable, it would be possible to examine its effect for both cognates and IHs. Although cognates by definition have the same meaning in the two languages, there is great variability in how similar in meaning the two cognate translations are. For example, Tokowicz, Kroll, de Groot, and van Hell (2002) conducted a norming study in which Dutch–English bilinguals were asked to rate how similar in form and how similar in meaning translation pairs were to each other on a 7-point scale. They did not find a correlation between form similarity and meaning similarity, suggesting that translations that share form (i.e., cognates) are not perceived as more similar to each other in meaning than translations that do not share a lexical form. More importantly, this study exemplifies that among cognates there are different degrees of semantic similarity between the two translations. For instance, the Dutch/English cognate "mist" was rated as overlapping completely in form and in meaning (i.e., received the highest score of 7 on both measures). The perfectly form overlapping cognate "pot", however, received a meaning similarity rating of only 5. Evidently, semantic similarity can be measured continuously, and the distinction between cognates and IHs is not clear-cut, but rather these words fall on a continuum with respect to semantic overlap. Indeed, some IHs share one meaning across languages but not another (referred to as *ambiguous cognates;* Arêas Da Luz Fontes, & Schwartz, in press; Schwartz, Yeh, & Shaw, 2008; or *partial false-friends*; Elston-Güttler, 2000). For example, the word "grave" means "serious" in both English and Spanish, but it means "place of burial" only in English.

To summarize, the similarity between the two meanings of the ambiguous word clearly plays a role in its processing. Whereas within-language ambiguous words mostly vary with respect to semantic similarity, cross-language ambiguous words can also vary in form overlap. The overlap between the two readings of IHs may be affected by the overall similarity between the two languages (i.e., system level), but it can also vary on a word-by-word basis. Critically, it is important to consider the overlap in orthography, phonology, and semantics between the two readings of cross-language pairs as a matter of degree and to consider the effect of these dimensions on processing as a continuous variable.

Task demands

Ambiguity processing may manifest itself differently in different tasks, because presumably not all processes are shared across different tasks (e.g., lexical decision and naming; Hino & Lupker, 1996). In the following section we seek to explain task differences in cross-language ambiguity research by expanding an account proposed to explain task differences in within-language ambiguity processing (i.e., degree of precision; e.g., Armstrong & Plaut, 2008). To arrive at a more complete explanation, we consider the degree of nontarget-language activation required by the task. We conclude this section by briefly considering the applicability of the issues discussed in this paper to production tasks.

Degree of precision

In the monolingual domain, the comparison between ambiguous and unambiguous words has led to different patterns of results across different tasks. To illustrate, ambiguous words are typically recognized as words faster than unambiguous words in the lexical decision task (e.g., Hino & Lupker, 1996, Experiment 1; for a review, see Piercey & Joordens, 2000), but are processed less quickly than unambiguous words when participants read connected text (e.g., Duffy et al., 1988). Further, Rodd et al. (2002) suggested that the advantage observed in lexical decision tasks is restricted to polysemous words. Hino, Pexman, and Lupker (2006, Experiment 2) found that homonyms were responded to more slowly than unambiguous words in a semantic categorization task. In a naming task, Hino and Lupker observed an ambiguity advantage but for only low-frequency words, and Borowsky and Masson (1996) obtained a null effect when comparing ambiguous to unambiguous words.

Potentially important in explaining these seemingly contrasting results is the degree of precision required by the task. In particular, Piercey and Joordens (2000) proposed the "efficient then inefficient" explanation. According to this explanation, when an ambiguous word is encountered, a blend of its two meanings is initially accessed very quickly. This first phase is followed, when necessary, by a slower phase in which the system settles on a specific meaning pattern. They further proposed that a lexical decision can typically be made based on the first meaning-blend state, and because this phase is reached very quickly, ambiguous words enjoy an advantage in lexical decision. When reading for comprehension, however, the meaning-blend state is unsatisfactory, and the system has to settle on one pattern of meaning. This inefficient process leads to a disadvantage for ambiguous words in reading tasks. (See Tolentino & Tokowicz, 2009, for an extension of this two-stage process to the concrete-word advantage.)

Support for the role of semantic precision in explaining task differences comes from a recent study by Armstrong and Plaut (2008) who differentiated polysemous words and homonyms. By manipulating the bigram frequency and orthographic neighbourhood density of the nonwords, they were able to make the nonwords more or less "word-like", thereby influencing the difficulty of the lexical decision. They showed that when the task is easy and requires little semantic precision, a polysemy advantage is evident. When the degree of precision required is raised, both a polysemy advantage and a homonymy disadvantage are observed, and when decisions are even harder there is only a homonymy disadvantage.

To apply the same logic to cross-language ambiguity one needs to consider an additional aspect of precision—language precision. That is, does the task require a differentiation between words in the two languages? Two variants of the lexical decision task that have been used to study IHs are relevant in this respect: the language-specific lexical decision task and the generalized lexical decision task. In the language-specific lexical decision task, participants should respond "yes" to words in a specific language and "no" otherwise, much like the typical lexical decision task used in within-language research. In the generalized lexical decision task, in contrast, bilinguals should respond "yes" to a word in either of their languages and "no" otherwise (e.g., Dijkstra et al., 2005; Dijkstra et al., 1998; Lemhöfer & Dijkstra, 2004; van Heuven, Schriefers, Dijkstra, & Hagoort, 2008).

These two variants clearly differ in the amount of precision they require, especially with respect to language membership. The language-specific lexical decision task requires participants not only to recognize whether a letter string corresponds to a lexical representation they know, but also to further identify that this lexical representation belongs to a particular language; this is likely to be especially difficult when words from the nontarget language are included as filler "nonwords". Much like within-language tasks with a high degree of precision, an ambiguity disadvantage is generally observed in this increased language precision task (e.g., de Groot et al., 2000, Experiment 3; Dijkstra et al., 2000a, second phase; Dijkstra et al., 1998, Experiment 2; van Heuven et al., 2008; von Studnitz & Green, 2002; cases in which a disadvantage was not observed are reviewed in the section on activation of the nontarget language).

To correctly perform the generalized lexical decision task, one would need only to identify that the letter string corresponds to some lexical representation—there is no need to specify its source. This relatively lower level of precision indeed gives rise to ambiguity facilitation (Dijkstra et al., 1998, Experiment 3; Lemhöfer & Dijkstra, 2004, Experiment 3; van Heuven et al., 2008, in accuracy).

Other tasks that have been used to examine how IHs are processed relative to single-language controls can be analysed according to the degree of precision required. For example, Dijkstra et al. (2000b) employed a go/no-go language-specific lexical decision task in which participants press a button only if a letter string is a word. In accordance with the precision notion, because this is a variant of a language-specific lexical decision task in which only words from one language, but not the other, should elicit a response, IHs were processed more slowly and less accurately than matched controls, especially when the frequency of the nontarget reading of the IHs was high. The study also included a language decision task, in which participants pressed one button if the stimulus was a word in one of their languages (e.g., English) and pressed another button if it was a word in their other language (e.g., Dutch). The need to differentiate words from the two languages to correctly perform the task again gave rise to an IH disadvantage.

Note also that the same task may require a different degree of precision when it is performed by monolinguals and bilinguals. The naming task, for example, shows an interesting disparity between the studies examining within- and cross-language ambiguities, which can potentially be explained by degree of precision. In particular, this task has led to a null ambiguity effect in the monolingual domain (e.g., Borowsky & Masson, 1996), but to a consistent ambiguity disadvantage in cross-language ambiguity research (Jared & Szucs, 2002; Smits, Martensen, Dijkstra, & Sandra, 2006, in isolation; and Altarriba et al., 1992; Schwartz & Kroll, 2006, in context). It has been suggested that the null effect of within-language ambiguity on naming is observed because this task does not necessarily require a specific meaning to be selected (Rodd et al., 2002). Even if this is the case, the naming task does require a specific phonological code to be selected, and this phonological precision may differ within and between languages. In particular, IHs do not always overlap completely in phonology across the two languages, even if they overlap completely in orthography. Thus, it is possible that in the case of IHs, the naming task requires a specification of one reading to allow the selection of one phonological form. This increased precision may be the reason that IHs are at a disadvantage relative to matched single-language control words in this task.

Note, however, that the degree of precision alone cannot explain the entire set of empirical evidence. First, the reading study by Nakayama and Archibald (2005), in which participants' eye-movements were recorded as they were reading sentences for comprehension, poses some difficulty for this explanation. As mentioned earlier, in that study, Dutch/English IHs were facilitated relative to controls. Even if one assumes that this silent reading task can be done without specification of phonology, it is not clear how it can be done without specification of meaning. Such specification of meaning has been used as a typical example of increased degree of precision in monolingual research and therefore should have led to a disadvantage (rather than an advantage) for IHs in this task. Indeed, reading studies examining within-language ambiguity found either no difference or longer gaze durations on ambiguous words (e.g., Duffy et al., 1988). The sentences used by Nakayama and Archibald were relatively neutral, and the IHs were more frequent in English than in Dutch. If one considers these to be biased IHs (though note that English was the L2, and therefore the subjective frequency of the words may be relatively comparable across languages), then one would expect no difference between IHs and controls, but facilitation was nonetheless observed. It is not entirely clear how these data can be reconciled with the degree of precision explanation, because the need to specify meaning to allow comprehension should have led to an ambiguity disadvantage. Note, however, that in a different eye-tracking study in which low- and high-constraint sentences were used, a disadvantage was observed for IHs relative to controls (Libben & Titone, 2009), as predicted by the degree of precision explanation.

A second challenge to the degree of precision explanation comes from a closer examination of the language-specific lexical decision task. In this task, participants have to verify not only that a letter string exists in the lexicon, but also that it is a word in the intended target language, and not in another language they know. This increased degree of precision would predict a disadvantage for IHs (e.g., de Groot et al., 2000, Experiment 3; Dijkstra et al., 2000a, second phase; Dijkstra et al., 1998, Experiment 2; van Heuven et al., 2008; von Studnitz & Green, 2002), but this disadvantage has not always been observed. In particular, some studies found no difference between IHs and matched controls (de Groot et al., 2000, Experiment 2, collapsed across language conditions; Dijkstra et al., 2000a, first phase; Dijkstra et al., 1998, Experiment 1), whereas others observed facilitation relative to controls for IHs with orthographic but not phonological overlap (Dijkstra et al., 1999, Experiment 2; Lemhöfer & Dijkstra, 2004, Experiment 1). This suggests that the degree of precision required by the task cannot explain the entire set of findings. Rather, it is likely to interact with other task demands or characteristics. Specifically, when the degree of precision required by the task is high, and the context is such that the nontarget-language activation is also high (bringing it closer to the level of target-language activation), the difference between IHs and controls should be exaggerated.

Activation of the nontarget language

Tasks differ in the amount of activation they require from each of a bilingual's languages. For example, the translation recognition task (in which pairs of words are judged as translations or not) includes the presentation of words from both languages and therefore probably activates both languages. The amount of nontarget-language activation has been identified as an important issue in cross-language ambiguity processing. Specifically, a high degree of nontarget-language activation should lead to increased interference from the nontarget reading of IHs. A lower level of nontarget-language activation may conceal any evidence of competition between the two readings of the IH (see Dijkstra & van Hell, 2003, for a discussion of the language activation metaphor). As mentioned earlier, a distinction is made between "top-down" (e.g., explicit instructions and participants' communicative expectations) and "bottom-up" (e.g., stimulus set composition) sources of information when considering how nontarget-language activation can be modulated. This distinction is theoretically important in distinguishing bilingual word recognition models (see Dijkstra, 2005; Dijkstra & van Hell, 2003).

The BIA model (Dijkstra & van Heuven, 1998) proposes that words from both languages are integrated in one lexicon and that lexical access is fundamentally nonselective. Furthermore, it proposes that language membership is represented via "language nodes", such that all words from the same language are connected to a specific language node, and the number of language nodes is equal to the number of languages known. Importantly, the model assumes that the language node level can suppress the activation of words in the other language because the node is inhibitorily connected to all words in the other language. Thus, the language nodes in the BIA model serve not only a representational function (to allow bilinguals to say whether a word belongs to Language A or to Language B), but also to modulate the activation of the nontarget language under some conditions. Bottom-up sources are assumed to directly affect the activation level of word forms, whereas top-down sources exert their influence via the language nodes.

A revised version of this model, the BIA+ model (Dijkstra & van Heuven, 2002), distinguished the word identification system (including the language nodes) and a task/decision system. This additional decision system, which is also proposed by the inhibitory control (IC) model (Green, 1998), allows one to distinguish processes that influence the activation level of lexical representations from processes that influence participants' response criteria. According to the BIA+ model, language nodes serve only a representational function and cannot influence the activation of lexical units in the word identification system. Accordingly, top-down information and nonlinguistic context can affect only the task/decision system, and there are virtually no top-down influences from the task/decision system to the word identification system. Furthermore, the model assumes that even factors like stimulus set composition exert their influence on the task/decision system and not word identification itself, but the model nonetheless leaves the option for linguistic context to influence activation of lexical representations.

As discussed in the language context section, there is ample evidence to suggest that top-down sources are very limited in their ability to inhibit nontarget-language activation (e.g., de Groot et al., 2000; Dijkstra et al., 2000a; Dijkstra et al., 2000b; Dijkstra et al., 1998; von Studnitz & Green, 2002), whereas stimulus set composition clearly affects the pattern of results. Von Studnitz and Green suggested that information about language membership can exert an influence only outside the bilingual lexico-semantic system. In their study, they found that including pure German words as "nonwords" in an English lexical decision task led to a greater IH disadvantage, and informing participants from the beginning of the experiment about the inclusion of IHs reduced the size of the disadvantage. However, these two sources of information differentially affected "carry-over effects" (reaction time to words immediately following the IHs or matched controls), which were taken to be a more direct measure of lexico-semantic activation itself, without involvement of decision processes. Whether these bottom-up stimulus set composition effects take place by influencing the relative activation level or whether they exert their influence by adjusting the criteria at the task/decision level is still debatable (e.g., Smits et al., 2006).

Comprehension versus production

This review is mostly concerned with tasks that tap word recognition, rather than production, because the main aspect examined is meaning activation and selection. However, selection among alternatives is of course relevant to production as well, as in the case of near-synonyms (e.g., Peterson & Savoy, 1998). Peterson and Savoy observed facilitation in naming target words that are phonologically related to both near-synonymous names of a picture. Both lexical forms were thus phonologically activated, but only one was selected for production, even though the participants habitually used only one of the picture's names (see also Jescheniak & Schriefers, 1998). Similarly, lexical forms in both languages of bilinguals are phonologically active in picture-naming tasks (e.g., Costa, Caramazza, & Sebastián-Gallés, 2000; Hermans, Bongaerts, de Bot, & Schreuder, 1998). The selection problem may be even more pronounced in bilingual production, because in many communicative settings words from only one language should ultimately be produced to convey the message (e.g., Costa, 2005; Kroll, Bobb, & Wodniecka, 2006). Although activation and selection are processes shared by recognition and production, different combinations of factors may nonetheless determine how they unfold in production, but this issue is not examined in detail in the current paper (for one comparison of ambiguity effects in a production and recognition task, see Tokowicz & Kroll, 2007).

Individual differences

Even in the same task, ambiguity is not resolved in the same way by all individuals. Rather, because it is a difficult aspect of language processing, ambiguity resolution emphasizes differences among individuals that may otherwise go unnoticed. Researchers studying within-language ambiguity processing indeed have identified systematic individual differences in the ability to resolve semantic ambiguity, but this issue has remained largely unstudied in cross-language ambiguity. Here, we distinguish between accounts that assume a difference in a general cognitive ability and accounts that assume that the differences are more local in nature, in that they arise from differential experiences with the words in question. As will be evident, this formulation is useful when one considers cross-language ambiguity resolution.

Generalized ability accounts

Differences in working-memory capacity have been linked to differences in within-language ambiguity resolution. For example, Miyake, Just, and Carpenter (1994) tested participants with lower, average, and higher working-memory span in a self-paced reading task. Biased homographs were preceded by a neutral context and followed by a disambiguating region that could favour the dominant or the subordinate meaning of the ambiguous word. Reading times of this disambiguating region revealed that higher span participants maintained both meanings of the homograph whereas lower span readers had kept only the dominant meaning active.

Alternatively, lower span individuals have been suggested to be less efficient at suppressing irrelevant information, rather than less efficient at activating different alternatives. For example, in an ERP study, Gunter, Wagner, and Friederici (2003) presented ambiguous words followed by a disambiguating cue and a final disambiguating verb to participants with lower or higher working-memory span. ERPs showed a greater N400 to the disambiguating cue (suggesting more difficult integration) when it favoured the subordinate meaning relative to the dominant meaning for only higher span individuals, suggesting that by the time the disambiguating cue was presented they had suppressed the subordinate meaning. Because this difference between the subordinate and the dominant meanings was not evident for lower span individuals they were suggested to be less efficient at suppressing irrelevant meanings (Gernsbacher & Faust, 1991).

The suppression account originated from a study by Gernsbacher, Varner, and Faust (1990), who focused on individual differences in comprehension skill (rather than working-memory span). In one experiment, participants verified whether a test word presented after two stimulus onset asynchronies (SOAs) matched the meaning of a previously presented sentence. Critically, on half of the "no" trials, the test word was related to the inappropriate meaning of a homograph presented at the end of the sentence. For instance, the test word "ace" reflects the inappropriate meaning of the homograph "spade" in the sentence "He dug with the *spade*". The results suggested that immediately after the sentence both more and less skilled comprehenders had activated both meanings of the homographs, but following a delay only less skilled comprehenders showed interference due to the inappropriate meaning of the homographs. Gernsbacher and Faust (1991) extended these results to homophones and further showed that less skilled comprehenders were less efficient at ignoring irrelevant information in a nonverbal task. The authors proposed that a less efficient suppression mechanism, rather than inefficient enhancement of the appropriate information, underlies individual differences in reading comprehension.

The direction in which differences manifest themselves (i.e., an advantage or a disadvantage for individuals with higher span or higher comprehension skill) clearly depends on the particular tasks used. More critical for the current discussion, accounts that emphasize either activation or suppression all assume that differences in ambiguity resolution reflect relatively stable individual differences that are likely to also be evident in other domains.

Function of experience

In contrast with these generalized ability accounts, other researchers have emphasized the role of experience in determining the relative frequency of the two meanings of ambiguous words and in the ability to resolve ambiguity (e.g., Hart & Perfetti, 2008). According to the *lexical quality hypothesis* (Perfetti & Hart, 2002), experience with a word underlies the quality of the representation of that word, and high quality knowledge of words is at the heart of reading comprehension. In an individualized training study, Hart and Perfetti trained less skilled readers with the less frequent meaning of a homophone and by doing so were able to eliminate the skill group differences in processing these items. Furthermore, in an artificial language vocabulary training study, they taught participants biased artificial homophones, with one reading trained more often than the other. Importantly, training took place over 20 hours, which allowed the researchers to track performance over time. Interestingly, the pattern of homophone interference showed that participants became more skilled readers of the artificial language with time, and reading skill changed within individuals as a function of experience.

Furthermore, Hart and Perfetti (2008) suggested that a time shift in the activation function of the two meanings of a homophone is sufficient to explain differences between more and less skilled comprehenders and that a suppression mechanism is not required. Replicating Gernsbacher and

Faust (1991), they showed that when a target related to the inappropriate meaning of a homophone (which was presented as the last word of a sentence) is presented 450 ms after the sentence, homophone interference is observed for both skill groups. Hart and Perfetti further showed, however, that at a 150-ms SOA, only more skilled comprehenders showed interference (whereas at 1,350 ms only the less skilled group showed interference in Gernsbacher & Faust, 1991). By 2,000 ms, neither group showed interference. Thus, slower processing by less skilled comprehenders can explain these results.

Distinguishing between accounts of individual differences based on general cognitive ability versus experience is beneficial when considering the extension of this research to the cross-language domain. In particular, if a general cognitive ability (such as working memory or the ability to suppress irrelevant information) underlies the observed differences, then a similar pattern should be observed across languages. That is, an individual with a particular working-memory span should be roughly as successful in processing within-language ambiguity as he or she is in processing cross-language ambiguity. In contrast, if experience with the word is what underlies the observed skill differences, then the particular experience of the individual with the language (i.e., proficiency) is likely to determine his or her ability to process ambiguity. Thus, differences may emerge between ambiguity resolution within L1 (in which perhaps the individual is more experienced) and resolution of cross-language ambiguity, which depends on the relative proficiency in the two languages in question.

A direct comparison of within-language and cross-language ambiguity resolution in the same individuals has not yet been reported. Nonetheless, several studies did examine ambiguity processing by native and non-native speakers of a language. Even though the comparison in these studies is made between participants, these studies in effect investigate within-language ambiguity in L1 (more experience with the words) and L2 (less experience with the words; e.g., Frenck-Mestre & Prince, 1997). The difference observed between ambiguity processing in L1 and L2 provides preliminary support to experience-based accounts of individual differences. For example, in an ERP study, Elston-Güttler and Friederici (2005) presented monolingual English and German–English bilinguals with biased sentences ending in an English homonym, followed by a target word for lexical decision. The target word was related to the appropriate meaning of the homonym, related to the inappropriate meaning, or unrelated. Both native and non-native speakers exhibited significant priming for both meanings of the homonym at a 200-ms SOA, as measured by both RT and the N400. At the 500-ms SOA, the appropriate meaning was primed for both groups of participants according to RTs, but the ERPs suggested that the non-native speakers still showed activation of the inappropriate meaning. In an extension of this study, Elston-Güttler and Friederici (2007) showed that by 800 ms both groups showed disambiguation according to both RTs and the N400. This suggests that processing of homonyms in L2 is simply shifted in time relative to the native language and is not qualitatively different. Such an account is compatible with that put forth by Hart and Perfetti (2008) for less skilled comprehenders. Non-native speakers appear to behave similarly to less skilled comprehenders, lending some support to the idea that experience (with the words and/or the language) underlies individual differences in ambiguity processing.

Nonetheless, the two classes of individual differences accounts are not mutually exclusive. The two sources (cognitive ability and experience/proficiency) may work in parallel or may interact. A study that controls for both individual differences in cognitive ability and relative proficiency in the two languages is required to illuminate this issue.

Individual differences in the three-factor framework

The three-factor framework emphasizes the contribution of frequency, semantic context, and language context to the evidence supporting the different meanings of ambiguous words. Individual differences may come about because of participants' differential sensitivities to these three factors. For example, bilinguals may be more affected by frequency in L2 than they are by frequency in L1. Indeed, a large-scale study by Lemhöfer, Dijkstra, Grainger, and Zwitserlood (2008) suggests that non-native speakers are more affected by frequency in L2 than are native speakers of that L2 (see also Duyck, Vanderelst, Desmet, & Hartsuiker, 2008). Although these findings mainly point to the fact that differences in frequency between two words in L2 are more salient to bilinguals (perhaps because these words fall on a steeper slope of a logarithmic frequency function), it may have consequences for frequency differences between the two meanings of IHs. Specifically, it may be the case that although L2 meanings are generally less frequent than L1 meanings, bilinguals may perceive high-frequency L2 words as extremely frequent, affecting their subjective relative frequency of the two meanings of an IH. This highlights the need to examine the relative subjective frequency of the two meanings of IHs for the particular bilingual population in question, with special attention to the language in which the bilinguals are more dominant.

Individuals may also differ in their sensitivity to language context and semantic context. For example, bilinguals who frequently use both languages interchangeably in the same communicative setting (i.e., code switch or code mix) are perhaps less sensitive to language context information than bilinguals who use each of their languages in a separate environment. The weight of the language context factor may thus be reduced for the former than the latter. How these different kinds of bilinguals process cross-language ambiguity remains to be tested. The possibility that frequency, semantic context, and language context differentially interact in less or more skilled/proficient participants remains to be examined further.

Direction of the effects

The issues examined thus far (e.g., frequency, context, individual differences) are important for both within- and cross-language ambiguity processing. One aspect that is unique to cross-language ambiguity is the direction of the effects from L1 to L2 versus L2 to L1. Although very sparse, the evidence reviewed below suggests that there are reduced effects from L2 to L1. We outline several explanations for these findings.

Asymmetry in the effects

The research on cross-language ambiguity has informed us about whether the two languages are active in parallel. In particular, effects of the non-target language on IH processing in the target language, with or without context, were taken to support nonselective-access models of bilingual word recognition (see Dijkstra, 2005, for a review). Most studies, however, did not directly examine whether the effect of L2 on L1 is as strong as the effect of L1 on L2. In fact, many studies examined only the effect of L1 activation on L2 processing (e.g., Elston-Güttler et al., 2005b). The few studies that did directly examine both directions found somewhat reduced effects of L2 on L1 (e.g., Altarriba et al., 1992; de Groot et al., 2000; Dijkstra et al., 2005; Dijkstra et al., 2000b; Jared & Szucs, 2002). For example, Jared and Szucs had participants name heterophonic French/English IHs. French–English bilinguals demonstrated L1 on L2 effects immediately, whereas English–French bilinguals only showed an L2 on L1 effect after having named French words in an interpolated block of trials. The results therefore show that the effect of L2 on L1 is weaker than the effect of L1 on L2 and depends on recency of use.

There may be time differences rather than strength differences in the effects of L1 on L2 versus L2 on L1. Elston-Güttler and Friederici (2005, 2007) indeed suggested that there may be differences in the time-course of ambiguity processing between L1 and L2 (see also the "temporal delay hypothesis"; Dijkstra & van Heuven, 2002; Lemhöfer & Dijkstra, 2004). Be it a matter of strength or time-course, the typically observed asymmetry can be explained by considering the effect of proficiency (on meaning frequency or on the nature of the connections between the word form and meaning), or by examining the density of the semantic representations in the two languages, as is discussed below.

Proficiency. One account of the directional asymmetry in IH processing centres on proficiency. If participants are more proficient in L1, the frequency of the L2 meanings of the IHs is likely to be reduced on average compared to the frequency of the L1 meanings (whether it is assumed across the board or computed word by word, as discussed in the "Frequency" section above). Because the meaning in L2 is less frequent, it will function as the subordinate meaning for that IH and will therefore be activated less strongly, especially when the IH is embedded in context. The L2 is then less likely to affect IH processing in an L1 task.

However, if one selects words such that some are of higher frequency in the L1, and some are of higher frequency in the L2 (assuming the objective measures used are satisfactory), the effects in the two directions should be equated. Indeed, when Dijkstra et al. (2000b) specifically examined IHs with high frequency in Dutch and low frequency in English, or vice versa, the effects were observed from both L1 to L2 and L2 to L1.

Proficiency may play a role not just in pure frequency of exposure but also in the nature of the connections between word form and meaning. Specifically, the *revised hierarchical model* (RHM; Kroll & Stewart, 1994) proposes a shift in the nature of the connections between words in the two languages and their meanings as a function of proficiency/experience. For beginning learners, meaning representations are assumed to be strongly connected to L1 word forms, but only weakly connected to L2 word forms (but see, e.g., Dufour & Kroll, 1995; Duyck & De Houwer, 2008, for results that challenge the assumption of limited access to meaning from L2 words). With increased proficiency, the connections between L2 words and their meanings become stronger, and bilinguals come to depend on these meaning connections more than on the form/lexical connections between translations (e.g., Talamas, Kroll, & Dufour, 1999; but see Sunderman & Kroll, 2006, for a different pattern of results). For two lexical forms that correspond to a shared meaning, the L1-meaning connections would be much stronger than the L2-meaning connections for less proficient bilinguals. IHs are not directly captured by the RHM, because for IHs a single word form corresponds to two meanings. Nonetheless, an extrapolation of the model (e.g., the *distributed lexical/conceptual feature model*, Kroll & de Groot, 1997) would perhaps predict that the connections between the lexical form of an IH and its L1 meaning would be stronger than the connection between the IH and its L2 meaning for less proficient bilinguals. Such an account would predict more influence of the L1 meaning than the L2 meaning, even when the two readings are of equal subjective frequency.

To test whether differential frequency is sufficient to explain the asymmetrical pattern of the effects, or whether different meaning connections in L1 and L2 are involved, one would have to select IHs with comparable subjective frequencies in the two languages and examine whether the L2 meaning of the IHs is capable of influencing processing in L1 with equal strength. Furthermore, because the nature of the connections in the bilingual lexicon is assumed by the RHM to change with increased proficiency, a change in the pattern of the effects would be predicted with increased proficiency, such that the asymmetry observed in the direction of the effect (i.e., stronger IHs influence when the target language is L2 than when it is L1) should be reduced with increased proficiency.

One-to-many versus many-to-one. Be it a matter of mere frequency of exposure or a consequence of different semantic connections, proficiency differences in the two languages are likely to explain why the L1 meaning of an IH is more likely to compete for selection when bilinguals try to process IHs in their L2 than the reverse. A complementary account emphasizes the density of the semantic representation in each language. The *distributed conceptual feature model* (de Groot, 1992) suggests that translation equivalents vary in the number of semantic features that overlap between languages. Capitalizing on this idea, Finkbeiner, Forster, Nicol, and Nakamura (2004) proposed the *sense model*, according to which meanings in L2 are less dense (i.e., include fewer senses or semantic clusters) than meanings in L1. They therefore suggested that masked priming is rarely observed from L2 to L1 (but see, e.g., Duyck & Warlop, 2009), but the reverse is often found, because a meaning composed of more senses is likely to prime a meaning composed of fewer senses ("head" priming "skull"), but not the reverse. This assumes that words in L2 have fewer senses than words in L1. If this is correct, then it is possible that fewer-sense meanings interfere with processing less than more-sense meanings. The asymmetry in the density of semantic representations may thus contribute to the observed asymmetry in the competition between L1 and L2 meanings of IHs.

The idea that fewer-sense meanings interfere with processing to a lesser extent than more-sense meanings is not specific to cross-language ambiguity. However, it is hard to envision how this could be measured in relation to the meanings of within-language homonyms because this would require ambiguous words with two related meanings, of which one is more semantically rich than the other (e.g., a homonym that encompasses both "head" and "skull"). However, the sense model was not directly tested across languages, and it still remains to be examined if indeed words in L2 include fewer senses than do words in L1. This semantic density explanation is therefore only speculative at this point.

The three-factor framework—redux

Cross-language ambiguity research has mostly been aimed at illuminating the debate between selective and nonselective access. This debate centres on whether bilingual lexical access is determined by language membership. To put it differently, it is concerned with whether language membership is the first factor that influences bilingual word recognition. If it is, then words from the nontarget language should never receive activation and never compete for selection. As shown throughout this paper, there is strong evidence to support nonselective-access accounts, which posit that when IHs are processed, the nontarget language remains active, even in the face of top-down instructions or expectations that suggest otherwise. This implies that language membership information is not the first factor to affect bilingual word recognition. Critically, however, this does not preclude the possibility that language context biases lexical access, and, more importantly, that it interacts with other factors such as frequency and semantic/syntactic context to determine comprehension.

The three-factor framework proposed in the introduction provides a context within which to discuss the interactions between these different sources of information. It extends the monolingual reordered-access model (Duffy et al., 1988) by incorporating language context as a third factor, in addition to frequency and semantic/syntactic context, in the same interactive system. The framework argues that all three factors can provide activation to the different meanings of IHs and therefore affect ambiguity resolution. Note that the primary components of language context predicted to have an influence are those obtained from the sentence, the stimulus set composition, or other bottom-up sources, whereas top-down explicit information is likely to be very limited in its effect (e.g., Dijkstra et al., 2000a). Furthermore, in the monolingual reordered-access model, the two factors (frequency and semantic/syntactic context) interact and exert their influence at the same level. However, the three-factor framework remains open to the possibility that the three factors do not necessarily exert their influence simultaneously. As previously mentioned, it remains to be determined whether language membership can operate at the same lexical-activation level, in accordance with the assumptions of the BIA model (Dijkstra & van Heuven, 1998), or whether it can operate only at the task/decision system, as suggested by the BIA+ model (Dijkstra & van Heuven, 2002).

When considering the possible complex patterns of interactions between these three factors (frequency, semantic/syntactic context, and language membership context), different outcomes are expected depending on the strength of each factor and/or the time-course of their influence. We have already discussed how semantic context can be manipulated separately from language context in the context section above (e.g., Altarriba et al., 1992; Greenberg & Saint-Aubin, 2004). If semantic context biases one meaning but the language information biases another, we can examine which of these factors is more influential by tracking the activation time-course of the different meanings. For instance, in the sentence "We waited till the *fin* of the shark was visible", the semantic context biases the Spanish meaning of the IH "fin", which means end, but the language context provided by the sentence biases an English interpretation, which in this case is the appropriate one. We could test whether words related to each of these meanings are primed relative to controls at various time points. Based on the number of alternatives constrained by a particular type of context (Kawamoto, 1993), language context is predicted to be less influential than semantic context because of a fan-type effect (e.g., Anderson, 1974, 1983), but the particular time-course of their influence awaits empirical investigation.

To illustrate how language membership can interact with frequency, we can consider the German/English ambiguous cognate "bank". This lexical form has two meanings in English (financial institution, called M1; edge of a river, called M2) and two meanings in German (financial institution, M1; bench, called M3).[1] To make this example more concrete, the norming data collected by Elston-Güttler (2000) demonstrated that in English, the relative dominance of M1 and M2 is 85:7, whereas the relative dominance in German of M1 to M3 is 61:35. Assume for simplicity that the word is equally frequent in German and English for German–English bilinguals. The relative frequency of the different meanings therefore will be 146 for M1 (combining German and English), 35 for M3, and 7 for M2. When German–English bilinguals encounter the lexical form "bank" in isolation in an English lexical context (e.g., in an English lexical decision task), the different meanings may be activated at different time points depending on the strength of frequency and language context. It could be that frequency is a stronger factor, and therefore the meanings would be activated in the order M1, M3, M2 (financial institute, bench, edge of a river). Alternatively, if language context plays a stronger role, the order may be M1, M2, M3 (financial institution, edge of a river, bench), because the English meanings would receive more activation than the German ones. As this example shows, the relative strength of the different factors will affect how bilinguals process ambiguous words. The notion that lexical access is nonselective suggests only that all three meanings will be activated, but it does not speak to the relative activation of these meanings.

As discussed in the individual differences section, the pattern of interactions among the three factors may vary as a function of skill. Some individuals may be less sensitive to the influence of language context (e.g., bilinguals who code-switch often), or more sensitive to frequency (e.g., bilinguals in their L2). A complete characterization of the influence of frequency, semantic context, and language context should consider the characteristics (experience and cognitive abilities) of the individuals performing the task.

Furthermore, to accurately tap these different patterns of interactions, the time-course of activation should be considered. The research on within-language ambiguity has addressed this by manipulating SOA (e.g., Onifer & Swinney, 1981) and more recently by employing methodologies such as ERP and eye tracking that are especially sensitive to time-course (e.g., Duffy et al., 1988; Meyer & Federmeier, 2007, 2008; van Petten & Kutas, 1987). The research on cross-language ambiguity lags behind, in that only four ERP studies (de Bruijn, Dijkstra,

[1]We assume here a shared meaning representation for words in the two languages, in accordance with most current bilingual models (for a review, see Kroll & Tokowicz, 2005), although the "financial institution" concept may be somewhat different in each language, such that subtleties may exist in the particular set of meaning features emphasized in each language (e.g., de Groot, 1992).

Chwilla, & Schriefers, 2001; Elston-Güttler et al., 2005a; Kerkhofs, Dijkstra, Chwilla, & de Bruijn, 2006; Paulmann et al., 2006) and two eye-tracking studies (Libben & Titone, 2009; Nakayama & Archibald, 2005) have examined IH processing.

Summary and future cross-language ambiguity research

Bilinguals are faced not only with ambiguity within each of their languages, but also with ambiguity that crosses the language boundary. The current review has focused on such cross-language ambiguities in the form of IHs, which share lexical form but not meaning in the two languages. Before summarizing what we know about the processing of these words, it is important to keep in mind one other type of ambiguity with which bilinguals are presented. *Translation ambiguity* refers to the existence of indirect mappings between translations, such that a word in one language can be translated into more than one word in another language. This translation ambiguity can occur because of within-language near-synonymy (e.g., the word "sofá" in Spanish can be translated into English as both sofa and couch), but more important for the current discussion, it can also be a direct consequence of within-language ambiguity. In particular, an ambiguous word in one language rarely corresponds to one word in another language (Frenck-Mestre & Prince, 1997); more commonly, each meaning is translated into a different word in another language. This is especially the case for ambiguous words with two unrelated meanings (e.g., organ), which presumably were accidentally created (Rodd et al., 2002), but it can also be the case for polysemous words with related senses. For bilingual individuals, such translation ambiguity may exaggerate or strengthen the already-present within-language ambiguity, and it clearly presents difficulty in processing relative to unambiguous translations (e.g., Tokowicz & Kroll, 2007; Tokowicz, Prior, & Kroll, 2009, in a translation production task; see also Degani & Tokowicz, in press, in a vocabulary training paradigm). Although translation ambiguity is widely prevalent (e.g., Prior, MacWhinney, & Kroll, 2007, for Spanish/English; Tokowicz et al., 2002, for Dutch/English), there is relatively little research examining how bilinguals process such ambiguities. In addition to its significance in understanding how bilinguals process their languages and how they process ambiguity in particular, translation ambiguity also provides a tool to examine some issues that are harder to study within a language, as is described in the next section.

Focusing on IHs, there are several observations that can be made on the basis of the current review. Most prominently, IHs have informed the debate between selective- and nonselective-access accounts in bilinguals and for the most part have provided strong support for nonselective-access accounts. In the majority of the studies reviewed in the Appendix, there was evidence for activation of the nontarget-language reading of the IHs.

It appears that the meanings in the nontarget language are active and compete for selection during word recognition. However, as mentioned above, the mere presence of activation does not rule out the possibility that language context could influence the degree of activation. Furthermore, the relative role of language membership information compared to frequency and semantic context in influencing lexical access remains to be examined.

In particular, studies that examined cross-language ambiguity have only drawn parallels to the within-language ambiguity research by making comparisons across studies (e.g., Greenberg & Saint-Aubin, 2004), but these two subtypes of ambiguity have not been examined jointly. It is pivotal to test both within- and cross-language ambiguities in the same individuals using the same task. By including both "monolingual" and "bilingual" items (e.g., Schwartz et al., 2008), we would be able to make more direct comparisons. Further, if the influential strength of the different factors (frequency, semantic context, and language membership context) is to be examined, it would be useful to manipulate all of them in the same study (see Marian & Spivey, 2003, for a comparison of within- and cross-language competition in the same study).

The review also suggests that IHs are not uniform. Rather, they overlap in orthography, phonology, and semantics to various degrees. Whereas several studies set out to examine the influence of orthographic and phonological overlap as a continuous measure (e.g., Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004), semantic similarity was taken to be an all-or-none factor. Cognates (which share semantics) were dichotomously distinguished from IHs. Because degree of semantic similarity was shown to affect how within-language ambiguity is processed (e.g., Rodd et al., 2002), and because the meanings of cross-language pairs (cognates, IHs, and partial-false-friends) may be more or less similar across the two languages (e.g., Schwartz, 2003, for IHs and partial false friends; Tokowicz et al., 2002, for cognates), it is essential to examine semantic overlap as a continuous variable in future cross-language ambiguity research.

The range of overlap in phonology and orthography of IHs clearly depends on the particular pair of languages examined. The existence of shared script, as well as the proportion of words with form overlap in a given pair of languages, is likely to affect their processing (e.g., Gollan et al., 1997). Unfortunately, there has been little variation in the pairs of languages examined in research on this issue. The vast majority of the studies have been conducted with Dutch–English bilinguals and have therefore drawn from the same pool of Dutch/English IHs. Indeed, Dijkstra et al. (2000b) reported that there are 1,087 three- to six-letter words that are orthographically identical in Dutch and English, and that only 212 of them are IHs. How the findings replicate in other pairs of languages and with other sets of items remains to be tested.

Furthermore, with the exception of four ERP studies, one functional magnetic resonance imaging (fMRI) study, and two eye-tracking studies, the cross-language ambiguity results are based only on behavioural measures. The field would benefit greatly from additional converging evidence from multiple measures, in particular with respect to time-course. This converging evidence could help disentangle effects occurring at the initial activation phase versus later selection and integration processes.

Lastly, there are several issues that have become central in the within-language ambiguity research and have been left unexamined in the cross-language domain. These include whether there are hemispheric differences in the resolution of semantic ambiguity (e.g., Faust & Chiarello, 1998; Peleg & Eviatar, 2008) and whether there are individual differences, other than proficiency per se, in ambiguity processing (e.g., Gunter et al., 2003). Moreover, recent within-language ambiguity studies have investigated whether the nonselected meaning of an ambiguous word simply decays in its activation or whether it is actively suppressed (e.g., Gernsbacher & St. John, 2001; Nievas & Marí-Beffa, 2002). It would be interesting to examine whether the nontarget-language meanings of IHs behave like the nonselected meanings of within-language ambiguous words.

Significance for ambiguity research in general

This review has mainly focused on how current conceptualizations in the domain of within-language ambiguity processing can inform and guide research on cross-language ambiguity. Nonetheless, there are several ways in which cross-language ambiguity research can provide a platform to examine issues relevant for understanding ambiguity processing in general.

As mentioned above, the indirect mapping between languages creates numerous situations in which a word from one language corresponds to more than one translation in the other. This translation ambiguity stems to a large degree from within-language lexical ambiguity and from near-synonymy. Both lexical ambiguity and near-synonymy involve an indirect mapping between form and meaning, and many of the processes (such as competition and selection) are relevant to both (as pointed out by Peterson & Savoy, 1998). However, in within-language research, these two types of one-to-many mappings have been investigated separately, with lexical ambiguity studied in recognition and near-synonymy studied in production. The existence of translation ambiguity allows one to compare the effects of lexical ambiguity and near-synonymy in the same task (e.g., Degani & Tokowicz, in press; Tokowicz et al., in press). Furthermore, translation ambiguity stemming from near-synonymy provides an opportunity to examine near-synonymy for both pictureable and nonpictureable concepts by using translation tasks, which is not possible in the picture-naming task traditionally used within a language.

Similarly, translation ambiguity can inform the discussion on the nature of representations that underlie the two meanings or senses of homonyms and polysemous words (Klein & Murphy, 2001; Klepousniotou et al., 2008). The fact that one language uses two labels to refer to two senses implies that two separate representations underlie the two senses for speakers of that language. By comparing ambiguous words that map to one translation in the other language (e.g., the English word "second" is translated into Hebrew as "shnia", which encompasses both of its meanings) to ambiguous words that map to two separate translations (e.g., "bark" is translated into Hebrew as "nevicha" to denote the sound a dog makes and "klipat etz" to denote the outer layer of a tree) one can examine whether these meaning representations differ.

Cross-language ambiguity may inform ambiguity research in general because it includes potentially more complex ambiguous words. For instance, it is conceivable that processing of homographs with two meanings of the same POS would be somewhat different from processing of ambiguous words with meanings that belong to two different grammatical categories (e.g., Simpson, 1984). This issue was in fact examined by Elston-Güttler and Friederici (2005, 2007) who found that whether the two meanings of homonyms belong to the same POS or not bears little influence on the results (despite evidence suggesting that even less proficient bilinguals are sensitive to differences in grammatical class; Sunderman & Kroll, 2006). Cross-language ambiguity provides a larger sample of items for which these constraints exist, in which IHs' meanings belong to the same or different POS in the two languages. Using cross-language ambiguity, one can further investigate whether meanings belonging to different grammatical categories are represented or processed differently. Unfortunately, only two studies (Greenberg & Saint-Aubin, 2004, 2008) examined IHs whose meanings differ in POS, but these were not compared to IHs with the same POS. (For effects of POS in translation ambiguity, see Prior et al., 2007.)

One final area in which cross-language ambiguity may inform ambiguity research in general is in exploring the interactions between factors. To illustrate, the SBE (Rayner et al., 1994) is a case in which context and frequency are put into conflict. Several attempts have been made to eliminate the SBE by increasing the strength of context (for a discussion, see Duffy et al., 2001). Despite these attempts, it appears that the SBE is persistent especially for highly polarized ambiguous words. It is possible, however, that a combination of cross-language activation and semantic context can overcome the effect of frequency. Indeed, Schwartz and colleagues (Schwartz et al., 2009; Schwartz et al., 2008) have recently shown that cross-language activation can enhance the competition not only from the dominant meaning, but also from the subordinate meaning. Specifically, ambiguous cognates were presented in sentences biasing the subordinate meaning. Importantly, these cognates shared only the dominant meaning across languages (e.g., the English word "novel" translates into Spanish as "novela", which means story but not something new). Thus, the dominant meaning was boosted by cross-language activation, and the competition it created to the subordinate meaning was even higher (i.e., strengthening the SBE). Moreover, when ambiguous cognates that share the subordinate meaning with Spanish were presented in sentences biasing the dominant meaning (Schwartz et al., 2009), this subordinate meaning was more available to participants than that of noncognate ambiguous words. This led the authors to propose that the contribution of cross-language activation should be considered along with frequency and context in processing of cross-language ambiguity.

Conclusion

The goal of the current review was to integrate the discussion on within-language and cross-language ambiguity to inform ambiguity research in general. The important factors that have been identified in research on within-language ambiguity, such as frequency and semantic/syntactic context, seem to play an important role in cross-language ambiguity as well. Furthermore, an approach that considers the interaction of these factors may be especially revealing and should be extended to include language context as a potentially influencing factor. The proposed three-factor framework allows one to evaluate the relative strength of these three factors. However, more empirical evidence is needed before the particular configuration of the weights of these factors can be determined. Moreover, this configuration is likely to vary with individual differences and task demands.

Within-language ambiguity research has provided insight into our understanding of cross-language ambiguity. The analysis of tasks as differing in degree of precision, for instance, and the attention to the similarity between meanings, appear to be highly relevant for cross-language ambiguity research. On the other hand, cross-language ambiguity offers a unique opportunity to examine some issues that are more difficult to test within a language, such as the combination of near-synonymy and semantic ambiguity and whether subordinate meanings can overcome dominant meanings in the SBE. Still other issues, such as the direction of influence, appear to be unique to cross-language ambiguity.

"It is most parsimonious to regard cross-language ambiguity and within-language ambiguity as two special cases of lexical ambiguity in general and, hence, to argue that these two types of ambiguity are resolved in similar ways (i.e., based on the activation of meaning representations)" (de Groot et al., 2000, p. 423). There is therefore a great need for studies that test both within- and cross-language ambiguity in the same individuals. These future investigations will help estimate how similar these two ambiguity subtypes really are and will surely highlight some interesting constraints for ambiguity processing in general.

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APPENDIX

Studies examining interlingual homograph processing

App.	*Study*	*Task*	*Measure*	*Language*	*Context*	*IH result*	*Notes*
1	Dijkstra et al., 2005, Exp. 1	English LDT	RT/Acc	Du/En	none	En MFS & freq facilitation, Du MFS & freq inhibition	
1	Dijkstra et al., 2005, Exp. 2	generalized LDT	RT/Acc	Du/En	none	En and Du MFS & freq facilitation	
1	Dijkstra et al., 2005, Exp. 3	Dutch LDT	RT/Acc	Du/En	none	Du MFS & freq facilitation, En MFS & freq inhibition	looked at L2 on L1
1	Greenberg & Saint-Aubin, 2004	letter detection	Acc	Fr/En	Passages; Exp. 2 scrambled text	omissions based on POS in target lang.; null in Exp. 2 with scrambled text	suggests the effects are postlexical
1	Greenberg & Saint-Aubin, 2008	letter detection	Acc	Fr/En	Fr/En sentences intermixed	omissions based on POS in target lang.	suggests the effects are postlexical
1,2	de Groot et al., 2000, Exp. 1	translation recognition	RT/Acc	Du/En	none	interference, especially for less freq meaning	
1,2	de Groot et al., 2000, Exp. 2	Dutch LDT/ English LDT	RT/Acc	Du/En	none	null (sig interference for low-freq Du, *ns* facilitation for low-freq En)	without nonwords from nontarget lang; looked at L2 on L1
1,2	de Groot et al., 2000, Exp. 3	Dutch LDT/ English LDT	RT/Acc	Du/En	none	RT & Acc interference for low-freq reading	with nonwords from nontarget lang; looked at L2 on L1
1,2	Dijkstra, Timmermans, & Schriefers, 2000b, Exp. 1	language decision	RT/Acc	Du/En	none	interference, size of effect affected by freq ratio	
1,2	Dijkstra, Timmermans, & Schriefers, 2000b, Exp. 2	English LDT go/ no-go	RT/Acc	Du/En	none	interference, size of effect affected by freq ratio	
1,2	Dijkstra, Timmermans, & Schriefers, 2000b, Exp. 3	Dutch LDT go/ no-go	RT/Acc	Du/En	none	interference, size of effect affected by freq ratio	looked at L2 on L1
1,2	Gerard & Scarborough, 1989	LDT Spanish then English or vice versa	RT/Acc	Sp/En	none	RT determined by target lang. freq only	

(*Continued overleaf*)

Appendix. Continued.

App.	*Study*	*Task*	*Measure*	*Language*	*Context*	*IH result*	*Notes*
2	Altarriba et al., 1992	naming RSVP	RT/Acc	Sp/En	sentence biasing target/nontarget-language meaning	interference in L2; in L1 interference only when context biased the nontarget (L2) meaning	looked at L2 on L1
2	Dijkstra et al., 2000a	English LDT	RT/Acc	Du/En	none	interference only after Du words were presented as nonwords (Phase 2), despite instructions informing about inclusion of Du fillers	
2	Dijkstra et al., 1999, Exp. 1	English PDM	RT/Acc	Du/En	none	O facilitation in RT, interference in Acc, OP and P interference in RT	phonological inhibition
2	Dijkstra et al., 1999, Exp. 2	English LDT	RT/Acc	Du/En	none	O facilitation in RT & Acc, OP interference in Acc, P interference in RT & Acc	phonological inhibition
2	Dijkstra et al., 1998, Exp. 1	English LDT	RT/Acc	Du/En	none	IH null (but cognate facilitation)	
2	Dijkstra et al., 1998, Exp. 2	English LDT	RT/Acc	Du/En	none	interference, modulated by Du freq	Du words as nonwords
2	Dijkstra et al., 1998, Exp. 3	generalized LDT	RT/Acc	Du/En	none	IH facilitation relative to En control but not Du control	
2	Libben & Titone, 2009	English reading	eye movements	Fr/En	sentences biasing the En meaning	interference in early & late comprehension measures (e.g., first-fixation and total reading time, respectively) in low-constraint sentences. Interference in early measures only in high-constraint sentences.	
2	Jared & Szucs, 2002	naming	RT/Acc	Fr/En	none	in a pure En block, interference for En/Fr bilinguals only in Acc but for Fr/En bilinguals in RT & Acc. Following a Fr block, interference for all bilinguals in RT & Acc.	collapse heterophonic cognates & IH; looked at L2 on L1
2	Lemhöfer & Dijkstra, 2004, Exp. 1	English LDT	RT/Acc	Du/En	none	O facilitation (sig only by participants in RT), OP interference in Acc. P no difference	
2	Lemhöfer & Dijsktra, 2004, Exp. 3	generalized LDT	RT/Acc	Du/En	none	O/OP facilitation in RT/acc relative to En control, but not to Du control, P slower than Du control	
2	Nakayama & Archibald, 2005	English reading	eye movements	Du/En	neutral sentence	first-fixation and gaze duration facilitation	

2	Schwartz & Kroll, 2006	English naming RSVP	RT/Acc	Sp/En	sentences biasing the En meaning	interference in Acc (null in RT) only for less proficient bilinguals regardless of sentence constraint	
2	Smits et al., 2006	naming	RT/Acc	Du/En	none	interference in RT & Acc in mixed list. In pure En list interference in Acc, null in RT. Effects modulated by freq ratio	mixed vs. pure lists b/w participants; heterophonic IH
2	van Heuven et al., 2008 (task A)	English LDT	fMRI/RT	Du/En	none	interference in RT (null in Acc), fMRI: greater activation in LIPC and preSMA/ACC	task manipulated b/w participants
2	van Heuven et al., 2008 (task B)	generalized LDT	fMRI/RT	Du/En	none	null in RT, facilitation in Acc, fMRI: greater activation in LIPC	task manipulated b/w participants
2	von Studnitz & Green, 2002	English LDT	RT/Acc	Ge/En	none	interference larger with Ge words as nonwords and when informed about IH at the beginning of experiment	also looked at carry-over effects
3	Beauvillain & Grainger, 1987, Exp. 1	primed English LDT (IH as prime)	RT/Acc	En/Fr	word pairs	sig priming to En meaning at 150-ms SOA, *ns* at 750-ms	instructed to read prime in French
3	Beauvillain & Grainger, 1987, Exp. 2	primed LDT (IH as prime)	RT/Acc	Fr/En	word pairs	priming to targets related to the higher freq reading of IH	looked at L2 on L1
3	de Bruijn et al., 2001	primed generalized LDT (IH as second prime)	ERP N400/RT	Du/En	word triplets	priming (RT+N400 modulation) to Word 3 (En) when related to En meaning of IH (Word 2), regardless of language prime (i.e., Word 1)	
3	Elston-Güttler, Gunter, & Kotz, 2005a	primed English LDT (IH as prime at the end of a sentence)	ERP N200/ N400/ RT	Ge/En	sentences biasing the En meaning	RT, N200, N400 priming to nontarget (Ge-L1) meaning of IH only in first part of study following an L1 film	
3	Paulmann et al., 2006	primed LDT (IH as prime)	ERP N400/RT	Ge/En	none	RT, N400 priming to nontarget (Ge-L1) meaning of IH regardless of whether a film presented in L1/L2	
1,3	Kerkhofs et al., 2006	primed English LDT on IH	ERP N400/RT	Du/En	word pairs	increased RT & N400 priming with freq in target lang., decreased priming with freq in nontarget lang.	looked at priming for target-lang. meaning

Note: IH = interlingual homographs. App. = approach: 1 = comparing IH with differences in characteristics in target and nontarget language; 2 = comparing IH to one-language controls; 3 = examining activation of the specific meanings of the IH. See text for more details. LDT = lexical decision task; PDM = progressive demasking; MFS = morphological family size; Freq = frequency; POS = part of speech; Sig = significant, *ns* = nonsignificant; En = English; Du = Dutch; Sp = Spanish; Fr = French; Ge = German; O = orthographic overlap only; P = phonological overlap only; OP = orthographic and phonological overlap; LIPC = left inferior prefrontal cortex; ACC = anterior cingulate cortex; preSMA = presupplementary motor area; RSVP = rapid serial visual presentation; RT = reaction time; Acc = accuracy; fMRI = functional magnetic resonance imaging; ERP = event-related potential; lang. = language.