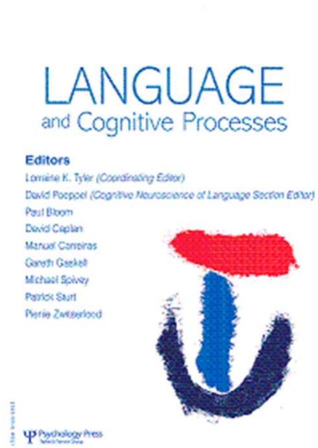

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Cognate and word class ambiguity effects in noun and verb processing

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Abstract

This study examined how noun and verb processing in bilingual visual word recognition are affected by within and between-language overlap. We investigated how word class ambiguous noun and verb cognates are processed by bilinguals, to see if co-activation of overlapping word forms between languages benefits from additional overlap within a language, and whether this effect is sensitive to the grammatical category of a word. Although effects of form overlap are ubiquitous in studies on nouns, little is known about such effects in verbs. In two experiments, Dutch-English bilinguals performed lexical decision tasks in L2 in which cognate status and word class ambiguity were manipulated in nouns and verbs. Responses to verb targets in both experiments showed facilitatory effects of both types of overlap. In contrast, noun targets in both experiments showed only a cognate effect, but no ambiguity effect. We argue that the difference between verbs and nouns arises because verb representations are more complex than those of nouns. As a consequence, verb processing benefits more from within language form overlap than noun processing.

Cognate and word class ambiguity effects in noun and verb processing

Bilingual readers are commonly faced with overlapping word forms in one or both of their languages. For instance, for Dutch-English bilinguals the word form ‘dance’ in their second language (L2) English is similar to the first language (L1) Dutch translation equivalent ‘dans’. In bilingual processing, such translation equivalents with form overlap, referred to as cognates, are recognized faster relative to words that have no such overlap, referred to as non-cognates (e.g., Lemhöfer et al., 2008). Apart from having semantic, orthographic, and phonological overlap across languages, the word ‘dance’ is also syntactically ambiguous within a language, because its word form is shared between two word classes, as it can occur both as a noun (‘the dance’) and a verb (‘they dance’). For these word class ambiguous items (or nounverbs), a similar processing advantage is observed in monolingual word recognition when the meaning and form of the noun and verb readings are (partially) shared (e.g., Rodd, Gaskell, & Marslen-Wilson, 2002). The same or similar words can thus belong to different syntactic categories, and to different languages, both of which can speed up processing in visual word recognition. This ought to have consequences for the bilingual processing of cognates that belong to multiple syntactic categories.

Despite a great interest in word class ambiguity in the monolingual domain (e.g., Burton, Krebs-Noble, Gullapalli, & Berndt, 2009; Federmeier, Segal, Lombrozo, & Kutas, 2000; Lee & Federmeier, 2006, 2009; Rodd et al., 2002; Snijders et al., 2009) and a recent upsurge of interest in cross-language overlap in the field of bilingualism (e.g., Beauvillain & Grainger, 1987; Dijkstra, Grainger, & Van Heuven, 1999; Duñabeitia, Perea, & Carreiras, 2010; Haigh & Jared, 2007; Van Hell & De Groot, 1998; Schwartz, Kroll, & Diaz, 2007), there are few bilingual studies that have considered the consequences of the combination of within-language and between-language lexical overlap for word recognition (e.g., Baten, Hofman, & Loeys, 2010). Moreover, by far the most evidence for the cognate effect has been obtained with noun stimuli. As a consequence, theoretical accounts on cognate representations are almost exclusively based on this item category. Nevertheless, linguistic and neurolinguistic studies point to differences between noun and verb processing (see Cappa & Perani, 2003; Druks, 2002; Vigliocco, Vinson, Druks, Barber, & Cappa, 2011, for reviews) and findings on representations and processing based on noun data do not always generalize to verbs (see Pickering & Frisson, 2001).

The present study addresses this gap in scientific knowledge by examining processing consequences of word class ambiguity and cognate status in nouns and verbs. Specifically, it considers the processing of words such as ‘dance’, which have largely overlapping forms and meanings between languages in combination with being ambiguous with respect to word class within a language. We were primarily interested to see how additional within-language overlap influenced effects of cross-language overlap. Secondly, the use of nouns and verbs allowed us to look at processing differences between these two word classes for bilinguals. To set the stage for our experiments, we first review the literature with respect to cognate processing before zooming in on differences between noun and verb processing.

Cognate processing

A large number of studies in the field of bilingual word recognition have provided evidence for activation of non-target language items when processing in only one language (see De Groot, 2011, Chapter 4 of for an overview). Non-target activation has been found for items with shared forms in the absence of semantic overlap, for example, in the case of interlingual homographs (e.g., Beauvillain & Grainger, 1987; Dijkstra, Moscoso del Prado Martín, Schulpen, Schreuder, & Baayen, 2005; Haigh & Jared, 2007) and interlingual homophones (Lagrou, Hartsuiker, & Duyck, 2011; Schulpen, Dijkstra, Schriefers, & Hasper, 2003). At the same time, priming studies also show cross-language effects for translation equivalents without any form overlap (e.g., Dimitropoulou, Duñabeitia, & Carreiras, 2011). Yet, bilingual lexical activation is most apparent when both semantics and form overlap between languages, as in the case of cognates. Relative to non-cognates, cognates are usually processed more quickly and more accurately, which is referred to as the cognate (facilitation) effect (e.g., Dijkstra et al., 1999; Dufour & Kroll, 1995; Lemhöfer et al., 2008; Yudes, Macizo, & Bajo, 2010). Cognate facilitation is not only found in L2, but also in L1 processing (Van Assche, Duyck, Hartsuiker, & Diependaele, 2009; Van Hell & Dijkstra, 2002), although it is usually larger for processing in L2 than in L1. Furthermore, the effect increases when a word is shared among more than two languages (Lemhöfer, Dijkstra, & Michel, 2004) and is sensitive to a participant's proficiency in a non-target language (see Van Hell & Tanner, in press, for a review).

The cognate effect is taken as evidence for language non-selective access (e.g., Dijkstra, 2005), meaning that representations in each of a bilingual's languages are co-activated upon reading a cognate. Such language non-selective processing assumes separate orthographic representations in the two languages, linked to a largely overlapping or shared semantic representation (e.g., Dijkstra & Van Heuven, 2002). Upon seeing a cognate, orthographic, phonological, and semantic representations in both languages are activated. Due to interactions between the semantic level and the orthographic level, activation patterns are stronger for cognates in comparison to non-cognates, resulting in faster recognition for the former (e.g., Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Lemhöfer & Dijkstra, 2004; Libben & Titone, 2009).

Facilitatory processing of cognates is found when their forms are fully overlapping between languages or when they are very similar, although the effect tends to be more pronounced for the former cognate type. Several studies have shown that the magnitude of the cognate effect increases with greater orthographic similarity between two readings of a cognate (e.g., Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010; Duyck et al., 2007). For this reason, the cognate effect is generally explained on the basis of the orthographic overlap between translation equivalents. Apart from the form overlap effect in terms of orthography, phonology has also been shown to play a role in cognate effects. Studies by Dijkstra, Miwa, Brummelhuis, Sappelli, and Baayen (2010) and Schwartz, Kroll, and Diaz (2007) showed that increased phonological overlap further speeded up responses for orthographically identical cognates (but cf. Dijkstra et al., 1999; Lemhöfer & Dijkstra, 2004). Furthermore, there is evidence that increased phonological overlap in the absence of orthographic overlap leads to larger cognate facilitation, as shown by cross-script cognate effects (Gollan, Forster, & Frost, 1997; Hoshino & Kroll, 2008; Voga & Grainger, 2007). Cognate processing thus benefits more generally from overlap at a lexical level.

In addition to lexical overlap, cognates may also benefit from more conceptual or semantic overlap compared to non-cognates (see Francis, 2005, on the semantic/ conceptual distinction; we shall use the term 'semantic' here). It is commonly assumed that semantics of translations equivalents are shared irrespective of form overlap between two word forms (e.g., Altarriba, Kroll, Sholl, & Rayner, 1996). However, semantic associations for cognates are assumed to be stronger than for non-cognates. Because of their striking resemblance in form, L2 cognate translation equivalents can be mapped more readily onto existing L1 representations (Van Hell & De Groot, 1998; see also Degani, Prior, & Tokowicz, 2011, for evidence suggesting that form overlap in L1 affects semantic representations in L2). In this interpretation, cognate translation equivalents are more semantically similar across languages than non-cognate pairs. Because activation patterns in word recognition result from interactions among semantic, orthographic, and phonological features, the combination of overlap at multiple levels gives rise to faster activation for cognates.

Effects of syntactic category have so far not been examined for cognates. Little is known about cognate representations for item categories other than (concrete) nouns, which are the items that accounts of bilingual activation in the word recognition literature are based on. We do not know, however, in how far conclusions for noun cognates also hold for verbs, which are more language specific with respect to both form and meaning. Therefore, the present study examines the recognition of both noun and verb cognates. Below we will give an overview of studies that have found representation and processing differences between nouns and verbs.

Noun and verb processing

Nouns and verbs constitute distinct word categories in language, and there are several linguistic differences between nouns and verbs (see Druks, 2002) that impact their processing in both monolinguals and bilinguals. Generally, nouns refer to objects while verbs refer to actions or events. Furthermore, the meaning of nouns is less variable than that of verbs (Gentner, 1981; Reyna, 1987) as nouns are assumed to have denser connections between properties in a distributed network (Tyler, Russell, Fadili, & Moss, 2001). In contrast, verb meaning is more often defined relative to context (Gentner, 1981) and more often polysemous than that of nouns (Miller & Fellbaum, 1991). Verbs are also considered to be structurally more complex than nouns, because they contain information on the number and kinds of arguments a verb can take, such as agent, theme, and goal (Grimshaw, 1990). Furthermore, nouns and verbs differ in terms of morphology. The morphological family size of nouns is larger than that of verbs (De Jong, Schreuder, & Baayen, 2000). More prominently, English nouns are generally inflected with a plural marker (-s), whereas English verbs can be inflected in a number of ways with markings for tense, aspect, and number, resulting in differential forms for the continuous, past tense, or third person singular (-ing, -ed, -s). These forms are even more diverse for irregular verbs. Differences between nouns and verbs may therefore be explained by differences in the complexity of representations in terms of form and meaning. Verbs are commonly considered to be "psychologically more complex and therefore more difficult to process than nouns" (Pickering & Frisson, 2001, p. 557) and even termed "the most complex lexical category" (Miller & Fellbaum, 1991, p. 214). In light of these complexity differences, it is not surprising that nouns are typically learned earlier than verbs (Gentner, 1981; Li, Jin, & Tan, 2004). There is also evidence that the more complex nature of verbs results in slower processing as compared to nouns in both the monolingual (Gentner, 1981; Tyler et al., 2001, Experiment 1; but see Burton et al., 2009) and the bilingual domain (Baayen, McQueen, Dijkstra, & Schreuder, 2003; Van Hell & De Groot, 1998).

Differential processing according to word class can be related to differences at underlying semantic and syntactic levels. Semantic differences between nouns and verbs can be explained by differences on the concrete - abstract dimension (see Federmeier et al., 2000). Verbs are considered as more abstract, whereas nouns are usually more concrete. The distinction between objects (nouns) and actions (verbs) is similarly semantic in nature, corresponding to sensori-motor accounts of language processing. These distinguish word classes in terms of their semantic associations, based on neuro-imaging evidence showing visual activation for nouns, and motor activation for verbs (e.g., Pulvermüller, Lutzenberger, & Preissl, 1999). Yet, other authors argue for a distributed representation of semantic information that is not specified for word class and attribute the differences between nouns and verbs to a syntactic level of representation (Tyler et al., 2001; Tyler, Bright, Fletcher, & Stamatakis, 2004; see also Damasio & Tranel, 1993). The distinction between nouns and verbs has also been linked to differences at multiple levels, i.e., in terms of stored representations at semantic and word form levels, as well as word class specific morphological processing (Shapiro & Caramazza, 2003). In an extensive review of noun and verb studies, Vigliocco et al. (2011) conclude that there are processing differences between the two word classes in that verbs are more complex in terms of semantics, syntax, and morphology, leading to greater processing demands for verbs than for nouns. This implies that representations for noun are more likely to be directly activated than those for verbs (see De Bleser & Kauschke, 2003 for converging evidence from aphasics).

In case of bilingual processing, differences according to word class are likely to be influenced by differences in crosslinguistic similarity between noun and verbs. Nouns are more semantically similar between languages than verbs (Van Hell, 2002), which implies that cross-language differences between verb cognates are greater than those between noun cognates. Semantic differences among word types for bilinguals in terms of grammatical class, cognate status, and concreteness have been examined by Van Hell and De Groot (1998). They compared the similarity of within-language and between-language performance on a word association task. Dutch-English bilinguals were asked to associate to nouns and verbs that varied in terms of cognate status and concreteness. For example, when given the word ‘skirt’, participants could respond by saying ‘dress’ in the within-language word association task or by mentioning the Dutch translation of ‘dress’ in the between-language version of the task. The number of times within-language associations generated the same responses (meaning equivalents) as the between-language associations was higher for nouns compared to verbs, for cognates compared to non-cognates, and for concrete words compared to abstract words. This finding again indicates a processing advantage for nouns in comparison to verbs, which in a distributed account is interpreted as evidence for sharing of more features between languages for nouns as compared to verbs (Van Hell & De Groot, 1998). In the case of cognates, Dutch-English verb translation equivalents are also less cross-linguistically similar than noun cognates with respect to orthography (see Dijkstra et al., 2010) in addition to being less similar across languages concerning semantics.

So far, we have established that there are differences between nouns and verbs, but with respect to word class representations, a further distinction can be made. Certain words cannot unambiguously be classified as either noun or verb, because they share a word form, such as the ambiguous word form ‘dance’. Such nounverbs are widely available in English (e.g., Clark & Clark, 1979). There is electrophysiological evidence to suggest that unambiguous nouns and verbs are processed differently from ambiguous nounverbs even in a syntactically disambiguating context (Federmeier et al., 2000; Lee & Federmeier, 2009; see Burton et al., 2009, for related neuro-imaging findings). In order to draw a complete picture of noun and verb representations, we must therefore also consider these word class ambiguous items. Here, it is important to distinguish semantically ambiguous items, such as ‘a watch’ and ‘to watch’ (referred to as noun-verb homonyms) from semantically similar items, such as ‘a drink’ and ‘to drink’. In a review of studies on semantically ambiguous word items including nounverbs, Rodd et al. (2002) showed that processing is different for polysemous words, which are related in meaning, compared to homonyms, which have unrelated meanings. When processed in isolation, ambiguous words with multiple related meanings (e.g., ‘twist’) yielded facilitatory processing for monolinguals (see also Beretta, Fiorentino, & Poeppel, 2005; Rodd, Gaskell, & Marslen-Wilson, 2004). In contrast, ambiguous words with multiple unrelated (e.g., ‘bark’) meanings caused a delay in recognition. Finding an ambiguity advantage only for polysemous words implies that, similar to co-activation between languages, the within-language effect is dependent on the degree of overlap in terms of form and meaning. The present study only considers semantically related items (see Degani & Tokowicz, 2010, for an overview of research on semantically ambiguous items).

Although no study so far has explicitly tested word class ambiguity effects in bilingual word recognition, there is some evidence for activation across word categories in bilinguals. Sunderman and Kroll (2006) found an effect of grammatical class in a task that involved bilingual participants making a translation judgement to form or meaning related words. Critical items were word pairs that consisted of a Spanish word and an English word that was form related to the correct translation of the Spanish word (translation neighbour), or was form related to the Spanish word itself (lexical neighbour); the English neighbour words could be from the same or a different word class as the Spanish word. An example word pair is the Spanish verb ‘corre’ (English ‘runs’) in combination with the translation neighbour ‘rug’ or the lexical neighbour ‘coral’. The results for such items showed less lexical interference when the two words of each pair were drawn from different grammatical classes, as the verb and noun combination in the example. This suggests that the link between neighbouring words from two different word classes is not as strong as the link between neighbouring word forms of the same word class.

Further evidence for cross category activation in bilingual processing comes from studies investigating homophones and homographs. A recent study by Vandeberg, Guadalupe, and Zwaan (2011) indicated an interlingual homophone effect in auditory comprehension for overlapping word forms that belong to different syntactic categories across languages. For example, when presented with a sentence containing the English verb form ‘spoke’, bilinguals were shown to activate the phonologically similar Dutch noun ‘spook’, meaning ghost. Another study by Baten et al. (2010) compared processing of Dutch-English homographs that share word classes between languages (e.g., the English noun ‘tree’, meaning ‘step on a staircase’ in Dutch) to that of homographs of different word classes in two languages (e.g., English adjective ‘big’, meaning ‘piglet’ in Dutch). More cross-language facilitation was reported for homographs that belong to one and the same word class. In spite of these findinds, it is not clear how the bilingual lexicon represents semantically similar words that are largely overlapping both within and between languages, and how representational differences between nouns and verbs may influence processing of these items. We therefore investigated such cognate effects in word class ambiguous and unambiguous nouns and verbs.

The present study

Both cognates and word class ambiguous items have been shown to yield faster processing. The available evidence indicates that both monolingual and bilingual processing benefit from the presence of multiple form and meaning related entries in the lexicon. So far, however, no study has considered the combined effects of lexical overlap between languages and grammatical overlap within a language. To test the claim that both between and within-language overlap lead to a facilitatory effect in bilingual word processing, we examined effects of cognate status in combination with word class ambiguity. We tested these effects in nouns and verbs, because previous studies have indicated differences between nouns and verbs in terms of complexity of processing. These differences may affect the extent to which cognate status and word class ambiguity affect processing of nouns and verbs.

Two lexical decision tasks were conducted in which word class ambiguity and cognate status were manipulated for both nouns and verbs. In the first experiment, we manipulated cognate status and word class ambiguity for nouns and verbs separately; in the second experiment, we manipulated the same factors, but also matched a smaller set of nouns and verbs on relevant psycholinguistic variables so as to allow for a direct comparison between the word classes.

We predicted facilitatory effects of form overlap across languages and across word classes for semantically-related lexical items. Between-language effects of cognate status were expected for both nouns and verbs. Given the different characteristics of nouns and verbs discussed above regarding cross-language orthographic and semantic overlap, we expected the cognate facilitation effect for verbs to be smaller than for nouns. We also expected to find a word class ambiguity advantage for bilinguals, similar to findings for semantically related items of different syntactic categories in monolingual processing. We predicted that full form overlap with a noun equivalent should benefit verbs more than the other way around, given that verb representations are more complex than noun representations and usually slower activated than nouns. Assuming an integrated lexicon, we predicted that overlap within and between languages could co-occur simultaneously, such that the processing of word class ambiguous cognates processing benefits from two forms of co-activation.

Experiment 1: Lexical decision with nouns and with verbs

Method

Participants. Thirty-three Dutch-English bilinguals (22 females), students drawn from the Radboud University participant pool, took part in the experiment. All had normal or corrected-to-normal vision and were between 18 and 28 years of age (M = 20.63, SD = 2.16). All participants were native speakers of Dutch and had learned English at school as an L2 starting around the age of 10. Their mean score on the English XLex vocabulary knowledge test (Meara, 2006) of 85.12% (SD = 6.96) indicates that they are highly proficient learners of English. The XLex task determines a participant's vocabulary range in English, which is generally taken as an indication of proficiency. Participants were paid a small amount of money or received course credit for their participation.

Stimulus materials. Cognate status and word class ambiguity were manipulated in a 2 (cognate vs. non-cognate) x 2 (unambiguous vs. ambiguous word class) design. The experiment comprised separate noun and verb blocks. Each block consisted of 50 unambiguous and 50 ambiguous items, half of which were cognates, yielding a total of 100 target stimuli per list that contained equal numbers of non-cognate unambiguous items, non-cognate ambiguous items, cognate ambiguous items, and cognate unambiguous items. The ambiguous items (nounverbs) in the noun and verb lists were largely the same, and were cognates with regard to both their noun and verb readings. In all cases did the noun and verb reading of ambiguous items converge on a related meaning. In addition to 100 test items, each list contained 60 filler words, half of which were cognates, and 160 pseudowords that respected English phonotactics, yielding a total of 320 items per list (see Appendix I).

A crucial dimension for matching word forms is word frequency, known to be one of the best predictors of word recognition, also in L2 (Duyck, Vanderelst, Desmet, & Hartsuiker, 2008). However, in case of words with identical forms and overlapping semantics, such as for syntactically ambiguous forms, determining a word's frequency is not straightforward. Matching a word on one of its forms cannot constitute a good control when a word is processed based on both its forms, as is assumed for co-activated word forms (but see Caramazza, Bi, Costa, & Miozzo, 2004, and Caramazza, Costa, Miozzo, & Bi, 2001, for form specific effects with homophones). An estimation of word frequency that reflects exposure to different forms of the word can be obtained by summing or averaging objective frequencies from standard databases (cf. Dijkstra et al., 2005; Federmeier et al., 2000). However, averaging frequencies over different occurrences of word forms, such as in case of the nounverb 'plant', might well underestimate the effect of encounters with both the noun and verb forms. At the same time, a summation of the frequencies for the noun and verb readings of 'plant' might lead to an overestimation of the frequency of the verb form. This is because the noun reading of 'plant' has a much higher lemma frequency than the verb reading according to CELEX (Baayen, Piepenbrock, & Van Rijn, 1993). As an alternative, we chose to match the word class ambiguous and unambiguous items on a logarithmic cumulative frequency measure of the noun and verb readings of a word. This measure was obtained by summing the Cobuild per million frequencies of the noun and verb readings of a word taken from CELEX and subsequently calculating the logarithm of this sum. The log frequency of the cumulative nounverb measure was matched with the single log frequency of unambiguous verbs or nouns. This implies that the frequency of unambiguous items was higher than the single frequency of the noun or verb readings of ambiguous items. Four-level analyses of variance for both nouns and verbs revealed no significant differences among the items with respect to frequency ($p > .10$). Furthermore, cognate and non-cognate nounverbs were matched on the single frequencies of both their noun and verb readings.

Additionally, subjective frequency ratings were obtained and used as an alternative frequency measure. Subjective frequency was included as a predictor in our analyses to control for double frequencies of overlapping word forms between languages. Balota, Pilotti, and Cortese (2001) showed that subjective frequency is a better predictor of monolingual lexical processing than objective frequency measures. Activation of words that have similar word forms in two languages also depends to a large extent on subjective frequency (Dijkstra, Hilberink-Schulpen, & Van Heuven, 2010; Dijkstra & van Heuven, 2002), although subjective frequency of L2 words is likely to entail more than frequency alone, such as meaning related effects (Van Hell, Oosterveld, & De Groot, 1996). Subjective frequency ratings were collected online from a group of 120 Dutch native speakers (mean age 19.89, *SD* = 2.15), drawn from the same participant pool as described above. Participants were asked to rate the frequency of a total of 444 English words, divided over 2 lists, including 81 nouns, 146 nounverbs, and 217 verbs on a scale of 1 (never used) to 7 (used daily).

Furthermore, concreteness was included as a predictor in our analyses. Concreteness ratings were collected from a different group of 52 Dutch-English bilingual participants (mean age 21.40, *SD* = 4.61), from the same participant pool as referred to before, in an online study in which participants were asked to rate the concreteness of 199 English nouns and 235 English verbs on a scale of 1 (very abstract) to 7 (very concrete); nounverbs were rated twice.

Items in the noun and verb lists were matched on word length and neighbourhood density in English across the four conditions (*p*'s > .10; see Appendix III). Furthermore, unambiguous and ambiguous verb cognates were matched on cross-language similarity as measured by Van Orden's orthographic similarity measure (Van Orden, 1987). The unambiguous and ambiguous noun cognates, however, could not be matched exactly on cross-language similarity, because of inherent differences between items in the languages; most selected nouns were identical cognates, while there are very few nounverbs that are identical cognates. This implies that nounverbs could be matched to orthographically less similar verb cognates, but that it was not possible to perfectly match nounverbs to orthographically more similar noun cognates. However, all items were chosen because of a high degree of overlap with their Dutch translation equivalents (see Appendix I).

In order to distinguish the noun and verb readings of the nounverbs, all items were presented in a minimally disambiguating context. Nouns were presented in combination with the articles a(n), the, or this. Verbs were presented with one of three personal pronouns: you, we, they. Minimal context combinations were counterbalanced across participants, so that each participant was presented with all possible articles and pronouns. Highly unlikely or grammatically incorrect combinations of context and target words (e.g., "a grass") were excluded.

Procedure. Participants were tested individually on a Windows XP Intel ® Pentium ® 4CPU computer. The experiment was run with Presentation software (Neurobehavioural Systems). Participants were seated at approximately 60 cm from the computer screen; stimuli were presented in Arial 24 pts lowercase white letters aligned in the centre to a dark grey background.

Prior to testing, participants read English instructions on the computer screen explaining the task. Participants were instructed to press the yes-button with the index finger of their dominant hand for letter strings they identified as words, and use the no-button with the index finger of their other hand for non-words. They were asked to react as quickly and as accurately as possible.

Each trial began with the presentation of an asterisk in the centre of the screen for 800 ms. After 300 ms, the target stimulus appeared at the same place and remained on screen for 1500 ms or until a response was given. The next trial started 700 ms after the participant had pressed a button. All stimulus presentation times were adapted to the monitor's 60 Hz refresh rate. Responses were registered by a button box.

At the beginning of the experiment, participants completed a 10-trial practise block to familiarise themselves with the procedure. Subsequently, the 320 items on the noun and verb lists were presented in 3 blocks, with pauses in between blocks. The experiment was resumed when participants pressed a button. Each block started with 3 dummy trials that were not included in the analyses. The order of presentation of trials was determined by a pseudorandomisation with no more than five words of the same type in a row. The experimental items had a different pseudorandomized order for each participant.

The order of noun and verb lists was counterbalanced across participants. Each participant was tested on both lists. After completing the lexical decision task, participants filled out a language background questionnaire and performed the XLex task. A complete session lasted approximately 30 minutes.

Results

RTs and accuracy data were analyzed with a linear mixed effects model with participant and item as random effects (Baayen, 2008). In the present design, no effort was made to match items across word classes; therefore nouns and verbs were treated as separate categories in the analyses. For both the noun and the verb data, we examined the effects of our manipulated factors word class, cognate status, and word class ambiguity, as well as RT on the previous trial (henceforth: previous RT; see De Vaan, Schreuder, & Baayen, 2007), subjective frequency, and concreteness. The latter two factors were included as predictors, because items on the noun and verb lists were not matched across the four conditions on subjective frequency and concreteness. Because nounverbs were presented repeatedly (i.e., once in the noun and the verb block), we checked for effects of block. By performing separate t-tests on the data of participants who saw the noun block or verb block first, we examined if an ambiguity effect would already occur on the first presentation of a nounverb. Furthermore, in case of a word class ambiguity effects, we also checked for an effect of word class ambiguity for items in the participant's L1, because several nounverbs also had overlapping readings in Dutch between the first person singular verb and the singular noun. Prior to modelling, cases of collinearity were determined by correlation analyses. Subsequently, a model was fitted to the data including all data points, which was then trimmed by removing outliers from the data set, defined as data points with standardized residuals exceeding 2.5 standard deviation units. Here we report fixed effects of trimmed versions of the best models (see Tables 1 and 2), and the outcomes of the subsequently performed analyses of variance on the linear mixed effects models, which are reported in the text. RT data were log transformed to correct for non-normal distributions.

Nouns. Only correct responses were considered for RT analyses. The overall error rate on the word items was 4% for the nouns. The data of one participant who had an error rate of more than 15% were removed; accuracy rates for other participants were high (*M* = 96%, *SD*

= 5). None of the items were removed, as there were no items that elicited errors in more than 20% of the trials. Furthermore, we eliminated data points with RTs smaller than 200 ms (less than 1% of the data). Data trimming removed less than 2% of the data. In order to avoid collinearity, subjective frequency and concreteness were residualized as a function of cognate status, so that both subjective measures were devoid of a cognate effect.

A model was fitted to the noun RT data including 3013 data points with previous RT, cognate status, subjective frequency, and concreteness, as predictors. This model indicated significant main effects for all predictors, but no significant interactions among any of the predictors. There was no effect of nounverb ambiguity ($t < 1$). The effect of orthographic similarity as measured by Van Orden (1987) was significant when cognate status was not included, but its effect was smaller than the effect of cognate status, and was therefore discarded from the model. The fixed effects of this model are summarized in Table 1. Cognate status and subjective frequency also showed to be significant predictors of the accuracy data (see Table 1); concreteness and previous RT did not contribute to this model.

[TABLE 1 ABOUT HERE]

The RT model revealed a facilitatory effect of cognate status; cognates (M = 558 ms, SD = 149) were recognized faster than non-cognates (M = 580 ms, SD = 149), $F(1, 3008) = 17.06$, $p < .001$. Additionally, the RT model showed facilitatory effects of residualized subjective frequency, $F(1, 3008) = 62.36$, $p < .001$, and residualized concreteness, $F(1, 3008) = 13.41$, $p < .001$, meaning that items that had been rated highest in these respects, were also fastest responded to. The factor previous RT was shown to have an inhibitory effect, $F(1, 3008) = 46.16$, $p < .001$, indicating that a slow item tended be followed by another slow item. The data did not show any differences between ambiguous nouns (M = 569 ms, SD = 151) and unambiguous nouns (M = 569 ms, SD = 147). Accuracy data showed facilitatory effects of cognate status, $F(1, 3188) = 4.16$, $p < .05$, and residualized subjective frequency $F(1, 3188) = 20.46$, $p < .001$; performance on cognates ($M = 97\%$, $SD = 16$) was better than on non-cognates ($M = 96\%$, $SD = 20$), and performance was better for items that had been rated as more frequent.

Verbs. Errors were removed prior to modelling the RT data (< 4%). Outliers were removed following a similar procedure as for the nouns. The data of one participant were discarded, because of an error rate of more than 15%. None of the items were removed, as there were no items that elicited errors in more than 20% of the trials. Furthermore, data points with RTs smaller than 200 ms were removed (< 1%). Data trimming removed less than 3% of the data. Following procedures for the noun data, subjective frequency was residualized as a function of cognate status and word class ambiguity, given that correlation analyses pointed to significant correlations between subjective frequency and cognate status, and subjective frequency and word class ambiguity.

The model that best fitted the 3002 data points of the verb RT data showed main effects of cognate status, nounverb ambiguity, previous RT, and subjective frequency. It furthermore pointed out a trend towards an interaction between cognate status and word class ambiguity. There was no effect of concreteness ($t < 1$) and no difference between items that were word class ambiguous in the L1 ($M = 582$, $SD = 159$) and those for which no such overlap was present in L1 ($M = 585$, $SD = 150$). Adding the factor word class ambiguity in L1 (residualized for correlating factors of word class ambiguity in L2, cognate status and subjective frequency) to the model showed no significant effect ($p = .149$); it was therefore discarded from the model. As in the analyses for the nouns, Van Orden's similarity had a significant but smaller effect than cognate status, and was therefore discarded. Fixed effects of the model are summarized in Table 2. The model on accuracy data revealed significant effects of word class ambiguity and residualized subjective frequency. The accuracy data also pointed to a marginal effect of cognate status (see Table 2), but there was no contribution of a cognate by word class ambiguity interaction.

[TABLE 2 ABOUT HERE]

Similar to the noun data, RTs to verbs indicated a facilitatory effect of cognate status, $F(1, 2996) = 29.96$, $p < .001$, showing that cognates ($M = 570$ ms, $SD = 148$) were recognized significantly faster than non-cognates ($M = 598$ ms, $SD = 156$). The verb data further showed a main effect of word class ambiguity; word class ambiguous items ($M = 573$ ms, $SD = 153$) yielded faster responses than unambiguous verbs ($M = 595$ ms, $SD = 151$). This difference was statistically significant, $F(1, 2996) = 21.32$, $p < .001$. The model also pointed to a marginally significant interaction between cognate status and word class ambiguity, $F(1, 2996) = 3.19$, $p = .07$. This interaction indicated that the cognate facilitation effect was significant for both the slower unambiguous verbs, $t(1532.81) = 4.80$, $p <.001$, and the faster ambiguous verbs, $t(1544.12) = 2.80$, $p < .01$, although the effect was smaller for the latter (see Table 3). Furthermore, RT data showed effects of previous RT, $F(1, 2996) = 74.22$, $p < .001$, and subjective frequency, $F(1, 2996) = 129.56$, $p < .001$, that went in the same direction as for the nouns. We subsequently conducted (Welch two-sample) t-tests comparing the RTs on ambiguous and unambiguous verbs in both blocks to see if the ambiguity effect was confounded with the repetition of these items. These showed that participants who had seen the noun block prior to the verb block (second presentation of the nounverb), responded significantly faster to previously seen ambiguous verbs ($M = 570$ ms, $SD = 165$) than to unambiguous verbs ($M = 600$ ms, $SD = 163$), $t(1529.79) = 4.01$, $p < .001$. A smaller but still significant difference between ambiguous verbs ($M = 576$ ms, $SD = 140$) and unambiguous verbs ($M = 590$ ms, $SD = 138$) was observed for participants who performed the verb block before the noun block (first presentation of the nounverb), $t(1551.23)= 2.33$, $p < .05$. Note that in spite of the different effect sizes, the model presented here was not improved by the inclusion of an interaction between block and word class ambiguity; a comparison of models showed no effect (p = .205). An overview of the mean RTs per word class can be found in Table 3.

The model on the accuracy data indicated a facilitatory effect of subjective frequency, $F(1, 3192) = 25.73$, $p < .001$. Furthermore, the model suggested a small effect of cognate status, with better performance for cognates (M = 97 %, SD = 16) than non-cognates (M = 96 %, SD = 20), but this was not significant in the analysis of variance, $F(1, 3192) = 3.12$, p = .10. Likewise, performance on ambiguous verbs (M = 97 %, SD = 17) was better than on unambiguous verbs, (M = 96 %, SD = 19), as indicated by the model (see Table 2). Yet, the word class ambiguity effect was not significant in the analysis of variance, $F < 1$.

[TABLE 3 ABOUT HERE]

Discussion

We studied the effects of cognate status and word class ambiguity for both nouns and verbs. For nouns, a cognate facilitation effect was observed in the RT and accuracy data. There were no differences between word class unambiguous and ambiguous nouns in terms of RTs or accuracy, suggesting that nouns do not benefit from an additional verb reading. For verbs, the results showed both cognate and ambiguity effects. These effects also occurred simultaneously, so that word class ambiguous cognate verbs yielded the fastest reaction times. This suggests that verb processing benefits both from the extra reading in another grammatical class and from the reading in the other language, although items benefit less from word class overlap when crosslinguistic overlap is also present. The word class unambiguous non-cognate items, which had no other formally overlapping readings either in the same language or in the other language of the participants, were responded to slowest.

Additionally, response times to nouns and verbs were shown to be influenced by subjective frequency, response times for the previous item, and, in case of nouns, also concreteness.

The cognate effect obtained for verbs suggests co-activation of the English and Dutch forms of a cognate verb for a Dutch-English bilingual, extending the commonly found cognate effect for nouns to a different syntactic category. Other than we predicted, the data suggested no difference in cognate facilitation between nouns and verbs; the observed facilitation effect for verbs was not smaller than that for nouns (see Table 3). Because the cognate verbs were never form identical between the two languages, this finding is in line with other studies showing that the cognate facilitation effect is not exclusive to identical cognates (e.g., Dijkstra et al., 1999; Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011). In fact, the cross-language orthographic overlap for cognate verbs in this experiment was rather low (mean Van Orden measure = .59); yet, the less than perfect form overlap between verb forms was enough for a cognate effect to occur.

The ambiguity advantage in response times to verbs occurred despite the presence of language-specific articles and pronouns, which provided a context that presented participants both with a language cue and a syntactic cue. Also, the effect arose despite the matching of unambiguous verbs with ambiguous verbs based on cumulative frequency of the nounverbs. Furthermore, the effect was shown even on the first presentation of a nounverb. This indicates that the ambiguity effect is more than a repetition or a frequency effect, and may rather reflect co-activation of the noun and verb readings. This is in contrast with data from De Jong (2002), which suggested that a minimally disambiguating context can constrain the activation of word class ambiguous items in L1 processing. The finding of an ambiguity effect in L2 can be related to the fact that the bilinguals in our study were less proficient in their L2, which could lead to less constrained activation (see also Elston-Güttler & Friederici, 2005). Seeing a nounverb for the second time did increase performance on such an item. Nevertheless, the advantage for word class ambiguous verb items was found in both blocks, making it similar to that found in monolingual studies (see Rodd et al., 2002). The results of other studies, however, do not suggest differences in word class ambiguity with respect to word class (e.g., Lee & Federmeier, 2006; Lemhöfer et al., 2008).

These results suggest differences between noun and verb processing. The absence of facilitatory processing for nouns overlapping with a verb in the present study could be due to a ceiling effect, given that nouns were processed faster than verbs. Furthermore, the combined effects of word class ambiguity and cognate status for verb items suggests that verbs benefit more from overlap than nouns. Because processing times for verbs are longer, there is more room for overlap effects to occur.

However, the results of Experiment 1 did not allow for a direct comparison between word classes, because of differences in matching for the nouns and verbs with regard to concreteness and frequency. Nouns were more concrete than verbs, and a comparison of word form frequencies of noun and verb readings of ambiguous items in CELEX confirms that, over all, noun readings of nounverbs are substantially more frequent than verb readings. This may have influenced the word class differences observed in the data with respect to ambiguity effects. In a subsequent experiment, we used a different set of stimuli that were matched on these variables across our manipulations of cognate status and word class ambiguity, but also across word class, so that nouns and verbs were more similar. This allowed for a direct comparison between nouns and verbs regarding cognate and ambiguity effects in one and the same design. In Experiment 2, we expected to replicate the results of Experiment 1. Cognate effects were again predicted for both nouns and verbs, whereas ambiguity effects were only predicted to occur for verbs. In comparison to Experiment 1, ambiguity effects should be smaller given that the frequencies of noun and verb readings for nounverbs were now more balanced.

Experiment 2: A direct comparison of nouns and verbs

Method

Participants. Twenty-eight Dutch-English bilinguals (27 females), students drawn from the Radboud University participant pool, took part in the experiment, all of whom had normal or corrected-to-normal vision and were between 18 and 28 years of age (*M* = 21.61, *SD* = 2.59). All participants were native speakers of Dutch and had learned English at school as an L2 starting around the age of 10. Their average score on the English version of XLex vocabulary knowledge test (Meara, 2006) of 85.76% (*SD* = 9.04) indicated that they were highly proficient learners of English. Participants were paid a small amount of money or received course credit for their participation.

Stimulus materials. Similar to Experiment 1, we manipulated cognate status and nounverb ambiguity orthogonally, but in the present experiment noun and verb items were matched directly to allow for a comparison between nouns and verbs, which lead to a 2 (noun vs. verb) x 2 (cognate vs. non-cognate) x 2 (word class unambiguous vs. word class ambiguous) design. Twenty English items were selected in each of the eight conditions, yielding 160 target items overall (80 for each list). The ambiguous items in the noun and verb conditions were identical for the cognate condition and nearly identical for the non-cognates (see Appendix II). Ambiguous items were presented twice, in both the noun and verb lists. Because of the many restrictions involved in the matching procedure, matching was done based on categories rather than on an item-by-item basis.

Prior to selecting stimulus materials for the experiment, we obtained ratings of semantic similarity between translation equivalents in English and Dutch to check for differences between nouns and verbs (based on Van Hell & De Groot, 1998). Sixty-one participants, drawn from the same participant pool as in Experiment 1, rated 340 different items on cross-language semantic similarity on a 5-point scale, with 5 indicating very similar meanings in both languages. Each participant saw only 180 target pairs, containing either the noun or the verb reading of the ambiguous items and its Dutch translation. English verb items were presented in their infinitival form (e.g., ‘to dance’); nouns were presented in singular form without an article and 20 dissimilar items were added to the list as fillers. The ratings indicated that selected nouns, verbs and nounverbs for Experiment 2 had similar semantic overlap between languages (see Appendix IV).

All target items were between 3 and 7 letters long. Across all categories, items were matched on word length, cumulative frequency of the noun and verb reading, concreteness (all p’s > .10), and English neighbourhood density ($p > .05$) (see Appendix IV). Nounverbs had similar frequencies in their noun and verb readings (frequency ratio around 1; see Burton et al., 2009).

For both nouns and verbs, ambiguous and unambiguous cognates were matched as closely as possible on cross-language similarity between the Dutch and English translation equivalents as expressed by Van Orden’s orthographic similarity measure. To this end, we chose as many non-identical noun cognates as possible, so that they were more similar to verbs. In spite of that, nouns still had more between-language overlap than verbs, because infinitival forms of Dutch verbs are generally made up of a stem plus an -en suffix (the verb ‘to drink’ is translated as ‘drinken’). To overcome this problem of a difference of two extra letters, we also calculated the Van Orden’s similarity for word stems, and matched noun cognates with verb cognates on this measure. In spite of our efforts, it turned out to be impossible to obtain a perfect match on cross-language orthographic similarity. Selected verb cognates were characteristically less overlapping than noun and nounverb cognates. Some of the discrepancy seemed to originate from systematic spelling differences between English and

Dutch that affect the Van Orden's measure for short words immensely, although the words are phonologically very similar (e.g. 'see'- 'zie', 'sit'-'zit', 'come'-'kom').

Furthermore, 80 pseudowords were added to each list, which were matched to the test items on length. Pseudowords were created by changing one or more letters in existing English words that were not included as target words, not constraining boundaries of English phonotactics and resembling nouns or verbs with regard to their suffix. All items were presented in a minimally syntactically disambiguating context, similar to Experiment 1.

Procedure. The procedure was similar to that in Experiment 1; again the presentation of nouns and verbs was blocked, the order of which was counterbalanced across participants, and nounverbs occurred twice.

Results

RTs and accuracy data were analyzed with a linear mixed effects model with participant and item as random effects. The data of the noun and verb lists were analyzed in one model, in order to make a direct comparison. We examined the effects of our manipulated factors word class, cognate status, and word class ambiguity, as well as previous RT and subjective frequency. As in Experiment 1, we checked for effects of word class ambiguity for items in the participant's L1 and block in case of an ambiguity effect. Prior to determining the model with the best fit, cases of collinearity were determined. Therefore, subjective frequency was residualized as a function of cognate status and word class ambiguity. Here we report fixed effects of trimmed versions of the best models (see Tables 5 and 6), and the outcomes of the subsequently performed analyses of variance on the linear mixed effects model, which are reported in the text. RT data were log transformed to correct for non-normal distributions.

Prior to analyzing the RT data, incorrect answers were removed. The overall error rate on the word items was smaller than 3%. All participants performed with an error rate of less than 15% (M = 95%, SD = 3). Three noun and three verb items were discarded, because they elicited 20% errors or more; among these items were two ambiguous non-cognate noun and one unambiguous non-cognate noun, and an unambiguous non-cognate verb, an ambiguous non-cognate verb and an unambiguous cognate verb (deleted items are marked with an * in Appendix II). Furthermore, RTs smaller than 200 ms were removed (< 1%). Data trimming removed about 3% of the data. An overview of the mean RTs per word category can be found in Table 4.

[TABLE 4 ABOUT HERE]

A model was fitted to the RT data including 4062 data points with word class, cognate status, word class ambiguity, subjective frequency, and previous RT as predictors. This model indicated a significant two-way interaction between word class and word class ambiguity. Furthermore, it showed significant main effects of word class, cognate status, subjective frequency, and previous RT. There was no three-way interaction between class, cognate status, and word class ambiguity ($t < 1$), and no significant effect of word class ambiguity in L1 ($t < 1$). When the factor cognate status was replaced by the factor Van Orden's similarity, the latter showed a significant but smaller effect than cognate status and was therefore discarded. Fixed effects are summarized in Table 5. The model on accuracy data revealed significant effects of word class, cognate status, and subjective frequency, but there were no effects of word class ambiguity or an interaction thereof with word class (see Table 6).

[TABLE 5 ABOUT HERE]

The linear mixed effect model showed a main effect of cognate status, $F(1,4055)$ = 30.97, $p < .001$, which reflected that cognates (M = 572 ms, SD = 146) were recognized significantly faster than non-cognates (M = 598 ms, SD = 150); this effect was independent of word class or word class ambiguity. The data further pointed to a two-way interaction between word class and word class ambiguity, $F(1, 4055) = 5.00$, $p < .05$, which indicated that the word class ambiguity effect was present for verbs, but not for nouns (see Table 4 and Figure 1). Subsequent t-tests comparing the RTs to ambiguous and non-ambiguous items confirmed a significant difference for verbs, $t(2080.93) = 5.15$, $p < .001$, with faster responses to ambiguous verbs ($M = 577$, $SD = 146$) than unambiguous verbs ($M = 608$, $SD = 154$). There was no difference between ambiguous items ($M = 576$, $SD = 151$) and unambiguous items, ($M = 578$, $SD = 142$) in the noun list ($t < 1$). Furthermore, the data showed a main effect of word class, $F(1, 4055) = 14.40$, $p < .001$, indicating that nouns ($M = 577$, $SD = 146$) were recognized faster than verbs ($M = 592$, $SD = 151$). Lastly, the data showed a facilitatory effect of subjective frequency, $F(1, 4055) = 104.37$, $p < .001$, and an inhibitory effect of previous RT, $F(1, 4055) =28.73$, $p < .001$ similar to Experiment 1. Regarding the ambiguity effect for verbs, we tested whether it was present both on first and second presentation. T-tests comparing the RTs on word class ambiguous and unambiguous verb items showed that participants who had been presented with the verb block after they had previously seen the nounverb items in the noun block showed a significant difference between nounverbs ($M = 549$, $SD = 128$) and verbs ($M = 599$, $SD = 155$), $t(1088.98) = 6.02$, $p < .001$. Participants who had been presented with the verbs in the first block showed a much smaller difference between nounverbs ($M = 611$, $SD = 158$) and verbs ($M = 619$, $SD = 153$), which did not reach significance, $t(968.78) = 1.14$, $p = .25$). Despite the different findings regarding the ambiguity effect for block presentation, the model presented here was better than a model that included an interaction between word class ambiguity and block ($p < .001$).

[FIGURE 1 ABOUT HERE]

The accuracy data revealed a significant effect of cognate status, $F(1, 4296) = 20.58$, $p < .001$, with better performance for cognates ($M = 99\%$, $SD = 12$) than for non-cognates ($M = 96\%$, $SD = 19$). There was also a facilitatory effect of subjective frequency, $F(1, 4296) =$

33.68, $p < .001$. There was no effect of word class, $F(1, 4296) = 2.98$, $p = .10$; performance was similar for nouns ($M = 98\%$, $SD = 15$) and for verbs ($M = 97\%$, $SD = 17$). The accuracy data showed no effect of word class ambiguity, $F(1, 4296) = 2.30$, $p = .10$, nor an interaction between word class and word class ambiguity ($F < 1$).

[TABLE 6 ABOUT HERE]

Discussion

Experiment 2 directly compared nouns and verbs by matching the items on relevant variables not only between conditions, but also between the two word classes. This meant that nouns and verbs were more comparable in terms of concreteness, frequency, and cross-language overlap, and that nounverbs were controlled for frequency of their noun and verb readings. We largely replicated the effects found in Experiment 1. The RT and accuracy data in the lexical decision tasks pointed to facilitatory processing for both noun and verb cognates. The word class ambiguity effect that was shown to affect verbs in Experiment 1 was less prominent in Experiment 2. Although the ambiguity advantage was present for verbs, it only arose when the ambiguous verbs, which largely overlapped between the noun and verb list, were presented for a second time in the experiment. There was only a numerical difference between unambiguous and ambiguous verbs upon the first presentation of these items. Note that the ambiguity effect in Experiment 1 also increased as the items were presented for a second time. The pattern observed in Experiment 2 suggests that the ambiguity advantage is a more subtle effect than the cognate effect. In line with Experiment 1, the data of Experiment 2 indicate that the ambiguity effect is only present for verbs, but not for nouns, suggesting that response times to nouns are almost at ceiling. Both noun and verb processing were largely dependent on subjective frequency, which was mostly responsible for variation in the RT and accuracy data. In spite of cross-linguistic activation, neither experiment showed an effect of ambiguity in L1. Note, however, that there is considerable collinearity between ambiguity in L1 and L2. It is possible that after residualizing the factor of ambiguity in L1, its effect became non-significant.

The differential findings for the two experiments concerning word class ambiguity can be explained by the stricter matching of frequency for the two readings of the nounverbs. Compared to Experiment 1, the nounverbs had more similar frequencies in their noun and verb readings, which may account for the smaller effect of word class ambiguity in Experiment 2. Where the more frequent noun readings of the nounverbs in Experiment 1 may have been beneficial to the verb readings thus boosting the word class ambiguity effect, the nounverbs in Experiment 2 could benefit less from their (better matched) noun frequencies, thus showing no word class ambiguity upon first presentation of the item. This suggests once more that noun representations are activated faster than verb representations.

Similar to Experiment 1, word class ambiguous cognates were the fastest category among the verbs, showing a trend towards an interaction between cognate and ambiguity effects. With a more constrained stimulus set, we find no evidence for the previously observed trend. Because unambiguous verbs were slower in Experiment 2 relative to Experiment 1, the ambiguity effect was now similar in size for cognate and non-cognate verbs.

General Discussion

This study examined the effects of between-language cognate effects and within-language ambiguity effects on the L2 processing of nouns and verbs in Dutch-English bilinguals. The data of two lexical decision experiments showed that where noun processing was subject to cognate status, verb processing was influenced by cognate status as well as word class ambiguity.

With regard to cognate effects, the present study is consistent with earlier ones reporting bilingual activation both in isolation and in a language-specific context for nouns (e.g., Dijkstra et al., 1999; Duyck et al., 2007; Van Hell & De Groot, 2008) and extends findings for a verb cognate effect in word association (Van Hell & De Groot, 1998). This study confirms that recognition of cognates is affected by a simultaneous activation of form representations in two languages, which need not overlap completely for the effect to occur. This is in agreement with the notion of language non-selective activation, suggesting that cognates have separate lexical representations in each language that are co-activated upon word presentation. Although verbs have on average less cross-language semantic and orthographic overlap, the cognate effect was shown to generalize to verbs when these were included in a phrasal context, which demanded little morpho-syntactic processing. Future studies should determine to what extent verb cognates show facilitation in a full-fletched sentence context. More language specific syntactic and morphological processing might reduce the amount of co-activation for verb cognates in sentence context (see Vigliocco et al., 2011).

Furthermore, with respect to the verbs, we replicated the word class ambiguity advantage indicated for monolinguals (Rodd et al., 2002). Lemhöfer et al. (2008) also reported such a finding as a side effect in a progressive demasking paradigm conducted with bilinguals, without specifying it by word class. The ambiguity effect in the present study showed up as a word class specific effect in that only verb readings of nounverbs were supported by an additional noun representation, whereas noun readings of nounverbs did not benefit from an additional verb reading. Furthermore, the ambiguity effect for verbs was particularly strong when nounverbs had higher noun frequencies. The results suggest that in particular verb recognition profits from multiple representations in bilingual memory. Activation of a verb representation occurs faster if it receives activation from multiple representations at a form level both across languages and across word classes. Interpreted within a localist connectionist approach, this implies that a semantic representation, shared at least to some degree between word classes and between languages, is fed by activation from one or more representations at the form level. This account is in line with the argumentation of other studies that explain effects of form overlap in terms of interactivity or resonance between lexical and semantic levels (Dijkstra & Van Heuven, 2002; Pecher, 2001; Pexman & Lupker, 1999; Van Hell & De Groot, 1998).

The word class specific findings concerning the ambiguity effect indicated processing differences between nouns and verbs. Only verbs benefit from word class ambiguity, and mostly so when the noun reading of such an item is more frequent. A more general difference between noun and verb processing is suggested by the slower processing times for verbs compared to nouns. These word class differences can be related to the general finding of greater processing demands associated with verbs due to more complex representations regarding semantics, syntax, and morphology (Vigliocco et al., 2011). This is also supported by neuro-imaging evidence showing higher levels of cortical activity when reading verbs as compared to nouns (e.g., Chan et al., 2008; Perani et al., 1999). This suggests that processing of verbs is more effortful, which may especially affect L2 processing - as proposed by the Distributed Features account (Van Hell & De Groot, 1998). Processing differences between nouns and verbs may be related to the mapping of L2 representations onto L1 representations during L2 learning. Similar to the notion that form overlap of cognates could enhance direct mapping in learners, it could also be argued that L2 nouns are more easily mapped onto L1 nouns than L2 verbs are onto L1 verbs, because nouns are conceptually more similar between languages (i.e., more concrete). For verbs, mapping of representations in L1 may be more difficult, due to their more language-specific use and a larger morphological complexity in comparison to nouns. Because of these complex representations, verbs are activated slower than nouns; hence there is more room for facilitatory effects to occur. Therefore, verbs benefit from form overlap across languages and across categories, which can speed up activation. It must be noted that verb cognates in this study were also orthographically more dissimilar than nouns. The within-language overlap may therefore have been more beneficial for verbs, given that a ceiling effect could have been reached for nouns. Yet, the word class specific pattern observed for the ambiguity effect need not be exclusive to bilingual processing. Because nouns are generally activated faster in both monolingual (e.g., Gentner, 1981) and bilingual processing (Baayen et al., 2003; Van Hell & De Groot, 1998), monolinguals are likely to show a similar pattern regarding word class ambiguity effects. Also note that the observed effect of word class ambiguity is particularly relevant for bilinguals who have English as one of their languages. Many other languages with more extensive morphology make a distinction between nouns and verbs, and it remains to be seen if word class ambiguity effects also occur when noun and verb forms do not show complete overlap.

The account sketched here explains facilitatory effects of largely overlapping forms in terms of cross-language and cross-category lexical activation. Indisputably, speed of recognition also depends to a large degree on frequency of usage, as was indicated by the analyses which showed that first and foremost, subjective frequency was the best predictor of noun and verb recognition latencies (see also Gollan et al., 2011). Similar or identically written forms strengthen the activation patterns due to a larger frequency of usage, in accordance with activation patterns observed in the data. The effect of overlapping form and that of frequency are inseparable, and operate in a similar way (see Strijkers, Costa, & Thierry, 2010). Although the present data preclude an explanation solely in terms of frequency effects, we acknowledge that frequency has a role to play in the co-activation process. Because a representation in the mental lexicon is shaped by experience with a word, which is logically related to the number of occurrences, it is clear that the frequency of an identical cognate or nounverb is higher than the frequency of one reading of that word suggests. In the same vein, Strijkers and colleagues argued that cognates activate representations in both the target and the non-target language, and such co-activation may arise even when they are not identical. When a non-cognate is encountered, its reading in the other language need not be activated directly (but see Dimitropoulou et al., 2011; Thierry & Wu, 2007; Wu & Thierry, 2010 for non-target activation of non-cognates); this can explain why cognates are characterized by a higher subjective frequency than non-cognates. In a similar way, frequency differences may affect noun and verb processing. The particular (singular) form in which the nouns occurred in our experiment is often more frequent than the infinitival verb form used given that verbs regularly occur as inflected forms in daily use, which may have influenced the word class and ambiguity findings to some degree. Effects of form overlap thus go hand in hand with those of a higher frequency, and they jointly influence activation patterns in lexical decision.

Conclusion

In all, the present evidence for facilitatory effects of word class ambiguity in combination with a cognate effect strongly suggests that lexical representations with overlap in form and meaning are closely linked in the bilingual's mental lexicon. Activation is not only non-selective across language boundaries, but can also be non-selective with respect to syntactic word class boundaries in L2, even in a disambiguating context. The word class ambiguity effect is word class dependent, however, given that the overlap affected verbs more than nouns. The more complex representation of verbs, particularly in L2, induces slower activation, which makes this word class more liable to effects of form overlap. Nouns benefit less from form overlap with verbs, given that nouns are naturally activated faster because their representations are more stable and more specific. These data strengthen the assumption of a fully integrated lexicon and indicate that experience with any written word form shapes the processing and the underlying lexical representations in the bilingual mental lexicon. In addition, the present data point out that when one investigates lexical form overlap, all forms of a target word within and between languages should be considered, because each additional form may increase the facilitatory effect in processing.

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APPENDIX I: STIMULUS MATERIALS EXPERIMENT 1, NOUNS

Cognates		Non-cognates	
Ambiguous noun	Unambiguous noun	Ambiguous noun	Unambiguous noun
win	rib	try	art
ski	week	need	fact
work	cent	play	case
help	baby	stay	hour
hope	hall	walk	city
cost	tent	rule	home
test	oven	push	road
film	hotel	vote	unit
hate	route	jump	meat
style	radio	dress	dirt
race	media	fool	arrow
click	title	rush	money
drink	robot	hunt	adult
start	insect	cure	novel
water	ball	bully	movie
plant	menu	smile	bullet
class	text	voice	bird
split	apple	sound	liar
dance	chaos	blame	aunt
storm	trend	paint	error
alarm	status	brush	fairy
filter	winter	gossip	tribe
sprint	partner	spoon	witch
bundle	student	regret	window
sponsor	grass	torture	prison

APPENDIX I: STIMULUS MATERIALS EXPERIMENT 1, VERBS

Cognates		Non-cognates	
Ambiguous verb	Unambiguous verb	Ambiguous verb	Unambiguous verb
win	see	try	buy
ski	sit	need	get
work	eat	play	ask
help	make	stay	add
hope	come	walk	know
cost	find	rule	tend
test	hang	vote	quit
film	clap	jump	deny
hate	sing	fool	sell
click	bring	rush	pray
drink	begin	hunt	save
start	bleed	cure	shut
plant	steal	bully	earn
split	infect	smile	write
dance	assist	sound	solve
storm	invest	blame	spoil
alarm	inform	paint	adjust
filter	select	brush	prove
sprint	accept	gossip	seduce
bundle	mislead	regret	injure
sponsor	realize	torture	betray
fish	inspect	take	borrow
wash	analyse	talk	depend
kiss	inspire	cough	resist
sweat	publish	spice	attach

APPENDIX II: STIMULUS MATERIALS EXPERIMENT 2, NOUNS

Cognates		Non-cognates	
Ambiguous noun	Unambiguous noun	Ambiguous noun	Unambiguous noun
dance	baby	bruise*	adult
drink	chaos	brush	case
film	concept	cure*	city
filter	dilemma	damage	destiny
hate	drama	jump	dirt
help	expert	gossip	editor
hope	hall	dress	error
pause	hotel	hunt	fact
plan	photo	look	home
plant	radio	lecture	hour
protest	status	paint	liar
respect	student	promise	meat
sleep	table	rush	money
sponsor	team	reply	movie
sprint	text	search	novel
start	title	smile	prison
stop	trend	sound	safety
storm	week	torture	tribe*
test	wine	vote	unit
work	winter	walk	witch

*outlier

APPENDIX II: STIMULUS MATERIALS EXPERIMENT 2, VERBS

Cognates		Non-cognates	
Ambiguous verb	Unambiguous verb	Ambiguous verb	Unambiguous verb
dance	accept	bruise*	add
drink	analyse	brush	ask
film	bake	cure	attach
filter	begin	damage	borrow
hate	bleed	gossip	bury*
help	bring	hunt	buy
hope	come	lecture	decide
pause	eat	look	destroy
plan	find	love	earn
plant	hang	need	explain
protest	hinder	paint	injure
respect	inform	promise	protect
sleep	inspect	reply	prove
sponsor	invest	rush	quit
sprint	make	search	receive
start	observe*	smile	resist
stop	see	sound	sell
storm	select	torture	shut
test	sing	vote	solve
work	sit	walk	write

*outlier

Note: the nounverbs in the noun and verb list are identical, apart from 2 items. This is due to different concreteness ratings for the items in the noun and verb conditions.

APPENDIX III: MATCHING IN EXPERIMENT 1

Nouns

	Word class ambiguous		Word class unambiguous	
	Non-cognate	Cognate	Non-cognate	Cognate
Word length	4.6 (.87)	4.72 (.94)	4.56 (.77)	4.84 (.99)
Cumulative log frequency	1.99 (.52)	1.96 (.62)	1.91 (.53)	1.74 (.48)
Subjective frequency	4.11 (.85)	4.63 (1.08)	3.98 (1.08)	4.58 (.92)
Concreteness	4.00 (1.28)	4.31 (1.08)	4.86 (1.07)	5.28 (1.26)
Neighbourhood density	6.12 (3.56)	6.28 (5.14)	4.52 (4.05)	5.24 (5.51)
Van Orden	0.12 (.13)	0.8 (.23)	0.15 (.16)	0.94 (.11)

Verbs

	Word class ambiguous		Word class unambiguous	
	Non-cognate	Cognate	Non-cognate	Cognate
Word length	4.56 (.87)	4.64 (.95)	4.64 (1.11)	5.24 (1.39)
Cumulative log frequency	2.00 (.63)	1.9 (.60)	1.91 (.66)	2.03 (.75)
Subjective frequency	4.08 (.94)	4.44 (1.10)	3.98 (.94)	4.15 (.98)
Concreteness	4.5 (1.05)	4.82 (.96)	3.93 (.86)	4.37 (.97)
Neighbourhood density	6.84 (3.70)	5.88 (4.97)	5.52 (4.77)	6.32 (6.68)
Van Orden	0.12 (.11)	0.62 (.20)	0.12 (.09)	0.54 (.23)

APPENDIX IV: MATCHING IN EXPERIMENT 2

Nouns

	Word class ambiguous		Word class unambiguous	
	Non-cognate	Cognate	Non-cognate	Cognate
Word length	5.15 (1.09)	5.00 (1.08)	4.80 (.89)	5.15 (1.04)
Cumulative log frequency	1.94 (.48)	2.06 (.61)	1.90 (.54)	1.85 (.43)
Subjective frequency	4.02 (.92)	4.94 (.98)	4.18 (1.06)	4.96 (.68)
N/V frequency ratio	0.92 (.28)	0.95 (.45)		
Semantic similarity	4.14 (.37)	4.54 (.27)	4.42 (.41)	4.63 (.25)
Concreteness	4.37 (1.02)	4.22 (1.08)	4.41 (1.11)	4.65 (1.51)
Neighbourhood density	5.63 (4.01)	5.24 (4.83)	3.95 (4.38)	4.50 (5.88)
Van Orden	0.16 (.13)	0.88 (.16)	0.15 (.18)	0.89 (.18)

Verbs

	Word class ambiguous		Word class unambiguous	
	Non-cognate	Cognate	Non-cognate	Cognate
Word length	5.10 (1.12)	5.00 (1.08)	5.10 (1.41)	4.95 (1.36)
Cumulative log frequency	2.01 (.54)	2.06 (.61)	1.97 (.49)	2.13 (.79)
Subjective frequency	4.19 (1.08)	4.94 (.98)	4.05 (.81)	4.28 (1.07)
N/V frequency ratio	1.12 (.24)	1.08 (.47)		
Semantic similarity	4.26 (.32)	4.56 (.17)	4.37 (.34)	4.49 (.30)
Concreteness	4.61 (1.13)	4.48 (.99)	4.43 (.59)	4.56 (.86)
Neighbourhood density	6.38 (4.67)	5.24 (4.83)	4.40 (3.45)	8.53 (6.93)
Van Orden (based on stem)	0.11 (.08)	0.87 (.17)	0.11 (.09)	0.69 (.20)

Table 1

Fixed effects of Predictors in the Linear Mixed Effects Models for the Noun RT and Accuracy Data in Experiment 1.

	RT				Accuracy			
	Estimate	SE	*t*	*p*	Estimate	SE	*t*	*p*
(Intercept)	6.23	0.03	248.86	.000	0.96	0.006	149.51	.000
Cognate	-0.04	0.01	-4.09	.000	0.01	0.007	2.00	.045
Subjective frequency	-0.04	0.005	-8.19	.000	0.02	0.004	4.52	.000
Concreteness	-0.01	0.004	-3.70	.000	-	-	-	-
Previous RT	0.0002	0.00002	6.79	.000	-	-	-	-

Table 2

Fixed effects of significant predictors in the linear mixed effects model for the verb RT and accuracy data in Experiment 1.

	RT				Accuracy			
	Estimate	SE	*t*	*p*	Estimate	SE	*t*	*p*
(Intercept)	6.27	0.02	259.90	.000	0.95	0.01	106.00	.000
Cognate	-0.06	0.01	-5.18	.000	0.03	0.01	2.34	.019
Ambiguity	-0.06	0.01	-4.51	.000	0.02	0.01	1.77	.076
Subjective frequency	-0.05	0.005	-11.22	.000	0.02	0.004	5.14	.000
previous RT	0.0002	0.00002	8.62	.000	-	-	-	-
Ambiguity by Cognate	0.03	0.02	1.79	.074	-0.02	0.02	-1.54	.124

Table 3

Reaction Times (ms) by Condition for the Verbs and Nouns in Experiment 1.

	Verb			Noun		
	Non-cognate	Cognate	Difference	Non-cognate	Cognate	Difference
Condition	RT (*SD*)	RT (*SD*)		RT (*SD*)	RT (*SD*)	
Unambiguous	612 (154)	578 (147)	34 ms	581 (144)	558 (150)	23 ms
Ambiguous	584 (158)	563 (148)	21 ms	580 (153)	558 (149)	22 ms
Difference	28 ms	15 ms		1 ms	0 ms	

Table 4

Reaction Times (ms) by Condition for the Verbs and Nouns in Experiment 2

	Verb			Noun		
	Non-cognate	Cognate	Difference	Non-cognate	Cognate	Difference
Condition	RT (*SD*)	RT (*SD*)		RT (*SD*)	RT (*SD*)	
Unambiguous	622 (158)	595 (148)	27 ms	593 (146)	564 (139)	29 ms
Ambiguous	589 (149)	566 (143)	23 ms	587 (144)	566 (156)	21 ms
Difference	33 ms	29 ms		6 ms	-2 ms	

Table 5.

Fixed effects of the linear mixed effects model on RTs.

	Estimate	SE	*t*	*p*
(Intercept)	6.31	0.03	219.67	.000
Word class	0.04	0.01	3.39	.000
Cognate	-.04	0.007	-5.48	.000
Ambiguity	-0.01	0.01	-1.02	.309
Subjective frequency	-0.04	0.004	-9.91	.000
previous RT	0.0001	0.00002	5.33	.000
Ambiguity by Word class	-0.03	0.01	-2.24	.025

Table 6.

Fixed effects of the linear mixed effects model on accuracy.

	Estimate	SE	*t*	*p*
(Intercept)	0.96	0.01	135.32	.000
Word class	-0.02	0.01	-0.25	.799
Cognate	0.02	0.01	4.53	.000
Ambiguity	-0.001	0.01	1.50	.133
Subjective frequency	0.02	0.003	5.84	.000
Ambiguity by Word class	-0.01	0.01	-0.66	.511

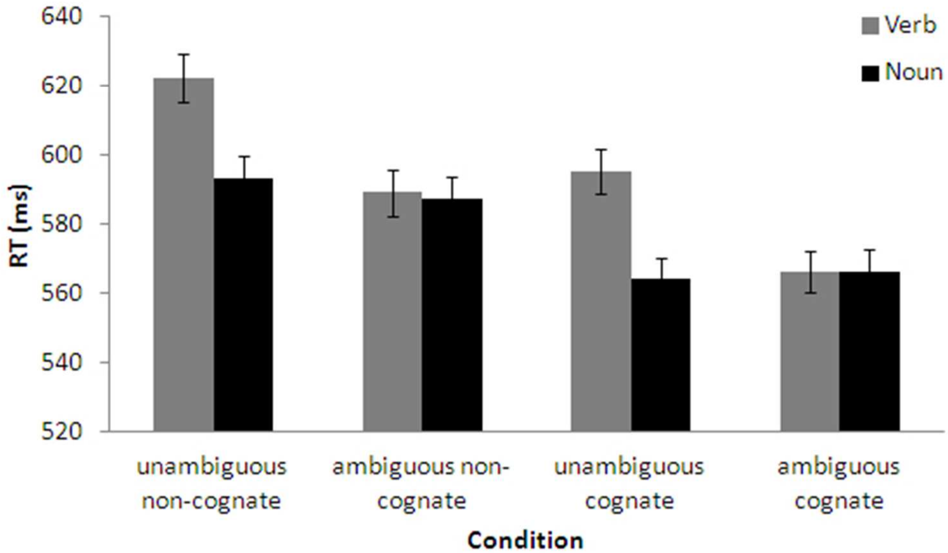

Figure 1. Mean reaction times (SE) for cognate and ambiguity manipulations in nouns and verbs.
203x122mm (72 x 72 DPI)