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# Letter detection for homographs with different meanings in different language texts*

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*Tests of inter-lingual homographs that have different meanings across two languages support models postulating initial non-selective access to competing language representations, e.g. Bilingual Interactive Activation (BIA) model. Most such research assessed inter-lingual homographs in the absence of connected text. Here a letter detection paradigm was used that required subjects to detect letters in words in connected text. Prior work with this paradigm suggested that readers respond to only one interpretation of an intra-lingual homograph when detecting letters. Three experiments described here indicate that letter detection patterns to inter-lingual homographs are similar, i.e. detection reflects only a context appropriate interpretation. However, the demonstration that text role, text cohesiveness and bilingual fluency affect inter-lingual letter detection (Experiments 1 and 2), and that word role affects detection even though target frequency is constant across inter-lingual meanings (Experiment 3) indicates that selectivity is in response to post-lexical processes. Thus, results are seen as compatible with tenets of the BIA model.*

The present research considers whether a reasonably robust letter detection pattern found for intra-lingual or same-language homographs in connected text can be obtained with inter-lingual or different-language homographs. Letter detection patterns for words appearing in connected text have consistently shown that high-frequency function words that support text structure engender more errors than do low-frequency content words (Drewnowski and Healy, 1977; Greenberg and Koriat, 1991; Koriat and Greenberg, 1991; Moravscik and Healy, 1995). Remarkably, this aforementioned response pattern holds even when the same word, i.e. the same orthographic pattern, appears in different roles (e.g. Koriat, Greenberg and Goldshmid, 1991; Saint-Aubin, Klein and Roy-Charland, 2003).

In a study of Hebrew word letter detection, Koriat et al. (1991) found that initial letters in simple orthographic patterns were more easily detected than the same initial letters standing for function morphemes in multi-morphemic words. Hebrew frequently injects structure-supporting morphemes into a text by attaching single-letter prefixes to content roots. Thus, a *shin* (similar to an *S*) can be either the first letter of a word, or a prefix meaning "that" appended to a root word. Similarly a variety of other letters are used either as function prefixes or routine first letters, e.g. *lamud* (similar to an *L*) can mean "to", a *hai* (similar to an *H*) can mean "the", a *mem* (similar to an *M*) can mean "with" or "from", and *bet* (similar to a *B*) can mean "in". The results suggested that the detection of these letters was worse when they served a structural role. Of particular interest to the present study, Koriat et al. (1991) also evaluated whether this response pattern held even when comparing intra-lingual homographs (Experiment 4). Hebrew consonant strings (e.g. *SMR*) can sometimes be interpreted as a simple un-prefixed content word (meaning "kept"). Yet, in another context the same letter string is a more complex construction with the initial letter *S* representing the function prefix "that", with the trailing morpheme *MR* meaning "mister". The results of this latter experiment matched the pattern of the earlier experiments, even though in this case the target orthographic sequences were matched. Thus, *S* in *SMR* was more likely to be missed when it functioned as a prefix.

This intra-lingual letter detection pattern is not a uniquely Hebrew phenomenon, but rather has been found in a variety of languages including English (e.g. Greenberg and Koriat, 1991; Greenberg, Koriat and Shapiro, 1992; Moravscik and Healy, 1995, 1998), French (Saint-Aubin and Poirier, 1997; Saint-Aubin, Klein and Roy-Charland, 2003), and German (Muesseler, Koriat and Nisslein, 2000). Greenberg and Koriat (1991) determined

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that detecting an *n* in the word *on* was more difficult when *on* had a prepositional role than when it was in the role of a modifier (e.g. *on switch*). Meanwhile, Greenberg et al. (1992) observed that detecting *r* in *for* suffered when *for* had a more defined structural role in a sentence than when it was a dangling preposition with little impact on structure. Reinforcing these findings in English were two other sets of studies, by Moravcsik and Healy (1995, 1998). In the first, the normal use of the article *the* was compared to both an artificial use of *the* to mean a Thai spice and the natural but highly unusual use of *the* as a content word referring to the definite article itself. In both conditions the content form produced fewer errors than did the normal article role. In the second study, *the* in its most usual role was compared with *the* in the role of an adverb (e.g. *none the wiser*). Again, more errors occurred for the structural *the*. In subsequent experiments (Experiments 2 and 3), manipulations that changed the prominence of the phrases in which *the* appeared (e.g. subject versus object noun phrases), although the syntactic and semantic sense of *the* presumably did not change under this latter manipulation, resulted in differences in error rates as a function of prominence. These results suggested that although role was important in determining letter detection patterns, it was not simply a matter of structural role versus content role.

Results with German (Muesseler et al., 2000) were more or less consistent with the picture described above. Across a series of experiments, various forms of "the" (in German) consistently produced more errors than control content words. Of particular interest here, though, was that the identical form of the definite article engendered different levels of errors as a result of phrase structure and the organization of phrases within a sentence. Function words embedded in subject–predicate–object constructions showed higher error rates than the same words in object–predicate–subject formats. Similarly, in a series of experiments, Saint-Aubin and Poirier (1997) examined several French words that could have either function or content roles in texts and in all cases (*les*, *or* and *outre*) the structure-supporting word generated more errors. It might be noted that this pattern held although the more familiar usage of *outre* is that of a content word. Taken together, these findings across languages indicate that letter detection in intra-lingual homographs depends upon the homograph's role in text.

Although the aforementioned findings indicate that a word's role is central to letter detection, other findings have implicated word frequency as another contributing factor. Specifically, a function-word-disadvantage often remains even when words in a passage are scrambled (Healy, 1976), and readers make a significantly higher proportion of detection errors in relatively common content words than in less frequent content words in both lists (Healy, 1976), connected text (Greenberg, Koriat and Vellutino, 1998), and with a rapid serial visual presentation procedure in which words are presented one at a time on a computer screen (Saint-Aubin et al., 2003). In addition, frequency of pronouns has been found to affect the rate of letter detection (Moravcsik and Healy, 1995).

To accommodate these and other, related findings, Greenberg, Healy, Koriat and Kreiner (in press) proposed the Guidance-Organization (GO) model of letter detection in connected text. Briefly, the model assumes quick identification of structure-supporting function units owing to their relative orthographic familiarity. Time spent processing high-frequency function words is relatively short enabling them to be used quickly to build a tentative structural frame (Bock, 1990). Identification of these words is normally achieved when they are in the parafovea area immediately following the location upon which the eye is fixated (e.g. see Reichle, Pollatsek, Fisher and Rayner, 1998). Of foremost importance here, contextual constraints are critical in helping to identify sentential slots where structure-supporting units are likely to reside. Such constraints operate top-down to assess whether a parafoveal pattern is signalling the start of a new unit. Orthographic patterns are assumed to engender different letter-detection patterns based on usage. Thus, the context can inhibit a reader from using a quickly identified function word from the parafovea to establish a structure when it indicates the word is unlikely to have that function role. Function words are interpreted as structural units fairly reliably, so evidence presumably must be strong to counter such an interpretation. Ambiguous homographs that can serve either structural or content roles will engender a function interpretation unless context strongly indicates otherwise (see Saint-Aubin et al., 2003). The source of the detection errors lies both in the possibility that function words are identified in the parafovea, where acuity is reduced and individual letters are thus less available, and in the process in which function words are pushed into the background of a text's cognitive representation as their role of structure building is completed. As structure-supporting units retreat from the foreground, their availability in the cognitive representation is reduced. Thus detection errors may reflect either early perceptual processes or later post-lexical analyses, at which time the word's role is determined. The observation that role affects letter detection in the single-language homograph (SLH) indicates that a primary source of letter detection errors in these words is a result of post-lexical assignment of role.

For bilingual readers homographic ambiguity can result not only from lexical competition within a language but across languages as well. Not infrequently bilingual readers confront orthographic patterns that appear in both languages with which they are familiar (Dijkstra, Van Jaarsveld and Ten Brinke, 1998). As with the SLH, in some cases the dual-language homograph (DLH) assumes different meanings and functions across the languages. In

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accordance with some models of the bilingual lexicon, such as the Bilingual Interactive Activation (BIA) model (Dijkstra and Van Heuven, 1998, 2002), recognition of a target word is influenced not only by the target language's entries, but by the non-target language's entries as well (integrated lexicon hypothesis). The BIA model represents an extension of the interactive activation model (McClelland and Rumelhart, 1981). Although this inter-lingual version maintains the hierarchical organization of the original interactive activation model, in which different levels of representational features are activated, it also incorporates mechanisms to handle likely features of a bilingual's lexicon. Dijkstra, Van Heuven and Grainger (1998) posit an integrated lexicon in which the words from both familiar languages reside. Moreover, the model suggests an extra layer of two-language nodes responsible for assigning language membership to each entry. What is novel about this approach is that activated lexical candidates compete with one another across both languages rather than from within just one. Asymmetries in unbalanced bilinguals (one language's usage is stronger than the other) are manifested in different resting level activations for L1 and L2 (primary and secondary languages), presumably resulting from the number of encounters with words from the respective languages (Kroll and Dijkstra, 2001). The model posits that activation in response to a word's orthography is initially automatic and non-selective, meaning that lexical entries from both languages are at least temporarily available. However, Dijkstra, Van Jaarsveld and Ten Brinke (1998) postulated that "bilingual word recognition basically involves a language non-selective processing system which may function more or less selectively depending on experimental circumstances" (p. 51). As noted by Altarriba and Gianico (2003), when task demands or the constraints of the processing situation require the use of a single language meaning, bilinguals should be capable of suppressing activity in the second language so that target language analysis proceeds effectively, and the circumstance of constraining connected text is likely to encourage that type of processing. Presumably, then, if the SLH data is an indication, the letter detection for the DLH should likewise give the appearance of selective access owing to post-lexical suppression of the incompatible entry.

Whether the letter detection task during reading will follow patterns often found in lexical decision and naming tasks in which evidence predominantly favours the availability of both lexical entries at the time of response, or whether it reflects the pattern of the SLH in letter detection, is the subject of the study. Although models such as BIA posit an integrated lexicon in which inter- and intra-lingual competition and activation behave similarly, it is not clear whether the path of activation and suppression (resulting from competition) are so similar as to produce common patterns for the SLH and DLH targets. Indeed, relatively little research has been done on inter-lingual homographic activity in sentence contexts (but see, for example, Altarriba, Kroll, Sholl and Rayner, 1996). Perhaps the DLH activation is more dominated by initial levels of activation during letter detection. Bilingual homographs might engender both meanings, and the frequency of a word's representations rather than the language context could order the access of a word's meanings (e.g. Beauvillain and Grainger, 1987) during letter detection. In that case, letter detection for the DLH should be consistently affected by the more prominent function word's frequency rather than by the less familiar content entry regardless of language context. Letter detection errors for the DLH would thus consistently reflect the high-frequency function word regardless of language context. As noted, though, should post-lexical processes as in the case of the SLH heavily affect letter detection in the DLH, then the patterns here should resemble those found with the SLH.

The present study examines the letter detection for the DLH targets to first establish whether the SLH pattern resonates with the notion of an integrated lexicon as specified by the BIA position. However, given that such a model assumes non-selective activation, will the detection for the DLH indicate a pattern consistent with early non-selective activation, or will it follow one that reflects an impact of context in determining role and hence eventual selection of a single appropriate meaning? Specifically, can it be shown that the DLH targets engender different error patterns in response primarily to post-lexical processing, as explained by the GO model? To investigate the issue, DLH targets that take on different roles in different languages are examined. Furthermore, a DLH target with different roles but similar frequencies in the competing languages is also tested to help evaluate whether differences in the DLH letter detection are achieved later in the post-lexical analysis. Given that language fluency is postulated to affect the resting level of competing entries across languages, bilingual dominant proficiency is examined as well. Finally, and importantly, unlike the SLH, the DLH's appropriate selection of meaning could be derived purely from the language of the text, independent of the context's meaning and structure. Semantic and syntactic constraints might have little impact on letter detection patterns relative to the context's language. Thus, letter detection for DLH targets is examined in scrambled passages in which the language is clear but meaning and structure are not.

## Experiment 1

The primary concern of Experiment 1 was whether inter-lingual homographs would replicate a pattern observed for intra-lingual homographs in a letter detection task. Specifically, does an inter-lingual homograph produce more errors in the language in which it has a structural role

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than in the language to which it contributes content? The BIA model assumes that the pattern of letter detection for inter-lingual and intra-lingual activation, competition and, ultimately, suppression operate similarly. It is postulated (e.g. Dijkstra, Van Heuven and Grainger, 1998; Van Heuven, Dijkstra and Grainger, 1998; Kroll and Dijkstra, 2001) that the presentation of input activates lexical candidates irrespective of language. A caveat though is that greater experience with one language (L1) elevates the subjective frequency of its words, relative to the second language's entries (L2). Thus, the resting level of L2 words is lower than that of L1 words resulting in slower activation of L2. In addition, suppression of L2 entries should be more efficient particularly when the task encourages suppression (e.g. reading material in a single language). Experiment 1 examined the possibility that inter-lingual homograph letter detection reflects the roles assigned by the language of the text. In addition, the pattern was examined for bilinguals whose L1 was French and whose L1 was English, as well as for English monolinguals. Thus, a comparison was made across three language groups to determine whether letter detection is possibly influenced not only by text role, but by dominance of one language over another (i.e. relative fluency).

## Method

### Participants

Sixty-six participants from New York State participated in the experiment. Twenty-four were English monolingual subjects recruited from the subject pool at Union College and received either participant credit towards their course or five dollars. Twenty-four French-dominant French–English bilingual subjects were sampled from l'Alliance Française in New York City, and 18 English-dominant English–French bilinguals were sampled from high schools and colleges in upstate New York. The bilingual subjects were paid five dollars for their participation. Bilingual participants filled out a questionnaire that was used to determine whether they met a criterion of being able to read, write and converse in each of the two languages. The questionnaire was a self-inventory that assessed the first language's dominance, i.e. one's self-reported relative ability to converse and read in each language, indication of preferred language, and years of usage. Subjects were assigned to the dominant French or English group based upon their reported experience, skill, and preference for a language when communicating and reading. All subjects in the dominant French sample indicated French was the dominant language, and in each case they had more experience speaking and reading French than English. The dominant English subjects unanimously selected English as the dominant language and indicated greater experience speaking and reading English than French. All subjects in both groups indicated extensive experience and fluency with the second language. Monolingual subjects had to be completely unfamiliar with French. Clearly subjects were quite skilled in both languages, however, as the results indicate (see below), subjects assigned to the different groups did respond somewhat differently.

### Materials and design

Two critical prose passages were assembled according to the same rules. There was one passage in English and one in French. For each prose passage, the critical words were not included in the first or the last sentence of the text and they were never adjacent to a word with the target letter. Each prose passage contained eight occurrences of *or* and eight occurrences of *pour*. In English, *or* assumes a function role and has a frequency count of 4,207 occurrences per million (Kučera and Francis, 1967), whereas in French, *or* can either be used as a noun meaning "gold", with a frequency count of 155 occurrences per million, or as a conjunction ("whereas"), with a frequency count of 174 occurrences per million (Baudot, 1992). Here, in French, *or* was always used as a noun. On the other hand, in English, *pour* assumes a content role and has a frequency count of 9 occurrences per million (Kučera and Francis, 1967), whereas in French it assumes a function role ("for") and has frequency of 7,982 occurrences per million (Baudot, 1992). The English and the French passages were, respectively, 267 and 248 words long.

The two critical prose passages were included in a stapled packet containing six prose passages. Each critical prose passage was preceded by an orientation passage that was only two-sentence long. The orientation passage was always in the same language as the critical passage following it. It was included to provide participants with a predictable orientation toward the language of the to-be-presented critical passage. The English and the French critical passages were separated by two German passages (not analysed) that served as a distraction. For each of the three groups, presentation order of the English and the French passages was completely counterbalanced across participants.

A $3 \times 2 \times 2$ mixed-design was used with language group (monolinguals, English-dominant bilinguals and French-dominant bilinguals) as the between-subjects factor. Text language and target word were within-subject factors.

### Procedure

All participants were instructed to read all passages regardless of whether they were or were not familiar with the language of the passage. They were encouraged to read the passages as if they were reading a familiar language, with appropriate pacing. As they read a passage they were to cross off every target letter *r* they saw. However, they were told that if they missed a target letter they were not to go back and cross it out, but rather to proceed at their normal reading pace.

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Table 1. *Means and standard deviations in parentheses for percentage of omission errors as a function of target word, text language and language group.*

| | Language group | | |
|---|---|---|---|
| Conditions | Bilinguals English-dominant | Bilinguals French-dominant | Monolinguals English |
| English text | | | |
| Or (function role; 4,207/million) | 67.36 (31.84) | 51.56 (33.85) | 69.79 (30.15) |
| Pour (content role; 9/million) | 10.42 (13.04) | 6.25 (10.43) | 6.77 (9.74) |
| French text | | | |
| Or (content role; 155/million) | 20.83 (27.12) | 5.73 (13.78) | 57.81 (28.98) |
| Pour (function role; 7,982/million) | 31.25 (26.52) | 32.81 (30.36) | 16.67 (20.08) |

### *Results*

Mean percentages of omission errors for the homographs *or* and *pour* are presented in Table 1 as a function of text language, language group and target word. These percentages were computed for each participant and each condition by dividing the number of omissions by the number of occurrences (namely, 8) and then by multiplying the result by 100. Inspection of Table 1 reveals that for the English text, there were more omissions of the target letter *r* in the frequent function word *or* than in the less frequent content word *pour* for all three groups. In French both bilingual groups made more omissions of the target letter *r* on *pour* that had assumed the role of a frequent function word ("for") than on *or* that was now a less frequent content word. However, for monolingual participants the pattern of results was similar to that found with the English text, with more omissions for *or* than for *pour*.

A $3 \times 2 \times 2$ mixed-design ANOVA, with language group as the between-subjects factor, and text language and target word as the repeated factor, confirmed those trends. In all analyses, the .05 level of significance was adopted. There were significant main effects of language group, $F(2,63) = 3.70$, $MSE = 1230.82$, text language, $F(1,63) = 12.50$, $MSE = 317.61$, and of target word, $F(1,63)$ 145.57, $MSE = 353.98$. More importantly, two of the three second-order interactions were significant. The significant second-order interactions were the interaction between target word and language group, $F(2,63) = 32.29$, $MSE = 353.98$, and between target word and text language, $F(2,63) = 96.11$, $MSE = 489.05$. The third-order interaction between target word, text language and language group was also significant, $F(2,63) = 9.20$, $MSE = 489.05$.

The interactions were decomposed by running separate analyses for each text language. For the English text, the $3 \times 2$ mixed-design ANOVA with language group as the between-subjects factor and target word as the within-subject factor revealed a main effect of target word, $F(1,63) = 215.20$, $MSE = 457.62$, reflecting the higher omission rate of the target letter *r* embedded in *or* than in *pour*. However, neither the main effect of language group, nor the interaction reached significance. For the French text, the corresponding ANOVA revealed a main effect of language group, $F(2,63) = 4.57$, $MSE = 862.22$, and a significant interaction between language group and target word, $F(2,63) = 38.82$, $MSE = 385.41$, but the effect of target word did not reach significance, $F < 1$. Simple main effect tests revealed that monolingual participants made significantly more omissions on the French usage of *or* as a content word meaning "gold" than on the French usage of *pour* as a function word, $F(1,63) = 52.71$, $MSE = 385.41$, whereas the French-dominant bilingual participants made more omissions on *pour* than on *or*, $F(1,63) = 22.84$, $MSE = 385.41$. However, although in the same direction as the French-dominant, the effect failed to reach significance for the English-dominant bilingual group, $F = 2.53$, $p = .12$. On the other hand, simple main effect tests revealed a significant effect of language group for omission rate on *or*, $F(2,126) = 27.35$, $MSE = 623.81$. Post-hoc comparisons (Tukey, HSD) revealed that all three groups differed from one another. For *pour*, the effect of language group was only marginally significant, $F(2,126) = 2.95$, $MSE = 623.81$, $p < .056$. Post-hoc comparisons revealed that omission rate was significantly lower for the monolingual group than for both bilingual groups, which did not differ from one other.

### *Discussion*

The findings are generally consistent with letter detection work on intra-lingual homographs (see e.g. Greenberg and Koriat, 1991; Greenberg et al., 1992; Moravcsik and Healy, 1995; Saint-Aubin and Poirier, 1997; Saint-Aubin et al., 2003) indicating that the word produces greater detection errors when it is a high-frequency function word than when it is a low-frequency content word. The bilingual data in contrast with the monolingual results

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appears consistent with the notion that the reader is responding to the word's role in the text, rather than simply to the orthographic pattern. Presumably, if letter detection rested upon the indiscriminate activation of an orthographic pattern, the total (or highest) frequency of the word patterns should have determined letter detection performance. Thus, since each word is of relatively high frequency in at least one language, then regardless of the passage's language, errors should have been high and relatively equal (Beauvillain and Grainger, 1987). Rather, the pattern indicates a language-specific contextual involvement in lexical selection (Altarriba, Carlo and Kroll, 1992). Although this pattern suggests that target lexical activation is appropriately selective, a non-selective model of bilingual representation and activation, such as the BIA model (Dijkstra and Van Heuven, 1998), can accommodate the findings. The letter detection task in text, in accordance with the GO model (Greenberg et al., in press), is often affected by a post-lexical determination of a word's role in text (as well as by word frequency). Presumably, then, during this relatively late post-lexical determination, the inappropriate though initially active other language meaning is suppressed.

Alternatively, it might be argued that the pattern is consistent with a selective-access model in which language context contributes immediately to selective activation of words in the passage's language. Specifically, in an English passage, for example, frequencies associated with the English language predominate. The *or*-disadvantage specific to English, and similarly the *pour*-disadvantage in French, could still imply a pre-lexical rationale for the observed pattern in which the target language biases pattern identification based upon the target word's frequency in that language. Such an explanation is more in the spirit of a selective model of bilingual processing (e.g. Gerard and Scarborough, 1989) in which only members of the target language are activated at all. Experiments 2 and 3 help to clarify whether the pre- or post-lexical explanation is better, and consequently, whether a non-selective model handles these findings.

The BIA position regarding the influence of fluency did gain some support from these results. Language dominance is assumed to bias activation in favour of one language or another, depending upon relative fluency and context (e.g. Kroll and Stewart, 1994; Altarriba and Mathis, 1997). In the French passage, monolinguals missed *r* in *or* more than did the two bilingual groups, as expected. Knowledge of a French content *or* tempered the bilingual error rates. In addition, the English bilinguals made more omission errors of *or* in the French passage than did the French bilinguals, and thereby achieved a smaller *pour* disadvantage. To the extent that this pattern captures a real effect of fluency, it suggests support for initial non-selective activation of lexical codes for the English-dominant readers who may be experiencing some influence from the English lexical entry *or*. Unfortunately, these results are not mirrored in the *pour* data, i.e. French-dominant bilinguals do not show a stronger *pour* error response than do the English bilinguals in the English passage. However, the difference between *or* and *pour* in the English passage for French-dominant bilinguals is somewhat less pronounced than that found for English-dominant bilingual (though the difference was not significant).

## Experiment 2

Though Experiment 1 indicated that in the letter detection task the inappropriate lexical entry is suppressed, it is not clear what aspect of the context encouraged the suppression. Whereas the selective processing observed for intra-lingual homographs is often attributed to the semantic and/or syntactic properties of the text, the similar pattern observed with inter-lingual homographs could reflect an additional or a different source, as indicated earlier. Inter-lingual selection or suppression could simply result from the language of the text, i.e. French or English. In such a case, it is then also possible to argue that relative activation of one lexical entry over another could occur quite early, perhaps during pattern identification. As noted, this possibility argues that homographic activation is selective.

Thus, Experiment 2 was designed to determine whether the same patterns would persist when passages in either language are scrambled. It is important to note that scrambling text does not altogether eliminate the function word disadvantage in the SLH (e.g. Drewnowski and Healy, 1977; Greenberg et al., 1998). Either the remaining, though reduced effect, suggests word frequency leading to unitization (Healy, 1994), and/or it indicates that function words even in scrambled texts tend to encourage the formation of phrases in which they still play a function role (Koriat and Greenberg, 1991). Key, though, is whether some reduction in the disadvantage occurs, for that implicates later post-perceptual analysis in the effect observed in normal text. In the case of the DLH, the effect of scrambling could be ineffective if the factor directing selection is the language of the passage, rather than the attributes of text cohesion, i.e. structure and meaning coherence. Therefore, crucial to the present investigation, is whether the effect of scrambling has less of an effect upon bilingual than monolingual subjects. Should the impact upon bilinguals be less than upon monolinguals, it would suggest that the language of the text is a factor in biased inter-lingual processing. However, a more comparable effect in scrambled texts for the two groups would suggest that a text's language is of relatively little importance to selective processing relative to linguistic properties of coherence in a text.

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In addition, the comparison in Experiment 2 is, again, between the processing of *or* and *pour*. Whereas *pour* has a single content interpretation in French and English as a function and content word, respectively; *or* has a function interpretation in English and either a content ("gold") or function ("whereas") interpretation in French. In the normal passages of Experiment 1 and here, in Experiment 2, contextual constraint indicates only the content interpretation of *or* in French. In the absence of contextual constraint, though, the scrambled passage could permit the alternative and equally frequent function interpretation. Thus, in the scrambled English passage, if context – and not simply the passage's language – is important, then the *or*-to-*pour* disadvantage should be weakened, and be about as strong for bilinguals as for monolinguals. In contrast, scrambling the French passage should have relatively little effect upon the English monolinguals, whose lack of familiarity with French renders the scrambled and normal passages equal in structure. However, scrambled French text for bilinguals ought to permit more intra-lingual competition, given the relative equal frequency of the interpretations, and thereby undermine the *pour*-to-*or* disadvantage in French.

## *Method*

### *Participants*

Forty-eight native-English speakers from Union College composed the monolingual group and forty-eight native-French speakers from Université de Moncton composed the bilingual group. The bilingual subjects indicated in a survey question that they were native French speakers and that French was used at home. However, all bilingual participants scored with a percentile rank of 50 or higher (mean = 83) on the comprehension scale of the Nelson-Denny Reading Test (form G) (Brown, Fishco and Hanna, 1993) with norms for ninth graders indicating good English reading skills. None of the participants took part in the previous experiment.

### *Materials and design*

The French and the English versions of the *or*/*pour* text used in Experiment 1 were used here. Those two texts, one in English and one in French, composed the normal presentation condition. A scrambled version of each text was assembled, by placing the words of each sentence from the normal passages in a new random order. Care was taken to destroy the overall syntactic cohesion of the sentence and more importantly to destroy the syntactic cohesion of the local structure around the target words.

A $2 \times 2 \times 2$ mixed-design was used with bilingualism and text structure (normal or scrambled) as between-subjects factors with 24 participants per condition. Text language was a within-subject factor. Presentation order of the two texts was completely counterbalanced across participants with 48 participants reading the French passage first and 48 beginning with the English one.

The two texts were included in a stapled packet with an instruction page on the front. The instructions informed participants that one text was in English and one in French. The instructions also encouraged participants to read the text for comprehension and at their normal reading speed. For the English monolingual subjects, a special sentence was added in which it was mentioned that even if they don't master French, they should try to read the French texts normally as if they understood what they were reading. Similarly, for the scrambled condition, a sentence warned the participants that the word order was random in the text, thereby producing nonsense sentences. Nevertheless, subjects were asked to read the passages as if they were understandable. For all participants and conditions, the instructions further mentioned that whenever they came across the target letter *r* (either in lower or upper case) they were to circle it. They were also warned not to backtrack in order to circle a target letter that they had missed. To familiarize the subjects with this task, they were asked to read again the instructions sheet and to circle all *t*s. Instructions were written in English for the monolingual participants and in French for the bilingual participants. In addition, a short instruction page was inserted between the two texts. The short instruction page reminded participants to read at their normal speed for comprehension and indicated that the target letter for the next text was also an *r*. In addition, the target letter was always displayed at the top of each text.

Bilingual participants were also administered the comprehension scale of the Nelson-Denny Reading Test (form G). The comprehension scale consists of seven prose passages and 38 multiple-choice questions. The extended-time administration procedure was used. Accordingly, participants were given 32 minutes to read the passages and answer the questions.

### *Procedure*

Participants took part individually in a private room in one session lasting approximately one hour for bilingual participants and 20 minutes for monolinguals. The Nelson-Denny comprehension scale was administered first to bilingual participants. All participants undertook the letter search task that was the first part of the experiment for monolingual participants and the second part of the experiment for the bilingual participants. Participants read silently the instruction sheet and before beginning the practice by circling all *t*s on it, the experimenter answered all their questions.

## *Results*

Mean percentages of omission errors for the homographs or and pour are presented in Table 2, as a function

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Table 2. *Means and standard deviations in parentheses for percentage of omission errors as a function of target word, text language, text structure, and bilingualism status.*

| | **Text structure** | | | |
|---|---|---|---|---|
| | **Normal** | | **Scrambled** | |
| Conditions | Bilinguals | Monolinguals English | Bilinguals | Monolinguals English |
| English text | | | | |
| Or (function role; 4,207/million) | 50.00 (32.60) | 72.22 (31.08) | 43.77 (23.24) | 52.78 (29.72) |
| Pour (content role; 9/million) | 15.10 (16.48) | 13.54 (16.45) | 23.96 (28.05) | 19.79 (20.82) |
| French text | | | | |
| Or (content role; 155/million) | 10.94 (19.96) | 66.15 (28.19) | 31.77 (30.84) | 71.88 (26.90) |
| Pour (function role; 7,982/million) | 26.56 (24.26) | 25.52 (17.86) | 30.21 (32.33) | 28.13 (23.39) |

of bilingualism status, text language, and text structure (scrambled vs. normal). Table 2 reveals that for the English text, there were more omissions of the target letter *r* on *or* than on *pour* for both bilingual and monolingual participants. In addition, for both groups, the omission rate difference between *or* and *pour* was smaller when the text was scrambled than when it was displayed normally. For the French text, a different pattern of results emerged. Just as they did for the English text, monolingual participants made more omissions when the target letter was embedded in *or* than in *pour*. As expected, the reverse pattern of results was observed for bilingual participants reading the normal version of the French text with more omissions for the French function word *pour* ("for") than for the French content usage of *or* ("gold"). However, omission rate was similar for *or* and *pour* when the French text was scrambled.

A $2 \times 2 \times 2 \times 2$ mixed-design ANOVA with bilingualism and text structure as between-subjects factor and text language and target word as the repeated factor confirmed those trends. There was a significant main effect of bilingualism, $F(1,92) = 14.18$, $MSE = 1482.94$, reflecting the fact that overall monolinguals made more omissions than bilinguals. There was also a significant main effect of target word, $F(1,92) = 171.07$, $MSE = 408.98$, due to the higher omission rate for *or* than for *pour*. However, neither the effect of text structure nor the effect of text language reached significance, both $F$s $< 1$. More importantly, there were four significant second-order interactions and two significant third-order interactions. The fourth-order interaction between bilingualism, text structure, text language and target word was not significant, $F < 1$. The significant second-order interactions included the interaction between target word and bilingualism, $F(1,92) = 67.95$, $MSE = 408.98$, between text language and text structure, $F(1,92) = 6.86$, $MSE = 425.00$, between text language and bilingualism, $F(1,92) = 15.36$, $MSE = 425.00$, and between target word and text language, $F(1,92) = 25.93$, $MSE = 328.40$. Because the second-order interactions were qualified by the third-order interactions, only the latter will be discussed. At the third-order level, there were two significant interactions. The first one was between target word, text language and text structure, $F(1,92) = 17.45$, $MSE = 328.40$ and the second one involved target word, text language and bilingualism, $F(1,92) = 16.86$, $MSE = 328.40$.

The interactions were decomposed by running separate analyses for each text language. For the English text, the $2 \times 2 \times 2$ mixed-design ANOVA with bilingualism and text structure as between-subjects factors and target word as the within-subject factor revealed a main effect of target word, $F(1,92) = 175.65$, $MSE = 362.36$, reflecting the higher omission rate for or than for pour, but neither the main effect of text structure, $F < 1$, nor of bilingualism, $F = 2.19$, reached significance. There were also two significant second-order interactions. The first one was between target word and bilingualism, $F(1,92) = 11.75$, $MSE = 362.36$. Simple main effect tests revealed that when collapsing data for the normal and the scrambled texts together, monolinguals made more omissions than bilinguals on or, $F(1,191) = 9.42$, $MSE = 649.90$, but not on pour, $F < 1$. More importantly, the interaction between target word and text structure was significant, $F(1,92) = 14.25$, $MSE = 362.36$. This interaction reflects the fact that the size of the missing-letter effect as evidenced by the difference in omission rate between *or* and *pour* was smaller for scrambled text, than for normal text. Simple main effect tests revealed that the effect of target word was significant for both the normal, $F(1,92) = 145.29$, $MSE = 362.36$, and scrambled, $F(1,92) = 45.01$, $MSE = 362.36$. No other interactions were significant.

For the French text, the corresponding mixed-design ANOVA revealed a main effect of target word, $F(1,92) = 39.55$, $MSE = 375.02$, reflecting the overall

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higher omission rate for *or* than for *pour*, and a main effect of bilingualism, $F(1,92) = 26.58$, $MSE = 966.62$, reflecting the higher omission rate for monolinguals compared to bilinguals. The main effect of text structure just failed to reach significance, $F = 3.34$, $p = .07$. The only significant interaction was between target word and bilingualism, $F(1,92) = 77.52$, $MSE = 375.02$. Simple main effect tests revealed that the effect of target word was significant for monolinguals, with more omissions on *or* than on *pour*, $F(1,92) = 113.19$, $MSE = 375.02$, but the effect of target word failed to reach significance for bilinguals, $F = 3.14$, $p = .08$. As can be seen in Table 2, the non-significant effect of target word for bilingual participants reading the French text is due to the scrambled passage, because, just as in Experiment 1, with the normal passage, they made more omissions on the French function word pour than on the French usage of or as a content word. This was further tested with a $2 \times 2$ mixed-design ANOVA with text structure as the between-subjects factor and target word as the repeated factor for bilingual participants reading the French text. Neither the main effect of text structure, nor of target word reached significance, but as expected, the interaction was significant, $F(1,46) = 5.89$, $MSE = 300.82$. Simple main effect tests indicated that the effect of target word was significant for the normal text, $F(1,46) = 9.74$, $MSE = 300.82$, but not for the scrambled text, $F < 1$.

### *Discussion*

The results of Experiment 2 reveal that scrambling the text reduced though did not eliminate the missing-letter effect – as evidenced by the higher omission rate for *or* than for *pour* for both bilinguals and monolinguals reading the English passage. For the French passage, a different picture emerged. Foremost, the pattern observed in Experiment 2 with the normal text replicated the earlier results. Specifically, whereas monolinguals made more errors on *or* than *pour* in both English and French passages, the French-dominant bilinguals reversed that disadvantage when reading the French normal passage. Thus, the performance of letter detection is apparently consistent with the notion that the role played by the homograph in a particular language is important. However, it is also possible that the mere presence of a language engages an early selective or suppressive process. The scrambling data, though, suggests otherwise.

Scrambling the passages changed performance. First, one notes that in the case of English text, although the function word disadvantage remained significant it was less strong than with normal text. In accordance with the GO model (Greenberg et al., in press) loss of role ought to make the function word more available for letter detection, although it still should maintain a residual disadvantage due to local binding and its frequency (see also Healy, 1994). The reduction, however, was equally strong for monolinguals and bilinguals. Had the language of the text affected the bulk of suppression then bilinguals should have shown an effect in the scrambled condition that was more comparable to that of the normal condition. Of course, assuming the activation and suppression of the DLH mimics that of the SLH then a reduced effect of scrambling is expected. Yet, importantly the reduction was very similar to that of the monolinguals, strongly suggesting that inter-lingual suppression is not achieved by the context's language. Rather, the reduced difference between *or* and *pour*, reflects the absence of linguistic features of a coherent text. The pattern is inconsistent with the possibility that selection occurs early based simply upon the language of the passage.

The French text pattern changes were even more dramatic. Though the monolinguals showed no diminished effect, probably because scrambling in French was irrelevant to them, the *pour* disadvantage for the bilinguals was entirely eliminated. At first blush, this could be taken as evidence that once the structure was destroyed, the alternative language's representation has an opportunity to compete. However, the more likely possibility, given the pattern for the scrambled English text, is that the alternative intra-lingual function representation of *or* ("whereas") was able to compete. The pattern is again consistent with notion that text coherence is important to the process of suppression for both the DLH and SLH targets. This explanation is also more consistent with the failure to find an effect on *pour* processing resulting from scrambling of the French passage. As an aside, it should be noted that intra-lingual competition could surface for *or* since the frequency of the two lexical entries were similar. Had the relative strengths of the intra-lingual interpretations been much different, e.g. the *gold* interpretation more dominant, the alternative's impact would have been weaker.

Of further interest is that once again (see Experiment 1) we found some evidence that language fluency impacts upon the function word disadvantage. Analyses indicate that the English monolinguals produced a stronger function word disadvantage in the normal English text than did the English-fluent though French-dominant bilinguals. Two explanations seem reasonable. Assuming that bilingual word activation is not initially selective, as argued in, for example, Dijkstra and Van Heuven (1998, 2002), then unlike the monolinguals when the bilinguals encounter the target words their response is somewhat affected by a diminishing but still available alternative inter-lingual representation. Thus, these results are suggesting at least some non-selective mechanism. Alternatively, fluency has an impact on letter detection. It has been demonstrated (e.g. Healy and Cunningham, 1992; Greenberg et al., 1998) that young children less fluent with a language, and presumably less acquainted

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with either the frequency (Healy) or role distinction afforded function words (Greenberg), process these words less differently than do more fluent adults. Whereas this latter alternative explanation is possible, it must be noted that the difference between children and adults disappears most often by middle elementary grades. Given that our bilinguals scored reasonably high on the Nelson-Denney Test, it is likely that their fluency exceeds that of children who no longer exhibit such differences. Thus, for now, the preferred explanation rests with non-selectivity. Among others, Gerard and Scarborough (1989) suggested that the difference between monolinguals and bilinguals on a task could indicate non-selectivity activation during the performance of that task. Once again, then, whereas the findings support the notion of eventual selective suppression of the inappropriate inter-lingual representation, they also continue to provide some support for the initial activation of competing representation.

## Experiment 3

The interpretation of the biased processing of the DLH, consistent with a non-selective model such as BIA, rests on the notion that the detection task reflects largely post-lexical processes. Thus, once a function word interpretation is assumed (usually the default, see Greenberg et al., in press), the competition from the alternative inter-lingual content interpretation is inhibited. Consequently, the chosen pattern consistent with the text role leads to a response pattern consistent with that witnessed for the SLH.

This understanding of the process is consistent with notions set forth in the GO model explanation of letter detection, whereby the role of a word in a sentence affects the availability of that word in the cognitive representation and consequently that word's constituent letters. Function words retreat into a background in which their letters are less available for identification. However, as described earlier, the model also posits that the frequency of a word can impact on letter detection as well, particularly by influencing parafoveal identification of frequent words. Whereas both orthographic frequency and word function impact on letter detection, it would be problematic for a model espousing non-selective activation to account for this clearly biased detection pattern based on orthographic familiarity. Under such an assumption, the activation of the most frequent bilingual representation should overwhelm the less frequent, regardless of context, and thus letter detection errors would be reasonably high and consistent across passages. Although the failure to generate equally large word disadvantages in scrambled as in normal passages (Experiment 2) is more consistent with the possibility that suppression and selection of an inter-lingual homograph's meaning occurs late, a more direct test of the involvement of post-lexical selection is possible.

Thus, Experiment 3 examined letter detection for a DLH *on*, which despite having different roles across the two languages is similar in frequency in both languages. Should role variations lead to different error rates for *on*, the evidence would reinforce the notion that the differential error patterns are the result of post-lexical suppression, and thereby lend further support to the postulates of the BIA model. For the purpose of comparison, a second DLH, *me*, is examined. It matches reasonably the relative frequency pattern of *on* across the languages but its role is constant in both texts.

### *Method*

#### *Participants*

Thirty-two native-English speakers from Union College composed the monolingual group and forty native-French speakers from Université de Moncton composed the bilingual group. All subjects indicated they were native French speakers, and that French was the language used at home. Again, though, all bilingual participants scored with a percentile rank of 50 or higher (mean = 76) on the comprehension scale of the Nelson-Denny Reading Test (form G) with norms for ninth graders. None of the participants took part in the previous experiments.

#### *Materials, design and procedure*

Four prose passages were assembled according to the same rules as those used in Experiment 1. There were two texts in English and two in French. Two prose passages contained 10 occurrences each of the homograph *on*. In English, *on* assumes a function role and has a frequency count of 6,742 occurrences per million (Kučera and Francis, 1967), whereas in French, *on* assumes a content role as a third person singular personal pronoun, with a frequency count of 5,306 occurrences per million (Baudot, 1992). The English and the French passages were, respectively, 237- and 211-word long.

The other two passages contained 10 occurrences each of the homograph *me*. In both English and French *me* assumes the same role as a personal pronoun and has a similar frequency with 2,151 occurrences per million in English (Kučera and Francis, 1967) and 2,022 occurrences per million in French (Baudot, 1992). The English and the French passages were respectively 289- and 196-word long.

All subjects read the four texts, and presentation order of the texts was blocked by text language. This is to say that half of the subjects first read the two French passages and the other half began with the two English passages. Presentation order of the *on* and *me* passages was systematically counterbalanced for each language.

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Table 3. *Means and standard deviations in parentheses for percentage of omission errors as a function of target word, text language and bilingualism status.*

| | **Bilingualism** | |
|---|---|---|
| Conditions | Bilinguals | Monolinguals English |
| English text | | |
| On (function role; 6,742/million) | 42.25 (31.09) | 48.44 (29.63) |
| Me (content role; 2,151/million) | 11.00 (14.82) | 13.75 (19.47) |
| French text | | |
| On (content role; 5,306/million) | 27.75 (26.46) | 56.25 (33.96) |
| Me (content role; 2,022/million) | 11.00 (19.32) | 15.31 (19.67) |

In sum, there were eight possible presentation orders [2 (order of text language) × 2 (order of *on* – *me* in French) × 2 (order of *on* – *me* in English)]. The procedure was the same as in Experiment 2.

### *Results*

Mean percentage of omission errors for the homographs *on* and *me* are presented in Table 3, as a function of bilingualism status and text language. Table 3 reveals a different pattern of omissions for bilingual and monolingual subjects. For monolinguals, for both critical words, omission rates were similar for the English and the French texts. However, for bilingual subjects, there were more omissions of target letter *n* when *on* was embedded in the English rather than in the French text, but for *me*, omission rates were similar in both texts. Homographs were analysed separately because controls were implemented across text languages rather than across critical words.

For *on*, a mixed-design analysis of variance (ANOVA) with bilingualism as the between-subjects factor and text language as the repeated factor confirmed these trends. There were significant effects of bilingualism, $F(1,70) = 7.10$, $MSE = 1505.69$, and of the interaction, $F(1,70) = 13.73$, $MSE = 322.41$, but the effect of text language did not reach significance, $F = 1.26$. Simple main effects revealed that bilingual participants made significantly more omissions of target letter *n* on *on* in the English than in French text, $F(1,70) = 13.04$, $MSE = 322.4$, but this was not the case for English monolingual participants, $F(1,70) = 3.03$. On the other hand, omission rates were similar for bilingual and monolingual participants for the English text, $F < 1$, but bilinguals made significantly fewer errors than monolinguals in the French text, $F(1,140) = 15.80$, $MSE = 914.05$. For *me*, the mixed-design ANOVA revealed that neither the effect of bilingualism, text language nor the interaction were significant, all $F$s $< 1$.

### *Discussion*

The results are quite straightforward. Experiment 3 replicated the DLH findings of the earlier experiments for both bilinguals and monolinguals. Thus, it is evident that the bilingual's selective pattern is in response to the role of a word in the passage, indicating that the derived pattern reflects relatively late post-lexical processes. As argued, the involvement of late post-lexical processes would permit the readers to suppress inappropriate cross-language activation. Had readers been responding primarily to the pre-lexical familiarity of the orthography then the relatively equal familiarity of meanings should have resulted in more equal error rates for *on* across the passages for bilingual subjects. The apparent ability of bilingual readers to respond appropriately to words in a passage suggests a process of post-lexical suppression consistent with the GO model. Importantly, these findings are also compatible with the BIA contention (Kroll and Dijkstra, 2001) that inter-lingual and intra-lingual activation and suppression operate similarly.

## Conclusions

Whereas the present results indicate that letter detection for words in context engender a selective process, the factors that appear to have a significant impact on the process of selection are likely to have influenced post-lexical processing and decisions rather than earlier perceptual identification. As such, these results are viewed as compatible with non-selective models of the bilingual lexicon that allow for selectivity at later stages following initial activation of both meanings, i.e. BIA and BIA+ (Dijkstra and Van Heuven, 1998, 2002, respectively). All relevant aspects of the present study are largely consistent with the proposition that words sharing a common orthographic representation across different languages are treated much like those that share a common orthography within a language. Although there

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is considerable evidence, particularly in the literature on lexical decision, to support the position of a lexicon that responds in a non-selective pattern to inter-lingual homographs (e.g. Dijkstra, Grainger and Van Heuven, 1999), far less support exists from tasks in which subjects are reading normally from printed text.

Whereas the present findings point to selectivity, it is apparent that selectivity results primarily from post-lexical consideration of activated representations. Of particular interest is that this relatively late selection process is responsive more to the coherent text features rather than simply the language. The results of Experiment 2 show that the language context in which a word appears is insufficient to maximize selection in the bilingual (see Grosjean, 2001, regarding conditions that maximize the monolingual mode); it is, rather, structure or meaning that contributes to the selection process. Thus, selection of one reading of a homograph occurs rather late, though the language of the item does not aid selection much (Dijkstra and Van Heuven, 2002). Dijkstra and Van Heuven (2002) contend that determination of the item's language depends upon lexical selection having occurred. Accordingly, top-down sources are viewed as not overtly affecting the bottom-up information, but rather exploiting the dual activation in the lexicon to respond appropriately to context. In that spirit, the BIA+ model accounts for context effects not by assuming differential activation but primarily through adjustments in decision criteria as a function of task requirements and context.

The present results are also consistent with the GO model view (Greenberg et al., in press) of letter detection for words appearing in connected text. Letter detection patterns here suggest that though word frequency plays a role in determining letter detection (e.g. differences still occur in a scrambled text), the word's use in a sentence is profoundly important. The present task affords a new opportunity for exploring non-selective and selective processes in inter-lingual homograph processing in the context of a task that more closely approximates the reading environment in which lexical choices are made from competing bilingual representations.

## References


Altaribba, J., Carlo, M. S. & Kroll, J. (1992). The multiple access of meaning in processing cross-language ambiguity. Paper presented at the Annual Meeting of the Midwestern Psychological Association, Chicago.

Altarriba, J. & Gianico, J. L. (2003). Lexical ambiguity resolution across languages: A theoretical and empirical review. *Experimental Psychology*, 50, 159–170.

Altaribba, J., Kroll, J. F., Sholl, A. & Rayner, K. (1996). The influence of lexical and conceptual constraints on reading mixed-language sentences: Evidence from eye fixations and naming times. *Memory & Cognition*, 24, 477–492.

Altarriba, J. & Mathis, K. (1997). Conceptual and lexical development in second language acquisition. *Journal of Memory & Language*, 36, 550–568.

Baudot, J. (1992). *Fréquence d'utilisation des mots en français écrit contemporain* [Frequency of usage of contemporary written French words]. Montréal, Québec, Canada: Les Presses de l'Université de Montréal.

Beauvillain, C. & Grainger, J. (1987). Accessing interlexical homographs: Some limitations of a language-selective access. *Journal of Memory & Language*, 26, 658–672.

Bock, K. (1990). Structure in language: Creating form in talk. *American Psychologist*, 45, 1221–1236.

Brown, J. I., Fishco, V. V. & Hanna, G. (1993). *Nelson-Denny Reading Test*. Itasca, IL: Riverside Publishing Company.

Dijkstra, A. (Ton), Grainger, J. & Van Heuven, W. J. B. (1999). Recognizing cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language*, 41, 496–518.

Dijkstra, A. (Ton) & Van Heuven, W. J. B. (1998). The BIA model and bilingual word recognition. In J. Grainger & A. Jacobs (eds.), *Localist connectionist approaches to human cognition*, pp. 189–225. Hillsdale, NJ: Lawrence Erlbaum Associates.

Dijkstra, A. (Ton) & Van Heuven, W. J. B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, 5, 175–197.

Dijkstra, A. (Ton), Van Heuven, W. J. B. & Grainger, J. (1998). Simulating cross-language competition with the bilingual interactive activation model. *Psychologica Belgica*, 38, 177–196.

Dijkstra, A. (Ton), Van Jaarsveld, H. & Ten Brinke, S. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism, Language and Cognition*, 1, 51–66.

Drewnowski, A. & Healy, A. F. (1977). Detection errors on *the* and *and*: Evidence for reading units larger than the word. *Memory & Cognition*, 5, 636–647.

Gerard, L. D. & Scarborough, D. L. (1989). Language-specific lexical access of homographs by bilinguals. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 15, 305–315.

Greenberg, S. N., Healy, A. F., Koriat, A. & Kreiner, H. (in press). The Go model: A reconsideration of the role of structure units in guiding and organizing text online. *Psychonomic Bulletin & Review*.

Greenberg, S. N. & Koriat, A. (1991). The missing-letter effect for common function words depends on their linguistic function in the phrase. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 17, 1051–1060.

Greenberg, S. N., Koriat, A. & Shapiro, A. (1992). The effects of syntactic structure on letter detection in adjacent function words. *Memory & Cognition*, 20, 663–670.

Greenberg, S. N., Koriat, A. & Vellutino, F. R. (1998). Age changes in the missing-letter effect reflect the reader's growing ability to extract the structure of the text. *Journal of Experimental Child Psychology*, 69, 175–198.

Grosjean, F. (2001). The bilingual's language modes. In J. L. Nicol (ed.), *One mind, two languages: Bilingual language processing*, pp. 1–22. Oxford: Blackwell.


https://doi.org/10.1017/S1366728904001622 Published online by Cambridge University Press

Healy, A. F. (1976). Detection errors on the word *the*: Evidence for reading units larger than letters. *Journal of Experimental Psychology: Human Perception & Performance*, 2, 235–242.

Healy, A. F. (1994). Letter detection: A window to unitization and other cognitive processes in reading text. *Psychonomic Bulletin & Review*, 1, 333–344.

Healy, A. F. & Cunningham, T. F. (1992). A developmental evaluation of the role of word shape in word recognition. *Memory & Cognition*, 20, 141–150.

Koriat, A. & Greenberg, S. N. (1991). Syntactic control of letter detection: Evidence from English and Hebrew nonwords. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 17, 1035–1050.

Koriat, A., Greenberg, S. N. & Goldshmid, Y. (1991). The missing-letter effect in Hebrew: Word frequency or word function? *Journal of Experimental Psychology: Learning, Memory & Cognition*, 17, 66–80.

Kroll, J. & Dijkstra, A (Ton). (2001). The bilingual lexicon. In R. Kaplan (ed.), *Handbook of applied linguistics*. Oxford: Oxford University Press.

Kroll, J. F. & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connection between bilingual memory representations. *Journal of Memory & Language*, 33, 149–174.

Kučera, H. & Francis, W. N. (1967). *Computational analysis of present-day American English*. Providence, RI: Brown University Press.

McClelland, J. L. & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception, I: An account of basic findings. *Psychological Review*, 88, 375–407.

Moravcsik, J. E. & Healy, A. F. (1995). Effect of meaning on letter detection. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 21, 82–95.

Moravcsik, J. E. & Healy, A. F. (1998). Effect of syntactic role and syntactic prominence on letter detection. *Psychonomic Bulletin & Review*, 5, 96–100.

Muesseler, J., Koriat, A. & Nisslein, M. (2000). Letter-detection patterns in German: A window to the early extraction of sentential structure during reading. *Memory & Cognition*, 28, 993–1003.

Reichle, E. D., Pollatsek, A., Fisher, D. L. & Rayner, K. (1998). Toward a model of eye movement control in reading. *Psychological Review*, 105, 125–157.

Saint-Aubin, J., Klein, R. M. & Roy-Charland, A, (2003). Direct assessments of the processing time hypothesis fort he missing-letter effect. *Journal of Experimental Psychology: Human Perception and Performance*, 29, 1191–1210.

Saint-Aubin, J. & Poirier, M. (1997). The influence of word function in the missing-letter effect: Further evidence from French. *Memory & Cognition*, 25, 666–676.

Van Heuven, W. J. B., Dijkstra, A. (Ton) & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognitions. *Journal of Memory & Language*, 39, 458–483.

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