The Influence of Language Exposure on Lexical and Syntactic Language Processing

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Abstract. Previous literature has argued that proficient bilingual speakers often demonstrate monolingual-equivalent structural processing of language (e.g., the processing of structural ambiguities; Frenck-Mestre, 2002). In this paper, we explore this thesis further via on-line examination of the processing of syntactically complex structures with three populations: those who classify as monolingual native English speaker (MNES), those who classify as non-native English speakers (NNES), and those who classify as bilingual native English speakers (BNES). On-line measures of processing of object-relative constructions demonstrated that both NNES and BNES have different patterns of performance as compared to MNES. Further, NINES and BNES speakers perform differently from one another in such processing. The study also examines the activation of lexical information in biasing contexts, and suggests that different processes are at work in the different type of bilinguals examined here. The nature of these differences and the implications for developing sensitive models of on-line language comprehension are developed and discussed.

Key words: psycholinguistics, bilingual, on-line, sentence comprehension

Introduction

There is a wealth of research in the literature exploring the moment-by-moment details involved in processing on-going, fluent speech (across a variety of syntactic constructions) by monolingual listeners. speakers of a language (particularly English). The question of how such evidence may be related to the processing of similar constructions by listeners, speakers of multiple languages is, however, relatively underspecified at this time. In recent years, bilingualism has become an increasingly important research topic as it provides us with new insights into the potentials for the mental representation and processing of language in the human mind (e.g., De Groot & Kroll, 1997; Romaine, 1995). Indeed, there seems to be growing consensus that bilinguals are not merely two monolinguals in one person, but rather that the language system of a bilingual may differ in important ways from that of a monolingual both functionally (Dussias, 2001; Grosjean, 1989, 1997) and neurologically (e.g., Kim, Relkin, Lee, & Hirsch, 1997; Perani et al., 1996). Thus, important generalizations may be missed if models of language processing are developed exclusively from research on monolinguals. The level of such generalizations may ultimately hold for processing in general or alternatively be stated across all aspects of language as different at each independent level of language analysis. At this point, the evidence for important differences in processing between monolingual and bilingual speakersilisteners is somewhat mixed - with arguments that (at least certain types of) bilinguals and monolinguals handle language processing in much the same fashion, and of course, with arguments holding the opposite position. One issue in this debate centers on the *tape* of bilingual population one compares to monolingual population. Another issue, the one we will begin with here, centers on the level of language processing one is evaluating.

Much of the research on bilingualism has focused at the word-processing level of language analysis. This research has used relatively immediate mea-

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sures of processing (such as reaction-time measures - as found in lexical decision times or translation times) to draw inferences about word-level processing in bilingual subjects (e.g., Dufour & Kroll, 1995; Keatley, Spinks, & De Gelder, 1994; Kotz, 2001; Scarborough, Gerard, & Cortese, 1984; Segalowitz, Segalowitz, & Wood, 1998). The work on bilingualism which has focused on sentence-level processing has largely examined comprehension and production (e.g., Altarriba, Kroll, Sholl, & Rayner, 1996; Hernandez, Bates, & Avila, 1996; Lanza, 1997; Slobin, 1997; Soares & Grosjean, 1984; Stockman, 1996) using "off-line" measures of processing. Off-line measures are generally untimed tasks, such as grammaticality judgment tasks or sentence picture matching tasks, which take place following sentence processing rather than during on-going processing. They are sensitive at revealing ultimate states of comprehension or production, but are relatively less sensitive to revealing the moment-by-moment processes that occur during the comprehension or production process itself. Notably, while the monolingual on-line sentence-level processing literature has flourished in the past, few studies (with some notable exceptions) have used what have become standard "on-line" measures of processing, measures which are capable of isolating details of the sub-processes involved in ongoing comprehension and production. A recent collection by Heredia and Altarriba (2002) has compiled many of the few extant studies employing sentence-level processing using on-line measures (see for example Altarriba, Kroll, Sholl, & Rayner, 1996; Heredia & Stewart, 2002; Hernandez, Bates, & Avila, 1996).

The present study was focused on providing an on-line study of sentence-level processing. In particular, we were concerned with comparing the minute details of structural processing of Monolingual native English speakers (hereafter NINES) with two other proficient English speaking groups: non-native (proficient) English speakers (hereafter: NNES) and bilingual native English speakers (hereafter: BNES).

There are only a few models that directly address bilingual sentence level, structural processing. They largely fall into two general themes: those that argue that structural processing in the bilingual mind is ultimately a blend of grammatical tendencies, strategies, or rules of the first language (L1) and the second language (L2), and those that argue that automatic structural routines are largely kept independent of each other for each language. The more recent evidence from researchers such as Cuetos and Mitchell (1988), Dussias (2001), Fernandez (2002), and Frenck-Mestre (2002), among others, has lead to what is now the likely dominant belief that sentences from Ll and L2 are processed via one structural route with such processes ultimately resulting from a blending of strategies from all language to which the listener has been exposed (particularly depending on level of expertise in L2). Such an approach would fit well with general statistically driven models of language comprehension, as found in, for example, the competition model of Bates and MacWhinney (1989). However, only a few types of structures and only a few levels of L1 and L2 expertise have been examined to date. It is early in the science to conclude that the *statistical-blending* hypotheses will hold for structural processing in all cases. Indeed, we have chosen a *different* type of structural process to examine here than has been previously studied in the bilingual literature.

The structural process we chose to focus on was the processing of object-relative constructions in English. The goal was to determine whether proficient English speakers (all demonstrably proficient with English) all operate in the same immediate, reflexive manner to such constructions, independent of their exposure to additional languages. We chose the object-relative construction to examine both because it is relatively common in English and because there exists a large literature detailing the on-line, moment-by-moment processing of this structure. Along with this study of structural processing, we also, simultaneously, provide an examination of the nature of immediate lexical access in strong biasing contexts in NON-MNES (non-monolingual English speakers) populations via use of lexical ambiguity.

One additional motivation for our study stemmed from an apparent conflict between observations in our laboratories and those in some of the literature. For the past few years we have noticed the appearance of subtle differences in on-line performance of multi-language exposed (but English proficient) speakers and English native monolingual speakers during sentence-level processing. However, there exist reliable observations in the literature on the processing of structural information which have been used to support the argument that there is little difference in structural processes between such populations (at least for certain structural processes). Thus, for example, Frenck-Mestre (2002) monitored eye-movements in reading structural ambiguities, and found that proficient bilinguals looked much like native readers. We felt that examination of a different structural process, and use of a different experimental on-line technique, would provide a strong test of the breadth and generalizeability of such conclusions.

There is an extensive literature about how MNES process English object-relative constructions, such as "The policeman saw the boy who the crowd accused of the crime." In such constructions, the direct object of the verb *accused* has been moved out of its canonical (English) post-verb position and placed in front of the verb (and, in this case, the relativizer *who* has been added). It is standardly argued that the underlying meaning of such a sentence is essentially: ["The crowd accused the boy of the crime" and "The policeman saw the boy"]. The literature over the past 15 years has been filled with empirical studies examining how the monolingual comprehender actually comes to recover the underlying meaning from the object-relative surface form of this utterance. A large range of on-line studies have examined, for example, whether the comprehender actually re-activates the moved direct object (*boy*) immediately after hearing the verb (*accused*), or whether the verb-object relation is established at some later point in processing (at the end of the sentence, for example). For details, see, among many others, on-line studies by Balogh, Zurif, Prather, Swinney, and Finkel, 1998; Bever and McElree, 1988; Clahsen and Featherston, 1999; Hickok, 1993; Kluender and Kutas, 1993; Love and Swinney, 1996; Nicol and Pickering, 1993; Nicol and Swinney, 1989; Stowe, 1986; Tanenhaus, Boland, Garnsey, and Carlson, 1989. The over-arching conclusions from such work is that MNES appear to standardly re-activate the moved (*fronted*) direct object (*boy*) immediately *after* the verb is processed in the sentence. In short, it appears that MNES understand such sentences by immediately recovering the canonical subject-verb-object order of such non-canonically ordered sentences. Such a process may make particular sense for comprehension in English, in which word order plays such a strong role.

To provide a bit of detail as to the nature of the on-line evidence that supports this *immediate reactivation* (canonical re-ordering), in what follows, we will briefly describe results of one such on-line experiment which examined precisely this issue. We will then use these data as a contrast case to the two new studies presented below. Love and Swinney (1996) used a cross-modal naming (CMN) task to examine when, where (or if) moved direct objects were re-activated during sentence comprehension. The CMN experimental paradigm is a variant of the cross-modal lexical priming paradigm (CMLP; Swinney, Onifer, Prather, & Hirshkowitz, 1979) in which participants are presented with an auditory sentence and, at theoretically critical points during the uninterrupted presentation of the sentence, a word that is associatively or semantically related to some aspect of the auditory sentence is presented visually on a computer screen. In the CMN paradigm, participants name the visually presented word as rapidly as possible. Studies with both CMN and CMLP have demonstrated that when a visual word is presented that is semantically/associatively related to a word that has just been heard in the sentence, it is named faster than if it appears after a word in the sentence to which it is unrelated (this general phenomenon is a form of automatic semantic priming; e.g., Meyer, Schvandeveldt, & Ruddy, 1975; Neely, 1991). When the experimental materials are equated and pre-tested appropriately, CMN has proven to be a sensitive measure of what is active at momentary points-in-time during ongoing sentence processing. Further, when done appropriately, participants are typically unaware of relationships between probes and sentences, and it serves as a relatively unconscious reflection of the state of the current processing of the sentence.[1]

Love and Swinney (1996) presented MNES with auditory sentences such as:

"The professor insisted that the exam be completed in ink, so Jimmy used the new <u>pen</u>*[(1)]* that *his mother-in-law recently[(2)] purchased_[(3)] because the multiple colors allowed for more creativity."*

These sentences contain a "fronted direct object" (*pen*) of a later-occurring verb (*purchased*). The study employed lexical ambiguities as the fronted direct objects, and thus activation of both the primary {*writing object*} and secondary {*jail*} meaning of these words could be examined at each of three test points: probe position 1 (PP1) = immediately after the direct object (*pen*) occurred in the sentence, probe position 2 (PP2) = 700 milliseconds before the verb (*purchased*), and probe position 3 (PP3) = immediately after the verb (*purchased*)[2]. Partici pants were required to understand the sentence (comprehension questions were asked on a number of trials) and also to name a probe word that came on the screen during the sentence while still comprehending the ongoing sentence.[3]

The results of the Love and Swinney, 1996 study are as follows: immediately upon hearing the fronted direct object (probe position 1), it was found that naming times for words related to each meanings of the word *pen* {writing object and jail} were significantly faster than those to the matched control words. Note that this is so, even though reaction times to these words in isolation is equivalent, and that all pre-tests indicated that both visual probes "fit" with the sentence at all the test points equally well.[4] This

[1] For some discussions of the task, see McKoon and Ratcliff, 1994; McKoon, Ratcliff, and Ward, 1994; Nicol, Fodor and Swinney, 1994; Seidenberg, 1982; Swinney, 1979; Swinney, Love, Nicol, Bouck, Hald, 2000.

[2] This was a completely counterbalanced factorial design. In all cases, participants contributed data to all conditions, however, no one participant ever heard or saw any sentence/visual probe more than once.

[3] Note that the "related" probes only appeared approximately 20% of the time throughout the study. Experiments 1 and 2 below use the identical materials and design as found in Love and Swinney 1996.

[4] Please see Love and Swinney, 1996 for specific details of all the pretest information and analysis of the materials.

result is consistent with earlier findings (e.g., Swinney, 1979) that demonstrated that immediately after a target word is heard in a sentence, responses to related visual probes are primed as compared to unrelated (control) visual probes. In that case, as in Love and Swinney (1996) related probes to both meanings of the ambiguity were primed even in a prior, strongly biasing context. Following immediate access of all meanings of an ambiguous word, Love and Swinney (1996) also found that these priming effects disappeared for both meanings of the fronted direct object when tested a short time later in the sentence (PP2). Importantly, however, they found that at PP3 (immediately after the verb) there was significant priming again found for the contextually relevant (in this case, "primary" interpretation of the ambiguous direct object), but no priming for the "irrelevant" interpretation of the ambiguity. Thus, when monolingual, native English listeners (NINES) hear a verb (in English) in a sentence in which there had been a fronted direct object, they immediately reactivate the stored contextually relevant meaning of that direct object in its canonical post-verb position. Comprehension, at least for NINES, appears to involve the immediate recovery of canonical Subject-Verb-Object relationships during ongoing comprehension. See Table 1 for these priming results.

Table 1. Priming Effects (in ms; control minus related) for Naming Times for Primary and Secondary Meanings of the Ambiguity at all Three Probe Points for NINES; Based on Naming Time Means Presented in Love and Swinney (1996)

Meaning		Probe Position ^1	Probe Position ^2	Probe Position ^3
Primary	Δ	+ 12*	+ 3 *ns*	+ 21*
Secondary	Δ	+ 8 *	+ 5 *ns*	+ 2 *ns*

* $p < .05$, one-tailed ns = nonsignificant difference

The use of ambiguous words as the fronted direct object in the present study also allowed us to examine the nature of lexical access in strongly biased contextual conditions in bilingual populations. There is an extensive literature that has examined whether initial lexical access is autonomous and independent from prior biasing contexts or whether it is guided by predictions from such contexts. The Love and Swinney (1996) study strongly supported an autonomy view of lexical access during comprehension by finding priming for both meanings of an ambiguous word even in strong biasing contexts (see Tabossi, 1988). The current study enables us to pursue this issue with NON-MNES (non-monolingual English speaking) populations.

To the best of our knowledge, there have been no on-line investigations of object-relative sentence processing in bilingual/multilingual listeners (see Heredia & Stewart, 2002). The very meager sentence structural-processing literature on bilingual populations is a bit mixed as to whether bilinguals and monolinguals differ in their on-line structural processing. On the one hand, there are studies by Hahne and Friederici (2001) and Weber-Fox and Neville (1996) using event-related brain potentials (ERPs), which reveal that late (and not highly proficient) L2 learners differed greatly in their response to violations of syntactic structure from monolingual native speakers. (Monolinguals display an early left anterior negativity in response to violations of syntactic structure, but the late/nonproficient learner populations show no such effect.) These results suggest that some aspects of automatic syntactic processing in some bilinguals may differ from such processing in monolinguals. However, such differences might be expected in populations that are not overly proficient in the tested language. On the other hand, the examination of structural processing with proficient L2 speakers/learners so far suggests that there may be little difference in the processing between this group and native monolingual speakers (Frenck-Mestre, 2002; in studies of on-line syntactic attachment).

The present studies were aimed at investigating the degree to which English proficient L2 speakers/listeners use the same moment-by-moment processes in on-line comprehension of noncanonical structural relationships, such as found in object-relative English constructions. The following two studies used the exact same materials and methodological design as Love and Swinney (1996), on two different English-proficient bilingual populations.

Experiment 1: Immediate Activation of Word Meaning(s) During Sentence Understanding

The goal of this initial study was to ascertain which of the materials from the Love and Swinney (1996) study would provide a valid basis for examining the reactivation of fronted direct objects at post-verb canonical positions in multilingual populations. Our desire was to utilize the data and materials of Love and Swinney exactly as they were originally designed, because that study had carefully controlled for: 1) participants being native monolingual English speakers/listeners only (no exposure to foreign language before the age of 6, no other language spoken in home, no proficiency in any language but English); 2) associativity/relatedness of visual probes (both related and control) to the key words (the fronted direct objects) in the sentence based on ratings by native monolingual English speakers/listeners; and 3) judgments of equivalence of relatedness between the related and control probes to sentential material at each probe point, (for both "goodness of continuation" and "relationship to entire sentence," based on NINES judgments; and 4) a priori reaction-time matches for related and control probes (in an isolated naming task), again, based on NINES populations. However, as everything was carefully tested on NINES populations, we knew that all of these materials would not be equally well matched or effective with populations other than native monolingual English speakers. For this reason, we first set out to find which of our materials would replicate the most basic of sentence-level effects; i.e., priming for related probes (compared to controls) immediately after hearing a critical word of interest (again, the fronted direct object) in a sentence.

Methods

Participants

Forty-four college students participated in Experiment 1 (note that Love and Swinney (1996) had 51 NINES participants in the equivalent experiment). All participants were students at University of California, San Diego (UCSD) who participated for course credit; all participants had normal or corrected-to-normal vision and hearing, and had no history of neurological problems.

Based on self-report questionnaires, participants were classified either as bilingual native English participants (BNES) or nonnative English participants (NNES). The same questionnaire procedure was used in Love and Swinney (1996) to categorize NINES groups. Criteria for inclusion in the BNES group were self-ratings (responding "yes") to questions: 1) "Are you a native English speaker?"; 2) "Were any other languages, besides English, spoken at home before you were 6 years old?"; and 3) "Was(were) the language(s) spoken at home before age 6 spoken "in phrases" or "conversationally" ?"(individuals were not included in this group if they reported that they were only exposed to "words here and there" in another language).

The NNES group differed from the BNES group only in that they answered "no" to the question "Are you a native English speaker?" The age at which the NNES participants considered themselves fluent in English ranged from 3 to 15 years old (M = 10.2 years). Of the 44 participants run in this study, 14 failed to meet the language (or other pre-determined) criteria, thus excluding them from any analysis.

Based on the language criteria listed above, there were 20 BNES bilinguals (15 female, 5 male; M age = 20.1, range 17-25) and 10 NNES bilinguals (7 female, 3 male; M age = 20.1, range 18-25). In both the BNES and the NNES group, there was exposure (or more) to a variety of language(s) other than English (Cantonese, French, Greek, Italian, Korean, Mandarin, Russian, Spanish, Tagalog, and Vietnamese). Note that most of these languages rely less on word order for structure than does English. Finally, all participants were proficient in English. They were not only high-performing students at a University with stringent English entrance requirements and English-only teaching, they originally self-selected themselves for participation in the study (our initial screening criteria) as proficient native English speakers; however, based on our further screening measures, as just detailed above, we reclassified them into the BNES and NNES categories. Finally, BNES and NNES participants were matched on comprehension performance tests on these materials (off-line) to the same criteria stylized for NINES participants (in Love and Swinney, 1996).

Materials and Design

We have noted that the materials and design were identical to those used in Love and Swinney (1996). Note that this implies that all the pretesting of stimuli was originally performed on native monolingual English speakers, an issue that guided this first study, and that will be discussed below in this study. Here, we present the entire materials and designs for this study (and that of Love and Swinney, 1996).

Materials consisted of 40 experimental object-relative sentences constructed as in the following example (repeated from the introduction):

"The professor insisted that the exam be completed in ink, so Jimmy used the new *pen*[(1)] that *his mother-in-law recently*[(2)] *purchased_*[(3)] *because the multiple colors allowed for more creativity."*

The fronted direct object was, in all cases, an ambiguous noun (here, *pen*) for which pretests had established a clear primary and clear secondary interpretation for NINES. For the experimental materials, pretests established both a strong associate (one of most frequent associates given to target word) which was of moderate frequency for each meaning of the fronted direct object. A word unrelated to the target word meaning(s) was matched with each related probe for a priori reaction time (again as established independently with a population of NINES participants in isolated word-naming studies). These control words were also matched for length to the related probe words. For the example above, the related probes were PENCIL (primary meaning) and JAIL (secondary meaning); the matched control probes were JACKET and TALE, respectively.

The contexts in these sentences were strongly biased toward the primary interpretation of the ambiguity ("writing implement", in the example) using both the criteria suggested by Tabossi (1988), and more stringent bias criteria of our own. Five of our experimental items were found to not meet these stringent criteria, and thus, only 35 experimental items were considered for further data analysis. In addition, 40 "filler" sentences were created (same length and general complexity) for which an unrelated probe word would appear at a pseudorandom place during the sentence (never at the very beginning or end). In addition 10 practice sentences, again of the same general length and construction were created with 9 of the 10 having unrelated probe words. The three test points are marked by arrows. The first immediately follows the ambiguous fronted direct object (*pen*), the second appears 700 ms before onset of the critical verb (*purchased*), and the third is at the offset of the critical verb (where canonical-order based reactivation might be expected. In Experiment 1, only probe point 1 came into play. In a completely counterbalanced factorial design, participants heard all 90 sentences (randomly arranged after the practice materials). For each sentence, they were required to (primarily) listen to the sentences and understand them (they were tested randomly throughout the study with a multiple-choice comprehension test inquiring about some aspect of a sentence they had just heard - largely to keep attention of participants on the comprehension task). They were also presented with a visual probe at some point during each sentence (in Experiment 1, at the first probe point for experimental sentences), and they were required to name the visual probe as rapidly as possible while still listening to the ongoing sentence. Participants never heard a sentence more than once and only saw one of the 4 possible experimental probes. All probe types were equally distributed across all materials conditions. Thus, there were four experimental group (materials counterbalancing) conditions, and eleven participants were randomly assigned to each group condition.

We note here again that each probe was submitted here to two pretests with the sentence with which it was paired: a goodness of fit pretest and a goodness of continuation pretest. These pretests were performed by obtaining judgments from a large independent group of subjects ranking how well a probe "fit with the portion of the sentence that had been heard" and "provided a good continuation for the portion of the sentence heard" up to each point at which a probe might appear (in this experiment and in Experiment 2). The only related-control materials that were used were those which were matched on these rating for both of these variables (see Love & Swinney, 1996, for further details).

Procedure

Participants entered a room and were given pretest questionnaires to fill out (the basis for selection into MNES, BNES, and NNES groups). Following that, they were comfortably seated in front of a computer monitor in a sound attenuated booth, and were told that they had two tasks. The first was to listen to and understand sentences that they would hear over headphones. They were told that, at certain times during the experiment, they would be tested on the content of the sentence they heard. Their second task was to watch the computer screen, and, whenever they saw a word appear on the screen, they were to name it aloud as rapidly as they could. As in all cross-modal studies of this type, the auditory sentence continued on, uninterruptedly, even while the visual probe was presented.

Each participant's attention was focused on the middle of a screen (where the word would appear) by means of a black mask that allowed only a small word-sized area of the screen to be visible. The participants' voiced responses were recorded via microphone by a tape recorder and by the computer. Onset of the voice response stopped timing which had initiated with the onset of the visual probe word. The RTLAB program controlled for all of the usual timing problems in video display (raster position, etc.), so timing was accurate to less than 1 ms. This program also recorded all reaction time responses. A Sony DAT recorder was used to present the auditory sentences to the participants.

The experiment was paused 5 times for each subject (each pause following a filler sentence and was prior to another filler sentence) and participants were asked a multiple choice question about the content of the sentence they had just heard. Following each such pause, participants were reminded of the tasks in the study.

Results

Experiment 1 was designed to serve as a basic replication of two well-established effects in the literature: 1) that a visual probe word occurring immediately after a related word in a continuously presented auditory sentence would demonstrate priming for related (compared with unrelated) probes; and 2) evidence of the activation of more than one interpretation of a lexical ambiguity even following occurrence of a strongly biasing context (e.g., Onifer & Swinney, 1981; Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979).

As noted earlier, because we had intentionally pretested all of our materials solely on MNES populations, we anticipated that many of our probes, etc. might not be effective for NON-MNES (non-monolingual native English speakers) populations. (Note, we explicitly did not want to use different probes with different populations.) Our initial analysis was therefore aimed at examining results from all populations for some evidence of a basic word priming effect for our materials (in order to determine which probes and sentence could even possibly reflect activation and, possibly, reactivation.)

For data analysis, we established as criteria that we would only further analyze materials for which we established reliable on-line priming for at least the contextually relevant, primary (most frequent) meaning of the lexical ambiguity, when tested immediately after its occurrence. This is theoretically neutral with regard to our hypotheses under question (reactivation at the post-verb gap site) and, most importantly, is critical to any judgment of appropriateness of our materials in that essentially every study of online sentence processing (whether with this task or any other) has demonstrated that, with appropriate materials, the contextually relevant, primary (most frequent) interpretation of an ambiguous word is accessed (e.g., with cross-modal tasks: Onifer & Swinney, 1981; Swinney, 1979; Tabossi, 1988; Tanenhaus, Leiman, & Seidenberg, 1979). Of the 35 experimental items (again, five failed to match the bias criteria of Tabossi, 1988, etc.), only 14 were found to demonstrate any evidence of priming of the contextually relevant, most frequent (primary) meaning of the ambiguous word immediately after it was heard. We restrict our further analysis and discussion to these 14 items which demonstrated standard priming effects; these are the only materials (probes plus sentences) from the prior study that we could reasonably assume were appropriate to all three of our targeted populations. We also present an analysis of a reduced set of items from the Love and Swinney (1996) data to establish that the effects reported there hold for 14 selected items with NINES.

MNES: Reanalysis of 14 Items from the Love Et Swinney (1996) Data Set for PP1

As in the original Love and Swinney (1996) data set, reaction times under 300 ms and over 2000 ms were removed. In addition, any reaction times differing by more than 2 standard deviations (SD) of the overall mean for each participant were removed. Analyses were performed on the remaining data of the 14 items for probe point 1 (PP1). Table 2 presents means for these items for all conditions. As can be seen, there is a 56 ms priming effect ($t_{50} = 5.375$, $p < .001$) for the contextually relevant, primary interpretation of the ambiguous word, and a 26 ms priming effect ($t_{50} = 2.318$, $p < .02$) for the contextually irrelevant and less frequent interpretation of the ambiguous word. This replicates effects reported for the entire MNES materials set in Love and Swinney, in which contextually independent lexical access was demonstrated (even in the most strongly biased materials types).

Table 2. MNES: Reanalysis of Mean RTs (*SDs*) at PP1 for the 14 Experimental Items from Love and Swinney (1996) data

Meaning		NINES (n = 51)
primary	control probes	564(79)
	related probes	508 (53)
	Δ	+ 56*
secondary	control probes	565 (82)
	related probes	538 (67)
	Δ	+ 27*

* $p < .025$
+ indicates facilitation (priming) for naming times for related compared to control probes

The further analyses of the bilingual groups are presented both for all NON-MNES participants together, and then for the BNES and NNES groups separately. We note at the outset that the small Ns (particularly for the NNES group) may make it likely that real effects/significance may be missed. However, as will be seen by comparing these performances of groups separately across test points 1, 2, and 3, different mechanisms appear to be at work in processing of object-relative constructions by these groups; differences that would be missed if we only pooled the bilingual populations.

NON-MNES: Combined Results for PP1

The screening procedures described above resulted in a data loss of 4.7% of the data. The first data column of Table 3 presents the results for the combined NON-MNES population tests.

As can be seen in Table 3, when combining both BNES and NNES (n = 30) the following patterns appear in the data: there is a 39ms priming effect evident for the primary meaning and a 20 ms priming effect for the secondary meaning.

For both bilingual groups combined, the overall subjects ANOVA with meaning (primary vs. secondary) and probe type (related vs. control) as within subjects factors and language group (BNES vs. NNES) as the between subjects factor revealed only

Table 3. Mean RTs (*SDs*) at PP 1 for the 14 Experimental Items

Meaning		BNES + NNES (n=30)	BNES (n = 20)	NNES (n = 10)
primary	control probe	593 (78)	584 (68)	611 (97)
	related probe	554 (70)	545 (74)	572 (60)
	Δ	+ 39 **	+39 **{.6}	+ 39 {.4}
secondary	control probe	569 (103)	562 (118)	583 (69)
	related probe	549 (81)	547 (88)	553 (67)
	Δ	+ 20 *	+ 15ns {.2}	+ 30*** {.5}

*p < .05, one-tailed
**p < .01, one-tailed
***p = .08
+ indicates facilitation (priming) for naming times for related compared to control probes
Cohen's effect size (1988), *d*, is noted next to the difference score in {brackets}

a main effect of language group, $F1(1, 29) = 19.667$, $p < .0001$. There were no other main effects or significant interactions, meaning: $F1(1, 29) = .025$, $p < .89$; probe position: $F1(1, 29) = 1.7$, $p < .2$; Probe Type: $F1(1, 29) = .362$, $p < .6$. In an items analysis on these data, there was a significant main effect of probe type $F2(1, 13) = 8.61$, $p < .01$. There were no other significant main effects or interactions; all Fs < 1, except Language Group x Meaning: $F2(1, 13) = 2.85$, $p < .1$; and Meaning x Probe Type: $F2(1, 13) = 1.39$, $p < .25$.

As can be seen in Table 3, the mean reaction times for both the contextually relevant primary and the less frequent secondary meanings were significantly faster than reaction times for the control words. A priori planned comparisons revealed that these were significant priming effects (primary meaning: $t_{29} = 2.88$, $p < .01$, secondary meaning: $t_{29} = 1.72$, $p < .04$). Thus viewed overall, the NON-NINES groups also provide evidence of "exhaustive" access of all interpretations of an ambiguous word immediately after hearing it in a strongly biased context sentence, as do their NINES counterparts on these materials.

BNES: Analyzed Separately at PP1

When data from the 20 BNES are examined separately, the overall subjects ANOVA demonstrates a significant main effect for probe type, $F1(1, 19) = 5.203$, $p < .03$. All other main effects and interactions were not significant. All $F2$s < 1, except for probe type, $F2(1, 13) = 1.77$, $p < .2$.

Of most significance to the hypothesis under investigation, a priori planned comparisons showed a significant priming effect for the primary meaning $t_{19} = 2.64$, $p < .01$, mean 39 ms effect, Cohen's effect size, $d = .6$),[5] but not for the secondary meaning ($t_{19}= 1.00$, $p < .17$, $M =$ 15 ms effect, Cohen's effect size, $d = .2$). See second data column of Table 3 for details. Thus, at least for this population and set of materials, only the primary interpretation of the ambiguity was accessed, suggesting that we may potentially encounter an interesting time-course difference for activation of meaning interpretation and of integration of context effects in this population as compared with NINES.

NNES: Analyzed Separately at PP1

For the 10 NNES participants, the overall subjects ANOVA demonstrated a significant main effect for probe type, $F1(1, 9) = 4.146$, $p < .05$. All other main effects and interactions were not significant. In an items analysis on these data, there was a main effect of probe type, $F2(1, 13) = 10.97$, $p < .002$. There was no significant main effect of meaning, $F2(1, 13) = 3.53$, $p < .07$, nor was there a significant Meaning x Probe Type interaction, $F2(1, 13) = 2.01$, $p < .17$).

Most importantly, the a priori planned comparisons revealed that there was no significant priming for either meaning (primary: $t_9 = 1.32$, $p < .12$, $M =$ 39 ms effect, Cohen's effect size, $d = .4$; secondary: $t_9 = 1.54$, $p < .08$, $M =$ 30 ms effect, Cohen's effect size, $d = .5$, although the latter is a marginal effect). See data column 3 of Table 3.

[5] Cohen's (1988) effect size is a measure of the magnitude of a treatment effect. The effect size is noted by *d*, which is a descriptive measure and is defined as the difference between the means, M1 - M2, divided by the standard deviation of either group. Cohen argued that the standard deviation of either group could be used when the variances of the two groups are homegeneous. Effect sizes are generally defined as "small, $d = .2$," "medium, $d = .5$," and "large, $d = .8$".

Experiment 2 - The Search for Activation/Re-activation of Fronted Direct Objects Following Their Verbs During Sentence Processing

Methods

Participants

Eighty-nine bilingual (BNES and NNES) college students participated in Experiment 2. All participants were students at UCSD and participated for course credit; all had normal to corrected-to-normal vision and hearing and had no history of neurological problems. Using the criteria described in Experiment 1, the BNES consisted of 41 participants (25 female, 16 male; *M* age = 19.7, range = 18-23), whereas the NNES group consisted of 36 participants (29 female, 7 male; *M* age = 18, range = 17-26). In addition to the native languages represented in the NON-MNES samples in Experiment 1, this study also included Arabic, Armenian, Farsi, Hungarian, Romanian, and Taiwanese.

Materials, Design, and Procedures

The same materials and procedures as described in Experiment 1 were used in Experiment 2, with the exception that probes appeared in this study at either probe position 2 or probe position 3. In this study, two tapes were created which were identical, except that probe points 2 and 3 were equally counterbalanced across the tapes. These two tape conditions were combined with the four visual probe list conditions (as in Experiment 1) in a counterbalanced factorial design in which, again, no participant heard or saw the same experimental sentence more than once. Thus, participants saw equal numbers of experimental items, related probes at each test point, but all from different experimental items. This multi-factorial design contained a 2 (probe position) x 2 (probe relatedness) x 2 (Ambiguity meaning) within factors -- by - 4 x 2 between-factors (materials counterbalancing) conditions.

Results Experiment 2

PP2 and PP3

The goal of Experiment 2 was to discover whether, like MNES, English proficient but NON-MNES populations perform canonical restructuring in object-relative constructions immediately upon processing the verb (often called the "gap") during ongoing sentence comprehension. Thus, the test points in Experiment 2 were designed to reflect the levels of activation for each of the meanings of the ambiguous word at the post-verb gap (PP3) and at a "baseline" point shortly before the gap (PP2).

MNES Results for PP2 and PP3

The analysis of the MNES data from the original Love and Swinney (1996) study demonstrated that neither of the meanings of the fronted ambiguity (direct object) was still active (showed significant priming) at a point 700 ms before the verb (PP2). However, at PP3 the contextually relevant primary meaning of the ambiguity was found to be significantly reactivated (the secondary interpretation was not); this was the evidence taken to support immediate canonical-reordering of interpreted structures. The secondary meaning had not been chosen as "relevant" and stored earlier in the sentence, and hence was not reactivated at the post-verb gap (See Table 1). The reanalysis of the 14 items chosen for this study from the original MNES data of Love and Swinney also reveals this same effect: The primary (contextually relevant) meaning of the fronted direct object showed no significant priming (*M* = 10 ms priming) at PP2 $t_{87} = 1.56$, $p < .13$), while this same meaning did show significant priming at PP3 (*M* = 14.1 ms priming; $t_{87} = 2.69$, $p < .01$.) This pattern of reactivation was not found for the secondary meaning of the ambiguity (e.g., no priming at all at PP3, *M* = 0.86 ms. priming; $t_{87} = 0.17$, $p < .9$).

NON-MNES Combined Results for PP2 and PP3

Twelve participants were excluded from analysis for reasons of high error rates on the comprehension questions (more than 40% incorrect, in order to match criteria for MNES populations), head injury with loss of consciousness, and computer errors. This left a total of 77 (41 BNES and 36 NNES) participants for the combined analyses (54 female, 23 male), with an average age of 18.9 years (range = 17-26 years).

As in Experiment 1 (and Love and Swinney, 1996), reaction times under 300 ms. and over 2000 ms. were removed (resulting in a data loss of 0.1% [1/1046 data points]). Data from the 77 participants for the 14 experimental items were submitted to descriptive and inferential statistical analysis.

As can be seen in Table 4, when combining both BNES and NNES (n = 77) the following patterns appear in the data: at the baseline probe point, there is a 61 ms priming effect evident for the primary

Table 4. Mean RTs *(SDs)* at PP2 and PP3 for the 14 Experimental Items for All NON-NINES populations (Data Columns 1 and 2), and for BNES (Data Columns 3 and 4) and NNES (Data Columns 5 and 6) Viewed Separately

Meaning		BNES + NNES (n = 77)		BNES (n = 41)		NNES (n = 36)	
		pp2	pp3	pp2	pp3	pp2	pp3
Primary	control probes	601 (114)	565 (121)	584 (118)	511 (61)	616 (110),	621 (150)
	related probes	540 (92)	554 (97)	503 (52)	531 (105)	585 (112)	586 (82)
	Δ	+61**	+11 *ns*	+81** {.7}	-20 *ns* {.2}	+31* {.3}	+35 *ns* {.2}
Secondary	control probes	555 (108)	577 (134)	537 (135)	532 (85)	582 (61)	632 (163)
	related probes	564 (105)	545 (99)	531 (98)	527 (86)	599 (106)	563 (111)
	Δ	-9 *ns*	+32 *	+6 *ns* {.05}	+5 *ns* {.2}	-17 *ns* {.1}	+69* {.5}

*p < .05, one-tailed
**p < .0001, two-tailed
+ indicates facilitation (priming) for naming times for related compared to control probes
Cohen's effect size (1988), d, is noted next to the difference score in {brackets}

meaning, while for the secondary meaning there is a -9ms effect (the reaction times for the related probes were slower than for the control probes). At PP3, the offset of the verb, there is an 11 ms effect for the primary meaning and a 32 ms priming effect for the secondary meaning.

The overall participants ANOVA with between-participants factor language group (BNES vs. NNES) and the within-participants factors probe point (PP2 vs. PP3), meaning (primary vs. secondary), and probe type (related vs. control) revealed significant main effects for language group, $F1(1, 76) = 31.42$, $p < .0001$, and significant interactions of Probe Point x Probe Type, $F1(1, 76) = 3.98$, $p < .05$, and Probe Point x Probe Type x Language Group, $F1(1, 76) = 4.09$, $p < .05$. There were no other significant main effects or interactions. In the items analysis, there was a significant main effect of language group, $F2(1, 13) = 30.15$, $p < .0001$, and significant interactions of Language Group x Probe Point x Probe Type, $F2(1, 13) = 4.96$, $p < .03$, and Language Group x Probe Point x Meaning x Probe Type, $F2(1, 13) = 5.39$, $p < .03$. No other significant main effects or interactions were observed.

Of primary significance to the hypothesis under investigation were a priori planned comparisons of related vs. control probes for each meaning of the ambiguity at each of the probe points. The planned comparisons for the primary meaning revealed a significant priming effect at PP2 ($t_{76} = 4.5\ 7$, $p < .0001$; $M = 61$ ms priming effect), but, importantly, no significant priming at PP3 ($t_{76} = .78$, $p < .23$; $M = 11$ ms effect). For the secondary meaning, these planned a priori t tests revealed no significant priming effect at PP2 ($t_{76} = -0.67$, $p < .51$, $M = -9$ ms effect) and, again, importantly, a significant priming effect at PP3 ($t_{76} = 2.33$, $p < .012$; $M = 32$ ms priming effect). See data columns 1 and 2, Table 4 for details for each condition.

BNES Participants Analyzed Separately (for PP2 and PP3)

A priori planned comparisons on the BNES participants alone revealed a significant priming effect for the primary meaning at PP2 ($t_{40} = 4.64$, $p < .0001$, $M = 81$ ms effect, Cohen's effect size, $d = .7$) but not at PP3 ($t_{40} = -1.27$, $p < .22$, $M = -20$ ms effect, Cohen's effect size, $d = .2$). For the secondary meaning, the t tests showed no significant effects at PP2 ($t_{40} = .37$, $p < .72$, $M = 6$ ms effect, Cohen's effect size, $d = .05$) or at PP3 ($t_{40} = .28$, $p < .4$, $M = 5$ ms effect, Cohen's effect size, $d = .16$). See data columns 3 and 4, Table 4 for details.

NNES Participants Analyzed Separately (for PP2 and PP3)

A priori planned comparisons revealed a significant priming effect for the primary meaning at PP2 ($t_{35} = 2.196$, $p < .04$, $M = 31$ ms effect, Cohen's effect size, $d = .3$) but not at PP3 ($t_{40} = -1.166$, $p < .3$, $M = 35$ ms effect, Cohen's effect size, $d = .2$). For the secondary meaning, the t tests showed no significant effects at PP2 ($t_{40} = .968$, $p < .4$, $M = -17$ ms effect, Cohen's effect size, $d = .15$) but a significant priming effect at PP3 ($t_{40} = 2.547$, $p < .02$, $M = 69$ ms effect, Cohen's effect size, $d = .5$).

Discussion

In this study we set out to discover whether proficient bilingual speakers/listeners process their English in a manner similar to monolingual English listeners. We were interested in examining the on-line details of a complex structural process (here, comprehension of object-relative constructions), particularly in light of suggestions in the literature that proficient bilingual and monolingual listeners may not differ in their structural processing. In addition, we also examined aspects of the nature of lexical access and context effects upon such access during ongoing comprehension in three populations: NINES, BNES, and NNES.

We begin with a brief examination of the second issue - lexical access in the face of context effects during ongoing comprehension. In Experiment 1, analysis of the 14 items that showed effective priming for the primary meaning for NON-MNES participants, demonstrated that: 1) for the NINES population, both the primary and secondary interpretations were activated immediately upon hearing the lexical ambiguity. This occurred with these items, despite the strong prior biasing contexts. This result replicated the original Love and Swinney (1996) effects (as well as a large range of other pieces of research supporting such exhaustive, context-independent effects). 2) when viewed overall, proficient English speakers/listeners - whether native in English or native in another language - demonstrate these same effects, exhaustive access of both meanings of the ambiguity even following strongly biased contexts. While separate analysis of the BNES and NNES populations could not sustain significance in these effects for each meaning condition, the data in even these small-sample individual analyses trended in the direction of supporting exhaustive access (although, interestingly, one population did show a significant effect for the primary interpretation and the other a strong trend for significance in the secondary interpretation). Importantly, however, the combined analysis of the two English proficient bilingual groups, which had a similarly matched number of participants as those in the NINES analysis, found significant priming for both interpretations (as did the NINES analysis). These results strongly suggest that proficiency in English - whether as a monolingual or a bilingual - results in similar exhaustive access of lexical information in sentence contexts.

We turn now to the issue of the time-course of analysis of object-relative constructions in English. The consistent evidence from many sources of on-line investigation, including ERPs (e.g., Kluender & Kutas, 1993) and cross-modal priming (e.g., Love and Swinney, 1996; Nagel, Shapiro, & Nawy, 1994) has suggested that NINES immediately reactivate a fronted direct object once the relevant verb is heard. This has been discussed as recovery of canonical subject-verb-object order in English. If sufficient time has passed from the time the fronted direct object is heard until the verb is heard, it appears that the basic, contextually-relevant interpretation of the fronted direct object is stored in memory, then decays from immediate availability, and then is reactivated once the verb is heard. Hence, Love and Swinney (1996) found that following the initial activation of both meanings of the ambiguous fronted direct object (PP1), neither meaning was any longer maintained actively when probed for at a point 700 ms before the verb was heard (PP2), but that the primary contextually-relevant interpretation was reactivated immediately after the verb was heard (PP3). This pattern and result was sustained in the analysis of the 14-item subset of the original items used for the reanalyses in this paper on the NINES population.

However, this same pattern was not found for the proficient English populations examined in this paper. When examined together (with a sample roughly equivalent to that of the NINES population), the English-proficient but NON-MNES populations demonstrated *no* activation for the primary (contextually relevant) interpretation of the fronted direct object immediately following the verb (PP3). This suggests that, even for proficient English speakers, exposure to a second language that relies less on word order for syntactic interpretation than does English (which was the case for nearly every participant) tends to make *immediate* reactivation of items in canonical structural order less imperative. We did not test down-stream from the post-verb position, but, as most subjects understood these materials, the correct verb-object relation was presumably derived at some point in processing. First and foremost, then, these data suggest that subtle details of on-line integration of structural information may differ between English monolinguals and persons exposed to other language-structure forms even if they are also proficient in English). Such subtle differences (such as not reactivating the direct object's meaning immediately after hearing a verb) have considerable potential consequences for attempts to build detailed models of language processing, for the choice of participants to be studied in building such models, and for issues of generalizeability.

One final set of observations about the differences found in the BNES and NNES populations in the study of canonical ordering is worth mentioning. Separate analyses revealed that the BNES bilinguals maintained initial word activation longer than NINES typically do (the primary meaning was still active at PP2 for the BNES group) but, if anything, appeared to suppress this interpretation at the post-verb gap site. Interestingly the NNES group suddenly demonstrated (re) activation of the secondary (contextually irrelevant) interpretation of the direct object at the post-verb gap site (PP3).

With regard to the general theoretical issue we raised in the introduction about theoretical models of bilingual processing strategies, there are two plausible conclusions that might be supported from these data. For one, because most of the L 1 languages in our sample are less word-order based than English in terms of structural constraints, our results can fit with approaches that argue that bilingual structural processing involves something of a statistical blending of structural routines from both L1 and L2. In line with issues raised by Cuetos and Mitchell (1988), Dussias (2001), and others, such support only is sustained here for those with high level functioning in L2. An equally plausible conclusion that can be drawn from these data is that even experienced L2 users never fully learn the native L1 syntactic reflexes needed for certain structural processing routines. This latter case might involve blending or it might simply involve independent, but not fully learned, L2 structural reflexes, even for highly competent L2 speakers/listeners.

In all, these findings lead us to the conclusions that: 1) lexical access in sentence comprehension, even in the face of strong a priori biasing contexts, is an autonomous process for any proficient speaker of English (native or nonnative, bilingual or not). 2) Structural processing of the type studied here (canonical word-order recovery) does differ among proficient English speakers, such that exposure to a second language appears to subtly change reflexive structural operations. 3) On-line tasks, such as the cross-modal priming task used here, are critical to unearthing these subtle processing differences. 4) There may be interesting, subtle differences between proficient English bilingual speakers who learned English as their first language rather than as their second language.

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