Second Language Effects on Ambiguity Resolution in the First Language

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Abstract

The processing of homonyms is complex considering homonyms have many lexical properties. For instance, *train* contains semantic (*a locomotive/to instruct*) and syntactic (*noun/verb*) properties, each affecting interpretation. Previous studies find homonym processing influenced by lexical frequency (Duffy et al., 1988) as well as syntactic and semantic context (Folk & Morris, 2003; Swinney, 1979; Tanenhaus et al., 1979).

This cross-modal lexical-decision study investigates second language (L2) effects on homonym processing in the first language (L1). Participants were monolingual English speakers and Canadian English/French bilinguals who acquired L2 French at distinct periods.

The early bilinguals revealed no significant differences compared to monolinguals (p=.219) supporting the Reordered Access Model (Duffy et al., 1988). However, the late bilinguals revealed longer reaction times, syntactic priming effects (p<.001), and lexical frequency effects (p<.001), suggesting a heightened sensitivity to surface cues influencing homonym processing in the L1 due to a newly-acquired L2 (Cook, 2003).

Introduction

The age at which a speaker acquires a second language (L2) may be one of the most influential factors affecting many speakers. Indeed, age of L2 acquisition may not only affect the extent to which a speaker can master his/her L2, but it may also affect the speaker's first language (L1) (Cook, 2003). This is not to say that acquiring a L2 will cause a speaker to be unable to achieve a native-like acquisition in either language. Rather, acquiring a L2 at varying periods of development has been found to correspondingly affect both languages to

varying degrees in terms of proficiency, reaction times (RTs), and neurological organisation as shown in lexical retrieval and processing (e.g., Cook, 2003).

The current behavioural study discusses the possible effects acquiring a L2 might have on the mental lexicon. We employed a cross-modal lexical decision task involving lexical ambiguities to investigate on-line processing differences, as evidenced by RT and accuracy. The study was conducted in English – the L1 of all participants. Canadian French was the only L2 and no participants were functionally proficient in any other language. Unfortunately, no proficiency score tasks were available at the time of testing, and therefore we are unable to report the possible effects that proficiency might have in this particular study. Bilingual participants were grouped according to the age at which they acquired French, enabling a comparison investigating the effects of acquiring an L2 at varying stages of development. More specifically, the study examined the effect of priming on syntactically-disambiguated homonyms versus ambiguous homonyms. The aim was to investigate how learning an L2 later in life might affect one's ability or strategy to process homonyms in the L1 which are either a) constrained to only one appropriate meaning due to the priming sentential frame, or b) presented in unconstrained sentential frames and thus remain ambiguous as to the intended meaning. As varying ages of L2 acquisition has been found to result in differences in language processing in the L2 (see Meisel, 2009, among others), as well as the L1 (Cook, 2003; van Hell & Dijkstra, 2002), any differences found between groups in processing the homonyms of this study were to be considered evidence of the speaker's mental lexicon having been affected by acquiring the second language at certain periods of language development.

The mental lexicon

The acquisition of an L2 adds a dimension of complexity to considerations regarding the mental lexicon, since any theory of language processing needs to account for

the storage and retrieval of lexical items from more than one language. A number of studies have attempted to resolve the issue of whether speakers with two languages maintain a single lexicon or recruit separate ones for their two languages (e.g. Fabbro, 2000; Hernandez et al., 2005; Klein et al., 1999; Klein et al., 2006; Perani et al., 1996). These studies have dealt with factors such as proficiency and age of acquisition, since acquiring a L2 can be achieved at any age, albeit with varying degrees of success. It is these differing degrees of success that have led a number of studies to suggest that the age of acquisition of a L2 may be one of the most important determinants of the structure of a mental lexicon involving more than one language (i.e. Hernandez, 2000).

It appears that the physiology of a L2 learners' mental lexicon varies depending on the age at which the L2 was acquired. Speakers who acquired both languages early in childhood – before the age of seven (Fabbro, 2001) – have been found to recruit the same language areas in the brain for language processing as monolingual speakers (Fabbro, 1997; Fabbro, 2000; Hernandez, et al., 2005; Paradis, 1998, 2001; Ullman, 2001a; 2001b). In contrast, speakers who acquired their L2 after puberty (late L2 learners) appear to recruit other areas (Paradis, 1998; Hernandez, et al., 2005; Osterhout, et al., 2008; Ullman, 2001b). As such, the mental lexicon of early bilinguals appears to resemble the monolingual mental lexicon more closely than the mental lexicon of late bilinguals. These findings suggest two things: 1) the existing models of the mental lexicon (Bock & Levelt, 1994; Gaskell & Marslen-Wilson, 1997; Jackendoff, 2003; Marslen-Wilson, 1984; Ullman, 2001a) need to account for the apparent similarities between early bilinguals and monolinguals compared to late L2 learners, and 2) further research needs to investigate possible differences between early bilinguals and monolinguals, such as varying processing strategies for issues such as lexical ambiguity resolution.

Since simultaneous bilinguals acquire two native languages concurrently from birth, current theories of language processing have been concerned with how simultaneous bilinguals might be different from monolinguals neurologically. Compared to adults, young children's brains have been found to be more plastic (Klein et al., 2006), enabling them to organise themselves much more easily than older brains (Paradis, 1998, 2001). This early flexible period of acquisition raises much speculation as to the effect of L2 learning on the organization of the younger mental lexicon. Do the mental lexicons of simultaneous bilinguals resemble those of monolinguals, since they are acquiring two L1s in the same developmental stage as monolingual acquirers? Or do the mental lexicons of simultaneous bilinguals more closely resemble those of other L2 learners, either early or late?

Although the current study presents behavioural evidence to attempt to answer these questions, we draw on recent neurophysiological studies which suggest the younger the brain, the more plastic it is. Linguistically speaking, this suggests that a prepubescent brain is flexible enough to acquire and store lexical items of two languages within the same memory system, supported by fMRI studies which have shown earlier L2 learners recruiting two overlapping locations of neural substrates (Hernandez, et al., 2000; Hernandez, Li, & MacWhinney, 2005; Kim et al., 1997; Klein et al., 1999; Klein et al., 2006; Proverbio, Čok & Zani, 2002), whereas later L2 learners recruit two non-overlapping locations (Hernandez, 2005). This may reflect early bilinguals organising their two languages as two native languages or 2L1s, with a shared storage for object representations (Costa & Caramazza, 1999; Green, 1998; La Heij, 2005).

If we consider simultaneous bilinguals to have two locations of overlapping neural substrates for each language, one semantic representation may be stored with networks to words in each language. Thus, as the representation is accessed and processed based on phonological information, both words, one in each language, are activated for processing.

This is commonly referred to as competition (Costa & Caramazza, 1999; Dijkstra, Van Heuven, & Grainger, 1998; Green, 1998; La Heij, 2005; Marian & Spivey, 2003; Spivey & Marian, 1999). It has further been suggested that there are no factors strong enough for most proficient bilinguals to inhibit or "switch off" the other language (Van Assche et al., 2009). This calls into question studies which have recruited native speakers to carry out a task in the L1 and have reported these participants as monolinguals speakers even though they may have been exposed to a second or even third language. By screening our participants carefully according to a set of strict criteria (see Methods), we hope to understand the varying effects that the L2 has on the L1 as well as the relationship between these variations and the age at which the learner acquired the L2.

Such evidence that 2L1 speakers have the same overall locus of processing within the brain (Hernandez et al., 2000, among others) also supports the notion that 2L1 speakers must access and process language in the same manner as monolinguals. However, simultaneous bilinguals have displayed delays in behavioural and on-line tasks compared to those of monolinguals (Fabbro, 2001; Paradis, 1998, 2001). Yet, the question of whether grammatical processing differs between simultaneous bilinguals and monolinguals remains to be investigated. It is this question which the present study addresses by attempting to investigate the effects that acquiring an L2 has on ambiguity resolution in a speaker's L1.

Grammatical processing evidence suggests simultaneous and early bilinguals have a similar system to monolinguals, where the lexicon and grammar are two systems with distinct computational, psychological, and neural bases which play parallel roles in the access and processing of lexical items (Ullman, 2001b). Thus, save for a timing delay, the effects of constraining syntactic context and neutral semantic context on lexical processing are not likely to differentially affect these groups. However, it is not known whether these contexts will affect later L2 learners differently even when processing in their L1.

Contextual influences on lexical decisions

Modular theories of language processing suggest that syntactic and semantic modules may be recruited independently for lexical processing (Fodor, 1983), and the order in which these may occur varies according to differing research. While some studies have found semantic and syntactic effects to occur independently and in a parallel manner (Van den Brink & Hagoort, 2004), others have found semantic context dominating lexical processing (Swinney, 1979), or syntactic context preceding semantic context and influencing lexical processing (Folk & Morris, 2003). Still others have found that listeners access multiple readings of ambiguous words even when syntactic context constrains against one of those meanings (Tanenhaus et al., 1979; Tanenhaus & Donnenwerth-Nolan, 1984). There is evidence that syntactic context affects lexical decisions without aid or influence of semantic context effects, supporting the possibility of syntactic processing dominating semantic processing. Goodman, McClelland & Gibbs (1981) found that lexical decisions were faster to target words when they were syntactically-appropriate continuations of a phrase following a prime word, such as *he agreed*, compared to syntactically-inappropriate continuations, such as *no agreed*. These findings suggest that the processing of lexemes may involve a bottom-up manner of processing as the recruitment of the syntactic module precedes semantic module recruitment.

However, levels of processing other than the syntactic level have been found during early stages of processing. In reading sentences, lexical and syntactic factors have been found to interact (Keller, Carpenter & Just, 2001), while in lexical decisions, lexico-semantic information has been found to be processed separately from syntactic information (Green, 1998). In an auditorily-presented lexical decision task, Bilenko et al. (2008) found that lexical information such as the frequency of a word affects the access routes and speed of lexical processing within the brain. In the case of ambiguity, the two meanings are rarely balanced in

frequency, resulting in one meaning being dominant over the other (Duffy et al., 1988, among others).

Contextual influences on lexical ambiguity

To test semantic context effects on lexical access of ambiguous words, Swinney (1979) carried out a cross-modal lexical decision task involving homonyms. The results revealed that semantic context does not direct lexical access, since immediately following the appearance of an ambiguous word, such as *bug*, all meanings for that word were momentarily accessed during sentence comprehension. Thus, without semantic context to facilitate one meaning over the other, *bug* could equally mean *insect* or *spy device* as both possible readings were accessed initially, as evidenced by equivalent RTs to targets related to both (Swinney, 1979). The only evidence of semantic context effects was found when appropriately-related target words were presented four syllables after presentation of the ambiguity. This delay suggests that semantic context effects appear to be the result of some process which follows lexical access and are not a reflection of the access process itself (Cairns & Hus, 1979; Swinney, 1979), suggesting that the influence dominating lexical decisions may be syntactic.

The role of syntactic context in the resolution of lexical ambiguity has been addressed in such studies by Folk & Morris (2003) and Tanenhaus et al. (1979), among others. Investigating homonyms of differing syntactic categories, Folk & Morris found that listeners used preceding syntactic context to decipher appropriate meanings without distinguishing semantic context. For example, in "*Construction workers often **duck** on site*", as *duck* is preceded by the adverb *often*, the only meaning appropriate is *duck* the verb. However, in "*Construction workers will often see a **duck** on site*", *duck* is preceded by the article *a*, and so the appropriate meaning is *duck* the noun. These examples illustrate the possible influence of

syntactic context (Gorrell, 1989) in interpreting ambiguous lexical items with differing syntactic categories without the influence of semantic context (Folk & Morris, 2003).

Models of lexical ambiguity resolution

Without prior disambiguating context, models of lexical processing suggest that all possible meanings of an ambiguous word are accessed initially, and it is only in the subsequent selection stage that one meaning is preferred. The timing of this appears to be influenced by the relative frequency of the various meanings. That is, for ambiguous words with two equally likely and frequently-used meanings, the two meanings are accessed simultaneously (Seidenberg et al., 1982; Swinney, 1979; Tanenhaus & Donnenwerth-Nolan, 1984). However, for ambiguous words with one dominant meaning, that is more likely and more frequently-used than the other subordinate meaning, the dominant meaning becomes available earlier than the subordinate meaning (Duffy et al., 1988; Simpson & Burgess, 1985).

However, according to the Reordered Access Model (Duffy et al., 1988), prior disambiguating context affects the access process by increasing the availability of the appropriate meaning without influencing the alternative meaning. This causes competition when the appropriate meaning is the subordinate meaning as the model predicts that the subordinate meaning would become available earlier than usual and consequently simultaneously with the dominant meaning.

Eye-tracking studies investigating the roles of preceding sentential context and meaning dominance in lexical ambiguity resolution in monolinguals (Duffy et al., 1988; Sheridan et al., 2009) have shown that preceding context and meaning dominance tend to interact and influence the timing of the availability of meanings. Duffy et al. (1988) found that fixation times were longer on homonymous nouns when the preceding sentential context biased them towards only the subordinate meaning compared to control words, an effect now

known as the Subordinate Bias Effect (Kambe et al., 2001; Pacht & Rayner, 1993; Rayner et al., 1994). However, fixation times on homonyms and control words did not differ when presented with a preceding neutral context or a context that supported the dominant meaning only (Duffy et al., 1988). Conversely, in a previous study, balanced homonymous nouns presented in a neutral context resulted in longer fixation times compared to control words (Rayner & Duffy, 1986). Unlike the Reordered Access Model, Duffy, Morris, and Rayner (1988) claimed that neither modular nor interactive theories of language processing could account for these findings. They argued that modular theories could not account for the different types of preceding context resulting in differing fixation times and that interactive theories were inconsistent with the Subordinate Bias Effect due to the expectation of preceding disambiguating context selectively accessing the subordinate meaning without any processing delays.

According to the Reordered Access Model, lexical access is exhaustive, and the order by which meanings are accessed is determined by both preceding contextual information and meaning dominance, with contextually-biased meanings and higher frequency meanings being accessed faster than unbiased and lower frequency meanings. Possible interactions of these factors can result in two or more meanings simultaneously becoming available and competing for processing, which lead to processing delays. For instance, if the subordinate (less frequent) meaning of a homonym is supported by preceding sentential context, the access to that meaning speeds up, causing the subordinate meaning to become available at the same time as the usually more available dominant (more frequent) meaning, resulting in the Subordinate Bias Effect.

The current study employs a cross-modal lexical decision task to investigate whether both meanings of ambiguous noun/noun and noun/verb homonyms are accessed when presented with neutral or preceding syntactically-constraining context. Based on the studies

discussed above, we anticipate, at least at the initial stages of lexical processing, a facilitation of lexical access for the slightly more subordinate meaning in the syntactically-constrained context condition. In consequence, both the dominant and subordinate meanings of the homonym might be retrieved at about the same time for this condition, resulting in lexical competition and observed longer reaction times. Specifically, according to the Reordered Access Model, biasing of the subordinate meaning in the syntactically-constrained condition should facilitate lexical access of this subordinate meaning such that it is more likely to compete with the dominant meaning, resulting in longer reaction times in the lexical decision task. In contrast, the neutral context condition is anticipated to support both the dominant and subordinate meanings, thereby reducing the likelihood of lexical competition and resulting in a slightly shorter reaction time for the slightly more dominant meaning.

As the task is carried out in English, we anticipate the monolingual English speakers to reveal lexical frequency effects when presented with unconstrained homonyms: those called the semantic condition. A shorter RT after presentation of a dominant lexical item will be considered evidence of such a frequency effect. In the case of syntactically-constrained homonyms, it is unclear whether this population will reveal evidence of syntactic priming or whether the syntactically-biasing context and meaning dominance will occur simultaneously. That is, to process the syntactically-biasing context while inhibiting the dominant meaning in order to facilitate and process the primed and appropriate, yet subordinate, meaning. A shorter RT upon presentation of appropriately-related target words, such as *wrist*, primed by syntactically-constrained homonyms, such as "...*a fine new* ***watch***..." will be considered evidence of syntactic priming. On the other hand, if syntactic and semantic modules are recruited in a parallel manner, with priming and frequency effects competing, inappropriately-related target words, such as *view* primed by "...*a fine new* ***watch***...", are expected to have reaction times equal to or shorter than appropriately-related target words.

As simultaneous bilinguals acquired both languages as two L1s, we expect this population to resemble monolinguals in accuracy scores and manner of processing. However, we hypothesise that the existence of a greater lexical store could have an effect on L1 lexical ambiguity resolution in the case of later bilinguals. That is, the early acquisition of a L2 could affect lexical ambiguity resolution even though the task is being carried out in the L1. Given postulations of the activation of multiple lexemes within the mental lexicons of earlier bilinguals (Fabbro, 2001; Paradis, 1998, 2001; Van Assche et al., 2009), evidence of longer RTs is expected as additional resources are recruited for these two populations to not only resolve competition between lexical frequencies, but also to inhibit the inappropriate translation equivalents of each.

Even though the task is being carried out in the L1 with non-cognate stimuli (phonologically and orthographically controlled to be dissimilar from French words), we anticipate that the later L2 bilingual group will reveal L2 effects due to the more recent acquisition of the L2 compared to the simultaneous and early bilingual groups. Differences in processing are expected to illustrate the theory that the earlier a bilingual acquires the L2; the more closely he or she resembles a monolingual speaker. This suggests that later L2 learners can no longer be considered monolingual native speakers of English. Indeed, according to Clahsen & Felser (2006) later L2 learners rely more on lexico-semantic information and other surface cues for interpretation during online sentence processing in their L2 (Neubauer & Clahsen, 2009). However, it is unclear to what extent such a strategy for processing in the L2 will affect processing in the L1. In cases where homonyms lack biasing syntactic context, we expect this group to reveal frequency effects, as evidenced in a shorter RT with presentation of a dominant meaning compared to subordinate.

Method

Participants

Fifty-one right-handed, English L1-speaking participants were recruited (39 females). All were between the ages of 18 and 35 (mean age: 25) years at the time of participation. 10 were monolinguals (8 females, mean age: 20), 14 simultaneous bilinguals (10 females, mean age: 26), 17 early bilinguals with L1 English (13 females, mean age: 22), and 11 late bilinguals with L1 English (8 females, mean age: 28). Linguistic status was ascertained via a short self-reported questionnaire and a short interview. Monolingual participants self-reported < 10% French exposure in any setting and did not successfully complete a short test version of the experiment in French. Simultaneous bilingual participants were raised in a balanced French/English environment from birth, and maintained both languages functionally until time of testing. Early L2 participants acquired French later than birth but before the age of six in more than one setting, such as in school, in the neighbourhood, with friends, and with siblings. Late L2 participants acquired French as L2 after the age of seven and maintained both French and English functionally until time of testing. Most participants were students at various academic levels in a university setting.

Design

Based on the cross-modal lexical decision tasks of Swinney (1979) and Tanenhaus et al. (1979), the present study was designed to couple the auditory presentation of an ambiguous homonym which differs in syntactic category (one reading being a noun, the other a verb) with a visual lexical decision task. Since the cross-modal priming method has been referred to as the perfect technique for investigating dependencies between two constituents (Klein et al., 2006; Love & Swinney, 1996; Swinney, 1979), this paradigm was used in the present study to investigate the effects of syntactic context on the associations between homonyms (the prime) and their relevant meanings (the target). As cross-modal priming permits the simultaneous presentation of a prime and target, the recording of participants' reaction occurs during on-line (i.e. unconscious and automatic) comprehension, thus

minimizing attention to extraneous variables. Further, as this method measures each participant's lexical decision response to the lexical target while the sentence is unfolding, rather than upon completion of the entire sentence, it poses less demand on working memory and minimises the risk of other confounding factors such as sentential context effects than if each response were made at the end of the sentence.

Materials

Experimental stimuli

The experimental stimuli presented to each participant involved auditorily presented priming or non-priming (control) items followed by visually-presented target items. The target items were either related or unrelated to the preceding priming items and these target items were what participants made lexical decisions on. All items were unique and distinguishable from French words. As the preceding sentential context is assumed to influence the prime and only through this influence to affect the performance on the visual target (Swinney, 1979; Tabossi, 1996), the priming items were syntactically-constrained homonyms (N=30) such as *watch* presented auditorily within a sentence, such as *Albert bought a fine new **watch** on the weekend*. The control items (N=30) included the same auditory sentence but with a non-priming item such as *house*, such as *Albert bought a fine new **house** on the weekend*. The visually-presented target items had one of three relations to the priming item: the related and subordinate reading such as *wrist*; the related and dominant reading such as *view*; or unrelated such as *lake*. Each participant saw one of the six versions of each sentence. Each participant saw five items in each condition, with no repetition of any one item. The conditions are outlined in **Table 1** and discussed below and all stimuli are given in **Appendix A**.

[Put Table One about here]

Each syntactically-constrained priming item, such as *watch,* is a homonym whose two possible meanings differ in grammatical category, one a noun (*a wrist*) and the other a verb (*to view*). Only homonyms with meanings balanced within a log frequency of 1.5 of each other were included to limit frequency effects. For example, the noun reading (*a wrist*) has a log frequency 3.23 and the verb reading (*to view*) has a log frequency of 4.28 (COBUILD, 1995).

To further control for frequency effects, the auditorily-presented sentences were biased towards the lower frequency reading even though there were no significant differences between the noun and verb reading frequencies. Our intention was to bias for the subordinate reading in an attempt to reduce activation of the more dominant reading in order to investigate priming effects. As such, the weaker homonym had a fighting chance. For example, the syntactic context preceding *watch* in (1) below, such as the preceding article "*a*" and the adjectives "*fine new*", directs its interpretation to the noun reading which is less frequent than the verb reading (COBUILD, 1995). The "▲" indicates the point at which the visual target was presented, with RT measured from the offset of the prime.

(1) *Albert bought a fine new* ***watch***▲ *on the weekend.*

Sentences and items were balanced in length and complexity. Only simple declarative sentences were used. Words in sentences were lexically-neutral to avoid semantic bias according to a panel of four native English speaking volunteers. Only preceding syntactic information, such as modal verbs or definite or indefinite articles, was expected to selectively favour either the verb or noun interpretation of the priming homonym. By maintaining semantic neutrality, while including biasing syntactic information of the primes, differences in reaction times to the targets could be attributed to the effects of syntactic influence.

While each sentence was auditorily-presented, one of three possible visually-presented target items was presented on a computer screen immediately upon completion of

the priming homonym. Each visual target was a) appropriately-related to the subordinate reading of the homonym, such as *wrist*, and appropriate given the sentence context, b) appropriately-related to the dominant reading of the homonym, such as *see*, but inappropriate given the sentence context, or c) unrelated, such as *lake*. All visual targets had a frequency of 2.00 frequency log or higher according to the COBUILD database (1995) with no significant difference between frequencies, were balanced for length, complexity, and syntactic category, and were chosen from a paper-based fill-in association task done by over one hundred volunteers at the time of stimuli creation.

Secondly, stimuli included unconstrained and semantically-ambiguous priming items (N=30) such as *cellar/seller* (as the stimuli were presented aurally, the difference in orthography of *cellar/seller* was not considered to be a confound). The number of auditorily-presented priming items, control items, and visually-presented target items was identical to the syntactically-constrained items. The two readings of the semantic homonyms were of the same syntactic category, that of noun/noun, such as *cellar* (a basement) and *seller* (a vendor). Sentences containing semantic homonym primes, such as in (2) below, were contextually-neutral such that either reading was plausible.

(2) *Peter and Joe knew of a* ***cellar▲*** *that later proved to be extremely valuable.*

Each semantic homonym pair was chosen for its close frequency between both readings (1.69–2.15 -log frequency) according to the COBUILD database (Collins, 1995).

An equal number of control frame sentences were included and followed the same criteria as the control sentences described above for the syntactically-constrained priming homonyms.

The visually-presented target words for this condition followed identical criteria as the target words of the syntactic homonyms. As such, the visual target for sentence (2) above was one of three following words: a) *basement*, b) *vendor*, or c) *napkin*.

Ninety filler sentences were included. These were common sentences in English, containing no homonyms, such as in (3) below.

(3) *Zoe really likes her **new**▲ stuffed panda bear.*

The visually-presented target words for filler sentences were pseudo-words, resembling legitimate English words. In the case of (3) above, the pseudo-word target *howply* appeared as it contains phonologically-permissible consonant clusters and may be considered close to an actual English word. Pseudo-word targets were included to prevent familiarization with the homonym items described above and to ensure equal expectations of "no" answers to the lexical decision task as participants were expected to respond "no" to these pseudo-word targets following fillers.

All sentences were pre-recorded by a female native speaker of common Canadian English dialect from the Ottawa region. The program CoolEdit 2000 was used to equalise volume, pitch, and frequency across conditions and items such that there were no acoustic differences between or across items and sentences.

To ensure that participants were attending to all sentences, and not just focussing on the button-press of the lexical decision task, each stimulus sentence was followed by a yes/no question related to the sentence content. The question following example (3) above was "*Does Zoe really hate her new stuffed panda bear?*" The question appeared on the computer screen and participants were required to answer either *yes* or *no* with a button press. There were an equal number of expected *yes* and *no* answers.

Procedure

The experiment was conducted in a sound attenuated room with a CRT monitor using the program DMDX (Forster & Forster, 2003). Participants were positioned comfortably in front of a computer screen, with the computer mouse in their right hand. Participants wore headphones which delivered the auditory stimuli while blocking out environmental noises.

Following a brief instruction session, six practice trials preceded the actual experimental trials. Participants began by clicking the space bar on the keyboard once at the ready prompt. A "*" fixation point appeared for one second before the onset of each item. Each item consisted of one sentence and one target word/pseudo-word, as described above. At the critical point within each sentence (see Materials above), a target appeared on the screen in front of the participant. When a target appeared, the participant indicated whether it was a correct word of English or not by clicking the appropriate mouse button. Participants were instructed to respond as quickly as possible after a target appeared. Participants then responded to the content question following each item. Responses and timing were recorded by the computer.

Results

In this section, we present first the results of an **overall analysis**; secondly the analysis of **priming effects**; and lastly the results of the analysis of **frequency effects**.

Overall

Incorrect trials were excluded from RT analyses, but were retained for calculations of accuracy. Accuracy was calculated for both lexical decisions to the target words as well as for responses to questions. All participants with scores below 70% accuracy were excluded. One early bilingual and two late L2 learners were excluded based on this criterion. A 1-way ANOVA with group as IV and accuracy as DV, revealed no significant difference in accuracy across groups ($F(1,3)=.826$, $p=.536$).

The RTs for the remaining correct trials were then averaged for each condition for each participant grouped according to their predetermined language background. Trials with RTs ±2 standard deviations from each condition mean were removed: 5.49% in Condition One, 4.70% in Condition Two, 4.70% in Condition Three, 3.92% in Condition Four, 4.70% in Condition Five, and 5.49% in Condition Six. The averages of each condition were then

compared to investigate the effect of homonym type (syntactic *vs.* semantic) and the effect of relatedness (subordinate and appropriate; dominant and (in)appropriate; unrelated). The mean group RTs for each condition are shown in **Table 2**.

[Put Table 2 about here]

The RT data was analyzed using a 3-way ANOVA with Homonym Type (2 levels: syntactic & semantic), Relatedness (3 levels: subordinate appropriate; dominant (in)appropriate; unrelated), and Language Group (LG with 4 levels) as factors. There was an overall effect of Homonym Type ($F(1,44)=4.319$, $p=.044$), shown in **Figure 1**. The effect of Homonym Type shows the syntactically-constrained and unambiguous homonyms being processed more slowly than the unconstrained and semantically-ambiguous homonyms.

[Put Figure 1 about here]

Significant interactions were found between Homonym Type and Relatedness ($F(2,88)=5.848$, $p=.004$). **Figure 2** shows the inappropriateness of Condition 2 in the Syntactically-constrained homonyms which results in a longer RT (757.820ms mean RT) compared to the Semantic condition (695.702ms mean RT). The syntactic condition shows both the appropriately- and inappropriately-related conditions with similar RTs (757.721ms mean RT for Condition 1 and 751.765ms mean RT for Condition 2), whereas these two conditions, both appropriate, differ within the Semantic condition (757.820ms mean RT for Condition 1 and 695.702ms mean RT for Condition 2).

[Put Figure 2 about here]

A 3-way interaction between Homonym Type and Relatedness and LG was also found ($F(6,88)=4.350$, $p=.001$), illustrated in **Figure 3**.

[Put Figure 3 about here]

Figure 3 shows that the monolinguals and simultaneous bilinguals have consistently shorter RTs across conditions compared to the other groups. The late L2 learners appear to

have the overall longest RTs, with the longest RT found in Syntactic Condition 2 involving the priming homonym followed by the target word related to the inappropriate reading. The early L2 group appears to fall somewhere between the two bilingual groups. Indeed, there is a significant effect of LG ($F(1,44)=2777.261$, $p<.001$) which **Figure 4** clearly illustrates. This data suggests that with later L2 acquisition longer RTs are found when processing the L1.

[Put Figure 4 about here]

Planned comparisons of RTs for each of the three bilingual groups to the monolingual group were carried out. The results of the simultaneous bilingual group did not differ significantly ($p=.918$) from the monolinguals, but the early bilingual group differed from the monolinguals with a trend toward significance: ($p=.070$), and the late bilingual group differed significantly ($p=.001$) from the monolinguals.

Analyses of the priming effects

Priming effects are shown with a negative value (such as -50), indicating a shorter RT relative to the control condition. Priming effects were analysed using repeated measures ANOVAs to first contrast the unconstrained semantic conditions to the control condition and secondly the syntactically-constrained conditions to the control condition. These conditions involved the subordinate target words only. As expected, no effect of Priming was found in the semantic condition ($F(1,44)=.013$, $p=.911$) since the homonym was presented in a contextually-neutral and non-priming sentence.

A main effect of Priming was found in the syntactic condition ($F(1,44)=24.326$, $p<.001$). A planned comparison of the priming words compared to the control words showed a significant difference between appropriately-related and unrelated target words ($p<.001$) only. These results are in **Figure 5**, showing that the syntactically-constrained condition resulted in a longer RT for monolinguals, a slight priming effect for the earlier bilingual groups, and the late L2 group show the greatest syntactic priming effect.

[Put Figure 5 about here]

Analyses of the frequency effects

A repeated-measures ANOVA analyzed the effects of lexical frequency in the syntactic condition by contrasting the results of the subordinate and appropriately-related target words to the dominant and inappropriately-related target words. A planned comparison revealed a significant difference between the appropriately-related and the unrelated target words (p=.002) and the inappropriately-related target words compared to the unrelated words (p=.003), but no difference between the appropriately- and inappropriately-related target words in this condition (p=.626). A main effect of Frequency (F(1,44)=2344.172, p<.001) and of LG (F(3,44)=5.441, p=.003) were found, shown in **Figure 6**. As the graph indicates, the dominant readings of homonyms are reflected in a shorter RT for the monolinguals, simultaneous bilinguals, and early L2 learners, but not for the late L2 learners. Thus, lexical dominance did not have an effect on the late L2 learners in this condition.

[Put Figure 6 about here]

A second repeated-measures ANOVA analyzed frequency effects in the semantic condition by contrasting the subordinate and dominant target words. In the semantic condition, all target words were appropriate. A planned comparison showed a significant difference between the dominant readings of the ambiguous homonyms and the subordinate readings (p=.040). There was a main effect of Frequency (F(1,44)=11.401, p=.002) within this condition of unconstrained, semantically-neutral homonyms. There was an interaction between Frequency and LG (F(3,44)=5.819, p=.002), and an effect of LG (F(3,44)=4.252, p=.010), indicating that the groups varied from each other in the effect of frequency. The Late L2 learners show the greatest effect of frequency in the semantic condition as shown in **Figure 7**.

[Put Figure 7 about here]

Conclusion

In this section, we first discuss the results of the reaction times overall; secondly the effects of syntactic priming; and lastly the effects of lexical frequency in online homonym processing in the L1.

Reaction time overall

We hypothesised that the three bilingual groups would differ in RTs to the monolingual group based simply on the fact that they had acquired a L2 at some period in life, which might therefore affect their processing time in the L1. The results of the simultaneous bilingual group did not support this hypothesis as they did not differ significantly in RTs overall compared to the monolingual group. However, the hypothesis was supported in the case of the early and late bilingual groups. In fact, the longer RTs appear to correspond to the ages at which these two groups acquired the L2, suggesting that the later one acquires an L2 in life, the longer it takes to make a lexical decision on an L1 item during online processing. Whether this may be due to a delay in access to the L1 item within the mental lexicon, or whether this may be due to a reduced ability to inhibit inappropriate items, need further investigation. Indeed, these findings support previous postulations that early bilinguals may be searching through a larger store of words (Paradis, 1998, 2001; Fabbro, 2001), as well as having to inhibit the inappropriate word due to a competition of lexical activation (Van Assche et al., 2009). The late L2 learners revealed the longest RTs overall, supporting our hypothesis of the recent acquisition of the L2 affecting this group's RTs in this particular task. Supporting the postulations of Cook (2003), the delayed RTs of the Late L2 group appear to indicate a heightened sensitivity to surface cues in the L2 influencing this group's processing of surface cues in the L1. These surface cues include syntactic constraints and lexical frequencies which are discussed next.

Syntactic priming

It was hypothesised that the presentation of syntactically-constrained (subordinate) homonyms followed by appropriately-related target words would reveal an overall effect of syntactic priming compared to the control condition. This would be evidenced as a longer RT due to the subordinate and dominant meanings being available simultaneously. However, the late L2 learners revealed syntactic priming with shorter RTs for target words appropriately-related to the priming homonym due to the biasing sentential frame.

Based on the Reordered Access Model (Duffy et al., 1988) and the Subordinate Bias Effect (Rayner et al., 1994), which suggest that the difficulty processing a subordinate and biased meaning does not necessarily negate syntactic priming, but rather, the subordinate meaning is available earlier than usual to compete with the dominant and unbiased meaning, our hypothesis was open as to the results of the monolingual group. We hypothesised that 1) a shorter RT to the items in Syntactic Condition 1 would be evidence of syntactic priming, thereby suggesting serial processing unaffected by a competing dominant meaning, whereas 2) an equal or longer RT to the same items would be evidence of parallel processing and the Subordinate Bias Effect as both syntactic priming and lexical frequency would be competing. Our results support the latter hypothesis as the syntactically-constrained items resulted in significantly longer RTs compared to the control condition. This suggests that the monolinguals were slowed down due to the Subordinate Bias Effect, whereby the subordinate meaning of the syntactically-biased target word becomes available for processing at the same time as the dominant meaning. The ensuing competition results in the significantly longer RT as found with this group, which will be discussed in the next section. This lack of syntactic priming also supports the results found by Tanenhaus & Donnenwerth-Nolan (1984) who suggest that listeners access all readings of an ambiguous word even when one of the readings is inappropriate given the preceding syntactic context.

Our hypothesis that the simultaneous and early bilingual groups would resemble the monolingual group in manner of processing was not supported as these two groups do not show the syntactic constraints slowing them down as significantly as did the monolinguals. Whereas the monolingual group shows syntactic priming and lexical frequency competing, these two bilingual groups appear to be neither aided nor hindered significantly by the syntactic constraints, as their RTs are equal for the syntactically-constrained homonyms and the control conditions. This suggests that acquiring French as an L2 before the age of 7 results in one's higher level of homonym processing in the L1 differing from that of monolinguals. Consequently, these findings require further research and do suggest that not all native speakers be considered equal without taking into consideration the possible affects that acquiring an L2 may have on the L1, regardless of age of L2 acquisition.

We hypothesised that the late L2 learners would contrast the most in RT and manner of processing from the other groups, revealing L2 effects on the L1. We hypothesised syntactic priming effects to be a substantiation of a reliance on lexico-semantic information and surface cues. Thus, if such a reliance were found, this would reveal an effect of an L2 learning strategy influencing lexical ambiguity processing strategies in the L1. A facilitating effect of syntactic priming was found, supporting the hypothesis that 1) late L2 learners do indeed rely on lexico-semantic information and other surface cues to aid in lexical ambiguity resolution. Thus, syntactic context facilitated the appropriately-related target word following the priming homonym compared to a sentence without surface cues. This not only supports the findings of Goodman et al. (1981) who found that syntactic context affects lexical decisions without influence of semantic context effects, but also suggests that the late L2 group shows serial processing since syntactic and semantic information do not appear to be competing.

Frequency effects

We expected all groups to show shorter RTs for dominant frequency items in the semantic condition since these items were not constrained by cues to one reading over the other, and would therefore conceivably be free of competition. Our hypothesis was supported as a main effect of Frequency showed that the dominant readings were shorter to respond to. This supports the findings of Bilenko et al. (2008) who found longer RTs and an increase in neural recruitment for the subordinate meaning of an ambiguous word. Our findings support their suggestion that additional neurological resources may be recruited to overcome lexical competition when accessing the subordinate meaning of an ambiguous word.

Frequency effects within the syntactic condition confirmed our hypothesis that syntactic and semantic processing occurs in a parallel manner at this higher level of processing, as syntactic priming and lexical frequency were found competing: significantly for the monolinguals, and slightly for the simultaneous and early bilinguals. For these groups, the main effect of Frequency shows that the faster processing of the more dominant reading is maintained even when inappropriately-related to the priming homonym. This also suggests that both meanings of homonyms are accessed, supporting the Subordinate Bias Effect (Duffy et al., 1988) as both the subordinate meaning and the dominant meaning of the target word become available simultaneously and compete. However, for the late L2 learners, the dominant reading resulted in a longer RT (118.11ms longer) than the subordinate reading, suggesting that lexical frequency is not in competition with syntactic priming, but rather syntactic priming appears more influential as appropriate meanings resulted in shorter RTs.

As such, our hypothesis that both meanings of ambiguous homonyms are accessed even when presented in a biasing syntactic context was supported in the results of the monolingual and early bilingual groups. This was evidenced as longer RTs were found in Syntactic condition 1, suggesting that access and inhibition of the inappropriate and dominant target word was occurring. This competition supports the suggestion that higher level

processing, such as with lexical ambiguity resolution, occurs in a parallel manner within the mental lexicons of these groups.

Our results show simultaneous and early bilinguals resembling monolingual speakers in the manner of processing homonyms, with no significant delay in RTs overall. As such, contrary to our hypothesis, there was no evidence that these two groups accessed any translation equivalents as they accessed both the dominant and subordinate meanings of the homonyms.

Our hypothesis suggesting that the acquisition of an L2 may affect higher levels of processing in the L1 was greatly supported by data from the late L2 learners. While showing longer RTs overall, this group showed effects of both syntactic priming and lexical frequency, without these two being in competition. The effects of frequency cannot be considered an overall strategy as they were not found in conditions where both lexical frequency and syntactic priming were present. In those conditions, the late L2 learners only showed effects of syntactic priming, thereby recruiting the syntactic module of processing without showing effects of competition. This suggests that this group processed these homonyms not in a parallel manner as evidenced by the other groups in this study, but in a serial manner of processing which is not influenced by the subordinate access effect. We suggest this is due to this group's higher level of processing in the L1 being influenced by acquiring an L2 after the proposed sensitive period of language development.

Discussion

This study found that the later the L2 is acquired, the more the L2 is found to influence the L1, as evidenced by overall longer RTs and evidence of serial processing rather than parallel. These findings support claims by Cook (2003) that bilinguals naturally focus their attentional skills on linguistic structure, resulting in an increased sensitivity to surface cues and possible interactions between the two languages, and by van Hell & Dijkstra (2002)

who found that foreign language knowledge affects L1 target word processing even in an exclusively native language context. Specifically, the results of the Late L2 group counter the Subordinate Access Effect suggested by Duffy et al. (1988) as this group showed a greater sensitivity to surface cues as they were influenced by syntactic priming in conditions where the monolinguals were not. This may be that as an L2 learner relies on surface cues as a strategy for processing in the L2, they may unconsciously become more aware of and aided by surface cues existing in the L1. This suggests that a person who has recently acquired an L2 may process their L1 differently. One of these ways may be that lexical access is not as automatically exhaustive, where the order in which meanings are accessed is determined either by preceding contextual information or by meaning dominance, but not by both (as was found with the monolingual speakers). This leads to the surprising and perhaps controversial conclusion that any speaker proficient in an L2 should not be considered as equal to monolingual native speakers given the evidence of L2 effects on ambiguity resolution in the L1.

The authors concede that not all factors have been taken into consideration which may have influenced the results of the bilingual groups. Factors such as the relationship to words in the L2, such as neighbourhood density, might have had an effect on the processing in the L1. A limitation of this study is that each participant saw only five items per condition, which is a small number considering the small number of participants this study currently involves. These and other unidentified factors still need to be investigated in order to substantiate or refute the findings presented in this study.

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Appendix A

Syntactic Condition Primes with Target Words

noun/verb Homonym Primes	Target Words							
	appropriate subordinate reading	freq.	inappropriate dominant reading	freq.	unrelated	freq.	control	freq.
PINCH	noun SALT	1.58	verb SQUEEZE	1.65	SHOE	2.48	PLUM	1.10
WATCH	noun WRIST	3.23	verb VIEW	4.28	LAKE	3.19	HOUSE	6.08
HUNCH	noun IDEA	0.68	verb BACK	0.98	MITTEN	0.54	HEADACHE	2.07
CHANGE	noun COIN	5.04	verb SWITCH	5.70	SNOW	3.52	BOOKS	4.78
BOX	verb FIGHT	1.67	noun CRATE	4.53	HOTEL	4.51	STUDY	3.21
RING	verb BELL	2.89	noun JEWEL	3.83	FLOOR	4.50	START	5.03
REAR	noun BACK	1.95	verb CHILD	2.25	WALL	4.59	OFFICE	5.52
SHED	noun BARN	2.02	verb SKIN	2.34	KNOB	0.80	TREE	4.03
SPELL	verb WRITE	1.93	noun CAST	2.70	BREAK	4.19	COOK	2.92
CROSS	verb TRAVERSE	3.00	noun CRUCIFY	4.40	CALCULATE	1.76	PAINT	3.01
STICK	noun TWIG	2.99	verb GLUE	3.25	KITE	0.53	DOG	4.18
TAP	noun SINK	2.40	verb TOUCH	2.80	DESK	3.78	BAG	3.78
PUNCH	verb FIST	0.96	noun FRUIT	2.39	ROOM	5.56	KISS	2.03
MUG	verb ROB	1.25	noun DRINK	1.46	SHAKE	2.63	VISIT	3.88
FALL	noun SEASON	4.09	verb GROUND	4.17	COFFEE	4.06	HILLS	3.13
SPOT	verb NOTICE	2.28	noun STAIN	3.88	CLOUD	2.82	NEED	5.68
PRESS	verb PUSH	2.96	noun PUBLISH	4.74	CRAWL	1.14	FIND	5.96
BLOCK	verb OBSTACLE	2.61	noun CUBE	3.73	JACKET	3.14	ASSIST	2.59
STALL	verb HINDER	0.24	noun ENCLOSE	1.65	SUBMIT	2.13	GUIDE	3.91
GROOM	noun BRIDE	1.30	verb COMB	1.68	APPLE	3.11	CHILD	5.46
DRAFT	noun RECRUIT	2.57	verb SKETCH	3.22	FOLLOW	4.50	HELP	5.68
TRAIN	verb INSTRUCT	2.61	noun TRAVEL	4.11	CARESS	0.94	JOIN	4.42
LOBBY	verb STRIKE	0.97	noun ENTRANCE	2.70	BISHOP	2.47	TALK	5.02
PRUNE	noun JUICE	0.52	verb CUT	1.32	BATH	3.25	SHOVEL	0.49
TIE	verb KNOT	2.17	noun NECK	3.32	BIKE	3.06	TOUCH	3.03

SHOW	noun THEATRE	5.13	verb EXHIBIT	6.16	FLAKE	0.11	PARK	4.00
PUZZLE	verb MYSTIFY	2.28	noun ASSEMBLE	2.48	SPRINKLE	1.14	HURT	3.06
DICE	verb CHOP	0.96	noun GAME	1.13	SING	3.09	TASTE	2.07
STEEL	noun METAL	3.65	verb THIEF	4.04	MOUTH	4.01	BOWL	3.26
HEEL	noun FOOT	1.97	verb CURE	2.13	RAIN	3.95	SLEEVE	2.00

Table 1: Stimuli by Conditions

Condition	Auditory Prime	Visual Target	Control Condition	Control Prime	Visual Target
1	*Albert bought a fine new watch on the weekend.*	*wrist* approp., subord.	1	*Albert bought a fine new house on the weekend.*	*wrist*
2	*Albert bought a fine new watch on the weekend.*	*view* inapprop., dominant	2	*Albert bought a fine new house on the weekend.*	*view*
3	*Albert bought a fine new watch on the weekend.*	*lake* unrelated	3	*Albert bought a fine new house on the weekend.*	*lake*
4	*Peter and Joe knew of a cellar that later proved to be extremely valuable.*	*basement* approp., subord.	4	*Peter and Joe knew of a kennel that later proved to be extremely valuable.*	*basement*
5	*Peter and Joe knew of a cellar that later proved to be extremely valuable.*	*vendor* approp., dominant	5	*Peter and Joe knew of a kennel that later proved to be extremely valuable.*	*vendor*
6	*Peter and Joe knew of a cellar that later proved to be extremely valuable.*	*helmet* unrelated	6	*Peter and Joe knew of a kennel that later proved to be extremely valuable.*	*helmet*
filler	*Zoe really likes her new stuffed panda bear.*	*stromble* pseudo word			

Table 2: Mean Group RTs by Condition

Mean RT (ms)	Homonym Type					
	syntactic homonyms			semantic homonyms		
	subord.	dominant	unrelated	subord.	dominant	unrelated
monolinguals	751.55	679.96	644.69	684.35	623.84	669.85
simultaneous bilinguals	702.51	672.46	665.87	701.40	661.92	674.08
early bilinguals	768.41	752.35	705.43	728.66	765.19	751.26
late bilinguals	808.39	926.50	818.79	892.62	731.84	811.19

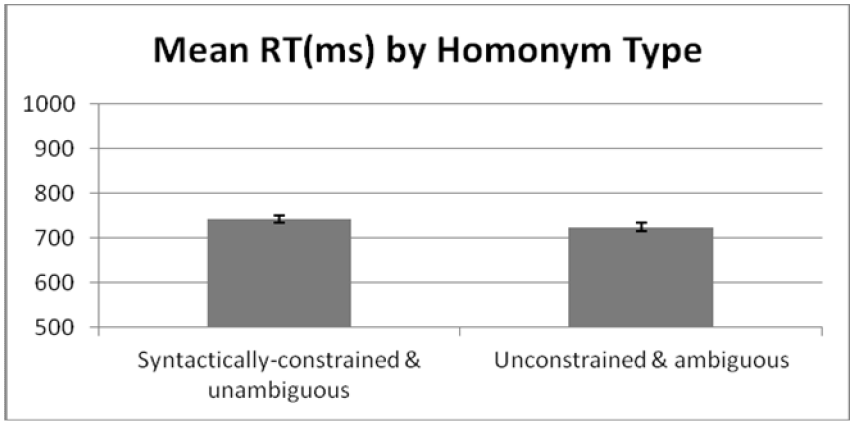

Figure 1: An Overall Effect of Homonym Type with Std Error bars shown

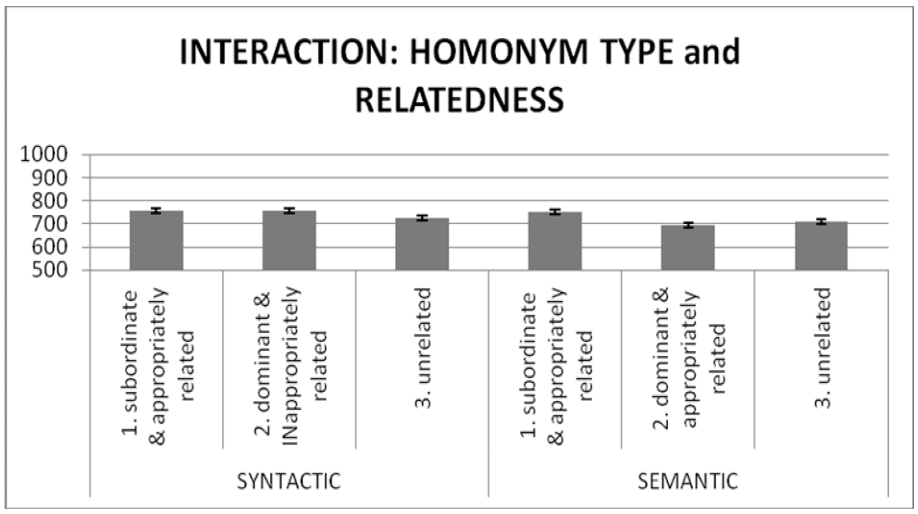

Figure 2: An interaction between Homonym Type and Relatedness

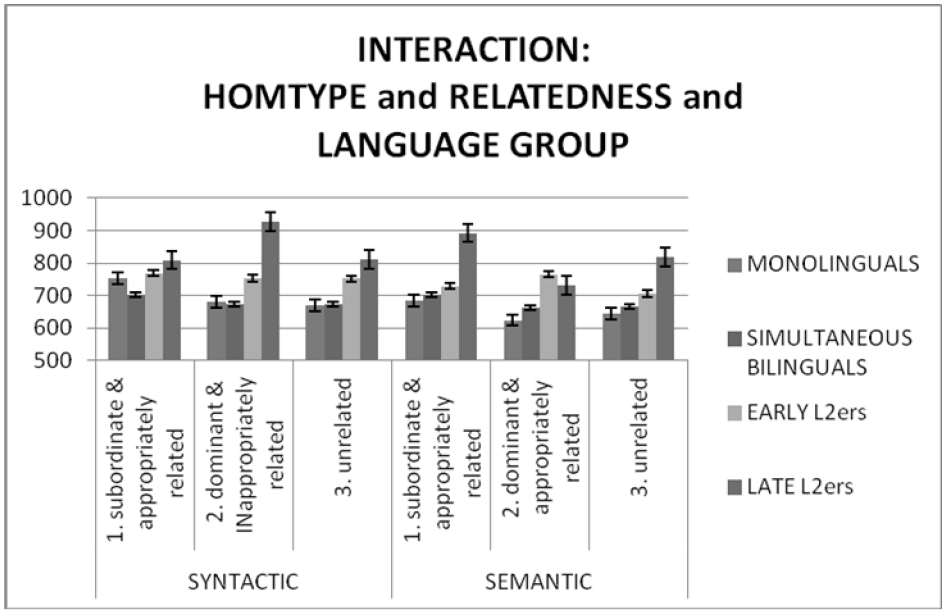

Figure 3: An Interaction between Homonym Type and Relatedness and Language Group

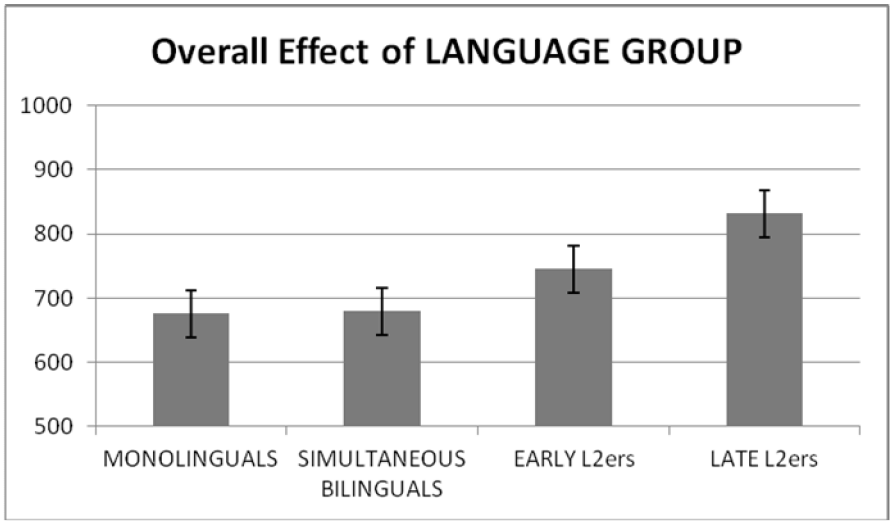

Figure 4: An Overall Effect of Language Group by Mean RTs

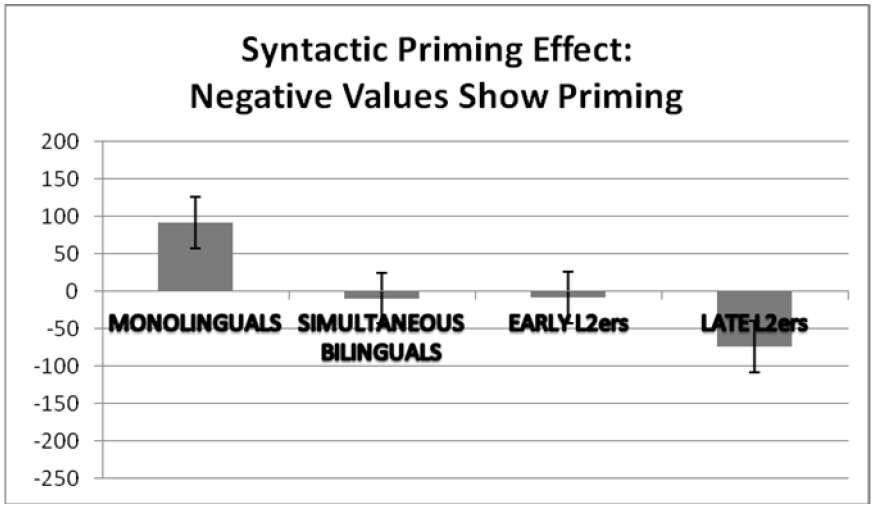

Figure 5: Syntactic Condition vs. Control with Std Error bars shown

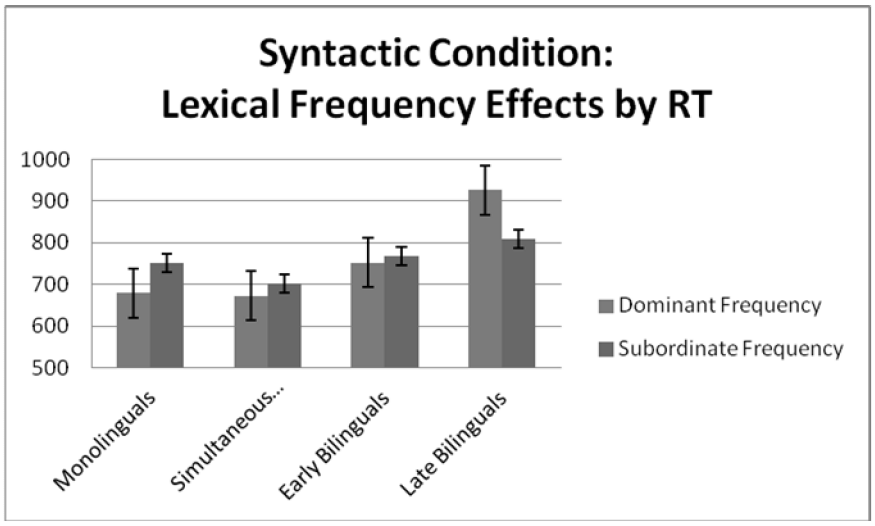

Figure 6: Frequency Effects in the Syntactic Condition with Std Error bars shown

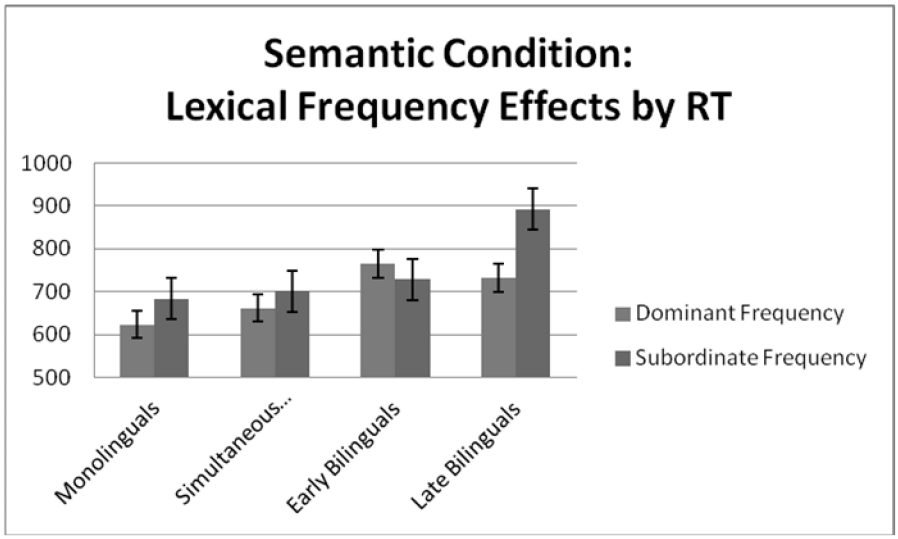

Figure 7: Frequency Effects in the Semantic Condition with Std Error bars shown