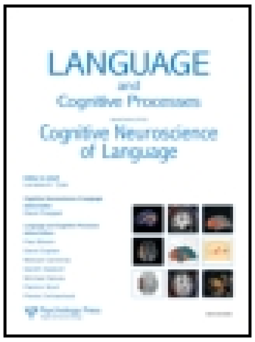

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Carpet or Cárcel: The effect of age of acquisition and language mode on bilingual lexical access

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Lexical access was examined in English–Spanish bilinguals by monitoring eye fixations on target and lexical competitors as participants followed spoken instructions in English to click on one of the objects presented on a computer (e.g., 'Click on the beans'). Within-language lexical competitors had a phoneme onset in English that was shared with the target (e.g., 'beetle'). Between-language lexical competitors had a phoneme onset in Spanish that was shared with the target ('*bigote*', 'mustache' in English). Participant groups varied in their age-of-acquisition of English and Spanish, and were examined in one of three language modes (Grosjean, 1998, 2001). A strong within-language (English) lexical competition (or cohort effect) was modulated by language mode and age of second language acquisition. A weaker between-language (Spanish) cohort effect was influenced primarily by the age-of-acquisition of Spanish. These results highlight the role of age-of-acquisition and mode in language processing. They are discussed in comparison to previous studies addressing the role of these two variables and in terms of existing models of bilingual word recognition.

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INTRODUCTION

In the past, the study of bilingualism had been restricted to the fields of educational and social science. The last decades, however, have shown a flourish of interest in the cognitive aspects of language representation and processing in bilingual speakers. One reason for this is the opportunity to assess the generality of the language processing system by investigating the validity of monolingual-based models in bilingual language processing. Another reason is that studying problems faced by bilingual speakers could inform models of language processing in monolinguals. Furthermore, an increase in the number of bilingual speakers in the USA has sparked controversies about bilingual education, language policy in the workplace, and second language acquisition. This makes it crucial to investigate language processes in people exposed to two or more languages. The design and implementation of educational programmes will depend largely on studies clarifying the impact that second language learning has on the acquisition of a first language and on studies comparing language processing in monolingual and multilingual speakers.

In this study, we investigate how bilinguals recognise spoken words. Work with monolinguals has demonstrated that during spoken word recognition, a listener considers multiple phonologically similar words until the intended word is uniquely identifiable (Allopenna, Magnuson, & Tanenhaus, 1998; Eberhard, Spivey-Knowlton, Sedivy, & Tanenhaus, 1995; Marslen-Wilson & Welsh, 1978; Marslen-Wilson & Zwitserlood, 1989). Here we examine how this research extends to bilingual speakers. In particular, we ask whether hearing a word in language 'A' activates only word candidates in 'A', or if this activation extends to phonologically similar words from language 'B' as well. The present experiment extends previous work on this question (Blumenfeld & Marian, 2007; Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Marian, Spivey, & Hirsh, 2003; Spivey & Marian, 1999) by focusing on the roles played by language context (specifically, language 'mode'; see below) and age of second language acquisition (AoA). We start by reviewing literature on the roles that age of acquisition and language proficiency play on the processing and the cognitive and neural representations of a bilingual's two languages.

Age of acquisition and language proficiency

A number of studies investigating language representation and processing in bilinguals have pointed out the need to consider the AoA and the level of proficiency of the first (L1) and second (L2) languages (Blumenfeld &

Marian, 2007; Elston-Güttler, Paulmann, & Kotz, 2005; Perani et al., 1998; Silverberg & Samuel, 2004). For example, in a study with Spanish–English bilinguals, Silverberg and Samuel (2004) used a lexical decision paradigm consisting of first language (L1, Spanish) targets preceded by second language (L2, English) primes. They found that both 'nail' and 'bull' (*toro* in Spanish) primed the Spanish word '*tornillo*' (screw) as examples of semantic and mediated priming, respectively.[1] Importantly, these priming effects were restricted to early bilinguals who had reached high proficiency levels in L2. In contrast, a group of late learners of L2, with comparably high proficiency levels, showed only inhibitory effects of cross-linguistic form primes (e.g., 'torture' – '*tornillo*'). The authors interpreted these results as evidence of a conceptual level shared by L1 and L2 in early bilinguals, versus a shared lexical level in late bilinguals. They concluded that the type and amount of interaction between a bilingual's two languages depend mostly on the age of acquisition of L2 (independent of proficiency).

In contrast, Perani et al. (1998) argue that attained proficiency is more important than AoA in determining cortical representation of L1 and L2 during auditory processing of native and second language stories. Using the positron emission tomography (PET) technique, they compared activity in brain areas of early and late highly proficient speakers of L2 with those of a group with low levels of L2 proficiency. They found that highly proficient learners of L2 (both early and late) showed comparable areas of activation for stories presented in either language. In contrast, differential areas of activation were elicited by L1 and L2 in the low proficiency group.

Jared and Kroll (2001) reported activation of spelling-sound correspondences in both languages of English–French and French–English bilinguals. In particular, the existence of word-body neighbours in the non-target language (French) impaired naming of the target language (English), depending on whether participants were naming words in their dominant or less dominant language and on their fluency and experience with French.

In another study, van Hell and Dijkstra (2002) found that L2 (English), but not L3 (French) cognate words, were activated during a native (Dutch) language performance task in trilinguals with lower proficiency levels in L3. In contrast, a second trilingual group with equal and minimal proficiency levels in L2 and L3 displayed activation of both L2 and L3.

Similarly, using a combination of reaction times and event-related potentials, Elston-Güttler et al. (2005) found that only bilinguals with low proficiency in L2 showed interference from L1 to L2 at the word-form level. In contrast, highly proficient L2 speakers showed brain and

[1] All auditory word stimuli will be placed in single quotation marks. We will identify when we are referring to a picture by placing the word in all-caps. All foreign words will be placed in italics.

behavioural responses similar to those observed in monolingual speakers of L2. Elston-Güttler et al. conclude that while bilingual word recognition may be non-selective, proficiency may modulate post-access task schemas or task/decision systems allowing highly proficient L2 learners to avoid visible L1 influences on L2 electrophysiological and behavioural patterns. The interference patterns found by Elston-Güttler et al. (2005) and Silverberg and Samuel (2004) in high/low proficiency and early/late bilinguals, respectively, are in line with the Revised Hierarchical model of Kroll and Stewart (1994). In this model, the authors propose a stronger L1–L2 interface at the word-form level in late or low proficiency bilinguals, in contrast with early or high proficiency bilinguals who display a stronger L1–L2 interface at the conceptual level. Also in line with this model and relevant to our own findings, Blumenfeld and Marian (2007) found group differences in the degree of cross-linguistic (German) activation of low and high proficiency speakers of German while they were performing a task entirely in English (see a detailed discussion of this study in the discussion section).

Eye-tracking and spoken word recognition

A number of current models of bilingual lexical access are based on the TRACE model of monolingual lexical access proposed by McClelland and Elman (1986). The TRACE model itself is based in part on the Cohort model proposed by Marslen-Wilson and colleagues (Marslen-Wilson, 1987; Marslen-Wilson & Warren, 1994; Marslen-Wilson & Welsh, 1978; Marslen-Wilson & Zwitserlood, 1989). Both the TRACE and the Cohort models argue that lexical access proceeds incrementally, with candidate words being constantly evaluated as the speech stream unfolds. As a person hears the initial phonemes of a word, a 'cohort,' or a set of candidate words matching the current phonetic pattern, is activated. For instance, people hearing the sound /b/ (b)[2] form a mental cohort of all the words they know that start with this sound. This cohort is continuously updated to reflect incoming information. As one hears more and more of a word, the cohort narrows until finally there is only one candidate left in the cohort. The activation of words in the cohort has been termed the 'cohort effect' (Allopenna et al., 1998; Marslen-Wilson, 1987; Marslen-Wilson & Warren, 1994; Marslen-Wilson & Welsh, 1978).

Studies using the eye-tracking visual world paradigm have supported these theories demonstrating the temporary activation of multiple lexical candidates consistent with the initial phonemes of a spoken word

[2] Throughout this paper, we will refer to all sounds using the International Phonetic Alphabet (IPA).

(Allopenna et al., 1998; Eberhard et al., 1995). By recording the eye movements of participants while presenting them with auditory instructions to manipulate objects in a co-present visual world, researchers were able to measure the activation of different candidate words in the cohort. For example, Allopenna et al. (1998) presented participants with pictures of four different objects on a computer screen, such as a BEAKER (/bik′r/, the target), a BEETLE (/bitl/, the cohort), a SPEAKER (/spik′r/, the rhyme) and a CARRIAGE (/kerIdZ/, the distracter). After gazing at a central fixation point, participants heard the instructions: ‘Pick up the /bik′r/ (beaker)’ (using the computer mouse). Researchers were able to track participants’ eye fixations with millisecond accuracy as they responded to the unfolding acoustic information and well before an overt response was made. The results of this experiment were consistent with the cohort model: before the disambiguating information at the end of the word, fixations on the BEAKER and the BEETLE were equivalent, and there were more fixations on both BEAKER and BEETLE than on the unrelated pictures. Following the disambiguating phonemic information at the end of the target word (/k′r/), fixations on the target increased, and fixations on the cohort competitor decreased.

Previous work with bilinguals

Although several on-line measures of language processing (e.g., event-related potentials, cross-modal lexical priming) have been used to study bilingual processing, most of them require presenting at least some words in *both* languages, resulting in a multilingual experimental setting. Thus, we decided to use the eye-tracking visual world paradigm because it provides us with an on-line measure of lexical activation in each of a bilingual speaker’s languages without the necessity of explicitly referring to the ‘irrelevant’ (or non-contextual) language.

In the study of bilingual lexical access, the eye-tracking visual world paradigm provides us with an on-line measure of lexical activation in each of a bilingual speaker’s languages without the necessity of explicitly referring to the ‘irrelevant’ (or non-contextual) language.

Using this technique, several studies have provided supporting evidence for non-selective lexical access in bilinguals (Blumenfeld & Marian, 2007; Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey & Marian, 1999). In a series of studies (Spivey & Marian, 1999; Marian & Spivey, 2003a, 2003b; Marian et al., 2003), late-fluent Russian–English bilinguals were presented with four objects and asked to pick up one of them. In some conditions, the target object was named in Russian, and a competitor object had an English name with a similar phonological onset as the target’s (Russian) name. In their first two studies, Spivey and Marian (1999, 2003a) conducted separate English and Russian monolingual sessions with the same group of bilinguals. Spivey and Marian (1999) found that during sessions carried out entirely in Russian (L1), participants looked at the inter-lingual cohort more often than at a distracter object phonetically unrelated to the target. For example, when presented with the name of a target object in Russian (e.g., *MARKA* /mArk′/ or stamp), participants looked not only at the target, but also at a MARKER (/mArk′r/), whose English (L2) name shares initial sounds with the Russian target. Evidence of an inter-lingual (Russian) cohort effect was also found during an English monolingual session, although this effect was of a smaller magnitude. These and related data obtained in later studies suggest that the strength of the inter-lingual cohort effect depends on which language, L1 or L2 is used in the study.

In a related pair of studies, Marian and colleagues (Marian & Spivey, 2003a; Marian et al., 2003) replicated their original work by including a condition where within-language and between-language competitors were presented simultaneously. Additionally, aware of the fact that in their first study (Spivey & Marian, 1999) they may have inadvertently induced a bilingual mode in their participants during an intended monolingual session, Marian and Spivey (2003a) set out specifically to control the language mode (Grosjean, 2001; see below for a more detailed explanation of the language mode concept). In particular, they carried out two separate studies (with two different groups of Russian–English bilinguals) placing them as close as possible in a monolingual second-language mode (English, in Experiment 1) or in a monolingual first-language mode (Russian, in Experiment 2), although, as they point out, it is almost impossible to secure a monolingual L1 language mode when participants are currently living in an L2 environment, even if the study is carried out completely in L1. Monolingual speakers of each language were used to record the stimuli. Each study was carried out in a single language with no code-switching, and no mention of the relevance of participants' bilingualism. In Experiment 1, the experimenters were native English monolingual speakers. In Experiment 2, the experimenters posed as monolingual Russian speakers but, as the authors concede, because the study was carried out in the USA, participants must have been aware that their bilingualism was known to the experimenters. In sum, the objectives of the study were disguised and participants' bilingualism was never mentioned as being relevant to the study. Confirming their previous findings, Marian and Spivey provided further evidence that bilinguals activate their two languages in parallel even in a language mode approaching the monolingual end of the language mode continuum. That is, in these two experiments they found activation of words belonging to the language used in the test (i.e., an intra-lingual cohort effect) but also activation of words belonging to the irrelevant language (i.e., an inter-lingual cohort effect).

Across all three studies, these authors concluded that the evidence supported a single common acoustic-phonetic system in bilinguals, providing differential, parallel, and automatic mapping to the two lexicons. In summary, Spivey and Marian (1999) and Marian and Spivey (2003a, 2003b) demonstrated that, even when participants are in a monolingual mode, they nevertheless show an inter-lingual cohort effect.

The current experiment

Two main factors underlie the ‘language mode’ concept: the base language (the main language being produced or perceived at a particular point in time), and the comparative level of activation of both the base and secondary languages (from very different levels in a monolingual mode to a similar level in a bilingual mode). However, a number of factors may affect the position of the speaker or listener on the language mode continuum: characteristics of the individual (e.g., AoA and proficiency in L1 and L2, habits and attitudes, kinship relation), the situation (e.g., presence of bilinguals, degree of formality), the form and content of the message (e.g., language used, topic, amount of mixed language), the function of the language act (e.g., to communicate information, to participate in an experiment), specific research factors (e.g., whether participants know the aims of the study or not), and the stimuli and the task used (Grosjean, 2001).

In one of the studies mentioned above, Marian and Spivey (2003) managed to put their bilingual participants as close as possible to a monolingual L1 or L2 environment. However, during their study in Russian, the experimenters pretended to be Russian monolingual speakers, a manipulation proposed by Grosjean (1998) to be a dangerous strategy, as subtle cues (e.g., facial expression, body language) could reveal the experimenter’s comprehension of the ‘unspoken’ language.

It is unclear whether participants immersed in a different language mode, or participants acquiring L2 at different ages would show similar levels of within- and between-language activation. The aim of the current experiment is to investigate the effects of language mode and AoA of the irrelevant language (the language NOT used in the context of the study) on lexical activation of candidates belonging to the contextual, as well as the irrelevant languages. We do this by examining the degree of within- and between-language activation in three types of bilingual participants, selected according to the age when they first acquired the irrelevant language (AoA), and testing these participants in one of three possible language modes; monolingual, mixed, or bilingual (see detailed description in the Methods section).

We predicted that when the experiment is carried out in Language A (English), the degree of activation of candidates belonging to Language A (English) or Language B (Spanish) will depend on which of the two languages is the participant's L1, and on the age that L2 was acquired, with more chances of observing an inter-lingual cohort effect when L1 is the irrelevant language. The ability to block an irrelevant language may increase if and when that language is acquired later in life. At the same time, this effect may be qualified by the level of activation of each language, with more chances of observing an inter-lingual cohort effect when the participants function closer to a bilingual mode and a stronger activation of within-language candidates when they function in a monolingual mode. That is, if a monolingual mode decreases the chances of inter-lingual activation, this may allow participants to fixate more 'freely' on within-language competitors (as compared with a bilingual mode, when the two languages are active to a certain degree).

On each trial, participants followed instructions in English to click on one of three pictures. Each participant was tested in two types of trials. The first were the *within-language competition* trials, where the name of the target picture (in English) had some initial phonological overlap with the name (in English) of one of the other two pictures on the screen (e.g., the competitor). The name of the third picture had no phonological overlap with the target or the competitor. The second type of trial was the *between-language competition* trials, where the name of the target picture (in English) had some initial phonological overlap with the name (in Spanish) of one of the two other pictures (again, the third picture was unrelated to the first two pictures). Note that the study itself was carried out entirely in English for all participants, even if (in the mixed and bilingual modes) there were sporadic conversations in Spanish before and after the experiment, and sometimes during breaks.

Given that our study was entirely carried out in English, we made the following predictions: (1) For within-language competition trials, we should obtain a clear within-language cohort effect in all three groups of bilinguals. However the strength of the effect might be modulated by the language mode and by the AoA of the second language. (2) For between-language competitor trials, we expected a stronger inter-lingual cohort effect in the two groups that acquired Spanish early in life (early bilinguals and S-E bilinguals) as compared with the group who acquired Spanish after 6 years of age (E-S bilinguals). (3) According to Grosjean (2001), the inter-lingual cohort effect should increase as participants move closer to a bilingual mode.

METHOD

Participants

A total of 133 adults, 45 males and 88 females (mean age = 29 years) were recruited for participation in the study. Participants were told that the purpose of the experiment was to investigate how people from different backgrounds follow instructions on a computer. Participants were recruited from the community with posters in local Hispanic venues and by word-of-mouth.

Participants were initially screened over the phone to assess their fluency in both English and Spanish. The phone screening was conducted entirely in English by native English monolinguals. Any participant unable to maintain a coherent conversation in English was excluded from participation. In addition, this screening conversation included two critical questions (mixed within 12 filler questions) intended to ensure that our participants had at least a minimal knowledge of Spanish. These questions were 'Do you speak any other language fluently?' and 'How old were you when you were first exposed to this language?' Filler questions (e.g., 'Are you right or left-handed?') were designed to distract attention from the language questions and, in so doing, to maintain a monolingual environment (see below). Based on their responses, participants who did not claim fluency in Spanish were excluded from participation. Participants were paid $40 upon completion of the study.

Participants had a wide range of linguistic backgrounds, thus we grouped them according to both their native language and the AoA of L2. We had a group of native English speakers ($N = 40$) who acquired Spanish after 6 years of age (E-S bilinguals), a group of native Spanish speakers ($N = 45$) who acquired English after 6 years of age (S-E bilinguals) and a group of bilingual speakers ($N = 48$) who acquired both languages before 6 years of age (early bilinguals).[3]

This age cut-off was motivated by two factors. First, in one version of the critical period hypothesis, Pinker (1994) argues that the critical period during which the learner must be exposed to a language in order to achieve native proficiency begins at birth, and extends until 6 years of age, or at the latest, when full neurocognitive maturation is reached (also see Johnson & Newport, 1989; Lenneberg, 1967; Newport, 1990). The second reason we used 6 years as our cut-off point is that prior studies investigating the possibility of a critical or sensitive period in second language acquisition have used this age as their cut-off, finding supporting evidence of the effects of AoA (Klein, Zatorre, Milner, Meyer, & Evans, 1994; Wartenberger, Heekeren, Abutalebi, Cappa, Villringer, & Perani, 2003).

Participants also rated their preferred language and language use. Fifty participants indicated that their preferred language of use was English, 36 indicated Spanish, and 46 indicated 'no preference'. (see Appendix A for a breakdown of language preference for each group). In relation to language

[3] Within the early bilingual group, 12 participants reported learning both English and Spanish from birth, 27 reported learning Spanish shortly before English, and 10 reported learning English shortly before Spanish.

use, 84% of the participants reported speaking Spanish more than 10 hours/week, 73% more than 20, 69% more than 25, and 60% more than 30 hours/week. For English, 93% of all subjects reported speaking it for over 10 hours per week, 90% more than 20, 86% more than 25, and 84% more than 30 hours/week. Therefore, although a handful of participants used only one language regularly, our sample was mostly composed of people using predominantly English in their everyday life but with considerable use of Spanish as well.

Design

On each trial, three pictures appeared on the corners of a hidden equilateral triangle drawn around a central fixation point, with one picture on the vertex directly above the centre and the other two on the two bottom vertices. All three pictures were located 6 cm from the centre of the screen. Additionally, the mouse cursor was centred on the calibration screen for each presentation, which guaranteed that it was located in the centre of the display and equidistant from all three pictures at the beginning of each trial.

Materials

Stimulus selection. A norming study was conducted in order to evaluate how native English speakers would name a set of 30 images selected to elicit specific names. Seventeen participants were asked to name each picture in isolation (presented on paper), and their responses were compared against the intended name. Of the 30 images, the name agreement (see Griffin & Huitema, 1999), or percentage of individuals who used the same name to describe the picture, was 100% for eight of the pictures. Eleven pictures had a name agreement of at least 75% of the participants and four were named using the same word by at least 50% of participants. The remaining seven pictures did not elicit the expected name and were modified to be more easily identifiable. Out of the 30 items, 10 were used as experimental targets, 10 were used as English cohorts, and 10 were used as Spanish cohorts. The unrelated items in experimental trials and all of the items in filler trials were taken from this same pool of 30 items.

The lexical frequencies of all 30 items were calculated using *The educator's word frequency guide* (Zeno, Ivens, Milard, & Duvvuri, 1995) for frequencies of occurrence in English ($M = 52$, $SD = 71.4$) and *Diccionario de frecuencias de las unidades lingüísticas del castellano* (Alameda & Cuetos, 1995) for frequencies of occurrence in Spanish ($M = 78.5$, $SD = 192.3$). The final stimulus set was selected to minimise frequency differences across languages and across all words. We confirmed the success of this manipulation with a t-test demonstrating the lack of a significant difference in frequency of occurrence between English and Spanish, $t(29) = 0.43$, *ns.* Additionally, care was taken to assure minimal overlap in semantic category between targets and cohorts. For example, EAGLE (/ig′l/) and BUTTERFLY (/b√t′rflai/) share the semantic category of 'flying creature' and hence would not be placed together. Finally, the only stimulus not referring to a concrete object in the whole set was the word 'east'. In this case, we portrayed 'east' by showing a compass and an arrow pointing to the 'E' indicating east. Note that the Spanish word for 'east', *este*, also begins with E. For a complete list of stimuli, see Appendix B.

Auditory stimuli. Based on the results of the norming experiment, 10 sets of critical stimuli were selected, each comprised of three words: a target word in English, an English cohort, and a Spanish cohort. Crucially, these three words shared phonological onsets. For example, the target BEANS (/bins/) had the English cohort BEETLE (/bitl/) and the Spanish cohort MUSTACHE (*BIGOTE* in Spanish /biɣote/). Only one cohort, either in Spanish or English, was presented in each cohort trial along with the target. The third picture on each trial was always of an object with no phonological overlap with either target or cohort.

In addition to phonological overlap, several criteria dictated the selection of stimuli. All were concrete nouns (with the exception of EAST; /ist/, mentioned above) referring to objects easily represented and recognised in a small and simple line drawing. The average number of shared phonemes between targets and their English cohorts was 2.1 phonemes, and the average number of shared phonemes between targets and their Spanish cohorts was 2.0 phonemes. The average overlap of phonetic features (i.e., place of articulation, manner of articulation, voicing and palatalisation) was 7.5 features between English cohorts and targets and 7.7 features between Spanish cohorts and targets.

Speech stimuli were digitally pre-recorded mono-aurally at a sampling rate of 44.100 kHz, 16 bits, by a female, monolingual English speaker who was blind to the experimental hypotheses. She was recorded saying 'Click on the' as well as 'Click on the X', where 'X' was each of the targets. Using an editing program, each target word was spliced off from each individual sentence and added to the 'Click on the' sound file recorded in isolation in order to eliminate early prosodic or co-articulatory information about the target words. These audio files were used for an English pre-test naming procedure (described below); audio files for a Spanish pre-test naming procedure were pre-recorded in the same way by a bilingual native Spanish speaker from Mexico City (the first author).

Visual stimuli. The pictures were black line drawings on a white background. Each picture was modified to a standard resolution and size, each occupying 100 × 100 pixels at a resolution of 72 pixels per inch (3.5 cm square). Pictures were mostly sourced from Clipart.com. A few were adapted from other academic labs, or were hand-drawn. Effort was made to standardise brightness and contrast.

Apparatus. An ISCAN RK-464B Remote Eye Imaging System was used to record participants' eye movements during the experiment. Participants sat in an adjustable chair facing a computer monitor and rested their chins on a headrest designed to minimise head movement. A video image of the experimental scene, along with the fixation crosshair and synchronised audio, were recorded at 30 Hz using a frame-accurate digital VCR (Sony DSR-30). The scene was presented to participants on a computer monitor 34 cm in size and 76 cm away from the participants' eyes. The screen subtended approximately 25 degrees of visual angle horizontally and 25 degrees vertically (see Figure 1 for a schematic representation of the eye-tracking setup).

Procedure

Participants were tested in three language mode conditions, based on the distinctions outlined by Grosjean (2001). These conditions were designated as 'monolingual mode', 'mixed mode', and 'bilingual mode.' Participants in all three conditions were told that the study was about investigating how people with different backgrounds follow instructions provided by a computer. The success of this manipulation was tested at the end of the study by asking our participants to indicate what they believed was the purpose of the study.

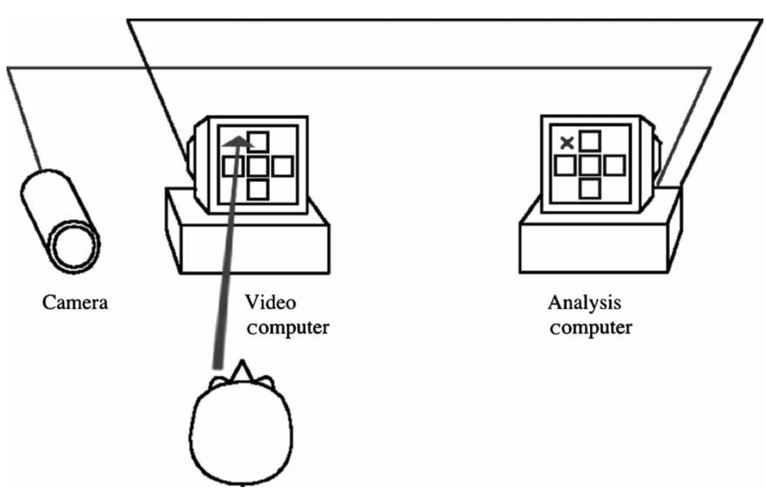

Figure 1. Eye-tracker setup.

As mentioned above, several factors can influence the position of the speaker or listener on the language mode continuum. We manipulated or controlled a few of these factors (e.g., presence of bilinguals, language used, amount of mixed language, participants' knowledge of the aims of the study) to produce three language modes. The differences among the three language modes were as follows. In the monolingual mode, participants were unaware that the experiment concerned bilingualism. All documents, stimuli, door signs, and instructions were presented in English. Furthermore, the experimenter was a monolingual English speaker, and was thus unable to inadvertently activate a bilingual mode. In the mixed mode, the participants were not informed that their bilingualism was a requirement to participate in the study. All stimuli were presented in English, and the experimental procedure was carried out entirely in English. However, in this mode, a bilingual experimenter, pretending to discover participants' bilingualism, presented some directions (e.g., 'Please take a seat') and conversed sporadically with the participant in Spanish. Finally, in the bilingual mode, participants were explicitly told that the experiment was about bilingualism and the sign on the door was presented in several languages. They were also asked to repeat the names of the stimuli in Spanish as well as in English during the naming procedure (see below).[4] As in the mixed mode, the experiment was entirely in English, but the experimenter spoke sporadically to the participant in Spanish (in a similar amount to the mixed mode). Finally, participants were also given the option to fill out a consent form in either language. See Table 1 for a breakdown of participants by AoA and language mode.

The experiment was composed of four parts: a naming procedure, practice trials, experimental trials, and a questionnaire. The naming procedure was included to ensure that each participant identified the target images using the English labels we intended.

Naming procedure. Participants, seated in front of a computer monitor, viewed each of the 30 experimental and 3 practice images (see below) as the name of the image was played over headphones. Images were presented in a different random order for each participant at a rate of one per second. After viewing each image once, the entire set of images was presented again in random order with its corresponding auditory name. Participants were then asked to remove their headphones and viewed the entire set of images a third

[4] We thank an anonymous reviewer for pointing out that this manipulation may have served to pre-activate the Spanish cohorts. However, if this was the case, all AoA groups should have been equally affected, which is inconsistent with our findings.

TABLE 1
Number of participants in each age of acquisition and mode group

	Mode			
	Monolingual	*Mixed*	*Bilingual*	*Total*
AoA				
Early bilingual	18	15	16	49
E-S	13	12	14	39
S-E	15	15	15	45
Total	46	42	45	133

time, but without hearing the sound file. Instead, they were asked to name each object and any mistakes were noted and corrected by the experimenter.

Practice trials. Participants completed 10 practice trials, which mimicked the experimental trials using a different stimulus set. Each trial contained the same three pictures (APPLE, /Qp′l/; BANANA, /b′nQn′/; and CHERRIES, /tSEris/) with the target being balanced across objects and positions. Practice trials were presented in the same randomised order to each participant.

Experimental trials. Participants completed 150 experimental trials, 40 of which were critical trials and 110 of which were filler trials. Experimental trials were presented in a different random order to each participant. In every trial, three pictures were presented, one of them being the target. In the 110 filler trials, the target was presented along with two unrelated objects that did not share initial phonemes with the target. Pictures were presented 500 ms before the onset of the auditory instruction ('Click on the') which had a duration of 783 ms. The 40 critical trials were of three types. In the within-language competition condition (English cohort, $N = 10$), the target (e.g., BEANS) was presented along with an object whose English name had some phonological overlap with the target at the onset (e.g., BEETLE) and an unrelated object whose name had no phonological overlap (e.g., CONE; /kon/; see Figure 2 for an example of this type of trial). In the between-language competition condition (Spanish cohort, $N = 10$), the target (e.g., BEANS) was presented along with an object whose name in Spanish shared phonological overlap at the onset with the target's English name (e.g., *BIGOTE*, or 'mustache' in English), and one unrelated object with no phonological overlap with either of the other two pictures in the scene (e.g., JAIL; /dZeil/; see Figure 3 for an example of this type of trial). These first two types of critical trials were designated as 'cohort-present' trials.

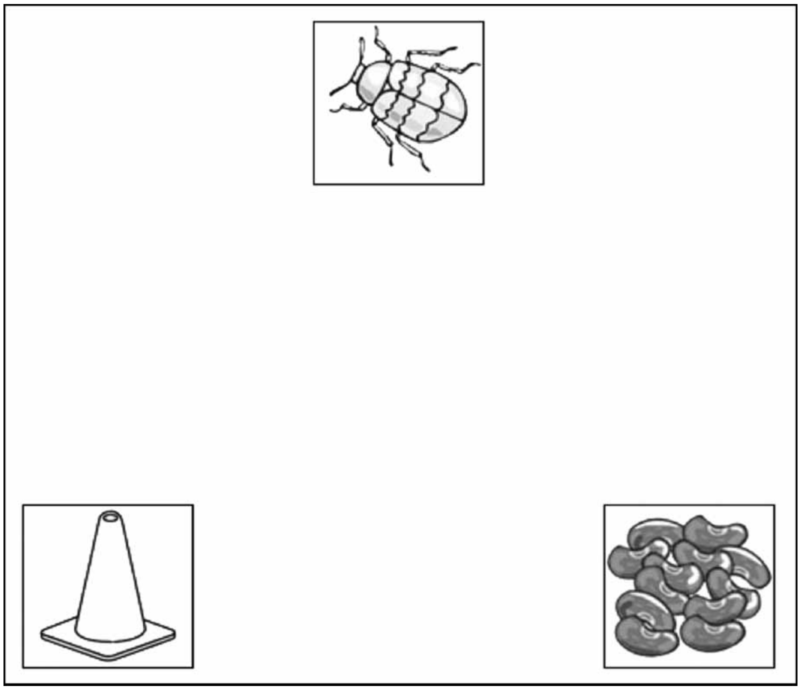

Figure 2. English-cohort trial – BEANS is the target, BEETLE is the cohort, and CONE the unrelated object.

Finally, in the 'cohort-absent' (control) trials ($N = 20$; 10 for each language), the target was presented along with two objects whose names lacked phonological overlap with the target or with each other. However, one of these unrelated objects was located in the same position as one of the cohorts in a corresponding cohort-present trial. Thus, cohort-present and cohort-absent trails were designed in pairs to contain the same target images located in the same position.[5]

Throughout the experiment, each object served as a target exactly five times and as a cohort or a control filler in 10 trials. The location of objects was pseudo-randomised to minimise expectations about the location of targets, cohorts, or individual pictures.

[5] We included these control trials in order to compare our coding procedure (mentioned below in the eye-tracking analysis section) with an alternative technique used by Spivey and Marian (1999), and Marian and Spivey (2003a, 2003b). This method yielded an identical pattern of results. Therefore, we will restrict our report to the analysis using our own coding procedure.

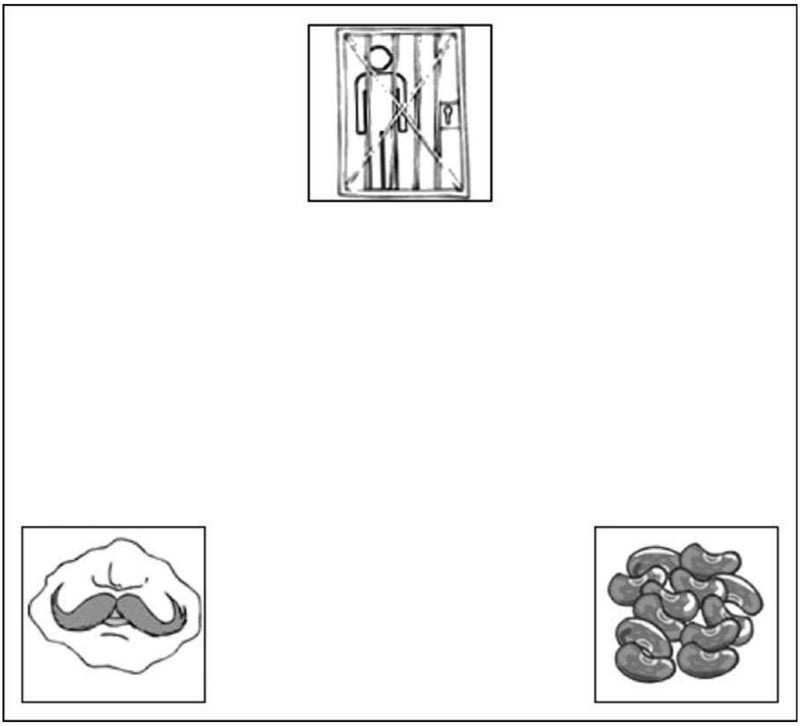

Figure 3. Spanish cohort trial – BEANS is the target, MUSTACHE (*bigote*) is the cohort, and JAIL the unrelated object.

Trial structure. Figure 4 shows the schematic representation of the timeline of a particular trial. Each trial started with the presentation of a 5-point calibration screen with one point located in the centre and one point on each corner of a 346 × 300 pixel rectangle. Once participants clicked on the central (fixation) point using the computer mouse, the calibration screen was replaced with three pictures, each one appearing on one of the corners of an imaginary equilateral triangle centred where the fixation point had been previously located. Participants heard pre-recorded instructions (e.g., 'Click on the beetle') through a pair of headphones and used a one-button computer mouse to click on the target. A new calibration screen appeared 500 ms after their response and remained until the participant clicked on the centre of the screen to start the next trial.

Questionnaires. Following the experiment, participants filled out a demographic and language history questionnaire. Finally, a stimulus questionnaire presented participants with each picture asking them to

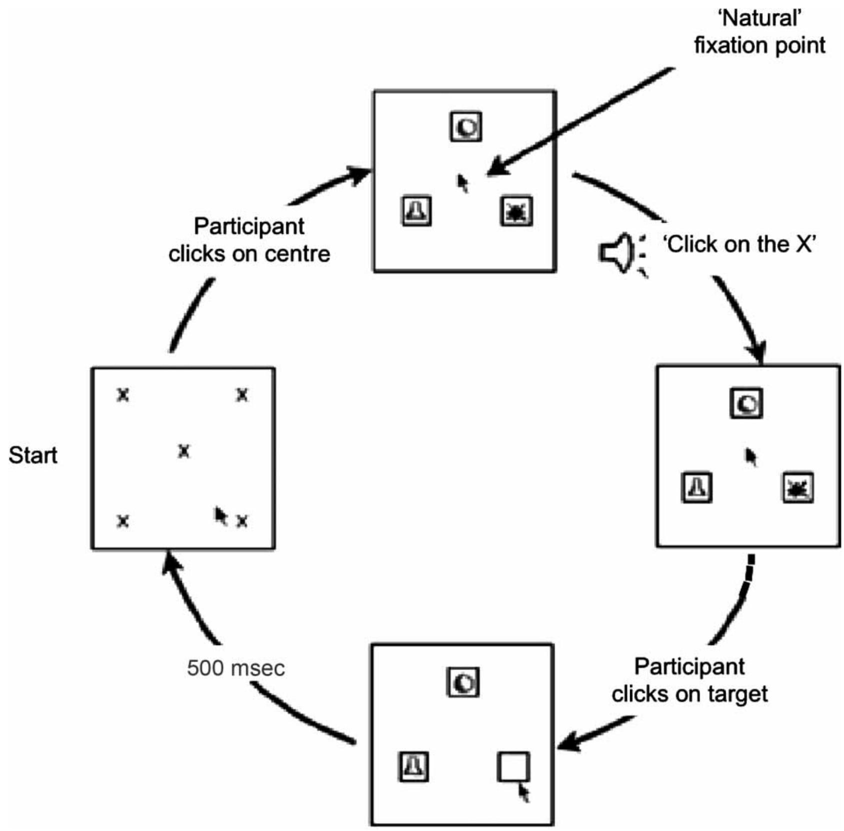

Figure 4. Trial timeline.

provide the corresponding English and Spanish labels, used later for exclusion criteria (see below).

Hypotheses

We expected the proportion of fixations on each object to vary according to the type of competitor, the speaker type, and the language environment. As stated above, our first prediction is that in our within-language competitor trials we should obtain a clear within-language cohort competition in all three groups of bilinguals. We hypothesised that the size of this effect would be modulated by both language mode and age of second language acquisition. Our second prediction is that a stronger inter-lingual cohort effect should be obtained in the between-language competitor trials for the two groups that acquired Spanish early in life (early bilinguals and S-E bilinguals). In contrast, the group who acquired Spanish after 6 years of age

(E-S bilinguals) should show a weaker inter-lingual cohort effect. Finally, our third prediction is that the inter-lingual cohort effect should be observed in all three language modes but, according to Grosjean, it should become larger the closer participants are to the bilingual mode.

RESULTS

Post-experimental questionnaires

Results of the stimulus questionnaire were used to exclude, on a participant-by-participant basis, any between-language (Spanish) competitor trials when a given participant failed to generate the expected Spanish name in the questionnaire. We excluded a larger number of trials in the E-S (30%) group compared with the early (10%) and S-E (3%) groups.[6]

Additionally, we asked our participants in this questionnaire to report what, according to them, was the purpose of the study. Twelve participants, mostly from the E-S group, expressed some suspicion upon the true nature of the study. Comparisons between analyses excluding and including these participants revealed similar results, therefore we decided to include all participants in the final analysis to increase statistical power. Discrepancies between the two analyses are noted when relevant.

Eye-tracking analysis

In experimental trials, participants' gaze was hand-coded using a frame-accurate digital VCR (a Sony DSR-30) as they listened to the instructions beginning at the onset of the critical noun target (e.g., at the /b/ of BEANS in 'Click on the b . . .') and continuing until the participant responded with the mouse.

The proportions of fixations on the target, cohort competitor, and unrelated pictures were calculated separately for three time windows (epochs) and for each trial type. In the rest of the paper we may use initials to refer to the three types of objects as follows: T = target, C = cohort, U = unrelated. Stimulus-driven eye fixations were not expected until 150–200 ms after the onset of a critical word due to ocular motor delay (Hallett, 1986), thus epoch 1 began at noun onset and ended 200 ms later, and was used as a baseline.

[6] We thank an anonymous reviewer for suggesting that just because a participant can not explicitly name a picture in L2, does not mean that its name was not co-activated during the task. Therefore, we carried out an extra analysis including all of the data. The results in the mixed and bilingual modes were quite similar to those reported here. In the monolingual mode, and collapsing across the three AoA groups, we just found a slightly smaller inter-lingual activation, suggesting that our participants indeed lacked the Spanish label of some of the objects.

Epoch 2 captured the region between 200–500 ms post-noun onset. It is in this epoch that we first expected to observe cohort effects. Epoch 3 captured a later time window, from 500–800 ms post noun onset, and was used to examine how the competition between target and cohort competitor was resolved.

Preliminary analyses

An initial analysis was done to compare the percentage of fixations on each of the three pictures across epochs in both within-language (English) and between-language (Spanish) trials. There was a significant main effect of Epoch, $F_1(2, 248) = 62.2$, $MSE = 0.29$, $p < .001$, $F_2(2, 18) = 375$, $MSE = 10580$, $p < .001$, and Object, $F_1(2, 248) = 378$, $MSE = 14.4$, $p < .001$, $F_2(2, 18) = 87.5$, $MSE = 126006$, $p < .001$, as well as their interaction, $F_1(4, 496) = 619$, $MSE = 7.4$, $p < .001$, $F_2(4, 36) = 72.8$, $MSE = 63691$, $p < .001$. Additionally, we found a significant Epoch by Object by Language interaction, $F_1(4, 496) = 24.6$, $MSE = 0.31$, $p < .001$, $F_2(4, 36) = 6.64$, $MSE = 2544$, $p < .001$. In consequence, we decided to look separately at within- and between-language trials. In addition to a series of ANOVAs reported below, and following the advice of an anonymous reviewer, we also report complementary binomial analyses.[7]

Within-language competition

The pattern of results for trials containing a cohort competitor from the same (contextual) language replicated previous findings with monolinguals (Allopenna et al., 1998) demonstrating a clear cohort effect (see Figure 5). At the beginning of the trial, fixations on the three object types were equivalent. Approximately 240 ms following word onset, fixations to the target and the cohort increased relative to fixations on the unrelated object. Around 430 ms following word onset, fixations on the cohort started to decrease while fixations on the target continued to increase, due to the disambiguating information at the end of the target word.

Figure 6 shows the proportion of fixations to the target, cohort competitor and unrelated picture for each epoch. An ANOVA with AoA (3) and Mode (3) as between-subjects factors, and Epoch (3) and Object (3) as

[7] In order to address a possible concern regarding violation of independence in the contrast analysis reported below, we also report complementary binomial tests based on the absolute number of fixations in each epoch. That is, whenever we carried out contrast analysis comparing the proportion of fixations on any two objects, we also tested whether the absolute number of fixations on those two objects differed reliably from a uniform 50:50 distribution. In the Results section we point out any differences between the two analyses, and address the implications of any such differences in the discussion section.

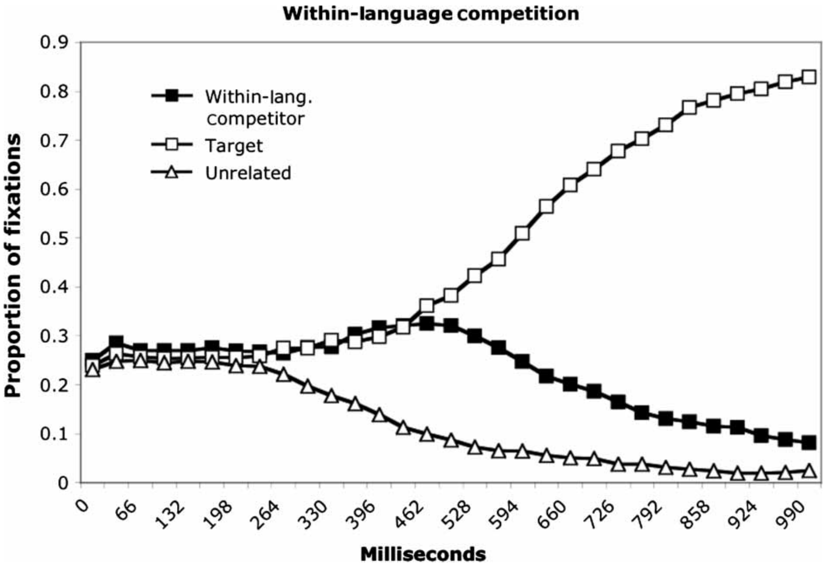

Figure 5. Time course of fixation probabilities for each object in within-language competition trials.

within-subjects factors was calculated on the proportion of fixations on the different objects. In this and the following analyses, the Greenhouse–Geisser correction for non-sphericity of variance was applied as needed. In these cases, we report adjusted *p*-values. For simplicity, we report unadjusted degrees of freedom.

The main effect of Epoch was significant by subjects, $F_1(2, 248) = 33.84$, $MSE = 0.142$, $p < .001$, and by items, $F_2(2, 18) = 245.8$, $MSE = 7740$, $p < .001$. We also observed a main effect of Object, $F_1(2, 248) = 173.9$, $MSE = 5.89$, $p < .001$, $F_2(2, 18) = 21.7$, $MSE = 59184$, $p < .001$, and a significant Epoch by Object interaction, $F_1(4, 496) = 258.6$, $MSE = 3.34$, $p < .001$, $F_2(4, 36) = 28.8$, $MSE = 69109$, $p < .001$. Simple effects tests revealed that while proportions of fixations on the three objects were indistinguishable in epoch 1, starting in epoch 2 there were fewer fixations to the unrelated object than the target, $F_1(1, 132) = 87.0$, $MSE = 0.032$, $p < .001$, $F_2(1, 9) = 23.7$, $MSE = 138$, $p < .001$, or the cohort, $F_1(1, 132) = 84.8$, $MSE = 0.028$, $p < .001$, $F_2(1, 9) = 19.8$, $MSE = 159$, $p < .005$. In epoch 3, there was a significantly higher proportion of fixations on the target than the cohort, $F_1(1, 132) = 371.9$, $MSE = 0.050$, $p < .001$, $F_2(1, 9) = 14.8$, $MSE = 1159$, $p < .005$, or the unrelated picture, $F_1(1, 132) = 1194.7$, $MSE = 0.031$, $p < .001$, $F_2(1, 9) = 110.7$, $MSE = 337$, $p < .001$, but there was still a higher proportion of fixations on the cohort than on the unrelated picture, $F_1(1, 132) = 202.2$, $MSE = 0.016$, $p < .001$, $F_2(1, 9) = 12.4$, $MSE = 313$, $p < .01$. A four-way

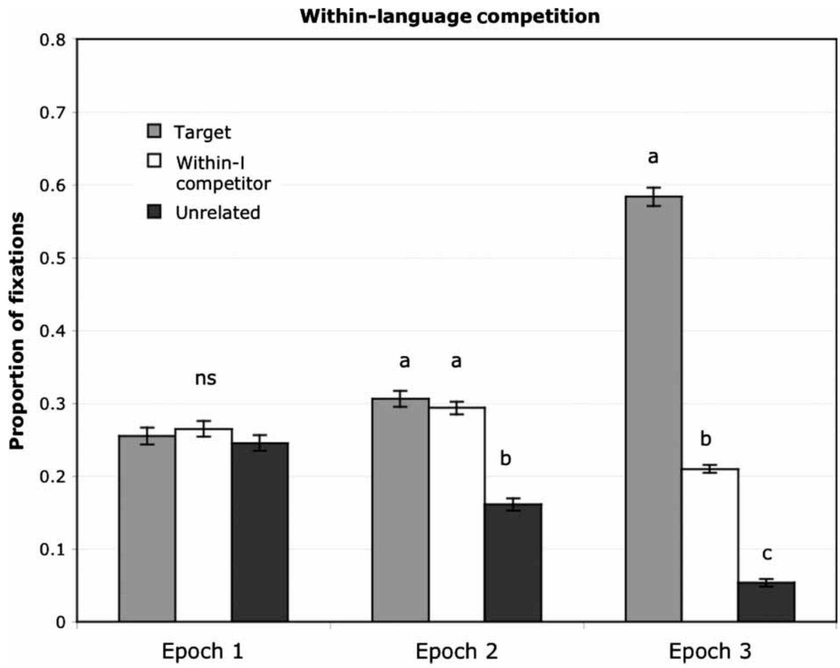

Figure 6. Proportion of fixations on each object for within-language (English) competition trials across groups. In this and similar figures, bars with different indices in a given epoch differ significantly from each other.

interaction was significant by subjects only, $F_1(16, 496) = 2.3$, $MSE = 0.030$, $p < .01$, $F_2(16, 144) = 1.14$, $MSE = 411$, *ns.* Table 2 shows the proportion of fixations on each of the three objects for each epoch, AoA, and mode. Post hoc contrasts (see Table 2) revealed that the E-S group showed a clear within-language cohort effect starting in epoch 2 (number of fixations: target > cohort > unrelated) independently of the particular language mode. Although in epoch 3 the same pattern continued for the E-S groups tested in the mixed and bilingual modes, the group tested in the monolingual mode was already focusing mostly on the target, the advantage of fixations on the cohort over the unrelated object *was not* significant in the binomial analysis. In contrast, in the early bilingual group, those tested under the monolingual and mixed modes, displayed the T > U, and T = C pattern of fixations in epoch 2, but the advantage of the cohort over the unrelated object was borderline in the contrast analysis and failed to reach significance in the binomial analysis. In epoch 3, the pattern T > C > U was significant independently of mode. Finally, in the two S-E groups tested in the mixed and bilingual modes, an apparent numerical advantage of fixations on the target and cohort objects over the unrelated object in epoch 2 failed to reach

TABLE 2
Within-language competition trials. Proportion of fixations on each Object by Epoch, Mode, and AoA, as well as results of the contrast analyses

	Monolingual Mode			*Mixed Mode*			*Bilingual Mode*		
	Epoch 1	*Epoch 2*	*Epoch 3*	*Epoch 1*	*Epoch 2*	*Epoch 3*	*Epoch 1*	*Epoch 2*	*Epoch 3*
English-Spanish									
Proportion of fixations									
Target	30.6	36.8	62.4	30.4	32.0	64.3	26.2	35.0	61.4
Cohort	25.2	29.0	17.4	22.1	30.6	18.5	34.0	31.3	22.3
Unrelated	24.4	13.2	6.7	24.2	13.4	2.5	21.2	11.9	4.2
Contrasts[a]									
TvC[b]	.81/.42	2.2/1.2	15*/21*	1.7/3.5	.06/.38	14*/35*	1.8/1.8	.52/.25	12*/15*
CvU	.02/.00	7.6*/11*	3.8*/5.3*	.11/.09	8.4*/7.4*	9.0*/19*	6.0*/7.1*	12*/40*	12*/40*
TvU	1.4/.46	14*/18*	14*/79*	1.4/78	8.2*/12*	16*/167*	.99/1.0	16*/22*	16*/95*
Early bilingual									
Proportion of fixations									
Target	22.5	26.3	57.1	25.3	28.8	60.2	25.9	29.9	55.4
Cohort	26.0	26.2	24.5	26.6	28.4	21.6	23.5	29.7	24.5
Unrelated	28.8	19.7	2.3	20.8	18.0	5.8	29.2	18.0	7.2
Contrasts									
TvC	.38/.34	.73/.31	8.0*/11*	.84/1.1	.66/1.1	13*/19*	2.4/2.0	3.4*/2.3*	16*/11*
CvU	1.0/1.1	5.0*/12*	6.7*/6.4*	.00/.00	3.8*/9.0*	7.4*/5.9*	.32/1.3	13/12	9.6*/9.1*
TvU	3.3†/4.2†	7.9*/10*	10*/51*	1.1/1.2	6.2*/12*	15*/158*	1.4/.24	2.9†/5.2*	18*/70*

TABLE 2 (*Continued*)

	Monolingual Mode			*Mixed Mode*			*Bilingual Mode*		
	Epoch 1	*Epoch 2*	*Epoch 3*	*Epoch 1*	*Epoch 2*	*Epoch 3*	*Epoch 1*	*Epoch 2*	*Epoch 3*
Spanish-English									
Proportion of fixations									
Target	25.7	29.7	47.9	22.0	31.9	58.7	22.8	27.3	61.7
Cohort	22.6	25.8	19.6	27.1	27.9	19.5	31.2	36.0	20.4
Unrelated	17.7	14.8	7.6	27.3	17.4	5.7	28.4	17.6	5.3
Contrasts									
TvC	.40/.39	.00/.03	8.9*/4.2†	.05/.07	.00/.03	13*/5.8*	.18/.02	.00/.03	7.9*/4.6†
CvU	.28/.05	1.4/1.5	21*/7.7*	1.3/.88	3.7†/3.8†	9.9*/12*	1.3/.94	4.6*/3.1	12*/7.3*
TvU	1.7/1.0	1.2/1.1	16*/35*	.88/.76	3.3†/5.9*	16*/43*	.47/.63	4.1*/2.6	12*/38*

[a]Contrasts are displayed as F1/F2 for the analyses by subjects (*df* = 1, 132) and by items (*df* = 1, 9) respectively. An asterisk indicates a corresponding *p*-value ≤.05 and a cross indicates a corresponding *p*-value. >.05 but. ≤09.

[b]T = Target, C = Cohort, U = Unrelated.

significance, and it was not until epoch 3 that finally all three S-E groups tested in the three possible modes show the T > C > U pattern.

Between-language competition

Although of a smaller magnitude, we also found evidence of between-language cohort competition. Figure 7 shows the proportion of fixations over time to each type of object for between-language competition trials. Initial fixations on the three objects are comparable until about 250 ms following word onset when fixations on the unrelated object start to decrease. In contrast with the within-language competition trials, fixations to the cohort and the target diverge much earlier, around 320 ms following word onset. However, the cohort object still attracted more fixations than the unrelated object until about 660 ms.

Figure 8 shows the proportion of fixations on each object and for each epoch when participants were subjected to phonological competition emerging from their non-contextual language. We again found a main effect of Epoch, $F_1(2, 248) = 57.9$, $MSE = 0.195$, $p < .001$, $F_2(2, 18) = 191.1$, $MSE = 6504$, $p < .001$, and a main effect of Object, $F_1(2, 248) = 309.7$, $MSE = 11.7$, $p < .001$, $F_2(2, 18) = 61.4$, $MSE = 91092$, $p < .001$, as well as a significant Epoch by Object interaction, $F_1(4, 496) = 358.9$, $MSE = 359$, $p < .001$, $F_2(4, 36) = 102.5$, $MSE = 91847$, $p < .001$. Simple effects tests revealed that while in epoch 1 proportions of fixations on each object were equivalent, in epoch 2,

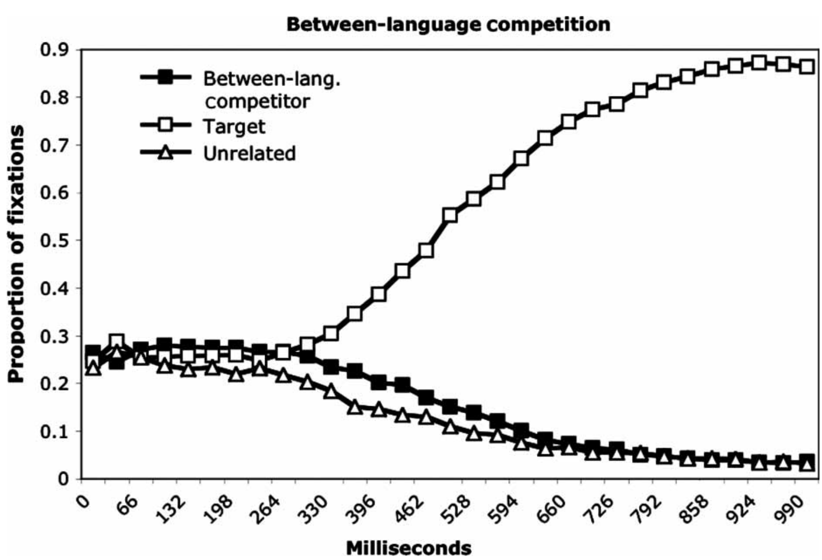

Figure 7. Time course of fixation probabilities for each object in between-language competition trials.

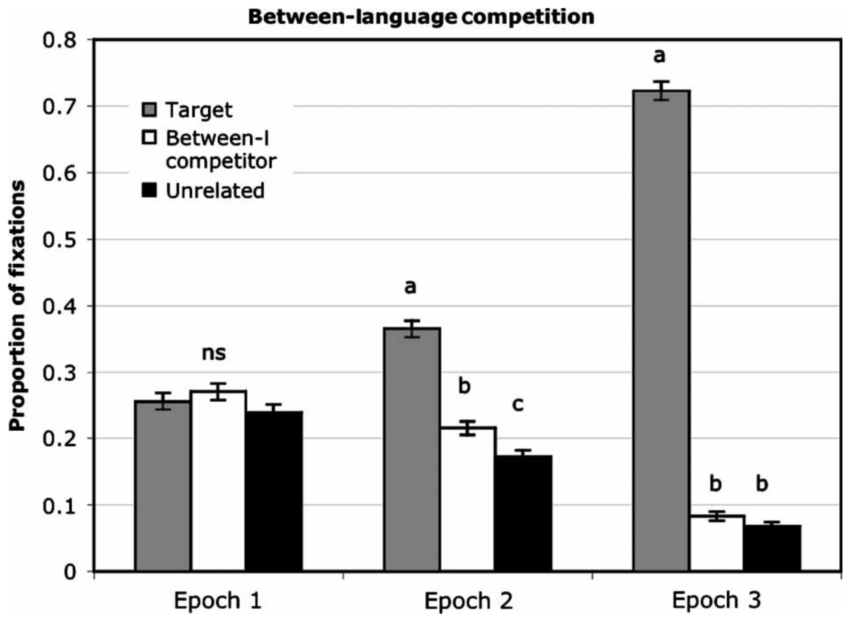

Figure 8. Proportion of fixations on each object for between-language (Spanish) competition trials across groups.

participants fixated significantly more on the target than on the Spanish cohort, $F_1(1, 130) = 63.9$, $MSE = 0.047$, $p < .001$, $F_2(1, 9) = 11.47$, $MSE = 0.018$, $p < .001$, or the unrelated object, $F_1(1, 130) = 108.9$, $MSE = 0.045$, $p < .001$, $F_2(1, 9) = 35.1$, $MSE = 0.010$, $p < .001$. More importantly, participants also looked significantly more at the Spanish cohort than at the unrelated object, indicating a between-language cohort effect, although this was significant only in the analysis by subjects, $F_1(1, 130) = 9.5$, $MSE = 0.026$, $p < .005$, $F_2(1, 9) = 2.0$, $MSE = 0.010$, *ns*. In contrast with the within-language competition, which was still evident in epoch 3, the between-language competition was short-lived and had already disappeared by then, $F_1(1, 130) = 2.9$, $MSE = 0.010$, *ns*, $F_2(1, 9) = 2.0$, $MSE = 0.002$, *ns*.

Nevertheless, a significant Object by AoA interaction (see Figure 9), $F_1(4, 248) = 3.4$, $MSE = 0.129$, $p \leq .05$, $F_2(4, 36) = 3.6$, $MSE = 1290$, $p \leq .05$, revealed that the S-E and the early bilingual groups looked significantly more frequently at the target than the Spanish cohort, S-E, $F_1(1, 130) = 70.5$, $MSE = 0.027$, $p < .001$, $F_2(1, 9) = 55.5$, $MSE = 127$, $p < .001$, early bilingual, $F_1(1, 130) = 115.3$, $MSE = 0.027$, $p < .001$, $F_2(1, 9) = 47.7$, $MSE = 221$, $p < .001$, and significantly more at the cohort than the unrelated object (but again only by subjects, S-E, $F_1(1, 130) = 8.7$, $MSE = 0.013$, $p < .005$, $F_2(1, 9) = 3.4$, $MSE = 102$, *ns*, early bilingual, $F_1(1, 130) = 5.9$, $MSE = 0.013$,

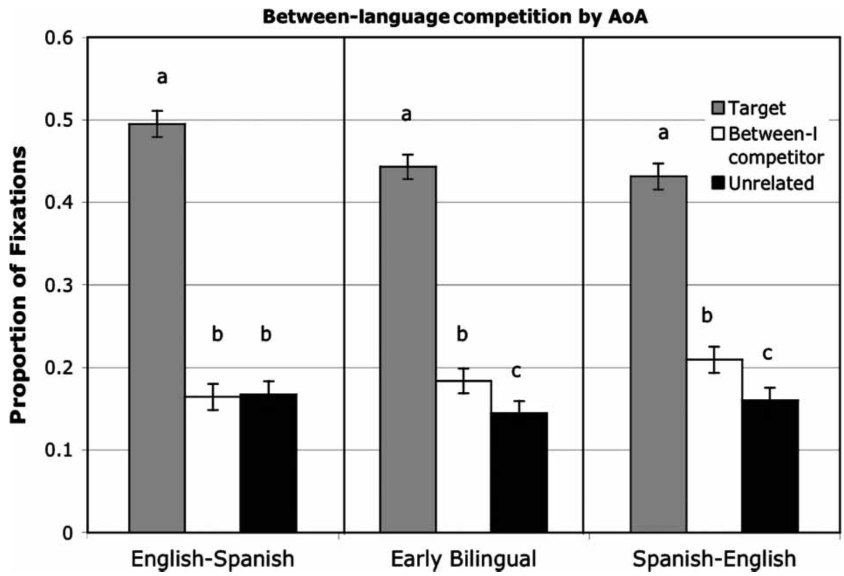

Figure 9. Proportion of fixations on each object for each age of acquisition (AoA) group in between-language competition trials (across epochs).

$p < .05$, $F_2(1, 9) = 1.6$, $MSE = 149$, *ns*. Additionally, both groups looked significantly more at the target than the unrelated object, S-E, $F_1(1, 13) = 124.6$, $MSE = 125$, $p < .001$, $F_2(1, 9) = 60.3$, $MSE = 102$, $p < .001$, early bilingual, $F_1(1, 130) = 176.5$, $MSE = 0.024$, $p < .001$, $F_2(1, 9) = 92.3$, $MSE = 149$, $p < .001$. In sum, the pattern of fixations for these two groups was T > C > U. In contrast, the E-S group looked significantly more at the target compared to the cohort, $F_1(1, 130) = 151.1$, $MSE = 0.027$, $p < .001$, $F_2(1, 9) = 64.3$, $MSE = 133$, $p < .001$, and the unrelated object, $F_1(1, 130) = 165.5$, $MSE = 0.024$, $p < .001$, $F_2(1, 9) = 74.4$, $MSE = 45.2$, $p < .001$, but the fixations to cohort and unrelated object were equivalent, $F_1(1, 130) = .07$, $MSE = 0.013$, *ns*, $F_2(1, 9) = .52$, $MSE = 45.2$, *ns*. In sum, T > C = U.

There were no significant higher-order interactions involving Mode or AoA in between-language competition trials. However, although the three-way interaction of Epoch, Object, and AoA failed to reach significance, a visual analysis of the data suggested that AoA played an important role (see Figure 10). In order to parallel the analysis of the within-language effects, we conducted planned contrasts to evaluate specifically the role of AoA on inter-lingual activation. This analysis revealed, for S-E bilinguals, a higher proportion of fixations on the cohort than the unrelated object in epoch 2, $F_1(1, 132) = 8.9$, $MSE = 0.026$, $p < .005$, $F_2(1, 9) = 4.9$, $MSE = 197$, $p = .053$; but this effect became marginal in epoch 3, $F_1(1, 132) = 3.8$, $MSE = 0.010$,

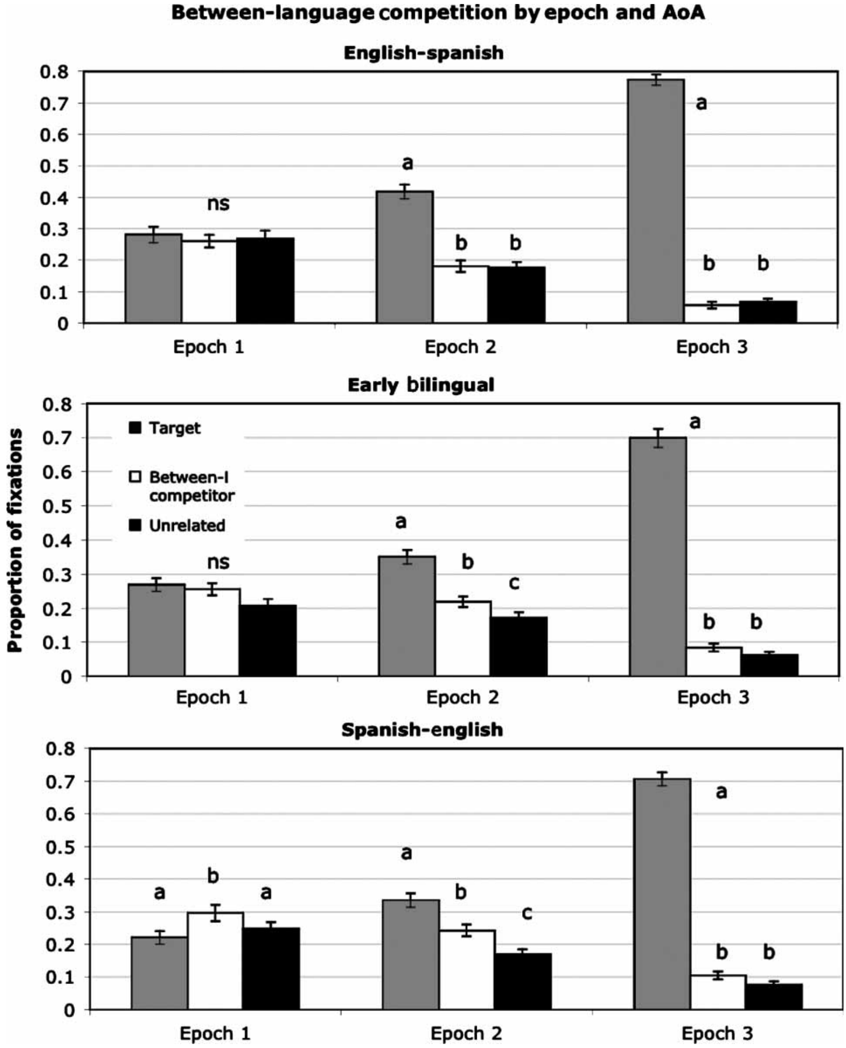

Figure 10. Proportion of fixations on each object for each epoch and age of acquisition (AoA) group in between-language competition trials.

$p = .053$, $F_2(1, 9) = 4.7$, $MSE = 28.0$, $p = .056$, and non-significant in the binomial analysis. The advantage of the target over the cohort was significant only in the contrast analysis, but not in the binomial analysis. In our early bilingual group this effect reached significance only in the contrast analysis, in epoch 2, $F_1(1, 132) = 4$, $MSE = 0.027$, $p < .05$, and only in our analysis by subjects (not significant in the binomial analysis). In both epochs, both groups had a larger proportion of fixations on the target than the cohort, epoch 2: S-E, $F_1(1, 132) = 5.8$, $MSE = 0.067$, $p < .05$, $F_2(1, 9) = 7.6$, $MSE = 238$, $p < .05$, early bilingual, $F_1(1, 132) = 9.9$, $MSE = 0.317$, $p < .05$, $F_2(1, 9) = 22.2$, $MSE = 351$, $p < .001$; epoch 3: S-E, $F_1(1, 132) = 361.7$, $MSE = 0.33$, $p < .001$, $F_2(1, 9) = 48.8$, $MSE = 617$, $p < .001$, early bilingual, $F_1(1, 132) = 85.5$, $MSE = 0.317$, $p < .05$, $F_2(1, 9) = 58.8$, $MSE = 168$, $p < .001$, and on the target than the unrelated object, epoch 2: S-E, $F_1(1, 132) = 5.8$, $MSE = 16.7$, $p < .05$, $F_2(1, 9) = 7.6$, $MSE = 182$, $p < .05$, early bilingual, $F_1(1, 132) = 9.9$, $MSE = 0.070$, $p < .05$, $F_2(1, 9) = 22.2$, $MSE = 195$, $p < .001$; epoch 3: S-E, $F_1(1, 132) = 112.0$, $MSE = 0.337$, $p < .001$, $F_2(1, 9) = 53.1$, $MSE = 520$, $p < .001$, early bilingual, $F_1(1, 132) = 404.2$, $MSE = 0.322$, $p < .05$, $F_2(1, 9) = 61.5$, $MSE = 159$, $p < .001$. Finally, our E-S group showed no evidence of inter-lingual activation in any of the two analyses.

In sum, our contrast analysis revealed a significant but short-lived between-language cohort effect restricted to those participants who acquired the non-contextual or irrelevant language (Spanish) before 6 years of age. However, the binomial analysis also revealed that this effect is less robust in the early bilingual group than in the S-E group. Participants who acquired Spanish after 6 years of age failed to show any evidence of competition from L2 (Spanish).

DISCUSSION

The objective of our study was to investigate whether, during on-line word recognition, bilingual speakers activate a cohort of words restricted to the active (contextual) language or alternatively, this activation extends to include candidates from an irrelevant (non-contextual) language. We also investigated the effects that age of second language acquisition and language mode have on the degree of within- and cross-linguistic activation.

Summary of results

We observed a within-language cohort effect in all bilingual groups that was somewhat affected by age of acquisition and language mode. We also observed a small between-language cohort effect in those participants who acquired the non-contextual language earlier in life. In what follows we discuss these findings in more detail.

Within-language competition

Based on previous research examining within-language lexical competition, our first prediction was that we would observe clear within-language cohort competition in all three groups of bilinguals. Consistent with this prediction and in line with multiple studies in monolinguals (Allopenna et al., 1998;

Marslen-Wilson, 1987; Marslen-Wilson & Warren, 1994; Marslen-Wilson & Welsh, 1978), and bilinguals (Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey & Marian, 1999), our three bilingual groups showed activation of onset-initial compatible English candidates as evidenced by a strong within-language cohort effect even in those participants who acquired the contextual language (English in this case) later in life. Mode seems to have played a minor role in our E-S group by either speeding up the selection of the target (and discarding of the cohort as a potential candidate) when they are tested in a monolingual mode or, by briefly slowing down the selection of the target, due to an interference from the irrelevant language, when tested in a mixed or bilingual mode.

Interestingly, both our early and S-E bilinguals demonstrated a slow activation of within-language candidates, failing to demonstrate the expected $T > C > U$ pattern of fixations until epoch 3. Considering the lack of early within-language competition effects in our S-E group, this suggests that the delayed activation of appropriate language (English) candidates may be due to low English proficiency. However, a similar delay found in the early bilingual group, which was very proficient in English (in addition to Spanish), suggests an alternative explanation. Perhaps both groups are subjected to some activation from their (other) native language that may interfere with normal activation of within-language candidates.

Similar within-language cohort effects were obtained by Marian and Spivey with Russian–English bilinguals (Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey & Marian, 1999), although our effect was slightly stronger (ours: 13.6% fixation difference between cohort and unrelated, theirs: 10.5%), possibly due to a difference in materials.[8] To be sure, a pilot study using the same stimuli with a group of 12 monolingual English speakers found a similar within-language cohort effect (12.6%). Together, the results for within-language competition trials provide further support to the cohort model of lexical access demonstrated in monolingual speakers (Marslen-Wilson, 1987; Marslen-Wilson & Warren, 1994; Marslen-Wilson & Welsh, 1978; Marslen-Wilson & Zwitserlood, 1989) suggesting that as long as fluent bilinguals are immersed in one of their languages, be it the first or the second, they will activate all possible word candidates compatible with the initial phonological information in that language. Furthermore, this is true even if during the study the bilingual speakers are intermittently exposed to another language. Finally, slight delays in the activation of relevant candidates may reflect lower proficiency or some interference from the irrelevant language.

[8] We restricted this comparison to those groups of participants and testing conditions that are similar between the two studies.

Between-language competition

Our second prediction was that the inter-lingual cohort effect should be stronger for the two groups that acquired Spanish early in life (early bilinguals and S-E bilinguals). In line with previous findings (Blumenfeld & Marian, 2007; Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey & Marian, 1999) and consistent with this prediction, we found evidence of activation of lexical candidates whose names in the irrelevant language (in this case Spanish) were compatible with the onset of the target presented in the contextual language (in this case English). That is, Spanish–English bilinguals activated lexical candidates in Spanish, even when they were totally immersed in an English-speaking environment (monolingual mode).[9] However, the degree of cross-linguistic activation was considerably smaller and shorter-lived than the within-language activation. Furthermore, in the early bilingual group the advantage of the Spanish cohort over the unrelated object was significant only in the contrast analysis. This smaller cross-linguistic activation indicates that the contextual language plays a major role in determining which language should be active at a given time and suggests that the degree of activation may be influenced by differential levels of fluency in each of the two languages. This is indirectly supported by the fact that our early bilingual group displayed a weaker inter-lingual activation than the S-E group. Presumably, the activation of the relevant language may be more successful if you are a proficient early bilingual accustomed to move back and forth between the two languages. This cross-linguistic activation has been reported before (Blumenfeld & Marian, 2007; Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey & Marian, 1999) but our results indicate that this effect is restricted to participants who acquired the irrelevant language before 6 years of age.

In order to investigate whether a different AoA breakdown could capture our findings more accurately, we carried out an extra analysis dividing our sample into three groups based on their age of first exposure to their second language: < 6, 6–14, and > 14 years of age. This analysis made evident that this new breakdown had no effect at all on the within-language competition. That is, the results look indistinguishable from those discussed above. However, the between-language competition trials indicate that the sensitive period for showing interference from one's native language could extend up to 14 years of age. That is, E-S speakers acquiring Spanish between 7 and 14 years of age ($N = 14$) displayed a similar percentage of fixations on the Spanish cohort object as that observed in early bilinguals. However, this

[9] The monolingual group tested with these materials lacked any evidence of inter-lingual activation, ruling out the possibility of our inter-lingual cohorts being associated with more salient pictures.

effect failed to reach significance probably due to the smaller number of participants per group. Importantly, we failed to observe any evidence of cross-linguistic activation in those acquiring Spanish after 14 years of age ($N = 31$). Furthermore, for our S-E speakers, the later in life they were exposed to English, the stronger the competition from their native language. That is, the > 14 S-E group ($N = 19$) showed a stronger and significant inter-lingual competition, $F(1, 78) = 5.49$, $p < .05$, than the one observed in the 7–14 S-E group ($N = 20$), $p = 30$, *ns*. This is again compatible with a decreased ability to inhibit the irrelevant language in this group as compared with the early bilingual group.

Finally, our third prediction was that the inter-lingual cohort effect should be observed in all three language modes, but it should become larger the closer participants are to the bilingual mode. Although we failed to find a significant interaction involving mode and AoA, numerically we observed that both the S-E and early bilingual groups displayed an inter-lingual competition that was twice as big when they were tested in a bilingual mode (9.5% more fixations on the cohort than on the unrelated object) than when tested in a monolingual mode (5%). However, being in a bilingual mode was not enough to elicit a significant competition from the irrelevant second language in our E-S speakers. In other words, the role of mode was limited to enhancing (although not significantly) inter-lingual activation in those participants who were exposed to the irrelevant language early in life.

The lack of cross-linguistic activation in our E-S group seems to be at odds with prior findings by Marian and Spivey (Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey and Marian, 1999). In particular, these authors found that their Russian–English bilinguals (late learners of English) showed activation of compatible English candidates (their L2) when performing the study in Russian (their L1). This group could be comparable to our E-S group, who nevertheless failed to show clear cross-linguistic activation. However, there are at least two critical differences between studies that could account for this apparent discrepancy.

First, in their study, the language of the test (Russian) was different from the broader language context. That is, the bilingual speakers were living in an English-speaking environment. It could be that for late learners of the irrelevant language, immersion in that language in a general context is enough to keep it active even if the study is carried out in their native language. In contrast, our E-S speakers (late learners of Spanish) were living in a broader English-speaking context, with no apparent pressure to keep their irrelevant language (Spanish) active. Additional support for this possibility is that, at least in one of their studies, Marian and Spivey found a smaller cross-linguistic activation of compatible Russian candidates (L1) when their Russian–English bilinguals performed the study in English (L2). This could be due to the fact that the environmental language was English and their participants were not as pressured to keep the 'irrelevant' (Russian) language active, even if it is their native language. This group is comparable to our S-E and early bilinguals who also showed a small cross-linguistic activation effect.

A second possible explanation for the discrepancy is that the Russian–English bilinguals may have been more proficient in English than our E-S group was in Spanish. After all, the Russian–English bilinguals were active students enrolled in an elite American university, while our sample was more varied. It could be that our E-S speakers were not as fluent in Spanish, allowing them to 'ignore' or inhibit the Spanish labels more readily. Important in this regard is the fact that not all prior studies have found parallel activation of a bilingual's two languages, and that fluency in the second language is an important factor to consider. For example, in a more recent study, Blumenfeld and Marian (2007) found activation of unrelated German words (e.g., *GUITER*, or 'bars' in English) while German–English bilinguals processed English target words (e.g., GUITAR). However, in the group with low German proficiency levels, this parallel activation was restricted to the condition where the English words had a German cognate pair (GUITAR-*gitarre*), and absent when using English-specific targets (SHARK-*hai*). In contrast, the bilingual group with high levels of German proficiency showed the effect with both types of words. Importantly, Blumenfeld and Marian's low-proficiency group is comparable to our E-S group, who also failed to show parallel activation under similar conditions. Similarly, their highly proficient group is comparable to our S-E group, with both groups (theirs and ours) showing evidence of parallel activation when tested with non-cognate targets. One possible confound in our study, as well as theirs, is between age of acquisition and proficiency. Both studies tested participants entirely in English, being the first language of their low-proficiency group and of our late Spanish learners (E-S group). In both studies, the non-contextual (irrelevant) language was the second language of the bilingual speakers (their high-proficiency group or German native, and our native Spanish speakers or S-E group). The difference between studies is simply the variable of focus, age of acquisition in our case, and proficiency in theirs, but we are in fact talking about similar populations. Therefore, similar to studies mentioned above (Perani et al., 1998; Silverberg and Samuel, 2004), future studies should investigate the independent contribution of these two variables to the type and degree of parallel activation of a bilingual's two languages.

However, beyond differences in the interplay between the environmental and test language, and the differences in proficiency and age of acquisition, the inter-lingual activation we observed was smaller than the one obtained by Marian and Spivey, even for our fluent and native Spanish speakers. Some of these differences can be better explained by the fact that in their early studies, Marian and Spivey may have failed to create a pure monolingual environment, increasing the chances for an inter-lingual activation. However, even if we restrict our comparison to their later studies (including Blumenfeld & Marian, 2007), where they intended to create a pure monolingual environment, they report an inter-lingual cohort effect size varying from 7% to 11% (depending on the particular study), while ours varied from 3% to 5% (depending on the particular bilingual group). One possible explanation is that we may have been more successful in creating a monolingual environment, reducing the amount of inter-lingual activation in our participants, especially those for whom the irrelevant language is their second and less proficient language. In addition, while Spanish words may share a phoneme onset with the English target, Spanish words may have been rejected as 'non-English' based on subphonemic differences between the languages, reducing activation of Spanish words in the cohort. For example, the /b/ of 'beaker' (as spoken by the native English speaker who recorded our stimuli) differs subphonemically from the Spanish /b/ (of 'bigote'). Similar subphonemic effects have been demonstrated in studies with monolinguals (Dahan, Magnuson, Tanenhaus, & Hogan, 2001; Dahan & Tanenhaus, 2004) and bilinguals (Blumenfeld & Marian, 2007; Ju & Luce, 2004). Blumenfeld and Marian (2007) found that the degree of co-activation of cross-language competitors was influenced by the degree of phonological overlap between the English target and its German competitor. Finally, given our design, we presented each picture several times playing a different role (target = 5, cohort or unrelated = 10). This may have reduced the degree of activation of lexical competitors, with a larger impact on an already smaller inter-lingual cohort effect.

In conclusion, our results indicate that when bilinguals are performing a task entirely in one of their two languages, they access all possible candidate words based only on initial phonological information compatible with any entry and independent of the particular language, as long as the irrelevant language is acquired at an early age (before 6 and possibly before 14). Furthermore, AoA seems to play a more important role than language mode. The role of language mode was restricted to enhancing an inter-lingual activation elicited in those bilinguals who acquired Spanish before 6 years of age (or 14 if we consider the more detailed breakdown of our sample).

Theoretical implications

Our results are in line with models of bilingual word recognition proposing non-selective access, such as Dijkstra and van Heuven's BIA+, an improved and extended version of a prior model termed 'Bilingual interactive activation' (or BIA; Dijkstra, 1998; Dijkstra, van Heuven & Grainger, 1998; Grainger & Dijkstra, 1992). Although this model was designed for visual word recognition, Dijkstra and van Heuven (2002) propose that it is also valid for auditory word recognition. However, it is clear that future models of bilingual auditory word recognition need to include phonological representations as one of the main factors determining the extent of non-selective bilingual activation. In the case of our materials, disambiguating information could potentially be available as early as any sub-phonemic differences between languages are detected and at the latest, as soon as enough disambiguating phonological information is received (see Ju & Luce, 2004; Blumenfeld & Marian, 2007).

In addition to AoA, we also manipulated language mode as one important factor that could influence a bilingual's relative activation of his/her two languages (Grosjean, 2001). Based on our findings, it is clear that at least in our early bilinguals, being immersed in an English environment and interacting with a monolingual English speaker without any knowledge of the relevance of their second language was insufficient to completely inhibit activation of the irrelevant (Spanish) language. Based on their own findings, van Hell and Dijkstra (2002) suggest that this may indicate that the activation of words in the weaker language occurs automatically and in a bottom-up fashion, overriding a control mechanism serving to inhibit non-target language words. Furthermore, being exposed to a bilingual environment, interacting with a bilingual speaker and using code switching in the conversation was insufficient to elicit any significant degree of activation of the irrelevant language in our late learners of Spanish. Therefore, at least under these conditions and in line with prior studies (Blumenfeld & Marian, 2007; Marian & Spivey, 2003a, 2003b; Marian et al., 2003; Spivey & Marian, 1999; van Hell & Dijkstra, 2002), mode seems to be playing a minor role in the degree of activation of an irrelevant language. This seems to be in contrast with a more influential role of AoA and/or proficiency.

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REFERENCES

Alameda, J. R., & Cuetos, F. (1995). *Diccionario de frecuencias de las unidades lingüísticas del castellano* (Vols 1–2). Oviedo, Spain: Servicio de Publicaciones de la Universidad de Oviedo.

Allopenna, P. D., Magnuson, J. S., & Tanenhaus, M. K. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. *Journal of Memory and Language*, *38*(4), 419–439.

Blumenfeld, H. K., & Marian, V. (2007). Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking. *Language and Cognitive Processes*, *22*, 633–660.

Dahan, D., Magnuson, J. S., Tanenhaus, M. K., & Hogan, E. M. (2001). Subcategorical mismatches and the time course of lexical access: Evidence for lexical competition. *Language and Cognitive Processes*, *16*, 507–534.

Dahan, D., & Tanenhaus, M. K. (2004). Continuous mapping from sound to meaning in spoken-language comprehension: Immediate effects of verb-based thematic constraints. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*(2), 498–513.

Dijkstra, T. (1998). From tag to task: Coming to grips with bilingual control issues. *Bilingualism*, *1*(2), 88–89.

Dijkstra, T., & van Heuven, W. J. B. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism*, *5*(3), 175–197.

Dijkstra, T., van Heuven, W. J. B., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language*, *39*(3), 458–483.

Eberhard, K. M., Spivey-Knowlton, M. J., Sedivy, J. C., & Tanenhaus, M. K. (1995). Eye movements as a window into real-time spoken language comprehension in natural contexts. *Journal of Psycholinguistic Research*, *24*(6), 409–437.

Elston-Güttler, K. E., Paulmann, S., & Kotz, S. A. (2005). Who is in control? Proficiency and L1 influence on L2 processing. *Journal of Cognitive Neuroscience*, *17*(10), 1593–1610.

Grainger, J., & Dijkstra, T. (1992). On the representation and use of language information in bilinguals. In R. J. Harris (Ed.), *Cognitive processing in bilinguals* (pp. 207–220). Amsterdam: Elsevier Science Publications.

Griffin, Z. M., & Huitema, J. S. (1999). Beckman spoken picture naming norms. Retrieved January 1st, 2004, from the University of Illinois, Beckman Institute, http://langprod.cogsci.uiuc.edu/~norms/.

Grosjean, F. (1998). Studying bilinguals: Methodological and conceptual issues. *Bilingualism: Language and Cognition*, *1*, 131–149.

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

Hallett, P. E. (1986). Eye movements. In K. R. Boff, L. Kaufman, & J. P. Thomas (Eds.), *Handbook of perception and human performance* (pp. 10.1–10.112). New York: Wiley.

van Hell, J. G., & Dijkstra, T. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin and Review*, *9*, 780–789.

Jared, D., & Kroll, J. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, *44*, 2–31.

Ju, M., & Luce, P. A. (2004). Falling on sensitive ears: Constraints on bilingual lexical activation. *Psychological Science*, *15*(5), 314–318.

Johnson, J. S., & Newport, E. L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology*, *21*, 60–99.

Klein, D., Zatorre, R. J., Milner, B., Meyer, E., & Evans, A. C. (1994). Left putaminal activation when speaking a second language: evidence from PET. *Neuroreport*, *5*(7), 2295–2297.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*(2), 149–174.

Lenneberg, E. (1967). *Biological foundations of language*. New York: Wiley.

Marian, V., & Spivey, M. (2003). Bilingual and monolingual processing of competing lexical items. *Applied Psycholinguistics*, *24*, 173–193.

Marian, V., & Spivey, M. (2003). Competing activation in bilingual language processing: within- and between-language competition. *Bilingualism: Language and Cognition*, *6*(2), 97–115.

Marian, V., Spivey, M., & Hirsch, J. (2003). Shared and separate systems in bilingual language processing: Converging evidence from eye-tracking and brain imaging. *Brain and Language*, *86*, 70–82.

Marslen-Wilson, W. D. (1987). Functional parallelism in spoken word-recognition. *Cognition*, *25*(1–2), 71–102.

Marslen-Wilson, W. D., & Warren, P. (1994). Levels of perceptual representation and process in lexical access: Words, phonemes, and features. *Psychological Review*, *101*(4), 653–675.

Marslen-Wilson, W. D., & Welsh, A. (1978). Processing interactions and lexical access during word recognition in continuous speech. *Cognitive Psychology*, *10*(1), 29–63.

Marslen-Wilson, W. D., & Zwitserlood, P. (1989). Accessing spoken words: The importance of word onsets. *Journal of Experimental Psychology: Human Perception and Performance*, *15*(3), 576–585.

McClelland, J. L., & Elman, J. L. (1986). The TRACE model of speech perception. *Cognitive Psychology*, *18*(1), 1–86.

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science*, *14*, 11–28.

Perani, D., Paulesu, E., Sebastian-Galles, N., Dupoux, E., Dehane, S., Bettinardi, V., Cappa, S. F., Fazio, F., & Mehler, J. (1998). The bilingual brian: Proficiency and age of acquisition of the second language. *Brain*, *121*, 1841–1852.

Pinker, S. (1994). *The language instinct: How the mind creates language*. New York: Morrow.

Silverberg, S., & Samuel, A. G. (2004). The effect of age of second language acquisition on the representation and processing of second language words. *Journal of Memory and Language*, *51*, 381–398.

Spivey, M. J., & Marian, V. (1999). Cross talk between native and second languages: Partial activation of an irrelevant lexicon. *Psychological Science*, *10*(3), 281–284.

Wartenburger, I., Heekeren, H., Abutalebi, J., Cappa, S., Villringer, A., & Perani, D. (2003). Early setting of grammatical processing in the bilingual brain. *Neuron*, *37*(1), 159–170.

Zeno, S. M., Ivens, S. H., Millard, R. T., & Duvvuri, R. (1995). *The educator's word frequency guide*. Brewster, NY: Touchstone Applied Science Associates.

APPENDIX A

Language preference by age of acquisition

	Age of acquisition			
	Early bilingual	*E-S*	*S-E*	*Total*
Preference				
English	24	22	4	50
No preference	18	13	16	47
Spanish	7	4	25	36
Total	49	39	45	133

APPENDIX B

Stimuli used in the experiment

	Target	Cohort	Unrelated
English	beans [bins]	beetle [bitl]	cone [kon]
	carton [kArtn]	carpet [kArpIt]	pope [pop]
	coal [kol]	coat [kot]	east [ist]
	comb [kom]	cone [kon]	butterfly [b√t′rflai]
	eagle [ig′l]	east [ist]	coal [kol]
	female [fimeIl]	feet [fit]	coal [kol]
	marker [mArk′r]	marbles [mArb′lz]	bull [bUl]
	pony [poni]	pope [pop]	carpet [kArpIt]
	seeds [sidz]	seal [sil]	coat [kot]
	toad [tod]	toes [tos]	beans [bins]
Spanish	beans [bins]	*bigote* [biƒote]	jail [dZel]
	carton [kArtn]	*cárcel* [kArsel]	beetle [bitl]
	coal [kol]	*collar* [ko¥ar]	eagle [ig′l]
	comb [kom]	*conejo* [konexo]	mustache [m√stQS]
	eagle [ig′l]	*iglesia* [iƒlesja]	coat [kot]
	female [fimeIl]	*fiesta* [fjesta]	coat [kot]
	marker [mArk′r]	*mariposa* [mAriposa]	toes [tos]
	pony [poni]	*pollitos* [po¥itos]	carton [kArtn]
	seeds [sidz]	*silla* [si¥a]	coal [kol]
	toad [tod]	*toro* [toro]	marbles [mArb′lz]