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

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Ca e Ca cel: The effec f age f ac i i i n and lang age m de n biling al le ical acce

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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 Englishclick on one ofthe objects presented on a computer (e.g., 'Click onthe beans'). Within-language lexical competitors had a phoneme onset in English that was shared withthe target (e.g.,' beetle'). Between-language lexical competitors had a phoneme onset in Spanish that was shared with the target (' ', '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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Ke, ord : Age of 2nd language acquisition; Bilingual lexical access; Bilingual word recognition; Interlingual competition; Language mode.

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

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 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., _ . . 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

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 similam16.9(32)ixedlanguge)dgetio
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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 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

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.

. 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

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.

[illegible]. 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.

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.

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,

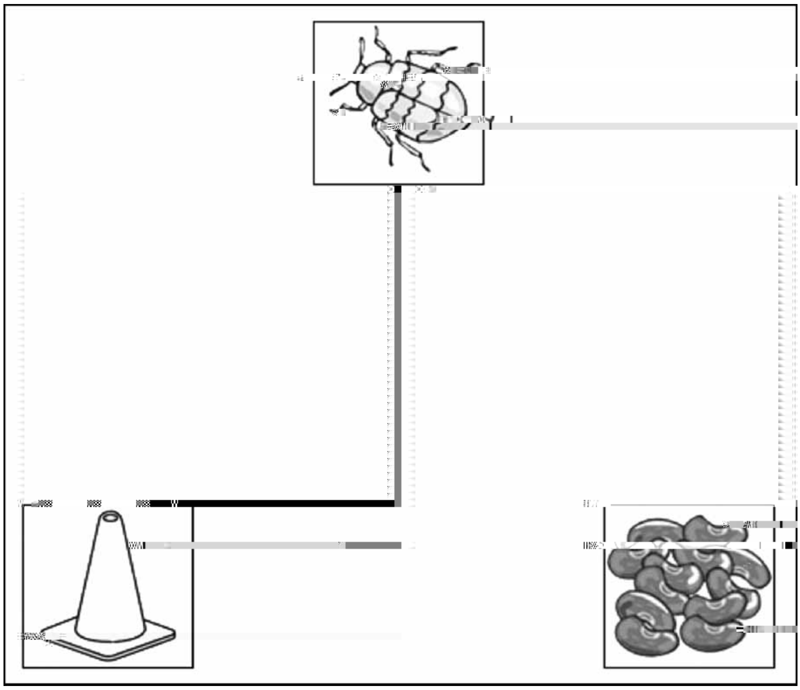

Figure 2. English-cohort trial – BEANS is the target, BEETLE is the cohort, and CONE the unrelated object.

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.

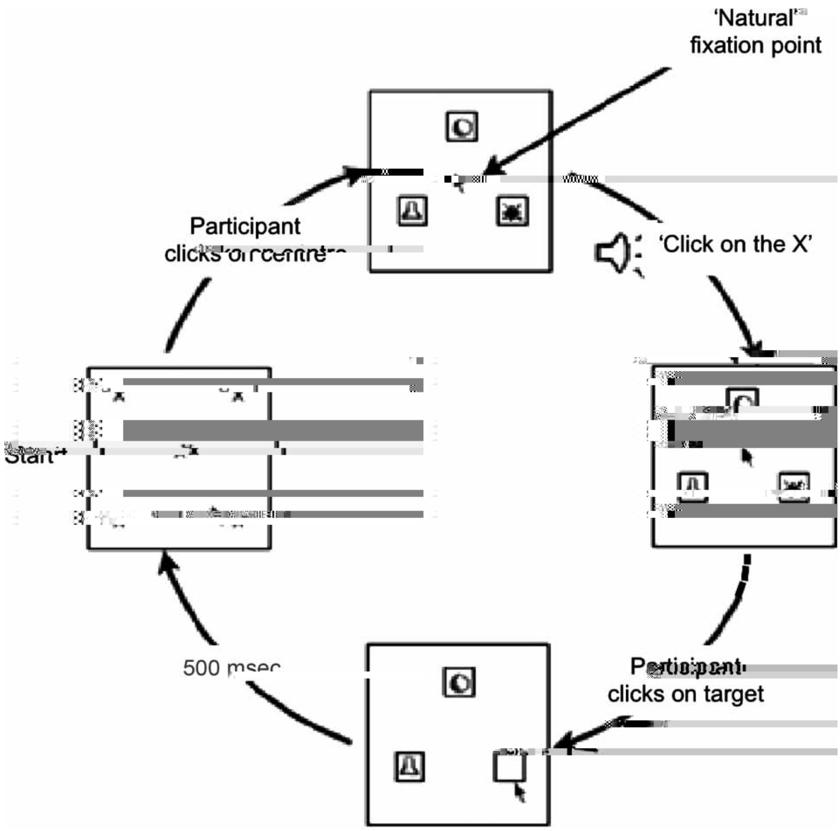

Figure 4. Trial timeline.

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%) [illegible]

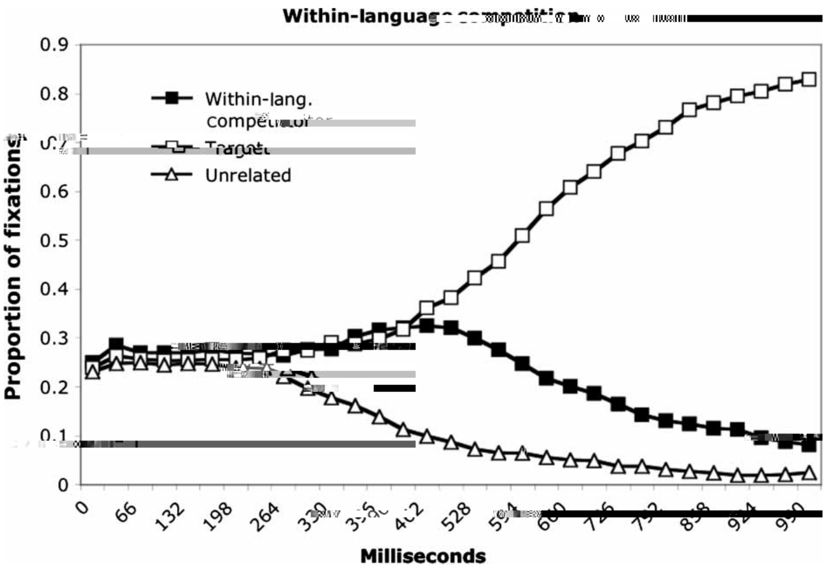

Figure 5. Time course of fixation probabilities for each object in within-language competition trials.

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

TABLE 2 (

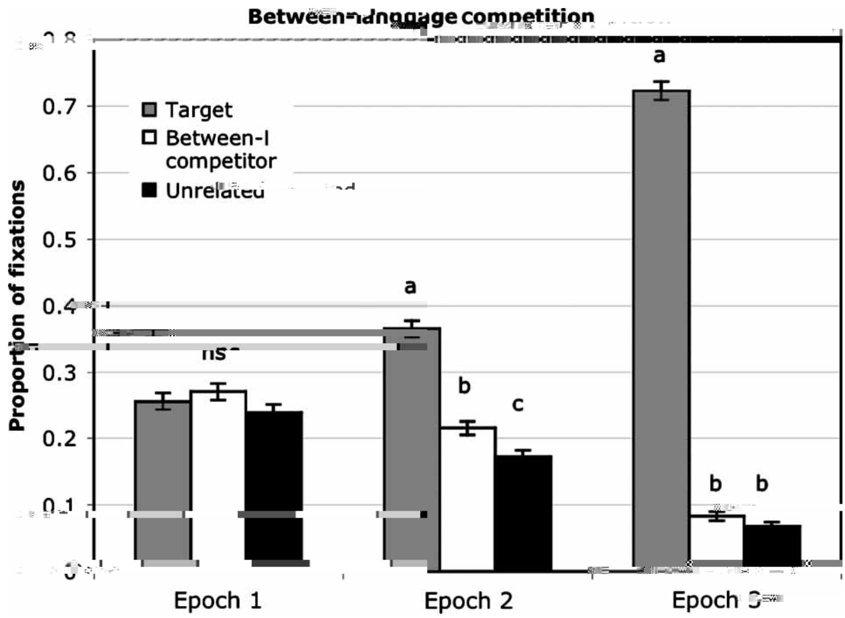

Figure 8. Proportion of fixations on each object for between-language (Spanish) competition trials across groups.

participants fixated significantly more on the target than on the Spanish cohort, $_{1}$(1, 130) = 63.9, = 0.047, < .001, $_{2}$(1, 9) = 11.47, = 0.018, < .001, or the unrelated object, $_{1}$(1, 130) = 108.9, = 0.045, < .001, $_{2}$(1, 9) = 35.1, = 0.010, < .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, $_{1}$(1, 130) = 9.5, = 0.026, < .005, $_{2}$(1, 9) = 2.0, = 0.010, . 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, $_{1}$(1, 130) = 2.9, = 0.010, , $_{2}$(1, 9) = 2.0, = 0.002, .

Nevertheless, a significant Object by AoA interaction (see Figure 9), $_{1}$(4, 248) = 3.4, = 0.129, ≤ .05, $_{2}$(4, 36) = 3.6, = 1290, ≤ .05, revealed that the S-E and the early bilingual groups looked significantly more frequently at the target than the Spanish cohort, S-E, $_{1}$(1, 130) = 70.5, = 0.027, < .001, $_{2}$(1, 9) = 55.5, = 127, < .001, early bilingual, $_{1}$(1, 130) = 115.3, = 0.027, < .001, $_{2}$(1, 9) = 47.7, = 221, < .001, and significantly more at the cohort than the unrelated object (but again only by subjects, S-E, $_{1}$(1, 130) = 8.7, = 0.013, < .005, $_{2}$(1, 9) = 3.4, = 102, , early bilingual, $_{1}$(1, 130) = 5.9, = 0.013,

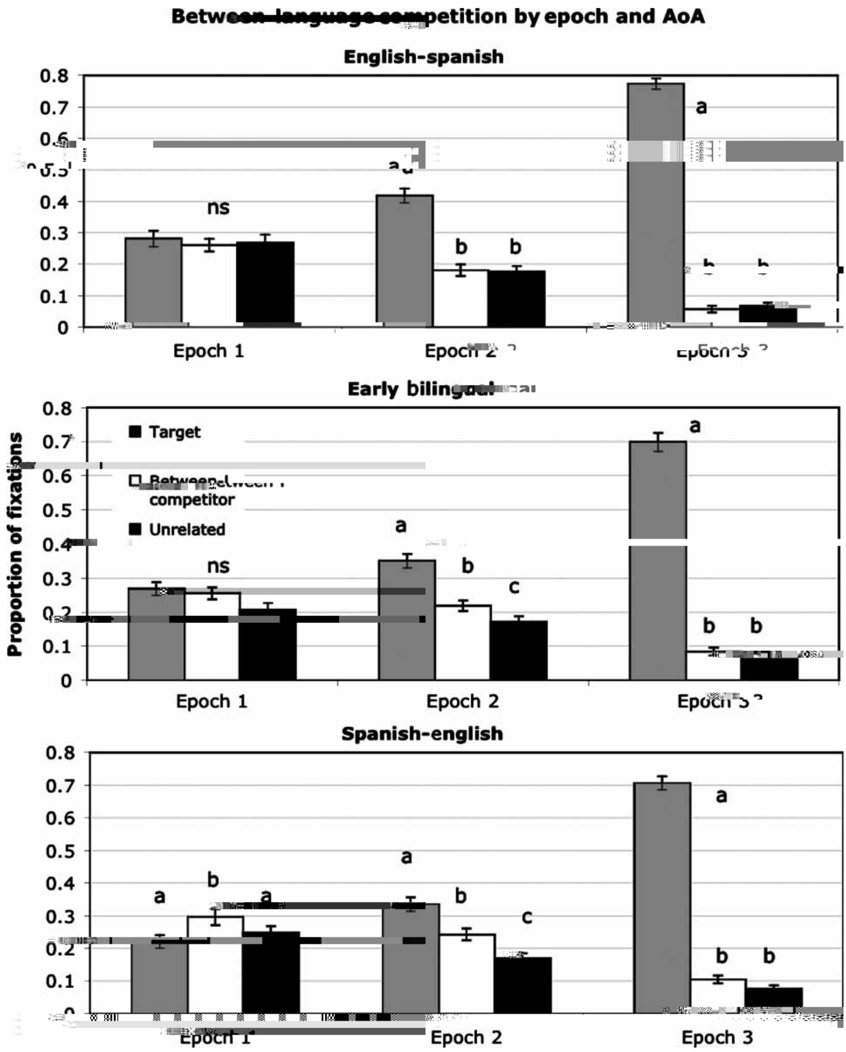

Figure 10. Proportion of fixations on each object for each epoch and age of acquisition (AoA) group in between-language competition trials.

$p = .053$, $F_2(1, 9) = 4.7$, $MSE = 28.0$, $p = .056$, 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, . $_1(1, 132) = 5.8$, _ , $= 0.067$, / $< .05$, . $_2(1, 9) = 7.6$, _ , $= 238$, / $< .05$, early bilingual, . $_1(1, 132) = 9.9$, _ , $= 0.317$, / $< .05$. $_2(1, 9) = 22.2$, _ , $= 351$, / $< .001$; epoch 3: S-E, . $_1(1, 132) = 361.7$, _ , $= 0.33$, / $< .001$, . $_2(1, 9) = 48.8$, _ , $= 617$, / $< .001$, early bilingual, . $_1(1, 132) = 85.5$, _ , $= 0.317$, / $< .05$, . $_2(1, 9) = 58.8$, _ , $= 168$, / $< .001$, and on the target than the unrelated object, epoch 2: S-E, . $_1(1, 132) = 5.8$, _ , $= 16.7$, / $< .05$, . $_2(1, 9) = 7.6$, _ , $= 182$, / $< .05$, early bilingual, . $_1(1, 132) = 9.9$, _ , $= 0.070$, / $< .05$, . $_2(1, 9) = 22.2$, _ , $= 195$, / $< .001$; epoch 3: S-E, . $_1(1, 132) = 112.0$, _ , $= 0.337$, / $< .001$, . $_2(1, 9) = 53.1$, _ , $= 520$, / $< .001$, early bilingual, . $_1(1, 132) = 404.2$, _ , $= 0.322$, / $< .05$, . $_2(1, 9) = 61.5$, _ , $= 159$, / $< .001$. Finally, our E-S group showed no evidence of

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.

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 ($N = 20$), $p = 30$, . 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 whe1(itiiov1(an)2cf)-8.2ion to find asi46 4-334.elmod 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., , 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-), and absent when using English-specific targets (SHARK-). In contrast, the bilingual group with high levels of German 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 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

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APPENDIX B

Stimuli used in the experiment

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]	[bi ote]	jail [dZel]
	carton [kArtn]	[kArsel]	beetle [bitl]
	coal [kol]	[ko¥ar]	eagle [ig′l]
	comb [kom]	[konexo]	mustache [m√stQS]
	eagle [ig′l]	[i lesja]	coat [kot]
	female [fimeIl]	[fjesta]	coat [kot]
	marker [mArk′r]	[mAriposa]	toes [tos]
	pony [poni]	[po¥itos]	carton [kArtn]
	seeds [sidz]	[si¥a]	coal [kol]
	toad [tod]	[toro]	marbles [mArb′lz]