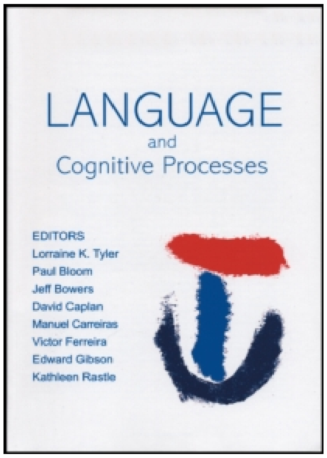

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Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking

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Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking

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During spoken word-recognition, bilinguals have been shown to access their two languages simultaneously. The present study examined effects of language proficiency and lexical status on parallel language activation. Language proficiency was manipulated by testing German-native and English-native bilingual speakers of German and English. Lexical status was manipulated by presenting target words that either overlapped in form across translation equivalents (cognate words) or did not overlap in form across translation equivalents (English-specific words). Participants identified targets (such as *hen*) from picture-displays that also included similar-sounding German competitor words (such as *Hemd,* "shirt"). Eye-movements to German competitors were used to index co-activation of German. Results showed that both bilingual groups co-activated German while processing cognate targets; however, only German-native bilinguals co-activated German while processing English-specific targets. These findings indicate that high language proficiency and cognate status boost parallel language activation in bilinguals.

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Recent evidence suggests that bilinguals activate their two languages in parallel during language comprehension both in the auditory modality (e.g., Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Schulpen, Dijkstra, Schriefers, & Hasper, 2003; Spivey & Marian, 1999; Weber & Cutler, 2004) and in the visual modality (e.g., Dijkstra & Van Heuven, 1998; Dijkstra, Van Heuven, & Grainger, 1998; Grainger, 1993). Yet, parallel language activation may be constrained by factors such as language proficiency (e.g., Weber & Cutler, 2004), language exposure (e.g., Spivey & Marian, 1999), and acoustic characteristics of the input signal (e.g., voice-onset time, Ju & Luce, 2004). The goal of the present research was to investigate how language proficiency and lexical status constrain parallel language activation during bilingual spoken word recognition.

During spoken word recognition, multiple word candidates (i.e., *cohort members*) that match the acoustic input become active, and as the input unfolds over time, the best match (i.e., the *target*) is selected (e.g., Marslen-Wilson, 1987). Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy (1995) covertly measured competition between target-words and cohort-words by using eye-tracking. Participants heard object names, and were asked to identify these target objects from a set of items in a visual display. During target identification, participants' eye-movements to cohort members (henceforth *competitors*) reflected parallel activation of both items.[1] For example, if participants heard the word *marker*, they were likely to also look at a *marble* (see Figure 1A). This monolingual eye-tracking paradigm (e.g., Tanenhaus et al., 1995) was extended to investigate whether cohort words in bilinguals' two languages become active in parallel during spoken word recognition (Marian & Spivey, 2003a, 2003b; Spivey & Marian 1999; see Figure 1B). Bilinguals heard a word in one language, and identified it from a set of objects that also included a competitor from their other language. Findings showed that when Russian-English bilinguals heard the word *marker* in English, they were likely to also look at the Russian between-language competitor *marka* ('stamp'). This finding of parallel language activation has since been replicated with Dutch–English bilinguals (Weber & Cutler, 2004), Spanish–English bilinguals (Canseco–Gonzales, Brick, Fischer, & Wagner, 2005; Ju & Luce, 2004), French–English bilinguals (Weber & Paris, 2004), and Japanese–English bilinguals (Cutler, Weber, & Otake, 2006). In the current study, we extended the bilingual eye-tracking paradigm to investigate constraints on parallel language activation. The influence of proficiency on parallel activation was examined by testing two bilingual groups. One bilingual group consisted of German-native bilinguals who were highly proficient in German; the other

[1] For a linking hypothesis between linguistic processing and eye-movements, see Tanenhaus, Magnuson, Dahan, and Chambers (2000).

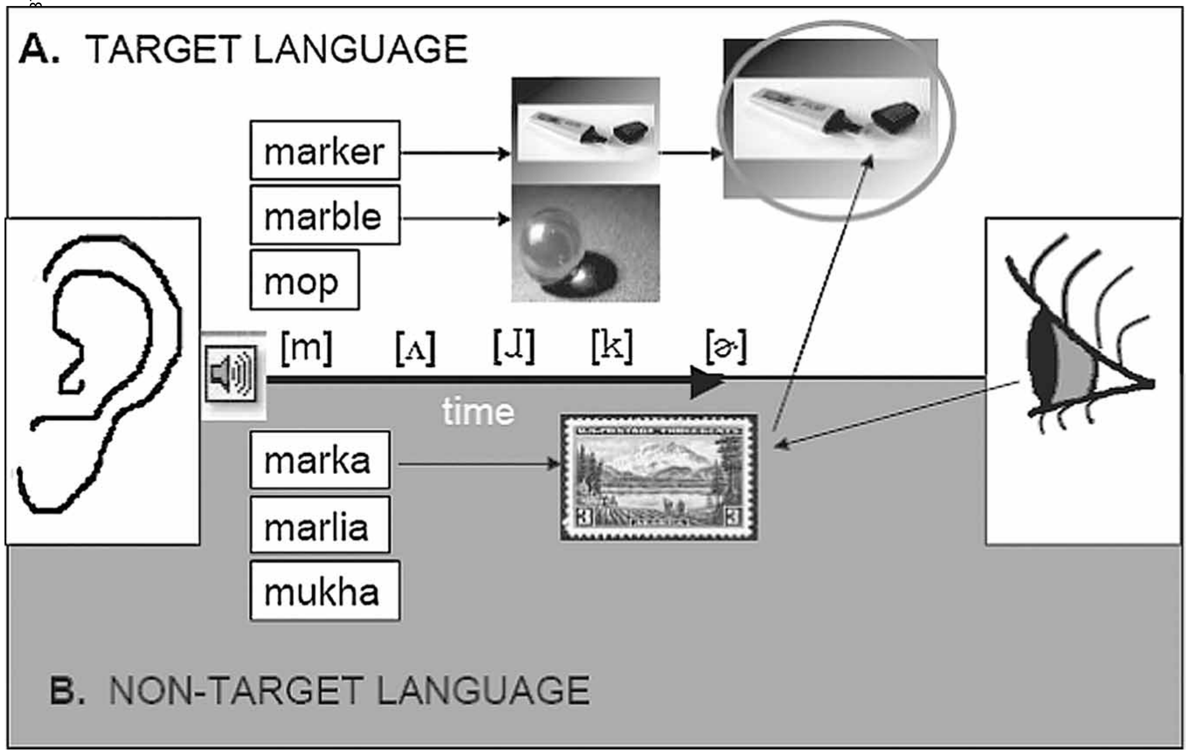


Figure 1. Unfolding of the acoustic signal, and cohort activation within and across languages, as indexed by eye-movements. The top panel illustrates Marslen-Wilson's Cohort Model (1987) in a monolingual scenario (Tanenhaus et al. , 1995). The bottom panel extends the model to a bilingual scenario, as proposed by Marian (2000) and replicated by others (Canseco-Gonzalez et al., 2005; Cutler, et al., 2006; Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Spivey & Marian, 1999; Weber & Cutler, 2004; Weber & Paris, 2004).

bilingual group consisted of English-native bilinguals who were less proficient in German. The influence of lexical status on parallel language activation was examined by presenting target words that either overlapped in form with their translation equivalents (cognate words, such as *hen, Henne* in German) or did not overlap in form with their translation equivalents (English-specific words, such as *dress, Kleid* in German). The entire experiment was conducted in English only, with no use of German before or during the study.

LANGUAGE PROFICIENCY AND PARALLEL LANGUAGE ACTIVATION

During bilingual word-recognition, proficiency in the language irrelevant to the task has been found to constrain parallel language activation. Parallel language activation is more reliable when proficiency in the unused language is high than when it is low (e.g., Jared & Kroll, 2001; Silverberg & Samuel, 2004; Van Hell & Dijkstra, 2002; Weber & Cutler, 2004). In the visual modality, for instance, Silverberg and Samuel (2004) found that late bilinguals with high L2 proficiency showed between-language form priming, while late bilinguals with low L2 proficiency did not. Jared and Kroll (2001) recruited French–English and English–French bilinguals and compared the degree to which they co-activated French phonology while reading aloud English words. French phonology was activated by French-native bilinguals (with higher proficiency in French), but not by English-native bilinguals (with lower proficiency in French). Further, Van Hell and Dijkstra (2002) tested trilinguals with a highly proficient second language and a less proficient third language. On an L1 lexical decision task, participants co-activated a highly proficient L2 while processing L1–L2 cognates, but did not co-activate a less proficient L3 while processing L1–L3 cognates.

In the auditory modality, the role of proficiency in parallel language activation has also been examined. Bilinguals listening to words in their lower-proficiency language have consistently shown co-activation of their higher-proficiency language (Marian & Spivey, 2003a, 2003b; Weber & Cutler, 2004; Weber & Paris, 2004). However, bilinguals listening to words in their higher-proficiency language have not always shown co-activation of their lower-proficiency language. Some studies have found parallel activation of a lower-proficiency language (Marian & Spivey, 2003a; Spivey & Marian, 1999), while others have not (Ju & Luce, 2004; Weber & Cutler, 2004). Extent of immersion in the second language may be one explanation for these differences between studies. Moreover, testing bilinguals in both languages may confound research on proficiency effects due to differences in linguistic structure and stimulus sets across languages. Another way to examine the influence of proficiency on parallel language activation is to hold the testing language constant and to vary proficiency in the unused language across groups. Such a design would allow for testing language and stimuli to remain constant across proficiency comparisons, so that confounds from these sources could be ruled out. In the current study, two bilingual groups with different proficiency levels in German were tested.

LEXICAL STATUS AND PARALLEL LANGUAGE ACTIVATION

In the bilingual lexicon, translation equivalents are connected via associative links (Chen & Leung, 1989; De Groot, 1992; Kroll & Curley, 1988; Kroll & Stewart, 1994). When bilinguals process words in one language, they co-activate translation equivalents in the other language (e.g., Hermans, Bongaerts, De Bot, & Schreuder, 1998). Previous studies have shown that form overlap between cognate translation equivalents results in high activation of both wordforms (e.g., Costa, Caramazza & Sebastian-Galles, 2000, Van Hell & Dijkstra, 2002). Therefore, *cognate* words with high form-overlap between translation equivalents (e.g., English *cactus*, German *Kaktus*) were used to examine whether processing of words with high cross-linguistic overlap facilitated parallel language activation. Evidence supporting parallel activation of cognate translation equivalents includes findings of stronger cognate translation priming (Gollan, Forster & Frost, 1997), faster cognate translation times (De Groot, 1992; De Groot, Dannenburg, & Van Hell, 1994), and more accurate cognate processing (Friel & Kennison, 2001; Tokowicz, Kroll, DeGroot, & Van Hell, 2002) relative to words with unrelated translation equivalents (noncognates). In general, a processing advantage for cognates is well-established during word production (e.g., Costa et al., 2000; De Groot, Borgwaldt, Bos, & Van den Eijnden, 2002; De Groot & Keijzer, 2000; Gollan & Acenas, 2004; Kohnert, 2004; Roberts & Deslauriers, 1999) and comprehension (e.g., De Groot et al., 2002; De Groot & Keijzer, 2000; Dijkstra et al., 1998; Dijkstra, Grainger, & Van Heuven, 1999; Lalor & Kirsner, 2001; Lemhöfer, Dijkstra, & Michel, 2004; Nakayama, 2002; Van Hell & Dijkstra, 2002). Nevertheless, it remains unclear how cognate processing influences *overall* activation of an unused language. In the current study, we examined whether processing cognate targets would boost co-activation of an unused language during bilingual word recognition. We used English-specific target-words that did not overlap phonologically across translation equivalents (e.g., *shark*, *Hai* in German), and cognate target-words that did overlap phonologically across translation equivalents (e.g., *guitar*, *Gitarre* in German). Previous research has shown that translation equivalents are co-activated more for words that share form than for words that do not share form (e.g., De Groot, 1992; De Groot et al., 1994). Thus, in the present study, German translation equivalents should be more active for

English cognate targets than for English-specific targets. In addition, German translation equivalents of cognate targets would overlap with German competitors and would directly co-activate them. For example, the translation equivalent *Gitarre* of the cognate target *guitar* would directly co-activate its German competitor *Gitter* ("bars"); yet the translation equivalent *Hai* of the English-specific target *shark* would not co-activate its German competitor *Schal* ("scarf"). It follows, then, that in the cognate-target condition, German translation equivalents would be more active and would also co-activate German competitors more. In contrast, in the English-specific-target condition, German translation equivalents would be less active and would co-activate German competitors less. As a result, when the target is a cognate, German competitors would be activated via links between translation equivalents, and via bottom-up acoustic input. However, when the target is English-specific, German competitors would be activated via bottom-up acoustic input only. Due to these differences in co-activation mechanisms, we predicted that co-activation of German competitors would be stronger with cognate targets than with English-specific targets.

CURRENT STUDY

In the current study, we investigated parallel activation of German during English word recognition. Participants heard object names in English, and identified them among four pictures that included a similar-sounding German competitor. German was never used overtly. Co-activation of German was probed covertly by tracking participants' eye-movements toward pictures of German competitors (relative to control items). To examine the role of proficiency in parallel language activation, we recruited two groups of late bilinguals. One group consisted of German-native bilinguals who were highly proficient in German; the other group consisted of English-native bilinguals who were less proficient in German. An English monolingual control group was also tested. To examine the role of Lexical Status in parallel language activation, we manipulated overlap between targets' translation equivalents. One condition consisted of English targets (with phonologically unrelated German translations); the other condition consisted of cognate targets (with phonologically similar German translations).

In addition, the Phonological Overlap between target and competitor word-onsets was manipulated for a preliminary look at the role of cross-linguistic overlap in parallel activation. Onset similarity between target words and German competitors was either *low* (e.g., English *ball* and German *Birne* / pear), *medium* (e.g., English *coral* and German *Korb* / basket), or *high* (e.g., English *mop* and German *Mops* / pug dog). Previous research suggests that longer ambiguity between targets and competitors leads to stronger competition (e.g., Weber & Cutler, 2004; Ju & Luce, 2004). We hypothesized that greater phonological onset similarity between targets and competitors would result in increased co-activation of German.

It was predicted that, during English word comprehension, German-native bilinguals would co-activate German more than English-native bilinguals. Further, it was predicted that both bilingual groups would co-activate German competitors of cognate targets more than German competitors of English targets. Finally, it was predicted that both bilingual groups would co-activate German high-overlap competitors more than German low-overlap competitors.

METHODS

Participants

Fifteen English-native bilinguals (mean age $=25.5$, $SD=8.5$; 7 females), 15 German-native bilinguals (mean age $=28.7$, $SD=12.9$; 7 females) and 15 English monolinguals (mean age $=27.3$, $SD=9.3$; 9 females) participated. Bilinguals were selected for participation if they rated their L2-proficiency to be at least a 3 on a scale from 0 (*no proficiency*) to 5 (*excellent proficiency*), and if they had been immersed in an L2 environment for at least 6 months (see Table 1). The three groups did not differ in age, $F(2, 42)=0.3$, $p>.5$. All participants were administered a standardized receptive vocabulary test (the *Peabody Picture Vocabulary Test*, *PPVT*, Dunn & Dunn, 1997). Bilingual participants were also administered a German translation of the PPVT's B-version.[2] When the three groups were compared on the English PPVT, $F(2, 42)=22.3$, $p<.001$, English-native bilinguals ($M=195.3$, $SD=3.7$) outperformed German-native bilinguals ($M=172.7$, $SD=15.2$), LSD post hoc: $p<.001$, and performed similarly to English monolinguals ($M=190.6$, $SD=6.5$), LSD post hoc: $p>.1$. On the German PPVT, German-native bilinguals ($M=193.9$, $SD=7.6$) outperformed English-native bilinguals ($M=179.4$, $SD=17.8$), $F(1, 28)=8.4$, $p<.01$. Participants also completed a *Language Experience and Proficiency Questionnaire* (*LEAP-Q,* Marian, Blumenfeld, & Kaushanskaya, in press). All bilinguals were native-language dominant. Participants completed informed consent in compliance with the Northwestern University Internal Review Board, and were paid for participation.

[2] This translation was made by a fluent German–English bilingual, and back-translated to English by two other fluent German–English bilinguals for reliability. The German and English versions were then balanced by-item on word frequency [CELEX lexical database, Baayen, Piepenbrock, & Van Rijn, 1995, $t(203)=0.6$, $p>.5$].

TABLE 1
Linguistic profiles of English-native and German-native bilingual participants

	English-native bilinguals M (SD)	*German-native bilinguals M (SD)*	*Between-group statistics*
Age of initial L2-learning	11.5 (8.4)	10.7 (3.3)	$t(28) = 0.4$, $p > .5$
Age of attained L2-fluency	17.7 (9.7)	18.8 (7.6)	$t(28) = 0.3$, $p > .5$
Role of friends in L2-learning[1]	3.4 (1.8)	3.9 (1.2)	$t(28) = 1.0$, $p > .1$
Number of years in a German-speaking country	1.5 (2.2)	21.9 (7.5)	$t(28) = 10.0$, $p < .001$
Number of years in an English-speaking country	23.6 (8.5)	5.7 (11.3)	$t(28) = 4.9$, $p < .001$
Self-reported proficiency – understanding German[2]	4.0 (0.5)	5.0 (0.0)	$t(28) = 7.3$, $p < .001$
Self-reported proficiency – understanding English[3]	4.9 (0.3)	4.3 (0.8)	$t(28) = 2.9$, $p < .01$
Current exposure to German (% time)	10.4 (6.9)	23.1 (16.3)	$t(28) = 7.7$, $p < .01$
Current exposure to English (% time)	87.2 (7.1)	74.0 (16.3)	$t(28) = 8.2$, $p = .01$

[1] As rated by participants on a scale from 0 (*not an important contributor*) to 5 (*the most important contributor*).

[2] As rated by participants on a scale from 0 (*no proficiency*) to 5 (*excellent proficiency*).

[3] English monolinguals reported the same proficiency levels understanding English as the English-native bilinguals, $M = 4.9$, $SD = 0.3$. English monolingual participants were not proficient in another language, and had never learned a language other than English.

Stimuli and design

Stimulus displays consisted of four pictures and a central fixation cross (see Figure 2). The four pictures in each display consisted of (1) the target-word (either an English target or a cognate target), (2) a German competitor or a control item, and (3, 4) two filler items. In half (64) of all trials, the targets were English words (e.g., *bike*) that did not have phonologically related German translations (e.g., *Fahrrad*). In the other half of trials, the targets were English-German cognate words (e.g., *pianist*), and had phonologically related German translations (e.g., *Pianist*, /π ι: αυ στ/). For cognate targets, the same word-root was shared by English translations (e.g., *pills*) and German translations (e.g., *Pillen*, e.g., Christoffanini, Kirsner, & Milech, 1986). Moreover, the same consonant-vowel (CV) structure was shared by English translations (e.g., *coffee*, CVCV) and German translations (e.g., *Kaffee*, CVCV, e.g., Friel & Kennison, 2001). Finally, to control for semantic overlap between stimulus-items (Huettig & Altmann, 2005), we ensured that the four stimuli in each trial were not related to each other. In half of all trials, target-pictures (e.g., *desk*) were accompanied by pictures of German

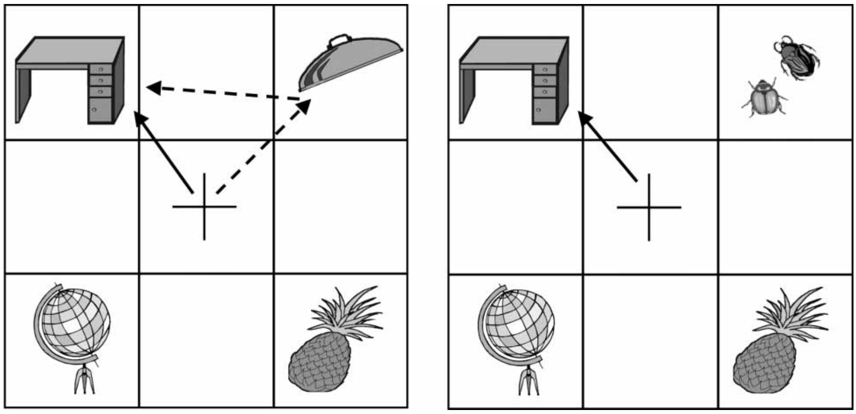


Figure 2. Sample stimulus panels for the competitor condition (shown on the left) and the control condition (shown on the right). When participants heard '*Click on the desk*' while viewing these panels, they were more likely to look at the lid (German *Deckel*), than at the control object, the bugs (German *Kaefer*). Predicted eye-movements in both conditions are marked by arrows across the display.

competitors with phonologically similar word-onsets (e.g., German competitor *Deckel, lid* in English). In the other half of trials, target-pictures (e.g., *desk*) were accompanied by pictures of control items phonologically unrelated to the target (e.g., German control item *Kaefer*, *bugs* in English). Consistent with previous work using the bilingual eye-tracking paradigm (e.g., Spivey & Marian, 1999; Marian & Spivey, 2003a, 2003b), we presented competitor and control items in the same positions within two otherwise identical displays. The purpose of this design was to control for picture position and salience of the visual environment. Note that, since competitor and control items were presented in different trials, the percentage of looks to targets, competitors and control items need not add up to 100%.

Auditory stimuli consisted of the instructions '*click on the [target picture] and the [filler picture]*', and were presented concurrently with picture displays. Recordings of auditory stimuli were made in a sound-proof booth (44,100 Hz, 16 bits) by a native female speaker of American English. After normalisation, the resulting sound files were exported from the DigiSound software into Superlab. Further segmentation and insertion of equal between-word breaks was performed using Sound Studio software. The name of the target picture was presented 400 ms after the picture display; the name of the filler picture was presented 3000 ms after the picture display. Instructions to click on a filler picture were included to disguise the purpose of the experiment. In the post-experiment interview, none of the participants identified the purpose of the study or noticed the existence of cognates. In 3.6% of all trials, participants noticed overlap between targets and competitors; these trials were excluded from further consideration and were not coded.

A total of 128 trials were prepared. Picture stimuli were selected from the IMSI Master Clips database and the Alta Vista search engine, or hand-drawn. Pictures were black line-drawings with gray shadings. Picture positioning in display quadrants I–IV was controlled across trials. Presentation order of trials was counterbalanced across participants and conditions. Stimulus sets were balanced for spoken word frequency in English and German using the CELEX lexical database (Baayen et al., 1995; $F(9, 310) = 0.4, p = .9$). To explore the role of phonological overlap between target-word onsets and competitor-word onsets, target-competitor overlap was manipulated along three levels: *low*-, *medium*-, and *high-overlap*. Stimuli were divided into one-, two- and three-phoneme overlap conditions, and final groupings were based on duration of overlap in milliseconds (due to the time-sensitive nature of cohort-activation, e.g., Marslen-Wilson, 1987). A summary of overlap conditions is shown in Table 2.[3] A complete list of all stimuli is available by request.

Procedures and apparatus

All participants were welcomed into the lab using only English, and were told that the goal of the experiment was to find out how they processed English speech (German was not used at any point). Although participants were recruited based on bilingual status, cues about the relationship between their language skills and experiment goals were minimised by using only English before and during testing sessions. After informed consent was obtained, participants were fitted with a head-mounted ISCAN eye-tracker. A scene camera provided an image of participants' field of view. A second camera, which provided an infrared image of the left eye, allowed the software to track the center of the pupil and the corneal reflection. Gaze position was indicated by cross-hairs superimposed over the image generated by the

[3] For purposes of subsequent analyses, English recordings of target words were compared with German recordings of competitor words (German recordings were made by native speakers of German). Onset similarity between English target-words and German competitor-words was assessed at the acoustic level (Ju & Luce, 2004) using Sound Studio software. The duration of acoustic overlap between target and competitor onsets was measured, and is shown in Table 2. A one-way ANOVA yielded significant differences between durations of target-competitor overlap in the *low*-, *medium*- and *high-overlap* conditions (cognate target condition, $F(2, 30) = 45.5$, $p < .001$; English target condition, $F(2, 28) = 45.2$, $p < .001$). Planned post-hoc comparisons yielded differences between *low*- and *medium*-overlap conditions, as well as between *medium*- and *high*-overlap conditions and between *low*- and *high*-overlap conditions (LSD post-hocs: $p < .01$). Significant differences between the three conditions were also found in terms of phonemes: cognate target condition, $F(2, 30) = 18.6$, $p < .001$; English target condition, $F(2, 28) = 4.8$, $p < .05$, and in terms of phonetic features: cognate target condition, $F(2, 30) = 10.2$, $p < .001$; English target condition, $F(1, 28) = 6.1$, $p < .01$).

TABLE 2
Phonological overlap in milliseconds, in phonemes, and in phonetic features

Condition	*Time (ms) M (SE)*	*Phonemes M (SE)*	*Features M (SE)*
Cognate Targets			
Low	33.9 (6.0)	1.2 (0.1)	4.1 (0.3)
Medium	116.2 (9.4)	2.2 (0.2)	6.1 (0.6)
High	253.5 (26.2)	2.6 (0.2)	7.2 (0.5)
Noncognate Targets			
Low	65.0 (6.8)	1.5 (0.2)	3.7 (0.3)
Medium	120.1 (4.7)	2.2 (0.3)	4.9 (0.6)
High	247.6 (21.6)	2.5 (0.2)	6.0 (0.5)

scene camera. Participants' eye-movements were calibrated to 9 points on the computer screen (G4 Macintosh, 27 cm $\times$ 34 cm). Participants were familiarised with the task during a five-trial practice session on neutral stimuli that did not re-occur during the experimental session. The experimental session lasted approximately 20 minutes. Following the session, participants were administered the English Peabody Picture Vocabulary Test, and bilingual participants were also administered a German translation of the PPVT. Finally, all participants filled out the Language Experience and Proficiency Questionnaire.

Coding and analyses

Eye-tracking data consisted of video output including participants' field of view and superimposed fixation cross-hairs, as well as auditory instructions, which were time-locked to participants' eye-movements. The video output was manually coded at a temporal resolution of 33.3 ms per frame using Final Cut software. Eye-movements to pictures were coded as looks if they entered the picture's quadrant and remained there for at least one frame. Fifteen percent of all data were re-coded by a second coder; point-to-point inter-rater reliability was 93.5% (pair-wise Pearson *R*). A total of 9.5% of data were excluded from analyses due to problematic competitor stimuli (i.e., stimuli that drew consistently more looks to competitor than to control items in the monolingual group).[4] These trials, as well as their control trials, were

[4] Of these, the target-competitor pairs cylinder / *Zylinder* (top-hat) and lock / *Lockenwickler* (curlers) were excluded due to within-language competition. The picture of *curlers* contained *locks* (of hair) and the *top hat* was *cylinder*-shaped. For evidence on eye-movements due to shape-similarities, see Dahan and Tanenhaus, 2005. The target-competitor pairs bear / *Band* (ribbon), file / *Pfeil* (arrow), turtle / *Tuer* (door) and tooth / *Tuch* (cloth) were excluded because these competitor pictures were fixated more than control items in the monolingual control group.

excluded in order to increase confidence that findings were due to linguistic effects rather than to picture characteristics.

Data were analyzed in two ways. First, overall percentages of looks to competitor and control items were compared in binary fashion (whether or not participants looked in each trial, 1 = *looked*, 0 = *did not look*). Second, for a closer look at the time-course of activation, eye-movements to targets, competitors, and control items were analyzed frame by frame. Since eye-movement planning takes approximately 200 ms (Hallett, 1986), time-course analyses focused on activation beyond the initial 200 ms. Note that percentages of overall looks are higher than percentages of looks in specific time-windows (since specific time-windows do not include any looks that happen earlier or later in time). Activation curves between 0 and 1200 ms post-stimulus-onset were examined visually, and time-windows where parallel language activation was apparent were further analyzed statistically. This approach was consistent with the expectation that the time-course of competitor co-activation would vary across stimulus status and proficiency levels.

RESULTS

A $2 \times 2 \times 3 \times 3$ full factorial ANOVA examined percentage of looks, with competitor status (German competitors, control items), target status (English targets, cognate targets), and phonological overlap (low, medium, high) as within-subject factors, and group (German-native bilingual, English-native bilingual, English monolingual) as between-subject factor. Results revealed a 4-way interaction between competitor, target status, phonological overlap, and group, $F(2, 42) = 3.5$, $p < .05$, $\eta^2 = .2$; a 3-way interaction between competitor, lexical status, and group, $F(2, 42) = 3.1$, $p = .057$, $\eta^2 = .1$, and a 2-way interaction between competitor and group, $F(2, 42) = 6.9$, $p < .01$, $\eta^2 = .3$. Across both target types (see Figure 3), German-native bilinguals looked more often at competitor ($M = 64.8\%$, $SE = 2.7$) than at control items ($M = 56.7\%$, $SE = 3.2$), $t(14) = 3.4$, $p < .01$; English-native bilinguals also looked more often at competitor ($M = 51.0\%$, $SE = 2.7$) than at control items ($M = 46.0\%$, $SE = 3.2$), $t(14) = 2.7$, $p < .05$; and monolinguals looked equally often at competitor ($M = 57.8\%$, $SE = 2.7$) and control items ($M = 59.7\%$, $SE = 3.2$), $t(14) = 1.3$, $p > .1$.

To compare the two bilingual groups directly, a parallel $2 \times 2 \times 3 \times 2$ ANOVA revealed a main effect of competitor, $F(1, 28) = 18.9$, $p < .001$, $\eta^2 = .4$, suggesting that both groups activated the two languages in parallel. In addition, a significant 3-way interaction between competitor, target Status, and bilingual group, $F(1, 28) = 5.2$ $p < .05$, $\eta^2 = 0.2$, suggested that English-native bilinguals and German-native bilinguals differed in competitor

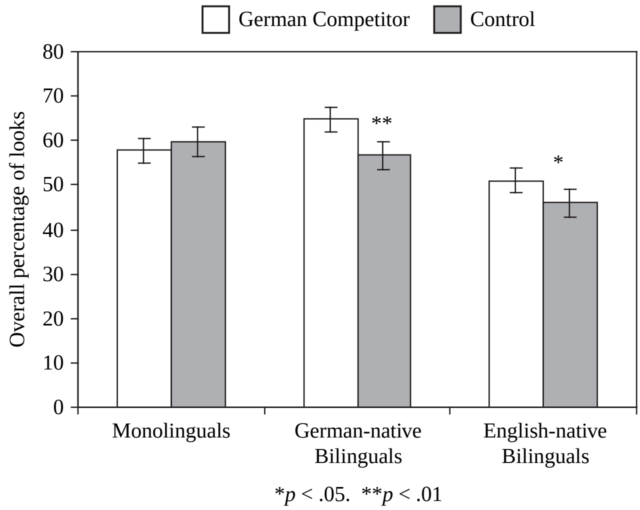


Figure 3. Overall percentage of looks to competitors and control items, for monolinguals, German-native bilinguals, and English-native bilinguals.

co-activation across cognate-targets and English-specific targets. The interaction between competitor and target status was significant for English-native bilinguals, $F(1, 14) = 6.4$, $p < .05$, $\eta^2 = .3$, but not for German-native bilinguals, $F(1, 14) = 0.5$, $p > .1$, $\eta^2 = .04$. Overall percentages of looks to competitor and control items in the presence of English targets and cognate targets are shown in Figure 4. Follow-up ANOVAs[5] and *t*-tests[6] were conducted in order to establish the locus of effects within each target condition.

[5] By-item analyses were significant or marginally significant in all between-group comparisons, but were not significant in within-group comparisons. This is likely due to the fact that duration of overlap (in milliseconds) was a continuous variable. Variations on the continuum within each category were likely to elicit different responses, resulting in large standard errors. This variability among items contradicted the inherent assumption in by-item analyses that all items be similar, prompting analyses of variance by subject only. To verify effects of phonological overlap across items, regression analyses were performed (where degree of phonological overlap was regressed on likelihood of parallel activation).

[6] Follow-up *t*-tests were only conducted to compare percentages of looks to competitor vs. control items, with competitor-control item differences reflecting parallel language activation. Looks to competitors in one condition vs. another (or to control items in one condition vs. another) were not compared statistically, because they do not reflect parallel language activation. Any differences between looks to competitors in different conditions (or looks to control items in different conditions) may be due to the presence of different stimuli across these conditions. Further, differences between looks to competitors in different groups (or looks to control items in different groups) may be due to general differences in response latencies across groups. Follow-up *t*-tests were 1-tailed.

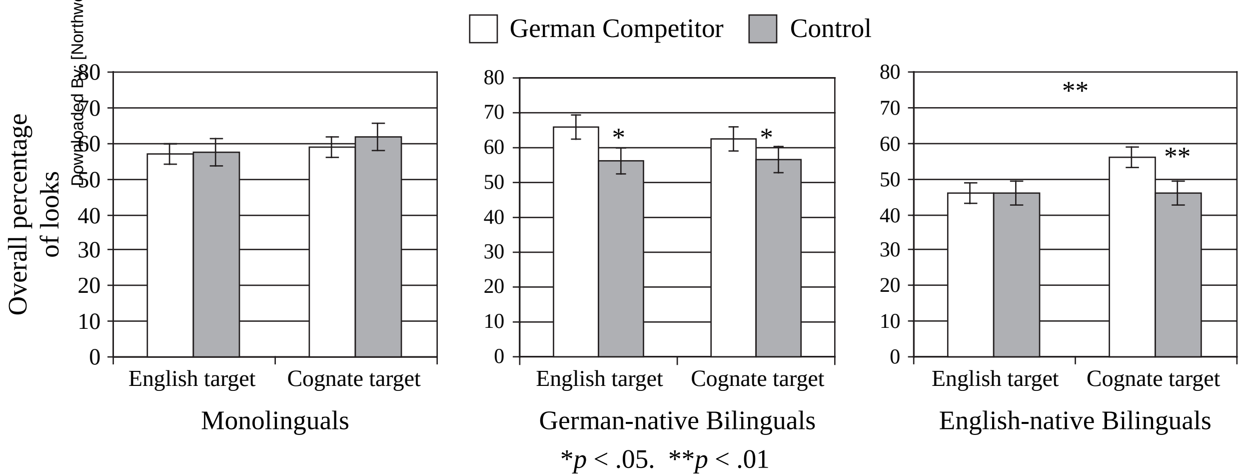
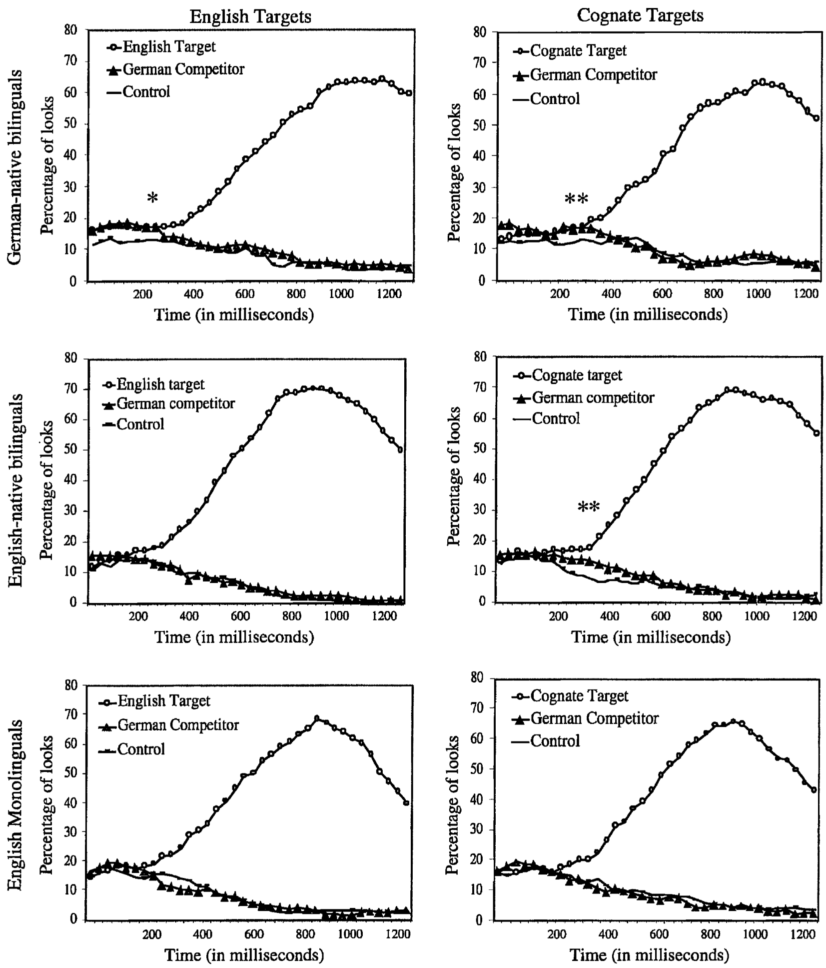


Figure 4. Overall looks to competitors and control items, in the presence of cognate targets and English targets in monolinguals, German-native bilinguals, and English-native bilinguals.

English targets

In the English target condition, a 2×3 ANOVA (Competitor $\times$ Group) on overall $\times$ percentages of looks revealed an interaction between competitor and group, $F(2, 42) = 4.8$, $p = .01$, $\eta^2 = .2$. A direct 2×2 comparison of the two bilingual groups also yielded a significant interaction between competitor and group, $F(1, 28) = 5.2$, $p < .05$, $\eta^2 = 0.2$. German-native bilinguals looked more often at competitor ($M = 67.2\%$, $SE = 3.1$) than at control items ($M = 56.9\%$, $SE = 3.5$), $t(14) = 2.7$, $p < .05$. English-native bilinguals looked equally often at competitor ($M = 46.2\%$, $SE = 3.1$) and control items ($M =$ 45.8%, $SE = 3.5$), $t(14) = 0.2$, $p > .1$. Monolinguals also looked equally often at competitor ($M = 56.9\%$, $SE = 3.1$) and control items ($M = 57.5\%$, $SE =$ 3.5), $t(14) = 0.3$, $p > .1$, confirming that differences in bilinguals were not an artifact of study design or stimulus selection. Together, results suggest parallel activation of both languages in German-native bilinguals, but not in English-native bilinguals. For a closer look at patterns of activation, the time-course of eye-movements to English targets, German competitors, and control items over the first 1200 ms post stimulus-onset is shown in Figure 5. Results of analyses on looks during the 200–400 ms time-window were consistent with results of overall looks. German-native bilinguals looked more often at competitor ($M = 15.2\%$, $SE = 1.8$) than at control items ($M =$ 12.3%, $SE = 1.8$), $t(14) = 2.2$, $p < .05$; English-native bilinguals looked equally often at competitor ($M = 12.2\%$, $SE = 1.2$) and control items ($M =$ 12.2%, $SE = 1.2$), $t(14) = 0.04$, $p > .1$; and monolinguals also looked equally often at competitor ($M = 13.9\%$, $SE = 1.4$) and control items ($M = 15.1\%$, $SE = 1.8$), $t(14) = 0.8$, $p > .1$.

To examine how extent of phonological overlap contributed to patterns of cross-linguistic activation, a $2 \times 3 \times 3$ ANOVA (Competitor $\times$ Phonological Overlap $\times$ Group) on overall percentages of looks was performed. No significant interactions between competitor, phonological overlap and group were found for analyses on overall percentages of looks, $F(2, 42) = 1.2$, $p >$ $.1$, $\eta^2 = .1$, or for analyses on percentages of looks during the 200–400 ms time-window, $F(2, 42) = 0.5$, $p > .1$, $\eta^2 = .02$. In addition, to examine the influence of phonological overlap on competitor activation, regression analyses were performed (with percentage of looks to competitors minus controls as dependent variable and with duration of phonological overlap as independent variable). No significant relationship between the two variables was observed for German-native bilinguals, $R = 0.2$, $F(1, 26) = 0.9$, $p > .1$, or for English-native bilinguals, $R = 0.1$, $F(1, 26) = 0.3$, $p > .1$, suggesting that neither bilingual group was sensitive to degree of phonological overlap in the English target condition.



*p < .05, **p < .01.

Figure 5. Percentage of looks to targets, German competitors and control items across the first 1200 msec post stimulus-onset for English and Cognate target conditions in German-native bilinguals, English-native bilinguals, and monolinguals.

Cognate targets

In the cognate target condition, a 2 $\times$ 3 ANOVA (Competitor $\times$ Group) on overall percentages of looks revealed an interaction between competitor and group, $F(2, 42) = 4.8$, $p < .05$, $\eta^2 = .2$. A direct 2 $\times$ 2 comparison of the two bilingual groups yielded no interaction between competitor and group,

$F(1, 28) = 0.8$, $p > .1$, $\eta^2 = .03$. German-native bilinguals looked more often at competitor ($M = 62.5\%$, $SE = 3.7$) than at control items ($M = 56.6\%$, $SE = 3.8$), $t(14) = 1.9$, $p < .05$; English-native bilinguals also looked more often at competitor ($M = 55.9\%$, $SE = 2.7$) than at control items ($M = 46.1\%$, $SE = 3.3$), $t(14) = 3.4$, $p < .01$; English monolinguals looked equally often at German competitor ($M = 58.8\%$, $SE = 2.5$) and control items ($M = 61.9\%$; $SE = 4.0$), $t(14) = -1.0$, $p > .1$. These results suggest similar degrees of parallel activation in German-native bilinguals and in English-native bilinguals. Absence of effects in monolinguals suggests that findings are due to bilingual status rather than an artifact of study design or stimulus-selection.

For a closer look at patterns of activation, the time-course of eye-movements to cognate targets, German competitors, and control items is shown in Figure 5. Results on percentages of looks during the 200–400 ms time-window were consistent with results on overall percentages of looks. German-native bilinguals looked more often at competitor ($M = 16.2\%$, $SE = 2.0$) than at control items ($M = 12.4\%$, $SE = 1.3$), $t(14) = 1.9$, $p < .05$; English-native bilinguals also looked more often at competitor ($M = 14.2\%$, $SE = 1.3$) than at control items ($M = 10.1\%$, $SE = 1.1$), $t(14) = 3.0$, $p < .01$; and monolinguals looked equally often at competitor ($M = 14.1\%$, $SE = 1.4$) and control items ($M = 14.4\%$, $SE = 1.4$), $t(14) = -0.2$, $p > .1$. Moreover, German-native and English-native bilinguals co-activated German competitors across different time-windows. German-native bilinguals looked more often at competitor ($M = 17\%$, $SE = 1.5$) than at control items ($M = 12\%$, $SE = 1.2$) during the 0–400 ms time-window, $t(14) = 3.3$, $p < .01$, while English-native bilinguals looked more often at competitor ($M = 13\%$, $SE = 1.1$) than at control items ($M = 8.4\%$, $SE = 8.7$) during the 200–533 ms time-window, $t(14) = 3.1$, $p < .01$. English monolingual participants looked equally often at competitor ($M = 14\%$, $SE = 1.0$) and at control items ($M = 14\%$, $SE = 1.1$) during the 0–533 ms time-window, $t(14) = 0.3$, $p > .1$.

To examine how extent of phonological overlap contributed to patterns of cross-linguistic activation, a $2 \times 3 \times 3$ ANOVA (Competitor $\times$ Phonological Overlap $\times$ Group) on overall percentages of looks was performed. Results revealed a significant interaction between competitor, phonological overlap and group, $F(2, 42) = 4.2$, $p < .05$, $\eta^2 = .2$.

A $2 \times 3 \times 2$ comparison of the two bilingual groups yielded no interaction between competitor, phonological overlap and group, $F(1, 28) = 0.4$, $p > .1$, suggesting that the two groups performed similarly. Follow-up ANOVAs showed that the interaction between competitor and phonological overlap was significant in English-native bilinguals, $F(1, 14) = 4.3$, $p = .05$, $\eta^2 = .2$, and in German-native bilinguals, $F(1, 14) = 10.4$, $p < .01$, $\eta^2 = .4$, but not in monolinguals, $F(1, 14) = 0.8$, $p > .1$, $\eta^2 = .06$. For both bilingual groups, parallel language activation increased as phonological overlap increased (see Table 3), suggesting that both German-native and English-native bilinguals

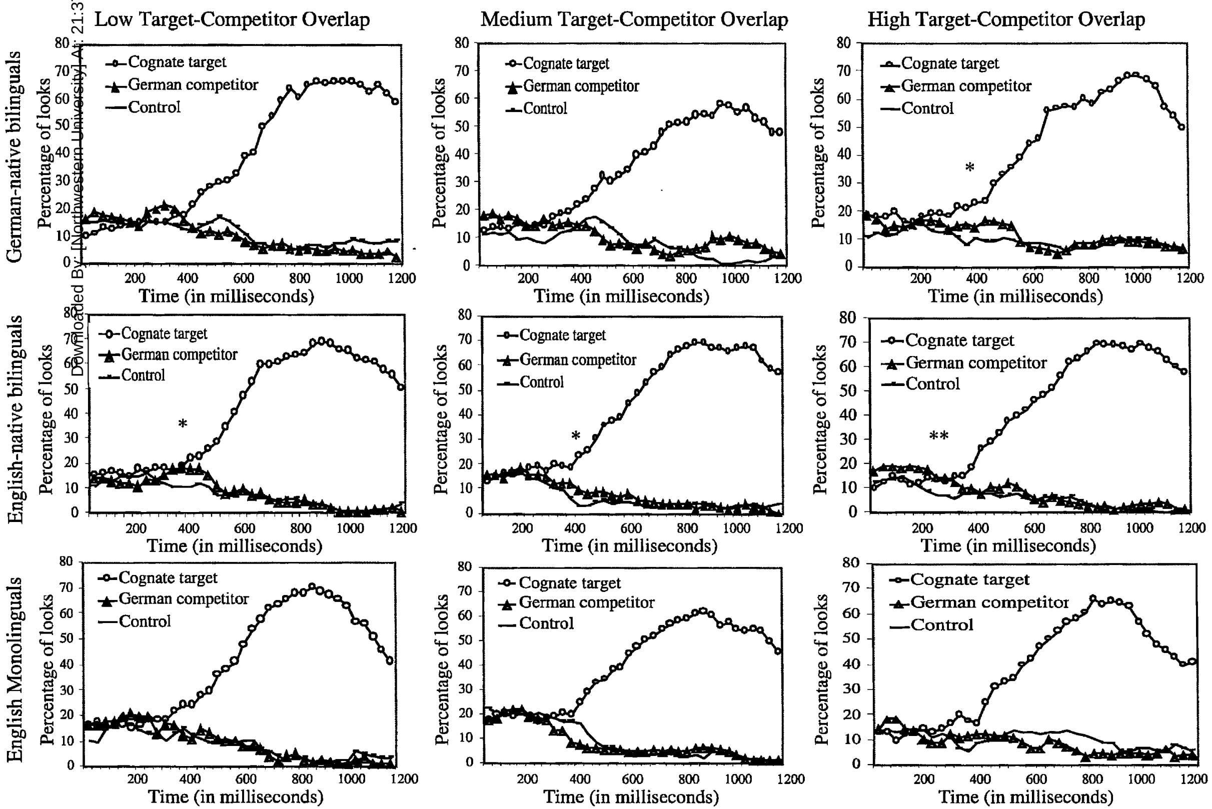
TABLE 3
Percentage of looks to competitor and control items for cognate targets

Target-Competitor Overlap	*Competitor (%) M (SE)*	*Control (%) M (SE)*	*Difference (Competitor-Control)*
A. Monolinguals			
Across all levels	58.8 (2.5)	61.9 (4.0)	−3.1
Low	64.4 (4.0)	60.0 (5.5)	4.4
Medium	52.7 (3.9)	64.8 (3.8)	−12.1
High	59.3 (4.2)	60.7 (5.4)	−1.4
B. English-native bilinguals			
Across all levels	55.9 (2.7)	46.1 (3.3)	9.8**
Low	54.8 (4.0)	51.9 (5.5)	2.9
Medium	55.6 (3.9)	45.2 (3.8)	10.4*
High	57.2 (4.2)	41.4 (4.5)	15.8**
C. German-native bilinguals			
Across all levels	62.5 (3.7)	56.6 (3.8)	5.9*
Low	59.3 (4.0)	61.5 (5.5)	−2.2
Medium	62.6 (3.9)	59.2 (3.8)	3.4
High	65.6 (4.2)	49.1 (5.4)	16.5**

* $p<.05$. ** $p<.01$.

were sensitive to degree of phonological overlap between cognate targets and German competitors. In addition, to examine the influence of phonological overlap on competitor activation, regression analyses were performed (with percentage of looks to competitors minus controls as dependent variable and with duration of phonological overlap as independent variable). Results revealed a significant positive relationship between the two variables for German-native bilinguals, $R=0.4$, $F(1, 30)=6.2$, $p<.05$, and for English-native bilinguals, $R=0.4$, $F(1, 30)=4.1$, $p=.05$. The activation time-course of cognate targets, German competitors, and control items in the three phonological overlap conditions is shown in Figure 6.

Separate 2×3 ANOVAs (Competitor $\times$ Group) were performed for low, medium, and high phonological overlap conditions. In the *low-overlap* condition, no differences were found between overall percentages of looks to low-overlap competitor and control items, $F(2, 42)=0.5$, $p>.1$, $\eta^2=.02$. However, the time-course of eye-movements revealed co-activation of low-overlap competitors during the 267–467 ms time-window, and this co-activation was significant for English-native bilinguals, $t(14)=1.85$, $p<.05$, but not for German-native bilinguals, $t(14)=0.8$, $p>.1$, or for monolinguals, $t(14)=0.9$, $p>.1$. In the *medium-overlap* condition, a significant interaction between competitor and group was found, $F(2, 42)=7.5$, $p<.01$, $\eta^2=0.3$, with significant co-activation for English-native bilinguals, $t(14)=2.8$,



*$p < .05$, **$p < .01$.

Figure 6. Percentage of looks to Cognate targets, German competitors and control items across the first 1200 ms post stimulus-onset for low, medium, and high target-competitor overlap in German-native bilinguals, English-native bilinguals, and monolinguals.

$p < .01$, but not for German-native bilinguals, $t(14) = 0.8$, $p = .4$, and with more looks to control items for monolinguals, $t(14) = -2.6$, $p < .05$. Consistent with overall percentages of looks, the time-course of eye-movements revealed co-activation of medium-overlap competitors during the 200–400 ms time-window, $F(2, 42) = 3.4$, $p < .05$, $\eta^2 = 0.14$. In addition, the time-course of medium-overlap competitor activation differed across bilingual groups: German-native bilinguals looked more often at medium-overlap competitor than at control items during the 0–400 ms time-window, $t(14) = 3.27$, $p < .05$; English-native bilinguals looked more often at medium-overlap competitor than at control items during the 200–700 ms time-window, $t(14) = 2.23$, $p < .05$; and monolinguals looked equally often at competitor and control items during the 0–700 ms time-window, $t(14) = -1.2$, $p > .1$. In the *high-overlap* condition, a significant interaction between competitor and group was found in analyses on overall percentages of looks, $F(2, 42) = 3.5$, $p < .05$, $\eta^2 = .14$, but not in analyses on percentages of looks during the 200–400 msec time-window, $F(2, 42) = 0.6$, $p > .1$, $\eta^2 = .03$. Follow-up *t*-tests on overall looks revealed significant co-activation of high-overlap competitors for English-native bilinguals, $t(14) = 3.0$, $p < .01$, and for German-native bilinguals, $t(14) = 3.1$, $p < .01$, but not for monolinguals, $t(14) = 0.3$, $p > .1$. The time-course of high-overlap competitor activation differed across bilingual groups: German-native bilinguals looked more often at high-overlap competitor than at control items during the 400–500 ms time-window, $t(14) = 1.8$, $p < .05$; English-native bilinguals looked more often at high-overlap competitor than at control items during the 0–600 ms time-window, $t(14) = 3.16$, $p < .01$; and monolinguals looked equally often at competitor and control items during the 0–600 ms time-window $t(14) = 0.2$, $p > .1$. In sum, longer phonological overlap resulted in increased co-activation of German competitors, and this co-activation lasted longer in English-native bilinguals than in German-native bilinguals.

DISCUSSION

The present study extended the bilingual eye-tracking paradigm to examine the role of language proficiency and lexical status in parallel language activation. Results revealed that German-native bilinguals co-activated German in the presence of English-specific targets (e.g., *bike, Fahrrad* in German) and in the presence of cognate targets (e.g., *arm*, *Arm* in German); while English-native bilinguals co-activated German in the presence of cognate targets only. Thus, higher German proficiency was associated with consistent co-activation of German during English word recognition. In contrast, lower German proficiency was associated with co-activation of German during recognition of cognate targets only. These findings suggest that cognate status boosted parallel language activation in English-native bilinguals.

Moreover, the present study extends the parallel-activation account of bilingual word recognition to a parallel-*and-interactive*-activation account of bilingual word recognition. The parallel-activation account was replicated by findings that bottom-up activation proceeds in parallel across the two languages (e.g., the English target *desk* and its German competitor *Deckel* were co-activated). Support for an interactive-activation account comes from evidence of lexical-level feedback between languages. For example, the target word *pianist* (*Pianist* in German), and its German competitor *Pik* ('spades') were co-activated not only via bottom-up phonological activation, but also via overlap between translation equivalents (*pianist*-*Pianist*), resulting in greater competitor co-activation.

Language proficiency and parallel language activation

Based on previous results (Jared & Kroll, 2001; Weber & Cutler, 2004; Silverberg & Samuel, 2004; Van Hell & Dijkstra, 2002), we predicted that co-activation of German would be stronger in German-native bilinguals than in English-native bilinguals. This prediction was confirmed when the target was an English noncognate. Our findings replicated previous eye-tracking studies showing no second-language co-activation during native-language processing (Ju & Luce, 2004; Weber & Cutler, 2004). Moreover, findings are consistent with studies showing that, even when the second language is co-activated, the thresholds of its activation are more sensitive to language experience (Spivey & Marian, 1999; Marian & Spivey, 2003a, 2003b). In sum, the present study confirms that language proficiency influences extent of co-activation during language processing.

Further, results of the present study are consistent with previous findings that L2-features within native-language input facilitate L2 co-activation (Ju & Luce, 2004). Ju and Luce found that Spanish-native bilinguals co-activated English competitors when listening to Spanish words with English-specific Voice Onset Times. The present study suggests that L2-cues within native-language input are effective in boosting parallel language activation not only when they are acoustic in nature (VOTs), but also when they are lexical in nature (i.e., cognate status). The finding that co-activation of a lower-proficiency language increased in the presence of cognate targets, while co-activation of a higher-proficiency language did not, was also reflected in the time-course of competitor activation. In the cognate condition, onset and duration of parallel language activation differed for low-proficiency and high-proficiency languages. In English-native bilinguals, German competitors were co-activated later and remained active longer. In German-native bilinguals, German competitors were co-activated earlier and remained active for a briefer period of time. Previous eye-tracking studies have shown that the onset of co-activation reflected the location of ambiguity within a word (i.e., ambiguity resulting from shared word onsets occurred earlier than ambiguity resulting from shared rimes, Allopenna, Magnusson, & Tanenhaus, 1998). Further, previous studies have also shown that longer co-activation of competitors was associated with longer target-competitor ambiguity (Ju & Luce, 2004; Salverda, Dahan & McQueen, 2003; Weber & Cutler, 2004). Therefore, in the present study, earlier and shorter co-activation of competitors in the high-proficiency language suggests that ambiguity occurs earlier and is resolved faster when proficiency levels are high. This faster competition resolution in the high-proficiency language may be due to control mechanisms associated with that language.

More research is needed to examine whether increase of parallel language activation through cognate targets is consistent across various proficiency levels, or is limited to a specific proficiency level. Results of the present study suggest that the boosting effect provided by cognates may only hold for lower-proficiency languages. In contrast, previous findings suggest that cognates may only be processed cross-linguistically for higher-proficiency languages (e.g., Van Hell & Dijkstra, 2002). Van Hell and Dijkstra found that bilinguals with a highly proficient L2 and a less proficient L3 showed facilitation in an L1 lexical decision task for L1–L2 cognates, but not for L1–L3 cognates. These differences could be reconciled by taking into account the stage of activation targeted in the two studies. While the present study captured covert activation early in the processing stream, Van Hell and Dijkstra's study captured overt activation later in the processing stream (most likely at the decision level). It may be possible then, that for a low-proficiency language, cognate targets boost early co-activation, but that this co-activation is not sufficient to influence decision-level processes.

Finally, differences in language status and proficiency levels across groups may be responsible for the unexpected between-group differences observed. First, monolinguals looked at control items more often than bilinguals. It is possible that bilinguals were more sensitive to ambiguity between items and spent more time looking back and forth between pictures, thus reducing overall fixation times. These repeated saccades may have resulted in a lower percentage of overall fixations on competitor and control items in the bilingual groups. Second, English-native bilinguals fixated competitor and control items less often than German-native bilinguals, perhaps due to better command of the testing language, and easier identification of targets. In general, the overall percentage of looks observed in the present study was higher than the overall percentage of looks observed in previous eye-tracking studies (Marian & Spivey, 2003a, 2003b). These differences are likely due to differences in stimulus-presentation format (computer displays of pictures in the present study vs. actual objects in a real-world environment in Marian and Spivey, 2003a, 2003b). Greater distances (and a larger visual angle) between objects in the real-world experiments (Marian & Spivey, 2003a, 2003b) may have resulted in fewer overall fixations of objects. Yet, these differences between studies reflect overall percentages of looks rather than differences in looks to competitor and control items. Finally, previous studies suggest that the ability to perceive phonetic contrasts in a non-native language influences bilingual auditory language processing (e.g., Bradlow & Pisoni, 1999; Cutler et al., 2006; Ju & Luce, 2004; Weber & Cutler, 2004). While the present study aimed to quantify aspects of language proficiency by administering receptive vocabulary tests and an extensive questionnaire of language experience and proficiency, participants' ability to perceive non-native phonetic contrasts was not determined. It is likely that participants in the present study had high phoneme discrimination abilities (given high L2-comprehension abilities); however, future studies might consider employing specific tests of L2 phoneme discrimination.

Lexical status and parallel language activation

The equal parallel activation effects for cognate targets and noncognate targets in German-native bilinguals could be explained with two possible accounts, a semantic-involvement account and a language-inhibition account.

First, semantic factors may have guided identification of cognate targets during co-activation of high-proficiency German. Within-language mappings between form and meaning are stronger in a more proficient native language than in a less proficient non-native language (e.g., Kroll & Stewart, 1994). Therefore, German competitors may have been more susceptible to semantic influences in German-native bilinguals than in English-native bilinguals. Specifically, in a native language, strong mappings between form and meaning may reduce competition from other cohort members. Such a mechanism might influence recognition of cognate targets and noncognate targets disproportionately for two reasons. First, native language form-meaning mappings may be stronger for cognate targets than for noncognate targets. Cognates are especially likely to rely on the L1 scaffold during processing in a non-native language (De Groot & Keijzer, 2000; Kohnert, Windsor, & Miller, 2004). If L1 form-meaning mappings were stronger for cognate targets than for English-specific targets, then cognate selection would be facilitated, reducing the amount of competition. Second, semantic representations are more shared for cognate targets than for noncognate targets (De Groot & Nas, 1991; Van Hell & De Groot, 1998), thus facilitating cognate selection. The role of semantics in parallel language activation may be explored in future research by directly probing sensitivity to semantic factors during L1 vs. L2 co-activation. Specifically, within a similar eye-tracking paradigm, one might orthogonally vary the degree of semantic and phonological similarity of cognate translation equivalents (Tokowicz et al., 2002 found that semantic similarity and phonological similarity in cognates are dissociable). If semantic overlap played a larger role in L1 co-activation than in L2 co-activation, then semantic convergence in the presence of cognates might reduce L1 competition. Conversely, if semantic overlap played no role, then reduced competition from L1 would likely be due to form-level inhibition.

Second, an inhibition mechanism may have reduced co-activation of high-proficiency German during cognate processing. In German-native bilinguals, German is strongly co-activated during English word recognition. As a result, they may develop inhibition mechanisms to dampen co-activation of German beyond a certain level. The bilingual word-recognition system has to be extraordinarily flexible, allowing for quick switches between languages. An inhibition mechanism that dampens activation, instead of eliminating it at this early stage, is consistent with this need for flexibility. Cognate targets may be more influenced by such inhibition than English noncognate targets. Specifically, it is possible that, in German-native bilinguals, parallel language activation during cognate target processing exceeds parallel language activation during noncognate target processing, and that this additional activation is inhibited to minimize interference. A form-level inhibition mechanism that responds to increased co-activation during processing of cross-linguistically overlapping words may explain cognate processing in German-native bilinguals. While top-down inhibition mechanisms are generally absent from models of bilingual word recognition (e.g., Dijkstra & Van Heuven, 1998), they are present in bilingual models of language production, and have been proposed to modulate lexical-level word selection (e.g., Costa & Santesteban, 2004, proposed an inhibition mechanism in unbalanced bilinguals; Green, 1998, proposed a general inhibition account). Future studies need to explicitly test the inhibition mechanism along with other possible accounts of parallel processing during bilingual word recognition.

Phonological overlap and parallel language activation

Finally, preliminary examination of phonological overlap between targets and competitors suggested that presence of cognate targets increased bilinguals' sensitivity to cross-linguistic phonological overlap. For *cognate targets*, German activation was sensitive to increased target-competitor phonological overlap in both bilingual groups. Unexpectedly, however, for *English* (*noncognate*) targets, German activation was not sensitive to increased target-competitor phonological overlap. In the case of English-native bilinguals, absence of sensitivity to phonological overlap might be explained by overall floor-effects in the noncognate condition. In the case of

German-native bilinguals, absence of sensitivity to phonological overlap might be explained by cross-linguistic differences at the sub-phonemic level masking the effect of phonological overlap.[7] With noncognate targets, sub-phonemic language differences have been found to restrict a non-native language from becoming co-activated (Ju & Luce, 2004). As suggested earlier, it is likely that, for noncognates, German cohorts were activated strictly by bottom-up acoustic input. In contrast, for cognates, it is likely that German cohorts were activated by bottom-up acoustic input, as well as through between-language translation associations. Therefore, for cognate targets, parallel language activation may be less sensitive to differences at the sub-phonemic level. Finally, while the manipulation of phonological overlap yielded promising preliminary findings, the present study had only limited generalizability across items, likely due to the continuous nature of target-competitor phonological overlap across items. In sum, preliminary findings suggest that sensitivity to acoustic and phonological overlap during parallel language activation may vary depending on between-language integration of lexical representations in cognate- vs. noncognate targets.

CONCLUSION

Results of the present study suggest that language proficiency and lexical status influence the extent of bilingual parallel language activation. Specifically, a high-proficiency language is reliably co-activated in the presence of both cognate targets and noncognate targets. A less proficient language, however, is not always active, and its activation is boosted by the presence of cognate targets. These findings suggest that language proficiency influences extent of parallel language activation and that cognate targets may be used to covertly co-activate, prime, and support less proficient languages. Results have implications for the organisation and processing dynamics of the bilingual lexicon, and suggest that cognates may be linked to between-language cohorts via translation

[7] Alternatively, it may be the case that the German L1 cohort was highly co-activated, even with target-competitor low phonological overlap. The increased duration of competition may have had no additional effect on competitor activation, and no sensitivity to phonological overlap would have been observed. Such an account has to be questioned for two reasons. First, absence of phonological overlap effects should also be apparent in monolingual auditory word recognition; however, this is not the case. Monolingual priming studies suggest that degree of phonological overlap influences co-activation of two words (Slowiaczek & Hamburger, 1992). Further, Weber and Cutler (2004) found a target-competitor overlap effect in Dutch-native bilinguals who processed words with confusable vowels in their second language, English. Therefore, since phonological overlap effects have been found within native and non-native languages, the absence of phonological overlap sensitivity, due to overall high L1 co-activation, is not a plausible account.

equivalents. Results support high interactivity between languages during bilingual auditory word comprehension.

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