Covert Bilingual Language Activation through Cognate Word Processing: An Eye-tracking Study

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Abstract

The present study examined effects of cross-linguistic overlap and language proficiency on bilingual parallel language activation. Recognition of cognates (e.g., English *hen,* German *Henne*) was compared to recognition of non-cognates (e.g., English *bike,* German *Fahrrad*) in English-German bilinguals, German-English bilinguals, and monolinguals. In an eye-tracking paradigm, participants identified English cognate and non-cognate targets in picture displays that also contained German competitors with shared phonological onsets. The duration of phonological overlap between targets and competitors was manipulated. English-German bilinguals co-activated German competitors of cognate targets, while German-English bilinguals co-activated German competitors of non-cognate targets, as well as German competitors of cognate targets with high phonological overlap. These results suggest that proficiency in target and non-target languages, as well as cross-linguistic overlap, determine the extent of bilinguals' parallel language activation.

Keywords: bilingualism; psycholinguistics; eye-tracking; spoken language processing

Introduction

Bilinguals have been shown to simultaneously activate both languages during auditory word recognition. For instance, covert and automatic activation of the non-target language was found in bilinguals during spoken word recognition tasks in monolingual settings (e.g., Marian & Spivey, 2003a,b; Spivey & Marian, 1999). Using an eye-tracking paradigm (Tanenhaus et al., 2000), bilinguals' eye movements were monitored while they identified target items (e.g., a marker) in a display that also contained competitor items with shared phonological onsets in the other language (e.g., a stamp, Russian *marka*). Bilinguals looked more at between-language competitors than control items, suggesting parallel activation of the two languages.

The current study extends this paradigm to study cognates' contribution to bilingual parallel language activation. Cognate words are opportune translation equivalents that sound highly similar across two languages (e.g., English *cactus*, German *Kaktus*) and provide processing advantages for bilinguals. For example, children's immersion in a second-language (L2) environment can improve native language (L1) vocabulary via cognates learned in the L2 (Cunningham & Graham, 2000). Bilingual anomic aphasic patients perform better in naming tasks when targets are cognates than when they are non-cognates (e.g., Roberts & Deslauriers, 1999). Cognate targets may co-activate phonological cohorts in the non-target language to a greater extent than non-cognate targets; such co-activation can be gleaned from different patterns of competitor activation for cognate and non-cognate targets.

Proficiency and Cross-Linguistic Overlap

The architecture of the bilingual lexicon is dynamic, in that it changes throughout the language learning process (Kroll & Stewart, 1994). During initial learning stages, bilinguals establish form-level associations between translation equivalents. Once an L2 word's L1 translation has been activated via form-association, semantic access occurs through form-meaning links in the L1. Highly proficient bilinguals have also established direct form-meaning links in their L2. Recent research by Silverberg and Samuel (2004) using an L1 lexical decision task found that late bilinguals with high L2 proficiency showed *form* L1-L2 priming (suggesting L1-L2 connectivity at the form level), but no *semantic* L1-L2 priming (suggesting that semantic representations were not shared). However, late bilinguals with low L2 proficiency showed no priming (suggesting weak connections, and lack of between-language interactivity). These findings suggest that language proficiency influences parallel language activation, and that late bilinguals may not share semantic representations for non-cognate translation equivalents.

Cognates, on the other hand, have been found to share semantic representations. Greater effects of cross-language association priming were found for cognates than for non-cognates (De Groot & Nas, 1991), and responses to association generation were more consistent across languages for cognates than for non-cognates (Van Hell & De Groot, 1998). Moreover, in a monolingual setting, Dutch-English-French trilinguals, with highly proficient English but less proficient French, showed shorter association generation and lexical decision times for Dutch-English cognates than for non-cognates and for Dutch-French cognates (Van Hell & Dijkstra, 2002). These findings suggest that only proficient non-target languages contribute to cognates' shared semantic representations enough to facilitate cognate selection.

In addition to semantic representations, phonological representations are also more convergent for cognates than for non-cognates. Studies of word-retrieval during production, where phonological form is accessed last, have ascribed facilitation effects for cognates vs. non-cognates to shared phonological-level cognate representations (Costa, Caramazza & Sebastian-Galles, 2000). Similarly, receptive language tasks that rely on phonological activation, such as lexical decision (Dijkstra, Van Heuven, & Grainger, 1998; Van Hell & Dijkstra, 2002) and cross-script repetition priming (Nakayama, 2000), have yielded shorter reaction times for cognates than for non-cognates.

The Current Study

To examine the role of *proficiency* in parallel language activation, we recruited two groups of late bilinguals. One group was more proficient (native) in the target language, English, and the other group was more proficient (native) in the non-target language, German. To examine the role of *cross-linguistic overlap*, we used cognate and non-cognate target stimuli, and manipulated the extent of between-language phonological overlap between targets and competitors. Parallel activation of the non-target language was probed covertly using English-only auditory cues. In an eye-tracking task, participants identified pictures whose names they heard in the target language, while pictures of between-language competitors were also present. German co-activation was measured as the percentage of looks to competitors relative to controls. For non-cognate targets, we predicted that co-activation of a non-target L1 would be stronger than co-activation of a non-target L2. For cognate targets, form-level and meaning-level integration across languages were expected to modulate this pattern. We specifically predicted that form-level integration of cognate targets would result in increased sensitivity to phonological overlap for competitors of cognate targets compared to competitors of non-cognate targets.

Methods

Participants

Fourteen English-German bilinguals (Mean age = 25.6, SD = 8.9; 5 females), 15 German-English bilinguals (Mean age = 28.7, SD = 12.9; 7 females) and 13 monolingual controls (Mean age = 28.5, SD = 9.4; 7 females) participated. An additional monolingual was excluded due to exposure to German at work. The three groups did not differ in age [$F(2, 39) = 0.4$, $p = .7$]. Participants completed a Language Experience and Bilingual Status Questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2003). All bilinguals considered themselves dominant in their L1. The ages when they started learning the second language [English-German bilinguals: M = 11.8, SD = 8.6; German-English bilinguals: M = 10.9, SD = 2.4; $t(27) = 0.4$, $p = .7$], and became fluent in it [English-German bilinguals: M=17.4, SD =10.0; German-English bilinguals: M = 19.1, SD = 6.8; $t(27) = 0.5$, $p = .6$] were similar across groups. At the time of study, English-German bilinguals had more exposure to the target language, English (M = 86.2%, SD = 7.3) than German-English bilinguals [M = 74.0%, SD = 16.3; $t(27) = 2.6$, $p = .02$]; German-English bilinguals had more exposure to the non-target language, German (M = 23.1%, SD = 16.3) than English-German bilinguals [M = 11.1%, SD = 6.8; $t(27) = 2.6$, $p = .02$]. On the English Peabody Picture Vocabulary Test (PPVT-III, Dunn & Dunn, 1997), English-German bilinguals performed best (M = 195.4, SD = 3.9), followed by English monolinguals (M = 190.9, SD = 6.8), and German-English bilinguals [M = 172.7, SD = 15.2; $F(2, 39) = 30.2$, $p < .001$; LSD post hocs: $p < .05$). A German translation of the PPVT (version B, which consists of different pictures) was administered to all bilinguals, and German-English bilinguals (M = 193.9, SD = 7.6) performed better than English-German bilinguals [M = 178.6, SD = 18.2; $F(1, 27) = 8.9$, $p = .006$]. The bilingual groups did not differ in their L1 [$t(27) = .7$, $p = .5$] or L2 proficiency levels [$t(27) = 1.0$, $p = .3$].

Stimuli and Design

Stimulus displays consisted of panels with four pictures and a central fixation cross. Concurrent with pictures, auditory stimuli were "*click on the [target picture] and the [filler picture].*" The name of the target picture was presented 400 ms after picture onset. A total of 128 trials were prepared. In half of all trials, target pictures were cognates, and in the other half they were non-cognates. For both, cognate and non-cognate targets, a 2 x 3 x 3 design was employed, with *between-language competitor* (competitor, control) and *phonological overlap* (low, medium, high) as within-

Table 2: Sample stimuli across conditions. Phonological onset overlap between targets and competitors is underlined.

Target status	English Target	Phonological Overlap	German Competitor	Control
Cognate	*<u>c</u>offee (<u>K</u>affee)*	**Low**	*<u>K</u>reis (circle)*	*Eichel (acorn)*
	<u>he</u>n (<u>He</u>nne)	**Medium**	*<u>He</u>md (shirt)*	*Pfeil (arrow)*
	<u>fi</u>le (<u>Fe</u>ile)	**High**	*<u>Pfei</u>l (arrow)*	*Korb (basket)*
Non-cognate	*<u>p</u>umpkin (Kürbis)*	**Low**	*<u>P</u>uppe (doll)*	*Hase (rabbit)*
	<u>Cu</u>rtain (Gardine)	**Medium**	*<u>Ki</u>rsche (cherry)*	*Bagger (digger)*
	<u>pick</u>le (saure Gurke)	**High**	*<u>Pick</u>el (zit)*	*Decke (blanket)*

subjects factors, and *group* as a between-subjects factor. For an overview and sample stimuli, see Table 2.

Between-Language Competitor Within half of all trials (64 trials), target pictures were accompanied by pictures of between-language competitors, whose onset in German was phonologically similar to the target's onset in English. In the other half of all trials, phonologically dissimilar controls were inserted into the panel positions of the between-language competitors. Each between-language competitor's picture served as a neutral filler in a different trial.

Picture stimuli were selected from the IMSI Master Clips electronic database and the Alta Vista search engine, or hand-drawn. Pictures were black line drawings with gray shadings, balanced for thickness of line and shades within each display. Positioning of the pictures in quadrants I-IV of the visual display was controlled across trials, and the order of presentation of trials was counterbalanced across participants and conditions.

Phonological Overlap Phonological overlap between target words and between-language competitors was manipulated categorically with three levels, *low*, *medium*, and *high.* Generally, these categories corresponded to one-phoneme, two-phoneme and three-phoneme overlap, but final grouping was based on measurements of overlap in milliseconds, due to the time-sensitive nature of cohort activation (e.g., Marslen-Wilson, 1987). Acoustic overlap over time was measured using Sound Studio speech analysis software, and recordings of English experimental stimuli were compared to recordings of German competitors. Between both cognate and non-cognate targets, and their respective competitors, there were significant differences between the low (cognates: M = 33.9ms, SE = 6.0ms; non-cognate: M = 65.0ms, SE = 6.8ms), medium (cognates: M = 116.2ms, SE = 9.4; non-cognates: M = 120.1ms, SE = 4.7), and high (cognates: M = 253.5ms, SE = 26.2; non-cognates: M = 247.6ms, SE = 21.6) overlap conditions [cognates: F(2, 30) = 45.5, p < .001; non-cognates: F(2, 28) = 45.2, p < .001; LSD post-hocs: p < .05].

Recordings of auditory stimuli were made in a sound-proof booth (44, 100 Hz, 16 bits) by a female speaker of American English. Stimulus sets were balanced for spoken word frequency using the CELEX lexical database (Baayen, Piepenbrock, & Van Rijn, 1995; F(9, 310) = 0.4, p = .9).

Procedures and Apparatus

All participants were welcomed into the lab using English as the sole language of communication, and were told that the goal of the experiment was to find out how they processed English speech. After informed consent was obtained, participants were fitted with a head-mounted eye-tracker (ISCAN) and calibrated. They then read instructions on a computer screen (G4 Macintosh, 11″x 13.5″), after which the experimenter verbally reinforced important points, and answered questions. A five-trial practice session on neutral stimuli that did not re-occur during the experimental session allowed participants to become familiar with the task. The experimental session lasted approximately 20 minutes. Following the session, participants were administered the English Peabody Picture Vocabulary Test (PPVT). Bilingual participants were administered a German translation of the PPVT, version B, after a brief conversation to establish the language and ensure participants' comfort with it. Finally, all participants filled out the Language Experience and Bilingual Status Questionnaire (LEABS-Q).

Coding and Analyses

Eye-tracking data, in the form of video output (participants' field of view, fixation cross-hairs indicating position of gaze, and auditory instructions) were manually coded at a temporal resolution of 33.3 ms/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. A second coder coded approximately 15% of all data; inter-rater reliability computed using Pearson's R was 93.5%.

A total of 9.6% of data were excluded from analyses. Of these, 3.6% were excluded due to participants noticing German items, and 7.8 % were excluded due to problematic pictures, which drew more looks to competitors than controls in all groups, including monolinguals.

Cognate and non-cognate trials were analyzed using 2x3x3 repeated measures ANOVAs. Follow-up comparisons were conducted for significant interactions.

Results

Cognate Targets

Between-group Comparisons A direct comparison across the three groups revealed a 3-way interaction of Competitor, Phonological Overlap, and Group [F(2, 39) = 3.8, p = .03, = .2], as well as a 2-way interaction of Competitor and Group [F(2, 39) = 3.1, p = .048, = .1]. These interactions were followed-up with pair-wise comparisons. Three-way interactions of Competitor, Phonological Overlap, and Group were found, both when comparing monolinguals to English-German bilinguals [F(1, 25) = 4.6, p = .04, = .2], and when comparing monolinguals to German-English bilinguals [F(1, 26) = 6.6, p = .02, = .2]. Further, comparing monolinguals to English-German bilinguals yielded a 2-way interaction of Competitor and Group [F(1, 25) = 6.0, p = .02, = .2, see Figure 1]. Comparing English-German bilinguals to German-English bilinguals yielded a main effect of competitor [F(1,27) = 12.2, p = .002, = .3], where bilinguals looked more at competitors (M = 59.2%, SE = 2.4%) than at controls (M = 51.7%, SE = 2.6%). Moreover, an interaction of competitor and phonological overlap was found [F(1, 27) = 16.0, p < .001, = .4]. There was no 3-way interaction between competitor, phonological overlap and group [F(1, 27) = 0.2, p = .7, = .006], suggesting that the same interaction patterns of competitor and phonological overlap existed across both bilingual groups. The significant interactions obtained in between-group comparisons were followed-up with within-group ANOVAs and are reported below.

English Monolingual Controls Monolingual participants looked at between-language competitors 58.5% (SE = 2.8) of the time, and at controls 60.3% (SE = 4.3) of the time. Within-group ANOVAs yielded no significant effects of Competitor [F(1, 12) = 0.3, p = .6, = .02] or interactions of Competitor and Phonological Overlap [F(1, 12) = 0.4, p = .5, = .03], suggesting no differences across conditions.

English-German Bilinguals English-German bilingual participants looked at competitors 55.9% (SE = 2.9) of the time, and at controls 46.8% (SE = 3.5) of the time, yielding a main effect of Competitor [F(1, 13) = 9.3, p = .009, = .4]. In addition, an interaction of Competitor and Phonological Overlap was found [F(1, 13) = 6.1, p = .03, = .3], with an equal percentage of looks to competitors (M = 54.8%, SE = 4.3) and controls (M = 54.0%, SE = 5.3) at low phonological overlap [t(13) = 0.2, p = .9], a greater percentage of looks to competitors (M = 55.7%, SE = 4.4) vs. controls (M = 45.1%, SE = 3.8) at medium phonological overlap [t(13) = 2.6, p = .02], and a greater percentage of looks to competitors (M = 57.4%, SE = 4.5) vs. controls (M = 41.2%, SE = 5.0) at high phonological overlap [t(13) = 2.9, p = .01].

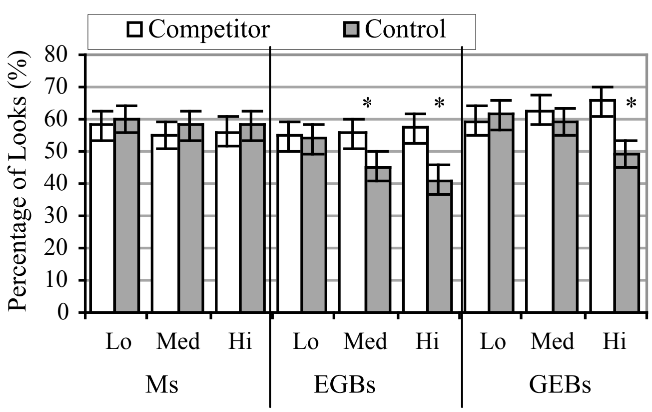

Figure 1: Percentage of looks to competitors and controls in the low, medium, and high phonological overlap conditions, for monolinguals (Ms), English-German bilinguals (EGBs), and German-English bilinguals (GEBs) when the targets were cognates.

German-English Bilinguals German-English bilingual participants looked at competitors 62.5% (SE = 3.7) of the time, and at controls 56.6% (SE = 3.9) of the time; the difference did not reach significance [F(1, 14) = 3.6, p = .08, = .2]. However, as in the English-German bilingual group, an interaction of Competitor and Phonological Overlap was observed [F(1, 14) = 10.2, p = .007, = .4]. There was an equal percentage of looks to competitors (M = 59.3%, SE = 4.8) and controls (M = 61.5%, SE = 4.5) at low phonological overlap [t(14) = 0.5, p = .6], an equal percentage of looks to competitors (M = 62.6%, SE = 3.6) and controls (M = 59.2%, SE = 3.8) at medium phonological overlap [t(14) = 0.8, p = .4], and a higher percentage of looks to competitors (M = 65.6%, SE = 5.0) vs. controls (M = 49.1%, SE = 5.7) at high phonological overlap [t(14) = 3.1, p = .007].

Non-cognate Targets

Between-group Comparisons A direct comparison across the three groups revealed a 2-way interaction of Competitor and Group [F(2, 39) = 3.2, p = .049, = .1]. Follow-up pair-wise comparisons revealed that the competitor-group interaction was significant only between monolinguals and German-English bilinguals [F(1, 26) = 4.0, p = .047, = .1], but was not significant between monolinguals and English-German bilinguals [F(1, 25) = 0.005, p = .9, < .001], or between English-German bilinguals and German-English bilinguals [F(1, 27) = 3.6, p = .07, = .1].

English Monolingual Controls Monolingual controls looked at competitors 55.1% (SE = 2.9) of the time, and at controls 54.6% (SE = 3.8) of the time. A follow-up ANOVA within the monolingual group yielded no main effect of competitor [F(1, 12) = 0.1, p = .8, = .006].

English-German Bilinguals English-German bilingual participants looked at between-language competitors 46.4% (SE = 3.3) of the time, and at controls 45.7% (SE = 3.6) of the time. No main effect of competitor was found [F(1, 13) = 0.08, p = .8, = .006], suggesting that English-German bilinguals did not co-activate the non-target language when the target was a non-cognate. At low phonological overlap, English-German bilinguals looked at competitors 40.0% (SE = 4.9) of the time and at controls 30.5% (SE = 4.9) of the time. At medium phonological overlap, they looked at competitors 47.2% (SE = 5.7) of the time and at controls 54.8% (SE = 5.9) of the time. At high phonological overlap, they looked at competitors 52.0% (SE = 5.3) of the time and at controls 52.0% (SE = 4.2) of the time. No interaction of competitor, phonological overlap, and group (Monolingual, English-German bilingual) was present.

German-English Bilinguals German-English bilingual participants looked at competitors 65.9% (SE = 3.2) of the time, and at controls 56.2% (SE = 3.6) of the time, yielding a main effect of competitor [F(1, 14) = 5.6, p = .03, = .3]. This suggests that German-English bilinguals co-activated the non-target language when the target was a non-cognate. At low phonological overlap, German-English bilinguals looked at competitors 64.7% (SE = 4.7) of the time and at controls 52.1% (SE = 5.1) of the time. At medium phonological overlap, they looked at competitors 65.8% (SE = 5.5) of the time and at controls 62.2% (SE = 5.5) of the time. At high phonological overlap, they looked at competitors 67.0% (SE = 4.8) of the time and at controls 54.3% (SE = 4.9) of the time. No interaction of competitor, phonological overlap, and group (Monolingual, English-German bilingual) was present.

Discussion

The present study employed eye-tracking to investigate covert activation of a non-target language. When the target language was an L1 (i.e., English for English-German bilinguals), competitors from the non-target L2 were co-activated in the presence of cognate targets, but not in the presence of non-cognate targets. When the target language was an L2 (i.e., English for German-English bilinguals), competitors from the non-target L1 were co-activated in the presence of cognate targets only when high phonological overlap existed between the competitors and the targets. Further, competitors were consistently co-activated in the presence of non-cognate targets. These findings suggest that parallel activation of two languages depends on relative proficiency levels in the target and non-target languages, as well as on cross-language overlap.

Cognate and Non-cognate Status

The pattern of competitor activation with cognate and non-cognate targets differed when the non-target language was an L1 compared to when it was an L2. L2 competitors were co-activated in the presence of cognate targets, but not in the presence of non-cognate targets, suggesting that cognate targets facilitated L2 competitor activation. L1 competitors were co-activated in the presence of cognate targets only when there was high phonological overlap, while being consistently activated in the presence of non-cognate targets.

Cognate Status We propose that during cognate processing in L2, L1 co-activation contributes strongly to activation of shared semantic representations, making competition from the L1 competitor unlikely. However, during cognate processing in L1, L2 co-activation contributes less to activation of shared semantic representations, which makes competition from the L2 competitor more likely. How does this L1-L2 'asymmetry' evolve? The Revised Hierarchical Model (RHM, Kroll & Stewart, 1994) suggests that late bilinguals learn their L2 via form-association, resulting in strong form-level connections between the two lexicons. While within-language form-meaning connections are strong in the L1, and L2 meaning is initially accessed via L1, the fluent late bilingual has also developed direct form-meaning links within L2. Other findings suggest that in late bilinguals semantic representations are generally not shared (Silverberg & Samuel, 2004), while cognates may be the exception to this rule (e.g., De Groot & Nas, 1991). Due to cognates' high form-level similarity, L2 cognate acquisition may rely heavily on existent L1 representations. Semantic access of L2 cognates may proceed through L1 representations for a longer time. When direct form-meaning links *are* established in L2, parallel semantic access through the strong L1 pathway (and onto shared representations) may prevail (Dijkstra & Van Hell, 2002). Thus, L1s continuous and consequently strong activation during cognate processing may account for its influence on semantic activation (and selection) of target L2 cognates. Further, strong co-activation of the non-target L1 pathway, leading onto shared semantic representations, may reduce the chance that L1 competitors will be co-activated to the level necessary to compete.

Non-cognate Status For non-cognate targets, consistent co-activation of L1 competitors, but not L2 competitors was found. This pattern is likely due to activation levels of the non-target language. Two determining factors for activation levels are overall proficiency and exposure. Since German-English bilinguals were more proficient in the non-target language, German competitors may have been more readily activated in this group. The lack of L2 co-activation in English-German bilinguals is consistent with Weber and Cutler (2004) who, using a similar eye-tracking paradigm, did not find L2 activation in Dutch-English bilinguals with a less proficient L2. Furthermore, at the time of study, German-English bilinguals had more exposure to the non-target language than English-German bilinguals. A series of eye-tracking studies suggest that recent exposure to a language may influence the extent of parallel language activation (Marian & Spivey, 2003b; Spivey & Marian, 1999). Asymmetric co-activation was found in a study in which bilinguals were immersed in their L2 country: while L2 was co-activated during L1 processing, L1 was *not* co-activated during L2 processing (Spivey & Marian, 1999). In other words, only the non-target language that was subject to high exposure was co-activated. In a follow-up experiment, preliminary measures were taken to boost L1 exposure, and results yielded L1 co-activation during L2 processing (Marian & Spivey, 2003b). In the current study, the higher levels of recent exposure to the non-target language in German-English bilinguals compared to English-German bilinguals, provide another reason for L1 co-activation in the former group.

The results in the non-cognate condition confirm previous findings, and suggest that non-target language resting activation, as influenced by proficiency and recent exposure, determines the degree of parallel activation. Findings with cognate targets suggest that where a non-target language is not prominent enough to be activated in parallel, such co-activation *does* occur with highly integrated lexical representations across languages.

Phonological Overlap and Lexical Status

The current study suggests that the effect of phonological overlap between targets and competitors depends on the lexical status of the target. When the target was a cognate, both bilingual groups looked more at competitors, relative to controls, as phonological overlap increased, suggesting that increased phonological overlap leads to increased parallel language activation. On the other hand, when the target was a non-cognate, increased parallel activation with increased phonological overlap was not found. Cognates have close form-level connections between languages, created by both, phonological overlap, as well as early learning by form-association. This may result in higher sensitivity to phonological overlap during competitor activation. Moreover, co-activation of the cognate's translation equivalents leads to phonological overlap between the target and the competitor *within* the non-target language. For non-cognate targets, where translation equivalents are not similar at the form level, and phonological overlap is strictly *between* languages, the amount of phonological overlap does not appear to influence the extent of between-language competitor activation as directly. In sum, our findings for phonological overlap manipulations suggest language co-activation through integrated form-level representations in the case of cognates, but less so for non-cognates.

Conclusion

In the present study of bilingual parallel language activation, findings with cognate targets, non-cognate targets, and varied phonological overlap suggest that proficiency levels, as well as overlap between languages, determine the extent of parallel language activation. We suggest that the pathway of second language word learning relies on form similarity to translation equivalents in the native language and shapes within-language and between-language representations. In turn, these mappings in the bilingual lexicon influence the nature of parallel language activation.

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