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Cross-language activation in children's speech production: Evidence from second language learners, bilinguals, and trilinguals

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ABSTRACT

In five experiments, we examined cross-language activation during speech production in various groups of bilinguals and trilinguals who differed in nonnative language proficiency, language learning background, and age. In Experiments 1, 2, 3, and 5, German 5- to 8-year-old second language learners of English, German–English bilinguals, German–English–Language X trilinguals, and adult German–English bilinguals, respectively, named pictures in German and in English; in Experiment 4, 6- to 8-year-old German monolinguals named pictures in German. In both language conditions, cognate status was manipulated. We found that the bidirectional cognate facilitation effect was significant in all groups except the German monolinguals (Experiment 4) and, critically, the child second language learners (Experiment 1) in whom only native language (L1) German had an effect on second language (L2) English. The findings demonstrate how the integration of languages into a child's system follows a developmental path that, at lower levels of proficiency, allows only limited cross-language activation. The results are interpreted against the backdrop of the developing language systems of the children both for early second language learners and for early bi- and trilinguals.

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Introduction

One of the fascinating phenomena in bilinguals' speech is the ease with which they access lexical items from both languages. Past research on bilingual speech production, in which adult bilinguals were asked to produce words in one of their languages in various experimental settings, shows that the language not in use is also activated during language retrieval and influences performance in the target language (Colomé, 2001; Costa, Caramazza, & Sebastián-Gallés, 2000; Hermans, Bongaerts, de Bot, & Schreuder, 1998; Hermans, Ormel, Besselaar, & Van Hell, in press; Kroll, Bobb, & Wodniecka, 2006). This evidence suggests that a bilingual's two languages are coactivated and compete for selection during the lexical retrieval process. Previous studies have mainly focused on adult and proficient bilinguals. In this article, we report five experiments in which we examined to what extent the nontarget language becomes activated during target language speech production in bilingual and trilingual children and adults with different levels of proficiency in their second and third languages and with different language learning backgrounds. Before discussing these experiments, we review current evidence on adult bilingual speakers' picture naming, a task that has been frequently used to examine lexical access in speech production and that we also used in our experiments.

Costa and colleagues (2000), Kroll, Dijkstra, Janssen, and Schriefers (2000), and Hoshino and Kroll (2008) studied the effect of language-specific properties and explored whether the nontarget language phonological representations of to-be-named pictures are coactivated during picture naming using cognate and noncognate stimulus materials. Cognates are orthographically and phonologically similar translation equivalents, for example, the English–German translations *apple–Apfel*. Noncognates have no orthographic and phonological overlap, for example, the English–German translations *tree–Baum*. Cognates have been used extensively in research investigating the bilingual mental lexicon because they allow a means to tap into how bilinguals, even in language-exclusive settings, show influences from their other language. The logic is that if the phonological representations in both the target and nontarget languages are retrieved, participants should be faster at naming pictures with cognate names than at naming pictures with noncognate names. With adult highly proficient Catalan–Spanish bilinguals, who had been exposed to their two languages from an early age onward, Costa and colleagues (2000) indeed found a cognate facilitation effect in both native language (L1) and second language (L2) blocked naming, albeit with a greater magnitude in the latter condition. These results suggest that, first, the nontarget language is also activated up to the level of phonology during retrieval and, second, language dominance plays a role inasmuch as that the stronger language exerts more influence on the weaker language than vice versa.

In Kroll and colleagues' (2000) study, adult fairly proficient, unbalanced Dutch–English bilinguals named pictures with cognate and noncognate names. In contrast to the participants in Costa and colleagues' (2000) study, these bilinguals had learned English only at around 10 to 11 years of age at primary school and were not immersed in an L2 environment. A cognate facilitation effect was observed in the blocked L2 condition but not in the blocked L1 condition.

Whereas in these studies same-script bilinguals performed the experimental tasks, Hoshino and Kroll (2008) compared cross-language interaction in adult highly proficient same-script Spanish–English bilinguals with that in different-script Japanese–English bilinguals. All bilinguals had started acquiring their L2 English at around 10 years of age but had been immersed in an L2 environment between 28 and 40 months at the time of testing. The results showed a cognate facilitation effect in the L1 and L2 of both groups of bilinguals.

What is the theoretical explanation of the cognate facilitation effect in bilingual speech production tasks such as picture naming? In general, when naming a picture, a speaker first needs to identify the object, retrieve its meaning, map the meaning to the appropriate word form, and retrieve the phonology associated with that word (e.g., Dell, 1986; Levelt, Roelofs, & Meyer, 1999). The cognate facilitation effect is seen as evidence for parallel lexical activation of word candidates from the two languages in bilingual speakers. Both the language in which an utterance is to be made and the language not intended for use are activated, after which nontarget language activation is finally inhibited to allow target language production (e.g., Costa, Santesteban, & Caño, 2005; Green, 1998; Hermans et al., 1998; Kroll et al., 2006; Poulisse & Bongaerts, 1994). Critically, with cognate words, activation is spread in

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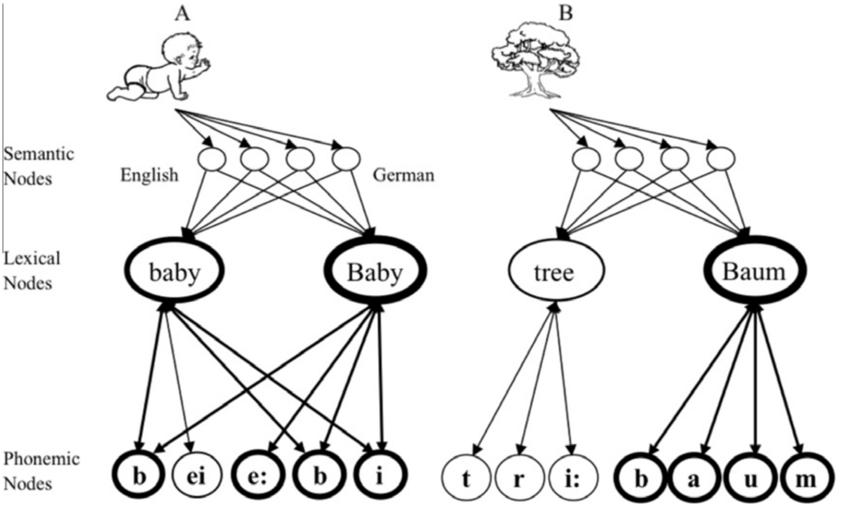

Fig. 1. Schematic representation of picture naming in German by German–English bilinguals: (A) cognates; (B) noncognates. (Adapted from Costa et al. (2005). On the facilitatory effects of cognate words in bilingual speech production. *Brain and Language 94*, 101). Copyright 2005 by Elsevier.

parallel to both the target word's and the nontarget word's phonological representation. As depicted in Fig. 1, this then results in overall higher activation, also caused by the phonological overlap evident in these cognate words. In contrast, noncognate words receive activation from only one language, namely the target language.

So far, the cognate facilitation effect in speech production has been shown with adult speakers of various languages and with different relative language proficiencies in their L1 and L2. Critically, the effect has not consistently been found in both the L1 and L2. As reported above, Costa and colleagues (2000) found significant cognate facilitation in both languages in highly fluent Spanish–Catalan speakers, although the magnitude of the effect was smaller in L1 than in L2. In contrast, Kroll and colleagues (2000) found the cognate effect in the L2 only in Dutch–English bilinguals, who showed greater dominance in their L1 compared with the bilinguals in Costa and colleagues' (2000) study. Relative language proficiency, thus, seems a likely factor to affect cross-language activation and the magnitude of cognate facilitation. A second factor that may affect cross-language activation in bilingual speech production is age of acquisition of the L2. Typically, age of acquisition is related to the amount of language exposure, so bilinguals who acquired their L2 at a younger age will have had an increased exposure to their L2. Moreover, a bilingual's extended use of two languages in various settings, and switching back and forth between two languages, may increase cross-language permeability during speech performance.

Furthermore, the bilinguals tested by Costa and colleagues (2000) had learned the L2 earlier in life than the bilinguals in Kroll and colleagues' (2000) study and had had continuous L2 input in the environment. To address the above-mentioned issues, in the current study four groups of children were studied, three of which had had continuous daily L2 input (i.e., L2 learners of English, bilinguals, and trilinguals) and a monolingual age-matched control group. Focusing on these four distinct groups of children offers (a) a view into developing multiple language systems with varied relative language proficiencies, (b) a more controlled assessment of previous language input in L1 and L2, and (c) varied language balances linked to both quantity of input and age of L2 onset.

The current study

Few (if any) studies have explored the cognate facilitation effect in language production in multilingual children, particularly children of varying levels of L2 proficiency and children who have productive knowledge of not only two but three languages (see Brenders, Van Hell, & Dijkstra, 2011, for cognate effects in word recognition in child L2 learners). A study by Jescheniak, Hahne, Hoffmann, and Wagner (2006) on monolingual children suggests that lexical retrieval in children may differ fundamentally from that in adults. Jescheniak and colleagues explored within-language competitor effects in lexical retrieval of 7-year-old monolinguals and observed mediating effects that had previously not become evident in testing adult speakers. More specifically, they argued that because "the lexical retrieval system has not gained maximum efficiency" (p. 374), it could be particularly insightful to examine lexical retrieval in children. Jescheniak and colleagues, furthermore, pointed out that children perform much more slowly than adults in lexical tasks, giving researchers a greater time window to observe lexical retrieval processes in children. For the current study, the slower processing of children as compared with adults may lead to two possible patterns of cognate effects. First, the overall slower performance of children could lead to a greater decay in activation over time during lexical retrieval (see, e.g., Dell, 1986, for activation and decay rates), which in turn may lead to little or no coactivation of a bilingual's languages. So, by the time children are ready to say out loud the name of the picture, activation of the nontarget language has decayed and no cognate effect will be observed in the ultimate response. Alternatively, slower language processing in children lengthens the time window for language coactivation and, therefore, may boost the cognate effect. Dell and O'Seaghdha (1992) noted for adults' lexical retrieval that their "performance may be so fast and skilled that it is largely immune to interference and insensitive to facilitation" (p. 308). The slower language processing in children will increase the duration of coactivation of languages, which should be reflected in observable cognate effects. It should be particularly informative to see whether and how cross-language activation becomes evident in groups of children with varying language dominance and whether this coactivation is modulated by relative proficiency. In sum, because children's lexical processing has not yet reached adult efficiency levels, we cannot simply assume that patterns of coactivation of languages observed in bilingual adults will be identical for bilingual children. Moreover, the cognate facilitation effect offers an avenue to further explore possible differences in cross-language activation across the lifespan, in the current study with a specific focus on child second language learners, bilinguals, and trilinguals.

Studying children with different L1 and L2 proficiencies also provides more insight into the role of relative language proficiency in modulating cognate effects. More specifically, larger relative proficiency asymmetries between L1 and L2 (i.e., language dominance asymmetries) should also yield larger asymmetric cognate effects in L1 and L2.[1]

Lexical retrieval in the still developing language systems of early bi- and trilinguals and child second language learners was the main focus of the current study. The absence of research on cognate effects in bilingual children's language production was the starting point for this study, which builds empirically on data obtained with adult bilinguals. More specifically, we examined whether the production of a target word in one language also activates the nontarget language up to the phonological level by asking children to name pictures with cognate and noncognate names presented in one-language-only blocks. Four groups of children and one adult group participated: German L2 learners of English (Experiment 1), German–English bilinguals (Experiment 2), German–English–Language X trilinguals (Experiment 3), German child monolingual controls (Experiment 4), and adult German–English bilinguals (Experiment 5).

Predictions

For Experiments 1 to 3 and Experiment 5, the first prediction was that cognates would be named faster and more accurately than noncognates, thereby showing a cognate facilitation effect in both languages. Second, because all participants were more proficient in their L1 than in their L2, it was also predicted that the cognate facilitation effect magnitudes would be larger in the L2. Third, because the bilinguals in Experiment 2 were more proficient in their L2 English than the participants in

[1] Another factor that has been found to modulate the magnitude of the cognate effect is the amount of phonological overlap of cognates. We did not manipulate this variable, but see Schwartz, Kroll, and Diaz (2007) and Dijkstra, Grainger, and Van Heuven (1999) for studies in which phonological overlap was manipulated.

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Experiments 1 and 3, the magnitude of differences in naming latencies between L1 and L2 was predicted to be smaller for bilinguals in Experiment 2. Finally, participants' naming latencies in L1 German in Experiments 1 to 3 should be longer than those of their monolingual peers tested in Experiment 4 simply because performance of monolinguals is not affected by cross-language competition.

Experiment 1: Picture naming in child second language learners

Method

Design

A 2 (Cognate Status: cognate or noncognate) by 2 (Language: German or English) factorial design was used.

Participants

The participants were 21 children (9 girls and 12 boys) whose ages ranged from 5.1 to 8.2 years ($M = 7.28$ years, $SD = 0.76$). All children were L2 learners of English enrolled in a bilingual German–English immersion kindergarten or primary school in Frankfurt, Germany (length of English immersion: $M = 1.50$ years, $SD = 0.62$) and spoke German as their native language (L1) and English as their second language (L2). None of the children had grown up with or had had any continuous exposure to languages apart from standard German since birth.

Children's language proficiencies in German and English were assessed by the Tests for Reception of Grammar in English (TROG-2) and in German (TROG-D) (see "Materials" section below for a detailed description). Table 1 displays the TROG results for Experiments 1 to 4. The children in Experiment 1 scored substantially higher in German ($M = 111.13$) than in English ($M = 69.63$), $t(18) = 11.66$, $p < .001$, reflecting their higher proficiency in German than in English.

Children's parents signed a consent form and filled in a questionnaire on their education levels and language history. Parents' education levels were considered to represent the families' socioeconomic status (e.g., Hoff, 2003). Mothers' highest levels of education were as follows: middle school (5.6%), high school (5.6%), bachelor's degree (44.4%), master's degree (38.9%), and doctoral degree (5.6%). Fathers' highest levels of education were as follows: middle school (16.7%), high school (5.6%), bachelor's degree (22.2%), master's degree (27.8%), and doctoral degree (27.8%).

The language background questionnaires (using 5-point scales: 1 = *no proficiency* to 5 = *native-like proficiency*) indicated that parents rated themselves as highly proficient in speaking German (mothers: $M = 4.94$, $SD = 0.24$; fathers: $M = 4.89$, $SD = 0.32$) and as rather proficient in speaking English (mothers: $M = 3.06$, $SD = 1.31$; fathers: $M = 3.39$, $SD = 1.38$).

Table 1
Parents' ratings of children's proficiencies and TROG-D and TROG-2 results in Experiments 1 to 4.

Language group	Parents' rating[a] German	Parents' rating[a] English	TROG score German standard score[b]	TROG score English standard score
Experiment 1: L2 learners	4.61 (0.61)	1.61 (0.85)	111.13 (11.95)	69.63 (12.77)
Experiment 2: Bilinguals	4.95 (0.23)	4.21 (0.86)	109.21 (19.21)	106.00 (16.51)
Experiment 3: Trilinguals	4.87 (0.52)	2.93 (1.34)	105.50 (18.82)	89.20 (23.62)
Experiment 4: Monolinguals	4.93 (0.26)	1.00 (0.00)	109.00 (12.36)	58.60 (5.01)

Note. Standard deviations are in parentheses.
[a] Parents' rating follows a 5-point language proficiency scale (1 = *no proficiency*, 2 = *low proficiency*, 3 = *moderate proficiency*, 4 = *moderate to high proficiency*, 5 = *native-like proficiency*).
[b] German standard score calculated on the basis of the TROG-D T-score in a range of 20 to 80 ($M = 50$, $SD = 10$) and, for easier comparison, transferred to the TROG-2 English standard score range of 55 to 145 ($M = 100$, $SD = 15$). Formula for converting T-scores into standard scores: $b = \{[(a – a \text{ mean})/a \text{ SD}] \times b \text{ SD}\} + b$ mean, where a = T-score and b = standard score.

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Materials

The materials consisted of the experimental stimuli and the Tests for Reception of Grammar (TROG-2 and TROG-D).

Stimuli experiment. For the picture naming task, 84 black-on-white line drawings of common objects were selected from the International Picture Naming Project database (Székely et al., 2004). These consisted of 28 cognate and 28 noncognate name pictures in both German and English (14 cognates and 14 noncognates were identical in both language conditions; see stimuli list in Appendix A).

The cognate and noncognate picture names in German and in English were matched on frequency (Baayen, Piepenbrock, & Van Rijn, 1993); word length, name agreement, and visual complexity (Székely et al., 2004); imageability (Lahl, Goeritz, Pietrowsky, & Rosenberg, 2009); and age of acquisition (German: Schroeder, Kauschke, & De Bleser, 2003; English: Morrison, Chappell, & Ellis, 1997). Stimuli characteristics are listed in Table 2. The distribution of onset phonemes was similar across both conditions (German cognates and noncognates: 14 plosives and 14 nonplosives; English cognates: 13 plosives and 15 nonplosives; English noncognates: 14 plosives and 14 nonplosives). A total of 15 practice items with similar characteristics as the critical items were selected for the practice trials.

Test for Reception of Grammar. The TROG, developed by Bishop (2003) for English (TROG-2) and, in a revised version, by Fox (2006) for German (TROG-D), measures children's receptive language proficiency. We administered the tests with a 2-week time lag between tests to prevent any spillover effects. (Note that half of the materials are different in the two tests.). Raw scores were transformed into standard scores. The results were used only as a within-group comparison of language proficiency as well as a within-participant measure to establish language balance.

Apparatus and procedure

The experiment was programmed in E-Prime (Schneider, Eschman, & Zuccolotto, 2002) and run on a Pentium computer. Voice onset was measured using a microphone (Philips SBC ME570) connected to an E-Prime serial response button box.

Table 2
Stimuli Characteristics for Experiments 1 through 4 and Experiment 5.

	Experiments 1 to 4				Experiment 5			
	German		English		German		English	
	Cognate	Noncognate	Cognate	Noncognate	Cognate	Noncognate	Cognate	Noncognate
Log frequency	1.24 (.64) $t(54) = .89, p = .38$	1.10 (.48)	1.33 (.62) $t(54) = .10, p = .92$	1.35 (.48)	2.73 (1.26) $t(54) = .26, p = .79$	2.62 (1.07)	2.87 (1.16) $t(54) = 1.16, p = .25$	2.49 (1.28)
Word length (in syllables)	1.75 (.75) $t(54) = .19, p = .85$	1.79 (.69)	1.89 (.74) $t(54) = .72, p = .48$	1.75 (.75)	1.75 (.65) $t(54) = .20, p = .85$	1.71 (.71)	1.71 (.66) $t(54) = .54, p = .59$	1.82 (.82)
Name agreement	.95 (.10) $t(54) = 1.73, p = .09$	.89 (.18)	.95 (.09) $t(54) = .67, p = .51$	.93 (.12)	.94 (.13) $t(54) = 1.23, p = .22$	.89 (.15)	.93 (.13) $t(54) = 1.72, p = .09$	.87 (.16)
Visual complexity	17485 (9105) $t(54) = .66, p = .51$	16049 (7117)	17448 (10337) $t(54) = .92, p = .36$	15371 (6008)	21391 (13398) $t(54) = 1.46, p = .19$	16647 (10788)	18845 (9773) $t(54) = 1.59, p = .12$	15446 (5761)
Imageability[a]	6.34 (.25) $t(54) = .29, p = .59$	6.30 (.27)	8.96 (.99) $t(54) = .03, p = .86$	8.99 (.50)	6.36 (.26) $t(54) = 1.75, p = .19$	6.26 (.29)	9.02 (.52) $t(54) = .05, p = .83$	9.05 (.46)
Age of acquisition	2.30 (.67) $t(54) = .06, p = .81$	2.34 (.44)	2.33 (.71) $t(54) = .62, p = .44$	2.08 (.66)	2.23 (.58) $t(54) = .73, p = .40$	2.46 (.53)	2.41 (.61) $t(54) = .92, p = .34$	2.23 (.72)

Note. Standard Deviations are in parentheses.
[a] Imageability for the German stimuli was determined using 7-pointLikert-scale, while for theEnglish stimuli a 10-point-Likert-scale was used.

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Participants were tested individually and were seated in a dimly lit room approximately 50 cm from the monitor. They were asked to name the objects on the screen as quickly and accurately as possible in the target language, speaking into the microphone set before them. Throughout each of the two language conditions, the experimenter used exclusively the language in which the pictures were to be named by the participants. Each language condition was set up in four blocks, the first of which was 15 practice trials used to familiarize the participants with the experimental procedure and, if necessary, to give them additional instructions. Each of the following three experimental blocks (two blocks of 19 stimuli and one block of 18 stimuli) was started with a button press by the researcher.

Each experimental trial was structured as follows. A fixation sign was displayed for 1000 ms, followed by a picture (whose visual onset was accompanied by an auditory cue) for 5000 ms or until the participants responded. Trials were presented in random order with the restriction that the following target picture name did not have an identical initial phoneme. The experimenter used a coding sheet to keep track of the participants' utterances, and the experiment was digitally recorded for later analysis. Participants performed the picture naming task in the first of the two language conditions, followed by a break of approximately 4 min during which the experimenter switched to the language of the upcoming condition and engaged the participants in a brief dialogue in the language of the upcoming block, and then the participants performed the picture naming task in the second language condition. All participants in Experiments 1 to 3 named 56 stimuli in the German language condition first; in the second block of naming, which was English, 28 of the stimuli (50.0%, 14 cognates and 14 noncognates) were novel and 28 stimuli (50.0%, 14 cognates and 14 noncognates) were identical to those in the German language condition and, thus, were repeated in the English condition. The order German before English was based on the children's language dominance (as based on the parents' ratings and the TROG results described above). The experiment lasted approximately 20 min.

A final remark on the order of the language conditions seems pertinent at this point. According to Grosjean's (2001) concept of language modes, words in both of a bilingual's languages are activated if the experimental context calls for the use of both languages; this exemplifies the bilingual language mode. In contrast, when the experimental context is limited to one language (the monolingual mode), only words from this language become active. All children in this study lived in Germany and were immersed in a German environment outside of school, so we decided that German should be the first language of naming. Moreover, we explicitly divided the two language conditions by adding a brief pause between naming in German and naming in English during which the experimenter initiated conversation in English, the upcoming language in the experiment, thereby generating a monolingual mode as much as possible (for more extensive discussions on language mode, cognate effects, and language proficiency, see Dijkstra & Van Hell, 2003; Van Hell & Dijkstra, 2002).

Results and discussion

For each participant and item, mean naming latencies and mean percentages of errors and omissions were calculated for the cognates and noncognates in German and in English. An omission was scored if the participant had not responded within 5000 ms after picture presentation. In this and the following experiments, we excluded the data of children who had named less than 10% of the stimuli correctly (and without voice key registration failures) in one of the language conditions. This criterion led to the exclusion of 2 children (who had named less than 10% of the stimuli in one of the English conditions). Trials associated with voice key failures (e.g., mouth clicks, stutters, false starts; 12.6% in German and 7.4% in English) and incorrect responses were excluded from the RT analysis. Outliers with response times (RTs) shorter than 200 ms or longer than 2.5 standard deviations above the participant's mean (2.1% in German and 0.5% in English) were also excluded from the RT analyses. 2 (Cognate status: cognates or noncognates) by 2 (Language: German or English) analyses of variance (ANOVAs) were performed separately on the mean participant RTs of the correct responses and on the mean error–omission rates. Cognate status and language were treated as within-participant variables. The corresponding ANOVAs were performed on the mean item RTs and the mean

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error–omission rates, treating cognate status and language as between-item factors.[2] We also performed one-factor (Cognate Status: cognate or noncognate) ANOVAs on the data in each of the language conditions separately. The resulting means and standard deviations are presented in Table 3.

The overall ANOVA on the RT data yielded a significant interaction between cognate status and language, $F_1(1,18) = 15.78$, $MSE = 24551.96$, $p = .001$, $\eta_p^2 = .47$, $F_2(1, 108) = 5.27$, $MSE = 78388.84$, $p = .024$, $\eta_p^2 = .05$, and significant main effects for cognate status, $F_1(1,18) = 29.65$, $MSE = 18497.48$, $p < .001$, $\eta_p^2 = .62$, $F_2(1,108) = 7.82$, $MSE = 78388.84$, $p = .006$, $\eta_p^2 = .07$, and language, $F_1(1,18) = 55.68$, $MSE = 131829.98$, $p < .001$, $\eta_p^2 = .76$, $F_2(1,108) = 146.55$, $MSE = 78388.84$, $p < .001$, $\eta_p^2 = .58$. The analysis on the error–omission rates also yielded a significant interaction between cognate status and language, $F_1(1,18) = 126.93$, $MSE = 46.73$, $p < .001$, $\eta_p^2 = .88$, $F_2(1,108) = 24.46$, $MSE = 375.55$, $p < .001$, $\eta_p^2 = .19$, and significant main effects for cognate status, $F_1(1,18) = 154.86$, $MSE = 51.51$, $p < .001$, $\eta_p^2 = .90$, $F_2(1,108) = 30.80$, $MSE = 375.55$, $p < .001$, $\eta_p^2 = .22$, and language, $F_1(1,18) = 474.54$, $MSE = 123.11$, $p < .001$, $\eta_p^2 = .96$, $F_2(1,108) = 244.17$, $MSE = 375.55$, $p < .001$, $\eta_p^2 = .69$.

The L1 German naming data revealed no significant main effect of cognate status in the naming latency analyses, $F_1(1,18) < 1.5$ and $F_2(1,54) < 1$, and a marginally significant main effect in the error–omission analyses by participants only, $F_1(1,18) = 2.83$, $MSE = 18.16$, $p = .054$, $\eta_p^2 = .10$, $F_2(1,54) < 1$. In contrast, in the L2 English naming data, the effect of cognate status was significant, $F_1(1,18) = 19.65$, $MSE = 42307.15$, $p < .001$, $\eta_p^2 = .52$, $F_2(1,54) = 7.48$, $MSE = 135951.53$, $p = .004$, $\eta_p^2 = .12$, revealing faster naming times for cognate pictures (1505 ms) than for noncognate pictures (1785 ms). Cognate status was also significant in the error–omission data, $F_1(1,18) = 185.72$, $MSE = 85.00$, $p < .001$, $\eta_p^2 = .91$, $F_2(1,54) = 30.90$, $MSE = 669.30$, $p < .001$, $\eta_p^2 = .36$, yielding a cognate advantage of 37.8%. Fig. 2 presents the cognate effect in the naming latencies.

Half of the pictures in the L2 English picture naming task had been named in the L1 German picture naming task. To test whether a cognate effect in L2 picture naming would also occur in items children had not seen and named before in the L1 picture naming task, we conducted one-way ANOVAs on the mean RTs and error rates of the nonrepeated items only. The effect of cognate status was significant in the RT analysis, $F_1(1,18) = 20.10$, $MSE = 130507.04$, $p < .001$, $\eta_p^2 = .50$, $F_2(1,27) = 3.69$, $MSE = 187147.86$, $p = .033$, $\eta_p^2 = .12$, and in the error analysis, $F_1(1,18) = 87.34$, $MSE = 80.30$, $p < .001$, $\eta_p^2 = .81$, $F_2(1,27) = 7.73$, $MSE = 604.91$, $p = .005$, $\eta_p^2 = .23$.[3] These results indicate that a cognate facilitation effect also occurs in L2 items children had not named in L1 and verify that the cognate effect in L2 English picture naming was not driven by the earlier naming of these items in L1.

In sum, the current data indicate that when naming pictures in L2 English, the L2 learners' L1 German was coactivated even if the L1 is the nontarget language. In contrast, their knowledge of L2 English exerted no significant influence when naming in L1 German.

Experiment 2: Picture naming in child bilinguals

Method

Design

The same design as in Experiment 1 was used.

Participants

The participants were 21 German–English early bilingual children (10 girls and 11 boys) whose ages ranged from 4.9 to 8.2 years ($M = 6.62$ years, $SD = 0.83$). All children had grown up bilingually with German and English in a German environment and attended the same kindergarten/school as the children in Experiment 1 (length of English immersion at preschool/kindergarten: $M = 2.67$ years, $SD = 0.92$). All children were regularly exposed to German and English at school as well as in the home

[2] Because we had a priori predictions on the direction of the cognate effects, *p* values are reported for one-tailed tests throughout this article.

[3] Additional 2 (Cognate Status: cognate or noncognate) by 2 (Repetition: repeated or nonrepeated) ANOVAs on the RTs and the error–omission rates in Experiments 1 to 3 yielded no main effect for repetition and no significant interaction (all *F*s < 1). This indicates that the effects were similar for the repeated versus nonrepeated items.

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Table 3
Mean response times (in ms) and error–omission rates (in %) for the blocked German and English picture naming tasks in Experiments 1 to 5.

	Noncognates		Cognates		Effect	
	RT (ms)	Error-omission (%)	RT (ms)	Error-omission (%)	RT (ms)	Error-omission (%)
Experiment 1: L2 learners						
German	1039 (140)	8.0 (6.8)	1017 (149)	5.8 (4.4)	22	2.2
English	1785 (319)	82.9 (8.4)	1505 (331)	44.2 (13.6)	280	38.7
Effect	746	74.9	488	38.4		
Experiment 2: Bilinguals						
German	1253 (205)	11.9 (7.2)	1187 (205)	8.0 (5.2)	66	3.9
English	1482 (378)	41.3 (24.7)	1285 (280)	21.9 (15.9)	197	19.4
Effect	229	29.4	98	13.9		
Experiment 3: Trilinguals						
German	1266 (211)	16.4 (12.0)	1198 (192)	9.3 (9.0)	68	7.1
English	1794 (507)	60.5 (22.7)	1438 (227)	26.7 (17.8)	356	33.8
Effect	528	44.1	240	17.4		
Experiment 4: Monolinguals						
German	1039 (119)	9.0 (5.4)	1026 (110)	7.5 (6.1)	13	1.5
Experiment 5: Adult bilinguals						
German	859 (132)	8.1 (6.6)	821 (123)	1.8 (2.8)	38	6.3
English	1070 (193)	19.6 (16.2)	968 (197)	6.6 (7.5)	102	13.0
Effect	211	11.5	147	4.8		

Note. Standard deviations are in parentheses.

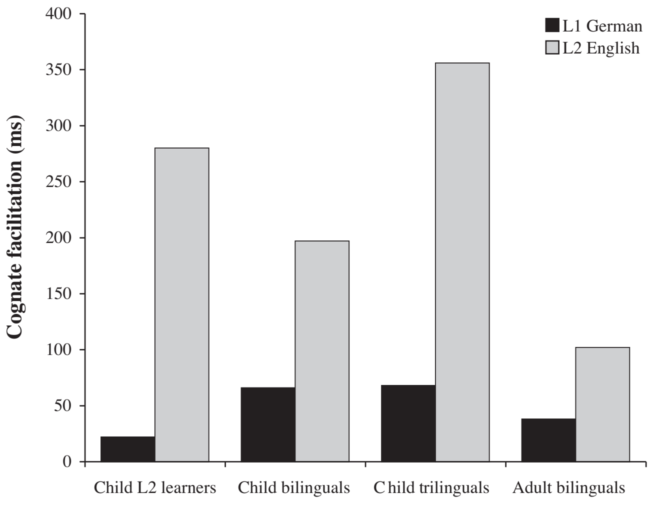

Fig. 2. Cognate facilitation effect for L1 German and L2 English (Experiments 1, 2, 3, and 5).

environment. Specifically, 8 participants had grown up with the mother speaking German and the father speaking English, whereas 13 participants had grown up with the mother speaking English and the father speaking German. None of the participants had grown up with or had had any continuous exposure to other languages since birth.

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Children's TROG scores in German (*M* = 109.21) were not different from those in English (*M* = 106.00), $t(20) = 0.70$, $p = .49$ (see Table 1), indicating that they were about equally fluent in the two languages.

Children's parents completed the same questionnaire as in Experiment 1. Mothers' highest levels of education were as follows: middle school (10.5%), high school (5.3%), bachelor's degree (36.8%), master's degree (42.1%), and doctoral degree (5.3%). Fathers' highest levels of education were as follows: middle school (10.5%), high school (5.3%), bachelor's degree (26.3%), master's degree (47.4%), and doctoral degree (10.5%).

On average, parents rated themselves as highly proficient in speaking German (mothers: *M* = 4.42, *SD* = 0.90; fathers: *M* = 4.89, *SD* = 0.32) and as highly proficient in speaking English (mothers: *M* = 4.05, *SD* = 1.35; fathers: *M* = 4.37, *SD* = 1.07).

Materials, apparatus, and procedure

The set of pictures and the experimental setup were identical to those in Experiment 1.

Results and discussion

Data cleaning procedures were identical to those used in Experiment 1. Trials associated with voice key errors made up 10.3% in German and 9.1% in English. Outliers (2.7% in German and 1.8% in English) were also eliminated. The statistical analyses were identical to those in Experiment 1. Results are presented in Table 3.

The overall ANOVA on the RT data revealed that cognate status interacted with language in the by-participant analysis, $F_1(1,20) = 7.80$, $MSE = 11546.97$, $p = .011$, $\eta_p^2 = .28$, $F_2(1,108) < 1$, indicating that the cognate effect was smaller in L1 German picture naming (66 ms) than in L2 English picture naming (197 ms) (see Fig. 2). The main effects for cognate status, $F_1(1,20) = 81.21$, $MSE = 4455.58$, $p < .001$, $\eta_p^2 = .80$, $F_2(1,108) = 9.09$, $MSE = 23089.61$, $p = .003$, $\eta_p^2 = .08$, and language, $F_1(1,20) = 6.23$, $MSE = 90941.68$, $p = .021$, $\eta_p^2 = .24$, $F_2(1,108) = 13.63$, $MSE = 23089.61$, $p < .001$, $\eta_p^2 = .11$, were significant. In the analysis on the error–omission rates, the interaction was significant, $F_1(1,20) = 29.14$, $MSE = 43.16$, $p < .001$, $\eta_p^2 = .59$, $F_2(1,108) = 7.89$, $MSE = 261.93$, $p = .006$, $\eta_p^2 = .07$, reflecting that the cognate effect was smaller in L1 German picture naming (3.9%) than in L2 English picture naming (33.8%). The main effects for cognate status, $F_1(1,20) = 58.18$, $MSE = 48.99$, $p < .001$, $\eta_p^2 = .74$, $F_2(1,108) = 16.25$, $MSE = 261.93$, $p < .001$, $\eta_p^2 = .13$, and language, $F_1(1,20) = 28.40$, $MSE = 347.67$, $p < .001$, $\eta_p^2 = .59$, $F_2(1,108) = 58.45$, $MSE = 261.93$, $p < .001$, $\eta_p^2 = .35$, were significant.

ANOVAs on the L1 German naming latency data revealed a significant effect of cognate status by participants, $F_1(1,20) = 10.07$, $MSE = 4507.59$, $p = .003$, $\eta_p^2 = .34$, that approached significance in the by-item analysis, $F_2(1,54) = 2.25$, $MSE = 22258.45$, $p = .070$, $\eta_p^2 = .04$. The error–omission analyses also revealed a significant main effect of cognate status by participants, $F_1(1,20) = 7.02$, $MSE = 22.90$, $p = .008$, $\eta_p^2 = .26$, that approached significance by items, $F_2(1,54) = 1.74$, $MSE = 112.84$, $p = .097$, $\eta_p^2 = .03$. In the L2 English naming latency analyses, the effect of cognate status was significant, $F_1(1,20) = 35.37$, $MSE = 11494.96$, $p < .001$, $\eta_p^2 = .64$, $F_2(1,54) = 7.53$, $MSE = 23920.76$, $p = .004$, $\eta_p^2 = .12$, revealing faster naming latencies for cognates (1285 ms) than for noncognates (1482 ms). The cognate effect in the error–omission rates was also significant, $F_1(1,20) = 57.00$, $MSE = 69.24$, $p < .001$, $\eta_p^2 = .74$, $F_2(1,54) = 14.90$, $MSE = 411.03$, $p < .001$, $\eta_p^2 = .22$; the error–omission rate for cognates (21.9%) was lower than that for noncognates (41.3%).

Finally, the analysis on the nonrepeated stimuli in L2 English revealed a significant effect of cognate status by participants, $F_1(1,20) = 6.78$, $MSE = 93132.01$, $p = .009$, $\eta_p^2 = .25$, that was marginally significant by items, $F_2(1,27) = 1.78$, $MSE = 19383.53$, $p = .097$, $\eta_p^2 = .07$. The error–omission analysis also revealed a significant effect of cognate status, $F_1(1,20) = 27.04$, $MSE = 99.24$, $p < .001$, $\eta_p^2 = .58$, $F_2(1,27) = 5.33$, $MSE = 395.26$, $p = .015$, $\eta_p^2 = .17$.

These results indicate that for highly proficient early bilinguals, when naming pictures in L2 English, L1 German is coactivated even if the L2 is the nontarget language. Their L2 English also significantly influenced naming performance in L1 German, although the magnitude of the cognate effect in L1 German naming was smaller than that in L2 English naming.

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Experiment 3: Picture naming in child trilingual second language learners

Method

Design

The same design as in Experiments 1 and 2 was used.

Participants

The participants were 19 children (10 girls and 9 boys), all bilingual third language (L3) learners of either German or English whose ages ranged from 5.2 to 7.9 years (M = 6.57 years, SD = 0.92). All children attended the same kindergarten/school as those in Experiments 1 and 2 (length of German and English immersion: M = 2.21 years, SD = 1.09). Among the sample, 10 participants had grown up bilingually with German and another language apart from English as dual L1 (see Genesee, Paradis, & Crago, 2004), 8 participants had grown up with English and a language apart from German as dual L1, and 1 participant had grown up with a dual L1 that was neither German nor English. All participants had been born in Germany and had German input in the environment from birth.

The TROG scores of the children showed that they were more proficient in German (M = 105.50) than in English (M = 89.20), $t(18) = 2.41$, $p = .03$ (see Table 1).

Mothers' highest levels of education were as follows: bachelor's degree (53.3%), master's degree (6.7%), and doctoral degree (40.0%). Fathers' highest levels of education were as follows: middle school (6.7%), high school (13.3%), bachelor's degree (26.7%), master's degree (20.0%), and doctoral degree (33.3%).

On average, parents rated themselves as highly proficient in speaking German (mothers: M = 4.60, SD = 0.83; fathers: M = 4.60, SD = 1.06) and as rather proficient in speaking English (mothers: M = 3.93, SD = 0.80; fathers: M = 4.27, SD = 1.10).

Materials, apparatus, and procedure

The set of pictures and the experimental setup were identical to those in Experiments 1 and 2.

Results and discussion

Data cleaning procedures were identical to those in Experiments 1 and 2. We excluded the data of 4 children because they named less than 10% of the stimuli correctly (without voice key errors) in one of the language conditions. Trials associated with voice key errors made up 10.4% in German and 11.9% in English. Outliers (2.4% in German and 1.4% in English) were also eliminated. Results are presented in Table 3.

The overall cognate status by language ANOVA on the RT data showed that cognate status interacted with language in the analysis by participants only, $F_1(1,14) = 5.24$, $MSE = 59273.72$, $p = .038$, $\eta_p^2 = .27$, $F_2(1,108) < 1$. The main effects for cognate status, $F_1(1,14) = 17.94$, $MSE = 37531.91$, $p = .001$, $\eta_p^2 = .56$, $F_2(1,108) = 6.46$, $MSE = 85975.19$, $p = .012$, $\eta_p^2 = .06$, and language, $F_1(1,14) = 10.83$, $MSE = 204099.45$, $p = .005$, $\eta_p^2 = .44$, $F_2(1,108) = 33.57$, $MSE = 85975.19$, $p < .001$, $\eta_p^2 = .24$, were significant. The ANOVA on the error–omission rates yielded a significant interaction between cognate status and language, $F_1(1,14) = 35.72$, $MSE = 74.65$, $p < .001$, $\eta_p^2 = .72$, $F_2(1,108) = 15.00$, $MSE = 314.24$, $p < .001$, $\eta_p^2 = .12$, and significant main effects for cognate status, $F_1(1,14) = 103.13$, $MSE = 60.98$, $p < .001$, $\eta_p^2 = .88$, $F_2(1,108) = 36.07$, $MSE = 314.24$, $p < .001$, $\eta_p^2 = .25$, and language, $F_1(1,14) = 23.30$, $MSE = 607.33$, $p < .001$, $\eta_p^2 = .63$, $F_2(1,108) = 91.38$, $MSE = 314.24$, $p < .001$, $\eta_p^2 = .46$.

In the German naming condition, the naming latency analyses revealed a significant 68-ms effect of cognate status, $F_1(1,14) = 5.03$, $MSE = 6887.92$, $p = .021$, $\eta_p^2 = .26$, $F_2(1,54) = 3.78$, $MSE = 33665.23$, $p = .029$, $\eta_p^2 = .07$. The error–omission analyses also revealed a significant effect of cognate status (cognate effect = 7.1%), $F_1(1,14) = 23.33$, $MSE = 16.40$, $p < .001$, $\eta_p^2 = .63$, $F_2(1,54) = 3.37$, $MSE = 212.05$, $p = .036$, $\eta_p^2 = .06$. The 356-ms cognate effect in the English naming condition was also significant, $F_1(1,14) = 10.56$, $MSE = 89917.64$, $p = .003$, $\eta_p^2 = .43$, $F_2(1,54) = 3.52$, $MSE = 138285.15$, $p = .033$, $\eta_p^2 = .06$. The same was true for the error–omission rates, $F_1(1,14) = 71.90$, $MSE = 119.23$, $p < .001$,

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$\eta_p^2 = .84$, $F_2(1,54) = 36.82$, $MSE = 416.43$, $p < .001$, $\eta_p^2 = .41$, yielding a 33.8% cognate advantage. Fig. 2 displays the cognate effect in the naming latencies.

The ANOVA on the RTs of nonrepeated items in the English picture naming task showed a significant effect for cognate status by participants only, $F_1(1,14) = 11.26$, $MSE = 91943.43$, $p = .003$, $\eta_p^2 = .45$, $F_2(1,27) < 1$. The ANOVA on the error–omission rates revealed a significant main effect for cognate status, $F_1(1,14) = 46.67$, $MSE = 131.19$, $p < .001$, $\eta_p^2 = .77$, $F_2(1,27) = 11.94$, $MSE = 447.12$, $p = .001$, $\eta_p^2 = .32$.

The results showed that when early trilinguals named pictures in English, German is coactivated even if German is the nontarget language. These results parallel the findings with L2 English learners and German–English bilinguals (Experiments 1 and 2). The trilinguals' picture naming in German is also affected by knowledge of English, in parallel with the data of the bilinguals in Experiment 2. As in Experiment 2, the magnitude of the cognate facilitation effect in German picture naming (68 ms) was substantially smaller than that in English picture naming (356 ms).

Finally, three issues were deemed necessary for further exploration: to assess (a) whether the trilingual participants' different L1 (German or English) in Experiment 3 had a differential effect on naming performance in German or English, (b) whether varying L2 English proficiencies in trilingual L1 German children (Experiment 3) and L2 English learners (Experiment 1) had a differential effect on naming performance in German or English, and (c) whether the trilingual children's L3 may have modulated the cognate facilitation in L2 English naming.

To address the first issue, additional 2 (Cognate Status: cognate or noncognate) by 2 (Participant L1: German or English) ANOVAs comparing the 7 trilingual L1 German children with the 7 trilingual L1 English children were conducted. The results showed no significant between-group differences or an interaction, in either naming condition, in both naming latencies and error–omission rates (all *p*s > .10).

Regarding the second issue, L2 English proficiencies of the trilingual L1 German children (Experiment 3) and the L2 learners (Experiment 1) were compared, $F(1,32) = 10.39$, $MSE = 341.21$, $p = .003$, $\eta_p^2 = .25$, indicating higher L2 English proficiency (mean standard score = 89.2 as measured by the TROG) for the trilingual L1 German children than for the L2 learners (mean = 68.6). Subsequent 2 (Cognate Status: cognate or noncognate) by 2 (Participant: trilingual or L2 learner) ANCOVAs with proficiency as a covariate yielded neither significant differences between the two groups nor an interaction in naming both in German and in English (all *p*s > .10).

To explore the third issue, adult native speakers of the trilingual children's third language (Arabic, Dutch, Farsi, French, Greek, Hebrew, Italian, or Spanish) were asked to indicate whether or not the items in this third language were cognates with English. The rationale for this was to explore whether items that were cognates not only between German and English but also in L3 ("triple cognates") could have offered an additional source for cognate facilitation in L2 English. For each trilingual, we then compared the English naming RTs for triple cognates with double cognates (cognates between German and English but noncognate with the L3). It appeared that 8 trilinguals processed triple cognates faster than double cognates, 1 trilingual showed no difference in processing the two types of cognates, and 6 trilinguals processed double cognates faster than triple cognates. This pattern suggests that the cognate facilitation effect is not driven exclusively by triple cognates.

Experiment 4: Picture naming in child monolinguals

Method

Design

Cognate and noncognates were presented in a German picture naming task.

Participants

The participants were 15 monolingual children (6 girls and 9 boys) who spoke German as their native language and whose ages ranged from 7.0 to 7.9 years ($M = 7.50$ years, $SD = 0.25$). All children were enrolled in German primary school in Frankfurt and had not yet begun L2 English instruction.

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None of the participants had grown up with or had had any continuous exposure to languages apart from standard German since birth.

Children's TROG scores were substantially higher in German ($M = 109.00$) than in English ($M = 58.60$) (minimum score at chance level is 55), $t(14) = 15.92$, $p < .001$ (see Table 1).

Mothers' highest levels of education were as follows: bachelor's degree (66.7%), master's degree (26.7%), and doctoral degree (6.7%). Fathers' highest levels of education were as follows: bachelor's degree (53.3%), master's degree (40.0%), and doctoral degree (6.7%).

On average, parents rated themselves as highly proficient in speaking German (mothers: $M = 5.00$, $SD = 0.00$; fathers: $M = 5.00$, $SD = 0.00$) and as mid-proficient in speaking English (mothers: $M = 2.20$, $SD = 0.94$; fathers: $M = 2.27$, $SD = 0.70$).

Materials, apparatus, and procedure

The set of pictures and the experimental setup used were identical to those used in Experiments 1 to 3. Only the German language condition was used.

Results and discussion

Data cleaning procedures were identical to those in Experiments 1 to 3. Voice key errors (9.0%) and outliers (1.0%) were eliminated from the RT analysis. Results are presented in Table 3. The ANOVAs yielded no effect for cognate status in the RT analysis, $F_1(1,14) < 1.5$, $F_2(1,54) < 2$, and the error–omission analysis, $F_1(1,14) < 1.5$, $F_2(1,54) < 1$.

As expected, the monolingual German-speaking children showed no cognate effect when naming in German. This verifies that the cognate effects obtained in the child second language learners, bilinguals, and trilinguals tested in Experiments 1 to 3 are related to their bilingualism/multilingualism and not to confounds or peculiarities in the stimulus materials.

Cross-group comparison: Experiments 1 to 4

Overall naming times in German of the monolingual children tested in Experiment 4 were faster than those of the bilingual and trilingual children tested in Experiments 2 and 3 but were similar to those of the German-dominant English L2 learners tested in Experiment 1. This suggests that bilinguals' and trilinguals' lexical retrieval in the target language German may be slowed down because of nontarget language lexical activation and, hence, greater cross-language competition.

To examine this, we ran a one-way ANOVA on the overall German picture naming times obtained in Experiments 1 to 4. This analysis revealed a significant effect, $F_1(3,68) = 8.25$, $MSE = 27634.47$, $p < .001$, $\eta_p^2 = .27$, $F_2(1,55) = 4.63$, $MSE = 6201.55$, $p = .036$, $\eta_p^2 = .08$. Subsequent post hoc between-group comparisons showed that the mean German picture naming times of L2 learners ($M = 1028$ ms, $SD = 136$, in Experiment 1) and German monolinguals ($M = 1033$ ms, $SD = 117$, in Experiment 4) did not differ significantly ($p > .10$). Likewise, the mean German picture naming times of the bilinguals ($M = 1220$ ms, $SD = 200$, in Experiment 2) and trilinguals ($M = 1232$ ms, $SD = 193$, in Experiment 3) did not differ ($p > .10$). In contrast, the picture naming times of the L2 learners were shorter than those of the bilinguals ($p = .002$) and the trilinguals ($p = .003$). Similarly, the monolinguals named pictures faster than the bilinguals ($p = .009$) and the trilinguals ($p = .010$).

Importantly, these differences in German picture naming times were not driven by variations in German language proficiency among the different groups, as was verified in an ANOVA on the German TROG data, $F_1(3,68) < 1$, $p > .10$, $F_2(3,60) < 2$, $p > .10$. Subsequent post hoc comparisons showed no significant differences between the groups (all $ps > .10$).

These analyses indicate that lexical retrieval during picture naming in the first language was indeed slower in the bilinguals and trilinguals as compared with the L2 learners and monolinguals, even though their proficiency in the first language, measured by a different and independent task, was not different. This suggests that in situations that promote cross-language activation, lexical retrieval may be slowed down, but only for multilingual speakers who have reached a relatively high level of fluency in the nontarget language (as was the case in the bilingual and trilingual children).

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Experiment 5: Picture naming in adult bilinguals

Method

Design

The same design as used in Experiments 1 to 3 was used.

Participants

The participants were 20 adult German–English bilinguals, all female students enrolled in the English department at Goethe University in Frankfurt. The mean years of English instruction was 12.0 (*SD* = 1.2). Participants had lived in an English-speaking environment for an average of 2.4 years (*SD* = 1.6). Their ages ranged from 20.2 to 28.1 years (*M* = 24.4 years, *SD* = 0.9).

On average, the bilinguals rated themselves as highly proficient in speaking German (*M* = 4.95, *SD* = 0.22) and English (*M* = 4.24, *SD* = 0.60). Additional support comes from independent proficiency tests that participants completed: the X_Lex Swansea Vocabulary Test (Meara & Milton, 2003) in English (*M* = 86.1%, *SD* = 0.09) and a lexical decision task (Lemhöfer, Dijkstra, & Michel, 2004) in German (*M* = 89.2%, *SD* = 0.08) and English (*M* = 86.3%, *SD* = 0.10). These scores indicate that the participants were highly proficient in both languages.

Materials

For the German and English picture naming task, 56 black-on-white line drawings of common objects were selected from the same source as used in Experiments 1 to 3 but, unlike Experiments 1 to 3, had no repetition except for two stimuli. Both the German and English stimulus picture sets contained 28 cognates and 28 noncognates (see Appendix B).

The cognates and noncognates in German and English were matched on mean frequency (Baayen et al., 1993); word length, name agreement, and visual complexity (Székely et al., 2004); imageability (Lahl et al., 2009); and age of acquisition (German: Schroeder et al., 2003; English: Morrison et al., 1997). The distribution of onset phonemes was similar across both conditions (German cognates and noncognates: 13 plosives and 15 nonplosives; English cognates: 12 plosives and 16 nonplosives; English noncognates: 13 plosives and 15 nonplosives). See Table 2 for a detailed presentation of word characteristics.

Apparatus and procedure

The procedure and apparatus were similar to those in Experiments 1 to 3. The order of the language conditions was German before English. The experiment lasted approximately 20 min.

Results and discussion

Data cleaning procedures were similar to those in Experiments 1 to 4. Voice key errors (7.1% in German and 4.2% in English) and outliers (2.4% in German and 2.7% in English) were eliminated from the RT analysis. The data were then analyzed as described in Experiments 1 to 3. Table 3 shows RTs and error–omission rates.

In the overall ANOVA on the RT data, cognate status interacted with language by participants, $F_1(1,19) = 30.57$, $MSE = 1220.88$, $p < .001$, $\eta_p^2 = .62$, and marginally by items, $F_2(1,108) = 3.28$, $MSE = 18010.06$, $p = .073$, $\eta_p^2 = .03$. The main effects for cognate status, $F_1(1,19) = 103.56$, $MSE = 1160.77$, $p < .001$, $\eta_p^2 = .85$, $F_2(1,108) = 10.64$, $MSE = 18010.06$, $p = .001$, $\eta_p^2 = .09$, and language, $F_1(1,19) = 28.31$, $MSE = 21663.68$, $p < .001$, $\eta_p^2 = .60$, $F_2(1,108) = 53.92$, $MSE = 18010.06$, $p < .001$, $\eta_p^2 = .12$, were significant. In the analysis of the error–omission rates, the interaction between cognate status and language was significant by participants, $F_1(1,19) = 6.68$, $MSE = 16.15$, $p = .018$, $\eta_p^2 = .08$, and marginally significant by items, $F_2(1,108) = 3.28$, $MSE = 194.76$, $p = .073$, $\eta_p^2 = .03$. The main effects for cognate status, $F_1(1,19) = 28.29$, $MSE = 37.90$, $p < .001$, $\eta_p^2 = .60$, $F_2(1,108) = 13.55$, $MSE = 194.76$, $p < .001$, $\eta_p^2 = .11$, and language, $F_1(1,19) = 17.48$, $MSE = 80.59$, $p = .001$, $\eta_p^2 = .48$, $F_2(1,108) = 15.23$, $MSE = 194.76$, $p < .001$, $\eta_p^2 = .12$, were significant.

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For L1 German picture naming, the RT analysis revealed a significant 38-ms effect of cognate status, $F_1(1,19) = 36.86$, $MSE = 374.82$, $p < .001$, $\eta_p^2 = .66$, $F_2(1,54) = 3.35$, $MSE = 11673.23$, $p = .037$, $\eta_p^2 = .06$. The effect of cognate status was also significant in the error–omission analysis, $F_1(1,19) = 22.60$, $MSE = 17.50$, $p < .001$, $\eta_p^2 = .55$, $F_2(1,54) = 5.84$, $MSE = 84.54$, $p = .010$, $\eta_p^2 = .09$. In the L2 English picture naming RT analysis, the 102-ms effect of cognate status was significant, $F_1(1,19) = 38.08$, $MSE = 2755.25$, $p < .001$, $\eta_p^2 = .69$, $F_2(1,54) = 6.51$, $MSE = 26998.20$, $p = .007$, $\eta_p^2 = .12$, as was the cognate effect in the analysis of error–omission rates, $F_1(1,19) = 17.40$, $MSE = 96.51$, $p = .001$, $\eta_p^2 = .46$, $F_2(1,54) = 8.04$, $MSE = 284.37$, $p = .003$, $\eta_p^2 = .13$.

The adult German–English bilinguals showed a two-way cognate effect, although they showed a smaller effect in L1 German picture naming (38 ms) than in L2 English picture naming (102 ms), suggesting that the bilinguals' L1 German is coactivated more strongly when naming in L2 English than vice versa (see Fig. 2). This pattern replicates Costa and colleagues' (2000) findings with adult Catalan–Spanish bilinguals who also showed weaker cognate effects in picture naming in L1 Catalan than in L2 Spanish.

General discussion

The goal of this study was to shed light on lexical processing in children, particularly in children who have had sustained and substantial input in two or three languages in their lives. More specifically, the current study examined the coactivation of languages in L2 learners, bilinguals and multilinguals and to what extent a nontarget language influences the target language during language production. The coactivation of languages was examined by comparing the naming of cognate and noncognate pictures in the dominant and nondominant languages. We were particularly interested in how the coactivation of languages is modulated by the relative language proficiencies in child L2 learners, and in child bilinguals and trilinguals, compared with adults in whom language development has reached its end state.

The L2 learners, bilinguals, and trilinguals (Experiments 1–3) all exhibited a cognate facilitation effect in their nondominant language, indicating that lexical processing in the nondominant language is affected by knowledge of the dominant language, which provides evidence for the coactivation of languages in picture naming in the nondominant language. Strikingly, the more language-balanced bilinguals and trilinguals also showed a cognate facilitation effect in their dominant language, although the magnitude of the effect was smaller in their dominant language than in their nondominant language. In contrast, the L2 learners' dominant language performance showed no cognate effect. This indicates that only bilinguals and trilinguals with a relatively high proficiency in the nondominant language show cross-language activation during picture naming in both their nondominant and dominant languages.

The cognate facilitation effect found in the L2 learners, bilinguals, and trilinguals was not observed in a matched monolingual control group (Experiment 4). Finally, highly proficient adult bilinguals displayed a significant cognate facilitation effect in both the dominant and nondominant languages (Experiment 5), although the magnitude of the effect was greater when naming in the nondominant language, replicating previous results obtained in Spanish–Catalan bilinguals (Costa et al., 2000).

The cognate facilitation effect in bilinguals has been explained by higher activation that cognate words receive from both their dominant and nondominant language nodes compared with noncognates, which receive activation from only their dominant language node (see Fig. 1). In addition, in bilingual speakers the links between the semantic system and the lexical nodes are stronger in the dominant language compared with the nondominant language (cf. Kroll & Stewart, 1994). Consequently, when a bilingual retrieves a cognate during picture naming in the nondominant language, the strong activation of its translation equivalent in the dominant language spreads to the phonological level, in turn facilitating the retrieval of the phonological segments in the nondominant language. In contrast, when the task is performed in the dominant language, the lower activation levels of the phonological segments in the nondominant language do not facilitate the retrieval of phonological segments in the dominant language to the same extent, thereby resulting in a smaller cognate effect when naming in the dominant language, as observed in the more proficient bilinguals/trilinguals tested in Experiments 2, 3, and 5.

The L2 learners tested in Experiment 1 showed a cognate facilitation effect only in the nondominant language, indicating an asymmetry in the activation of nontarget language codes related to relative language proficiency in the dominant and nondominant languages. How can variation in language proficiency affect the coactivation of languages during picture naming? In line with the model depicted in Fig. 1, it is possible that the activation levels of phonological segments in the nondominant language did not suffice in facilitating the retrieval of the phonological segments in the dominant language. Alternatively, one could argue that the activation levels of phonological segments in the dominant language in the L2 learners were sufficiently high to coactivate phonology in the nondominant language but not high enough to actually facilitate the retrieval of the phonological segments in the nontarget language during picture naming. Therefore, the coactivation of phonology did not materialize into an observable cognate facilitation effect in the L2 learners. Because the proficiency levels in the two languages were more balanced in the bilingual and trilingual speakers, the activation levels of lexical items in the nontarget language were closer to those in the target language, resulting in an observable cognate facilitation effect in both German and English. An additional variable, age of L2 onset, may also have played a role in influencing the activation levels of lexical items in the two languages. Because the bilinguals and trilinguals had experienced an earlier onset of L2 language input outside the family environment (measured by years of exposure: L2 learners = 1.5, bilinguals = 2.7, trilinguals = 2.2), one could assume that relative L2 activation is higher in the bilinguals and trilinguals than in the L2 learners. To gain more insight into this issue, we performed an ANOVA on the L2 naming latencies, comparing the L2 English naming latencies of the L2 learners with German as their L1 (Experiment 1) with those of the L1 German trilingual children (Experiment 3). We found no significant difference (see "Cross-group comparison: Experiments 1 to 4" section above for the full report). Obviously, our study was not designed to tease apart effects of age of onset and language proficiency.

In an inhibitory mechanism view (cf. Green, 1998), the results could be interpreted as the basic level of activation of dominant language words being high in a bilingual speaker's lexicon, and in naming these words in the dominant language, the nondominant language, whose lexical entries have comparatively less activation, needs to be inhibited to only a small extent during the lexicalization process. This causes an insignificant or relatively small cognate facilitation effect in the dominant language. In naming nondominant language words, in contrast, the dominant language needs to be inhibited to a greater extent. The significant and larger cognate facilitation effect in the nondominant language found in our study could be assumed to result from the fact that with cognate words only part of the dominant language competitor needs to be inhibited, namely those segments that do not overlap in phonology. With noncognate words, however, the entire word in the dominant language needs to be inhibited, resulting both in overall slower naming latencies for noncognate pictures and in larger cognate facilitation effects. In addition, the effects in Experiments 1 to 3 are in line with the proficiency differences between the dominant and nondominant languages and, thus, the relative language proficiencies.

Either account could potentially explain the asymmetry in cognate facilitation effects in both children and adults in this study. What has become evident in the current study is that, contrary to the within-language competitor effects found only in children and not in adults by Jescheniak and colleagues (2006), the children in Experiments 1 to 3 showed a similar overall naming latency pattern to that of the adults (Experiment 5). Specifically, children and adults named cognate pictures faster than noncognate pictures in both the dominant and nondominant languages; moreover, the child bilinguals and trilinguals and the adult bilinguals displayed significant cognate facilitation effects in both languages. Critically, as discussed in the Introduction, the children exhibited slower overall naming latencies compared with the adults, offering a greater time window to observe language coactivation and, hence, for any cognate effects to show. From these results, it follows that there is evidence for language coactivation in children exposed to multiple languages, that this coactivation is modulated by relative language proficiency, and that coactivation is stronger in the nondominant language.

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The finding that bilinguals and trilinguals (Experiments 2 and 3) displayed slower naming latencies in their dominant L1 than did L2 learners and monolinguals (Experiments 1 and 4) replicates results obtained in a cognate picture naming study with adults (Ivanova & Costa, 2008). Ivanova and Costa (2008) interpreted their findings as a frequency effect given that bilinguals retrieve items from their L1 lexicon less often than monolinguals do, which in turn decelerates L1 lexical item retrieval in bilinguals. This is reminiscent of the weaker links hypothesis proposed by Gollan, Montoya, Cera, and Sandoval (2008), which is based on the assumption that bilinguals (need to) divide their language use between the two languages, from which it follows that these speakers have less exposure to each language compared with monolinguals. More recently, Sandoval, Gollan, Ferreira, and Salmon (2010) found differences between bilinguals and monolinguals in verbal fluency tasks to be better explained by between-language interference than by the weaker links account. In particular, the fact that bilinguals produced significantly more lower-frequency words than monolinguals speaks against the weaker links hypothesis. Interestingly, in a study with bilingual and monolingual children (rather than adults), Yan and Nicoladis (2009) explored lexical access in comprehension and production in L1 and found no differences between bilingual and monolingual children in receptive vocabulary but did so for productive vocabulary. In other words, the bilinguals did not know fewer words than monolinguals (as ascertained by the number of words correctly identified in comprehension posttests) but displayed greater difficulty in accessing and retrieving them for production.

Finally, in a language comprehension study (in contrast to the current production study) using, among others, lexical decision tasks with adult Dutch–English–French trilinguals, Van Hell and Dijkstra (2002) found a cognate facilitation effect in the dominant language (Dutch) in which response times for Dutch words that were cognates with L2 English were faster than those for noncognates. Moreover, facilitation was also found for cognates with the trilinguals' L3 (French), but only in those trilinguals whose relative L3 fluency was comparable to that of their L2 (English). Critically, in Van Hell and Dijkstra's study, participants were in a solely L1, and thus dominant, language mode. Still, words presented in the dominant language automatically activated information in the nontarget language in parallel, implying that the multilinguals' processing system is profoundly nonselective with respect to language. Furthermore, the authors concluded that a high level of nontarget language fluency is necessary before the weaker language exerts enough influence on the target language to have a measurable impact in processing. This parallels the current findings in the child L2 learners versus the child bilinguals and child trilinguals in that a cognate effect in the L1 emerged only when children had gained a relatively high level of nontarget (L2) language proficiency.

To conclude, our study showed that coactivation of languages is evident in child L2 learners, bilinguals, and trilinguals. Furthermore, in children with varying proficiencies in their nondominant language(s), the activation level of the nondominant language(s) needs to be sufficiently developed to allow for any cross-language activation that results in a significant cognate facilitation effect when naming in the dominant language. Finally, researching language coactivation in children who have grown up or are in the process of learning multiple languages and have varying language dominance yields valuable insights into understanding developmental patterns in bilingual/multilingual language processing.

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Appendix A

List of stimuli used in Experiments 1 to 4.

German block					English block			
Cognates		Noncognates			Cognates		Noncognates	
German	English	German	English		English	German	English	German
Anker	[Anchor]	Ast	[Branch]	1	Apple	[Apfel]+	Airplane	[Flugzeug]
Apfel	[Apple]	Baum	[Tree]	2	Baby	[Baby]+	Arrow	[Pfeil]
Baby	[Baby]	Burg	[Castle]	3	Balloon	[Ballon]	Basket	[Korb]+
Ball	[Ball]	Dach	[Roof]	4	Banana	[Banane]+	Bat	[Fledermaus]+
Banane	[Banana]	Drachen	[Kite]	5	Boat	[Boot]	Bell	[Klingel]
Bank	[Bench]	Ente	[Duck]	6	Book	[Buch]+	Bicycle	[Fahrrad]+
Bär	[Bear]	Esel	[Donkey]	7	Camera	[Kamera]	Bone	[Knochen]+
Buch	[Book]	Fahrrad	[Bicycle]	8	Carrot	[Karotte]	Box	[Kiste]
Bus	[Bus]	Fenster	[Window]	9	Cat	[Katze]+	Branch	[Ast]+
Clown	[Clown]	Fledermaus	[Bat]	10	Clown	[Clown]+	Bucket	[Eimer]
Daumen	[Thumb]	Gabel	[Fork]	11	Cow	[Kuh]	Butterfly	[Schmetterling]+
Geist	[Ghost]	Kartoffel	[Potato]	12	Dinosaur	[Dinosaurier]	Button	[Knopf]+
Kamm	[Comb]	Kissen	[Pillow]	13	Dolphin	[Delphin]	Castle	[Burg]+
Känguru	[Kangaroo]	Knochen	[Bone]	14	Flag	[Flagge]	Cup	[Tasse]+
Katze	[Cat]	Knopf	[Button]	15	Ghost	[Geist]+	Donkey	[Esel]+
Kerze	[Candle]	Korb	[Basket]	16	Gorilla	[Gorilla]	Goat	[Ziege]
König	[King]	Pferd	[Horse]	17	Guitar	[Gitarre]	Pear	[Birne]
Kreuz	[Cross]	Pilz	[Mushroom]	18	Kangaroo	[Känguru]+	Pencil	[Bleistift]
Leiter	[Ladder]	Pinsel	[Brush]	19	King	[König]+	Pig	[Schwein]
Löwe	[Lion]	Puppe	[Doll]	20	Lion	[Löwe]+	Pillow	[Kissen]+
Palme	[Palm tree]	Schildkröte	[Turtle]	21	Nail	[Nagel]	Pineapple	[Ananas]
Papagei	[Parrot]	Schmetterling	[Butterfly]	22	Penguin	[Pinguin]	Potato	[Kartoffel]+
Telefon	[Telephone]	Tasche	[Purse]	23	Puzzle	[Puzzle]	Pumpkin	[Kürbis]
Tiger	[Tiger]	Tasse	[Cup]	24	Table	[Tisch]+	Strawberry	[Erdbeere]
Tisch	[Table]	Teller	[Plate]	25	Telephone	[Telefon]+	Tent	[Zelt]∗
Tür	[Door]	Topf	[Pot]	26	Tiger	[Tiger]+	Tree	[Baum]+
Traktor	[Tractor]	Tüte	[Bag]	27	Toilet	[Toilette]	Truck	[Laster]
Windmühle	[Windmill]	Zug	[Train]	28	Tractor	[Traktor]+	Turtle	[Schildkröte]+

Note. +, repeated item in the English condition; ∗, near cognate item considered as noncognate.

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Appendix B

List of stimuli used in Experiment 5.

German block					English block			
Cognates		Noncognates			Cognates		Noncognates	
German	English	German	English		English	German	English	German
Anker	[Anchor]	Ast	[Branch]	1	Apple	[Apfel]	Airplane	[Flugzeug]
Ball	[Ball]	Baum	[Tree]	2	Baby	[Baby]	Bell	[Klingel]
Bank	[Bench]	Dach	[Roof]	3	Balloon	[Ballon]	Belt	[Gürtel]
Bombe	[Bomb]	Dusche	[Shower]	4	Banana	[Banane]	Bicycle	[Fahrrad]
Bus	[Bus]	Ente	[Duck]	5	Bear	[Bär]	Bottle	[Flasche]
Clown	[Clown]	Esel	[Donkey]	6	Boat	[Boot]	Bucket	[Eimer]
Delphin	[Dolphin]	Fenster	[Window]	7	Camel	[Kamel]	Butterfly	[Schmetterling]+
Gitarre	[Guitar]	Fledermaus	[Bat]	8	Camera	[Kamera]	Cloud	[Wolke]
Kaktus	[Cactus]	Gabel	[Fork]	9	Carrot	[Karotte]	Fence	[Zaun]
Kamm	[Comb]	Kartoffel	[Potato]	10	Cat	[Katze]	Genie	[Flaschengeist]
Kerze	[Candle]	Kissen	[Pillow]	11	Cow	[Kuh]	Goat	[Ziege]
König	[King]	Knochen	[Bone]	12	Cross	[Kreuz]	Pear	[Birne]
Krebs	[Crab]	Knopf	[Button]	13	Dinosaur	[Dinosaurier]	Pen	[Kugelschreiber]
Krone	[Crown]	Korb	[Basket]	14	Dragon	[Drache]	Pencil	[Bleistift]
Leiter	[Ladder]	Pfau	[Peacock]	15	Flag	[Flagge]	Piano	[Klavier]
Maske	[Mask]	Pferd	[Horse]	16	Ghost	[Geist]	Pot	[Topf]
Maus	[Mouse]	Pilz	[Mushroom]	17	Gorilla	[Gorilla]	Present	[Geschenk]
Nase	[Nose]	Pinsel	[Brush]	18	Kangaroo	[Känguru]	Pumpkin	[Kürbis]
Palme	[Palm tree]	Ritter	[Knight]	19	Lion	[Löwe]	Rabbit	[Kaninchen]
Papagei	[Parrot]	Schildkröte	[Turtle]	20	Nail	[Nagel]	Skunk	[Stinktier]
Rose	[Rose]	Schmetterling	[Butterfly]	21	Pan	[Pfanne]	Strawberry	[Erdbeere]
Telefon	[Telephone]	Schwein	[Pig]	22	Penguin	[Pinguin]	Sweater	[Pullover]
Tiger	[Tiger]	Strauß	[Ostrich]	23	Pirate	[Pirat]	Tank	[Panzer]
Traktor	[Tractor]	Tasse	[Cup]	24	Puzzle	[Puzzle]	Racket	[Schläger]
Tür	[Door]	Teller	[Plate]	25	Rainbow	[Regenbogen]	Tent	[Zelt]
Vulkan	[Volcano]	Tisch	[Table]	26	Rocket	[Rakete]	Truck	[Laster]
Windmühle	[Windmill]	Tüte	[Bag]	27	Sun	[Sonne]	Turtle	[Schildkröte]+
Zebra	[Zebra]	Zug	[Train]	28	Toilet	[Toilette]	Witch	[Hexe]

Note. +, repeated item in the English condition.

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