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Cross-language activation in same-script and different-script trilinguals

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Abstract

In a picture naming study, we examined cross-language activation during speech production in three groups of trilinguals: L3-immersed German–English–Dutch, non-L3-immersed Dutch–English–German, and L3-immersed Russian–English–German trilinguals. All trilinguals named pictures with cognate and non-cognate names in their L2 and their L3. Specifically, we examined cognate effects in same-script trilinguals who were either immersed or not immersed in their L3 and trilinguals whose first language (Russian) differs in script from their other two languages (German, English) to address the questions (1) whether, as non-target language knowledge is co-activated, cognate effects accrue across languages during word production, and (2) whether immersion in L3 is a modulating factor in cross-language activation. We found cognate facilitation in the same-script trilinguals across all languages, although with patterns modulated by the trilinguals' L3-immersion status and L3 proficiency, corroborating and extending earlier findings in bilingual adults and children. Critically, we also found cognate effects in the different-script trilinguals when the pictures had cognate names in all three languages, indicating that the L1 Russian phonology was activated during naming in L2 English when L3 German was also present, and vice versa.

Keywords

Trilingualism, word production, cognate facilitation, cross-language activation

Past research has demonstrated that when bilinguals and second language learners use one language only, for example in naming words or pictures, both languages are nevertheless active (e.g., Colomé, 2001; Costa, Caramazza, & Sebastián-Gallés, 2000; Hermans, Ormel, Besselaar, & Van

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Hell, 2011; Kroll, Bobb, Misra, & Guo, 2008; Van Hell & Dijkstra, 2002). A frequently used technique to examine the co-activation of languages in multilinguals is by using cognate and non-cognate words. Cognates are word translations that have orthographic (in same-script languages) and phonological overlap, such as the English–German translation *carrot–Karotte*, making them similar in both spelling and pronunciation. Non-cognates, in contrast, have negligible phonological and orthographic overlap, such as the English–German translation *chicken–Huhn*. Cognates have been widely used in bilingual research to investigate how bilinguals exhibit influences from their other language, even in settings where only one language is to be used (e.g., Costa et al., 2000; Costa, Miozzo, & Caramazza, 1999; Hoshino & Kroll, 2008; Kroll, Dijkstra, Janssen, & Schriefers, 2000; Poarch & Van Hell, 2012). These studies observed that bilinguals name cognates faster than non-cognates. For example, in a picture naming study with Spanish–Catalan bilinguals, Costa and colleagues (2000) found that cognates are named faster than non-cognates both when presented in the second language (L2) and in the first language (L1). Results from this and related studies suggest that phonological representations in both target and non-target languages are activated and retrieved, resulting in bilinguals naming pictures with cognate names faster than pictures with non-cognate names. The cognate facilitation effect during picture naming is taken as evidence for co-activation up to the level of phonology of the non-target language lexical candidate during lexical retrieval of the target-language candidate.

Costa and colleagues (2000) observed cognate facilitation effects in L1 and L2, although the magnitude of the effect was smaller in L1. The bilinguals in this study were highly fluent speakers of L1 and L2, who had learned both languages at an early age. Recent picture naming studies (Hoshino & Kroll, 2008; Kroll et al., 2000) suggest that language proficiency and language learning history may affect the magnitude of the observed cognate effect and cross-language activation patterns. For example, Kroll and colleagues (2000) tested fairly proficient but unbalanced Dutch–English bilinguals who were more proficient in their L1 Dutch than in their L2 English, had learned English around the age of 10–11, and lived in an L1 environment (non-L2-immersed). In a picture naming study with cognate and non-cognate pictures, these bilinguals showed a cognate facilitation effect when naming pictures in L2 but not in L1. In a study with 5–8-year-old children, Poarch and Van Hell (2012) found that while German learners of L2 English behaved similarly to the adult bilinguals in the Kroll et al. study, fluent German–English bilinguals and fluent German–English–Language X trilinguals showed a cognate facilitation effect when naming pictures in L2 and, critically, in L1. Cross-language activation in these children was thus assumed to be modulated predominantly by relative language proficiency. Taken together, the results obtained in these studies show that the stronger a non-target language is, the stronger its effect on the target language, an effect that has been explained on the grounds of a strong language spreading more activation to the weaker language than vice versa, and this becoming particularly visible in naming cognates between two languages.

In the present study, we seek to examine two factors that may affect cross-language activation in production: (a) relative language fluency; and (b) immersion in a language environment other than L1. Specifically, we report three experiments that examined to what extent same-script L3-immersed German–English–Dutch trilinguals (i.e., immersed in an L3 language environment), non-L3-immersed same-script Dutch–English–German trilinguals, and L3-immersed different-script Russian–German–English trilinguals experience cross-language activation during speech production. To explore this, we examined cognate effects in L2 and L3 picture naming. We were particularly interested in whether (1) the L3-immersion status of each group had an effect on cross-language activation patterns between L3 and the other two languages, and whether (2) the L1 Russian and the L1 German trilinguals, both of whom were immersed in their L3, would show similar or different cross-language activation patterns given that their L1s differed in script. In the remainder of this section, we briefly review studies on bilinguals and trilinguals and outline the effects of proficiency and immersion.

Relative language proficiency has been shown to have an influence on language co-activation in bilinguals. In a study by Van Hell and Dijkstra (2002), Dutch–English–French trilinguals performed word association and lexical decision tasks in L1. Word association and lexical decision times to L1–L2 and L1–L3 cognates were shorter relative to non-cognate controls, although the L1–L3 cognate facilitation effect reached significance only in trilinguals with sufficient L3 proficiency. These results imply that language co-activation only becomes evident above a specific proficiency threshold, in this case in the L3. Lemhöfer, Dijkstra, and Michel (2004), in a similar study using an L3 lexical decision task with proficient Dutch–English–German trilinguals, found that all the trilinguals' languages were involved during the process of word recognition and even stronger cognate facilitation became evident for triple cognates (i.e., Dutch–English–German) than for double cognates (i.e., Dutch-German). For sufficiently proficient trilinguals, the cognate effect can thus accumulate over languages in language comprehension tasks.

Kroll, Sumutka, and Schwartz (2005) reviewed studies that have shown that for beginning L2 learners, L1 on L2 effects are greater than vice versa. As speakers become more proficient in their L2, the magnitudes of the effects become more similar, although L1 on L2 effects typically still remain greater than L2 on L1 effects. Interestingly, this is even the case in bilinguals who speak two languages with different scripts. Hoshino and Kroll (2008) used cognates to explore cross-language activation in picture naming with same-script and different-script bilinguals. They found that both groups of bilinguals named cognates faster than non-cognates, which in the case of the different-script bilinguals led the authors to assume that during picture naming both languages are activated to the level of phonology during the retrieval process, even when the written form is absent.

A second factor that has been found to affect the co-activation of languages in multilinguals is immersion experience. To explore how access to languages is affected in speakers immersed in an L2 environment, Linck, Kroll, and Sunderman (2009) compared English-speaking learners of Spanish either exposed to Spanish in the classroom or immersed in the L2 environment in Spain. Participants were asked to perform an L2–L1 translation recognition task and verbal fluency tasks in both English and Spanish. Results revealed that the immersed group had reduced access to their L1 relative to the classroom learners. The authors interpreted this as being caused by the necessary inhibition of L1 during immersion in L2. In a study by Levy, McVeigh, Marful, and Anderson (2007), L1 inhibition was induced in participants in a laboratory setting using the retrieval-induced forgetting paradigm. After having named pictures repeatedly in the L2, participants generated significantly fewer words in L1 than participants who had previously named pictures in L1. As such, these results indicate that whether or not speakers are immersed in L2 environments has effects on the ease of access to all of their languages.

Present study

To test how relative language proficiency and length of language exposure affect cross-language activation across three languages in trilinguals, we manipulated cognate status across different language combinations, namely triple three-language cognates (L1–L2–L3 cognates), double two-language cognates (L1–L2 cognates and L2–L3 cognates in L2 naming and L1–L3 cognates and L2–L3 cognates in L3 naming), and non-cognate control words. We then compared L2 and L3 naming performances of L3-immersed German–English–Dutch same-script trilinguals with non-immersed Dutch–English–German same-script trilinguals and with L3-immersed Russian–English–German different-script trilinguals.

For the trilinguals in this study, relative language proficiency should have an effect on these individuals' sensitivity to L1 and L3 co-activation when processing in L2 and sensitivity to L1 and L2 when processing in L3. The rationale is that less effort is needed to retrieve and name words that have been used more often by speakers, which in turn is influenced by the current language environment. At the same time, the more proficient speakers become in their languages, the more often they are likely to retrieve and use words in these languages.

Thus, for the same-script trilinguals, cognate facilitation should be observed in naming in L2 if, for example, one (L1 or L3) or both (L1 and L3) non-target languages are also activated during L2 naming. For the different-script trilinguals, if both non-target languages are also activated even when L1 differs in script from L2 and L3, then cognate facilitation across all three languages should be observed. If, however, script is a modulating factor in the co-activation of languages or serves as a cue to direct lexical access, then the Russian–German–English trilinguals are expected to receive no facilitating activation from their L1 Russian. Finally, for all three groups and irrespective of any script differences, whether or not participants are immersed in their L3 may also have an effect on L3 activation. Specifically, those participants immersed in L3 could be assumed to outperform the non-immersed participants' L3 regarding speed and accuracy in L3 naming.

Experiment 1 – L3-immersed same-script trilinguals naming in L2 and L3

Method

Participants. Thirteen female German–English–Dutch trilinguals, enrolled in the Faculty of Social Sciences at Radboud University, Nijmegen, the Netherlands, took part in the experiment. They received course credits for their participation. Their ages ranged from 19.2 to 26.9 years ($M = 21.5$, $SD = 2.0$), they had all been born in Germany and had had an average of 8.7 years of English instruction ($SD = 1.8$) at school. They had been living in the Netherlands for 2.1 years ($SD = 1.3$) and had had 1.5 years of Dutch instruction ($SD = 0.6$) during this time.

Participants were asked to fill in a language history questionnaire to assess their language learning biographies and time spent immersed in any of the languages. They also self-rated their proficiencies in speaking, writing, reading, and listening in L1, L2, and L3 on a five-point Likert scale. Participants also completed proficiency tests in German, English, and Dutch: The English X-Lex vocabulary test (Meara & Milton, 2003) and German, Dutch, and English lexical decision tasks (Lemhöfer et al., 2004). The outcomes of the language background and proficiency measures are given in Table 1.

They rated themselves highly proficient in speaking German and about equally proficient in L2 English and L3 Dutch (mean difference = 0.3; $t(12) = 1.23$, $p = .22$). In the proficiency measures, the L2 English lexical decision accuracy was marginally significantly higher than that in L3 Dutch, $t(12) = 2.11$, $p = .057$.

Materials. The materials consisted of two sets of experimental stimuli: one for the L2 English and one for the L3 Dutch picture naming task. One-hundred-and-twenty black-on-white line drawings of common objects were selected from the International Picture Naming Project database (Székely et al., 2004). The L2 English materials consisted of 20 cognates between L1, L2, and L3 (triple cognates), 12 cognates between L1 German and L2 English and between L2

Table 1. Mean years of foreign language instruction, immersion experience, frequency of speaking, and proficiency scores (self-ratings, lexical decision tasks, and X_Lex) of participants in Experiments 1–3.

Language	Years of instruction	Years immersed in language environment	Frequency of speaking (1–5)[a]	Self-rated oral proficiency (1–5)[b]	Lexical decision task	English X_ Lex score
Experiment 1: L1 Germans						
L1 German	13.0 (0.0)	19.4 ()	4.9 (0.1)	4.9 (0.1)	97.9 (1.2)	N/A
L2 English	8.7 (1.8)	0.0 (0.0)	2.9 (0.4)	3.6 (0.7)	89.7 (5.1)	4206 (478)
L3 Dutch	1.5 (0.6)	2.1 (1.3)	4.3 (0.8)	3.3 (0.6)	83.7 (8.1)	N/A
Experiment 2: L1 Dutch						
L1 Dutch	12.0 (0.0)	19.8 (1.8)	4.9 (0.2)	4.9 (0.2)	97.9 (1.4)	N/A
L2 English	8.1 (1.7)	0.0 (0.0)	3.1 (0.5)	3.4 (0.6)	93.0 (3.9)	4423 (392)
L3 German	5.2 (1.4)	0.0 (0.0)	1.1 (0.3)	2.5 (0.8)	74.9 (6.1)	N/A
Experiment 3: L1 Russians						
L1 Russian	11.6 (0.3)	20.1 (3.9)	4.7 (0.3)	5.0 (0.2)	N/A	N/A
L2 English	10.3 (1.9)	0.2 (0.4)	4.0 (0.6)	3.9 (0.5)	74.2 (11.4)	3970 (650)
L3 German	5.5 (2.3)	6.5 (3.2)	4.6 (0.5)	4.1 (0.4)	72.7 (11.8)	N/A

Note. See text for more details on each of the tests. Standard deviations are in parentheses.
[a] 1 = "never", 2 = "seldom", 3 = "sometimes", 4 = "often", and 5 = "daily".
[b] 1 = "none", 2 = "low", 3 = "moderate", 4 = "moderate to high", and 5 = "native-like" proficiency.

English and L3 Dutch (double cognates), and 28 non-cognates. The L3 Dutch materials consisted of 19 L1, L2, and L3 (triple cognates), 17 cognates between L1 German and L3 Dutch and between L2 English and L3 Dutch (double cognates), and 24 non-cognates (see stimuli lists in Appendices A and B).

The three word types of picture names in English and in Dutch were matched on frequency (CELEX database, Baayen, Piepenbrock, & Van Rijn, 1993), word length, name agreement, visual complexity (Székely et al., 2004), and imageability (Lahl, Goeritz, Pietrowsky, & Rosenberg, 2009), all p values >.10, save visual complexity in English, in which they differed significantly, $F(2,57) = 3.64$, $p = .03$; this difference, however, worked against the predicted cognate effect, as the triple cognates stimuli had higher visual complexity ratings than the other two word types. Table 2 presents the mean word characteristics for the stimuli sets.

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 (Schneider, 1995).

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 as accurately as possible in the target language, speaking into the microphone set before them. Throughout the experiment the experimenter (a balanced English–German bilingual) used exclusively the language in which the pictures were to be named by the participants. The experiment was set up in four blocks, the first of which being 15 practice trials. These trials were used to familiarize the participants with the experimental procedure and, if necessary, to give them additional instructions before proceeding. Each of the three experimental blocks was made up of 20 stimuli and was started with the press of a button by the researcher.

Table 2. Word characteristics of the word types used in Experiments 1–3.

	Word characteristics			
Word type	Word length	Log frequency	Name agreement	Visual complexity
L1 Germans (L2)				
Non-cognate	1.7 (0.7)	1.2 (0.4)	.90 (.13)	15,593 (5065)
Double cognate	1.8 (0.7)	1.4 (0.6)	.88 (.16)	16,654 (7231)
Triple cognate	1.8 (0.7)	1.2 (0.5)	.96 (.08)	20,992 (10,840)
L1 Germans (L3)				
Non-cognate	1.8 (0.7)	1.1 (0.5)	.94 (.13)	15,682 (6609)
Double cognate	1.7 (0.7)	1.3 (0.5)	.90 (14)	17,831 (9027)
Triple cognate	2.0 (0.6)	1.0 (0.5)	.93 (.10)	23,572 (15,709)
L1 Dutch (L2)				
Non-cognate	1.5 (0.6)	1.5 (0.4)	.90 (.11)	16,386 (6806)
Double cognate	1.6 (1.0)	1.3 (0.4)	.90 (.16)	13,465 (4639)
Triple cognate	1.6 (0.6)	1.4 (0.6)	.95 (.05)	21,224 (11,423)
L1 Dutch (L3)				
Non-cognate	1.9 (1.0)	1.4 (0.5)	.87 (.10)	17,948 (6741)
Double cognate	1.7 (0.8)	1.4 (0.7)	.91 (.15)	16,580 (5899)
Triple cognate	1.6 (0.7)	1.6 (0.6)	.94 (.13)	16,381 (8721)
L1 Russians (L2)				
Non-cognate	1.5 (0.6)	1.5 (0.4)	.90 (.11)	16,386 (6806)
Double cognate	1.6 (1.0)	1.3 (0.4)	.90 (.16)	13,465 (4639)
Triple cognate	1.6 (0.6)	1.4 (0.6)	.95 (.05)	21,224 (11,423)
L1 Russians (L3)				
Non-cognate	1.9 (0.7)	1.3 (0.5)	.89 (.10)	18,357 (7098)
Double cognate	1.9 (0.7)	1.4 (0.4)	.90 (.14)	16,674 (6670)
Triple cognate	1.7 (0.6)	1.5 (0.5)	.96 (.07)	17,604 (9503)

Note. Standard deviations are in parentheses.

Each experimental trial was structured as follows. A fixation sign was displayed for 1000 ms followed by a picture for 5000 ms or until the participant responded. The pictures were presented in a pseudo-random order with the restriction that no more than three cognates or non-cognates or pictures with an identical initial phoneme would be displayed in a row. The experimenter used a coding sheet to register the participant's utterances and the experiment was digitally recorded for later analysis. Participants performed the task in the first of the two language conditions, followed by a break of approximately 4 minutes in which the experimenter switched to the language of the upcoming condition, after which the participants performed the task in the second language condition. The order of language conditions was counterbalanced across participants.

Results and discussion

For each participant and each item, mean naming latencies and mean percentages of accuracy were calculated for the three word types in English and Dutch. An omission was scored if the participant had not responded within the 5000 ms allotted for naming after picture presentation. Trials associated with voice-key failures and incorrect responses, as well as outliers with reaction times (RTs) shorter than 200 ms or longer than 2.5 standard deviations (*SD*) above the participant's mean were excluded from RT analyses.

The data for L2 and L3 naming were analyzed separately. One-factor analyses of variance (ANOVAs) were performed by participants ($F1$) and by items ($F2$) on the mean naming latencies of the correct responses, as well as on the accuracy rates, with word type (for L2 naming: triple cognates, double cognates, and L2 non-cognates; for L3 naming: triple cognates, double cognates, and L3 non-cognates) serving as the independent variable. In the participant analysis, word type was treated as a within-participant variable, while in the corresponding item analysis word type was treated as a between-items factor. Post hoc analyses included pairwise comparisons by participant with a Bonferroni correction and Tukey HSD (honestly significant difference) comparisons by item. The resulting means and *SD* values are presented in Table 3.[1]

Naming in L2 English. Voice-key failures made up 7.3% of triple cognates, 4.6% of double cognates, and 5.5% of non-cognates. Outliers made up 1.8% of triple cognates, 2.9% of double cognates, and 2.0% of non-cognates. To prevent extremely low accuracy rates from biasing the pattern of findings, the following data trimming procedures were used. Cut-off points at 40% participant accuracy rate and 25% item accuracy rate were employed, only above which threshold a participant's data and an item's data were entered in the final analysis. Following this, one participant had to be dropped from the L2 and, consequently, also from the L3 data analyses. Note that only the data of participants who had performed above the threshold in both L2 and L3 naming was included in the final analysis. None of the items had to be excluded.

In the naming latency analysis, there was a significant effect of word type, $F1$ (2,22) = 13.14, MSE = 25,438, $p < .001$, $\eta_p^2 = .54$; $F2$ (2,57) = 3.93, MSE = 137,918, $p = .013$, $\eta_p^2 = .12$. The post hoc analysis yielded significantly shorter RTs for triple cognates than double cognates ($p1 = .016$,

Table 3. Mean response times (in ms), accuracy rates (in %), and cognate effect magnitudes for the trilinguals' L2 and L3 picture naming in Experiments 1–3.

Word type & effect magnitude	L1 Germans (Exp. 1)		L1 Dutch (Exp. 2)		L1 Russians (Exp. 3)	
	RT	Accuracy	RT	Accuracy	RT	Accuracy
L2 Picture naming						
Triple cognate (A)	1338 (223)	79.6 (8.7)	1307 (238)	86.3 (8.6)	1187 (259)	81.7 (10.2)
Double cognate (B)	1548 (280)	59.4 (14.2)	1582 (417)	70.8 (15.2)	1382 (374)	67.7 (14.1)
Non-cognate (C)	1668 (265)	61.3 (14.4)	1435 (211)	80.1 (11.6)	1399 (296)	66.4 (15.3)
– Effect A over B	209*	20.2***	275*	15.5**	195***	14.0***
– Effect A over C	330***	18.3***	128**	6.2*	212***	15.3***
– Effect B over C	120	–1.9	–147	–9.3	17	1.3
L3 Picture naming						
Triple cognate (A)	1492 (322)	72.8 (17.7)	1664 (311)	56.8 (18.9)	1100 (143)	90.9 (7.7)
Double cognate (B)	1601 (311)	66.4 (17.1)	1791 (446)	65.4 (15.1)	1221 (203)	81.4 (10.6)
Non-cognate (C)	1765 (358)	57.0 (22.4)	2114 (606)	38.8 (13.3)	1284 (214)	82.5 (12.4)
– Effect A over B	109	6.4	128	–8.6	121***	9.5***
– Effect A over C	273*	15.8*	450*	18.0*	284***	8.4***
– Effect B over C	164	9.4*	323*	26.6***	63	–1.1

Note. Standard deviations are in parentheses. Significant effects are indicated by: * $p < .05$; ** $p < .01$; *** $p < .001$.
RT: reaction time.

but $p2 > .20$) and non-cognates ($p1 < .001$, $p2 < .01$). Double cognates did not differ significantly from non-cognates (both p values $> .25$).

The ANOVA on the accuracy data revealed a significant effect of word type, $F1$ (2,22) = 22.49, $MSE = 66$, $p < .001$, $\eta_p^2 = .67$; $F2$ (2,57) = 3.61, $MSE = 671$, $p = .017$, $\eta_p^2 = .11$. The post hoc analysis yielded significantly higher accuracy rates for triple cognates than for double cognates ($p1 < .001$, $p2 = .05$) and non-cognates ($p1 < .001$, $p2 = .02$). Double cognates and non-cognates did not differ significantly (both p values $> .40$). Figure 1 displays naming latencies and accuracy rates.

Naming in L3 Dutch. In L3 Dutch naming, voice-key failures made up 2.4% of triple cognates, 1.3% of double cognates, and 0.8% of non-cognates. Outliers made up 1.4% of triple cognates, 0.5% of double cognates, and 2.0% of non-cognates. For data trimming, the same cut-off points were used as in L2 naming. None of the participants or items in the L3 Dutch naming condition had to be excluded.

In the L3 naming latency analysis, there was a significant effect of word type, $F1$ (2,22) = 3.69, $MSE = 61{,}213$, $p = .021$, $\eta_p^2 = .25$; $F2$ (2,57) = 2.98, $MSE = 113{,}251$, $p = .03$, $\eta_p^2 = .10$. The post hoc analysis yielded significantly shorter RTs for triple cognates than non-cognates ($p1 = .012$, $p2 = .027$), while none of the other pairs differed significantly (all p values $> .20$).

The accuracy data analysis revealed a significant effect of word type by participant, $F1$ (2,22) = 5.66, $MSE = 133$, $p = .005$, $\eta_p^2 = .34$, and a marginally significant effect by item, $F2$ (2,57) = 2.21, $MSE = 601$, $p = .06$, $\eta_p^2 = .07$. The post hoc analysis yielded significantly higher accuracy rates for triple cognates than non-cognates ($p1 = .02$, $p2 = .07$), and for double cognates than non-cognates ($p1 = .034$, but $p2 > .10$). Triple cognates and double cognates did not differ significantly ($p1 > .25$, $p2 > .40$). Figure 2 displays naming latencies and accuracy rates.

The results from Experiment 1 showed significantly shorter naming latencies and higher accuracy rates for triple cognates than for double cognates and non-cognates in L2 naming. In L3 naming, triple cognates were named faster than non-cognates, and triple cognates and double cognates were named more accurately than non-cognates. These results indicate that in these same-script L1 German trilinguals, who at the time of the experiment had been and were still immersed in an L3 Dutch

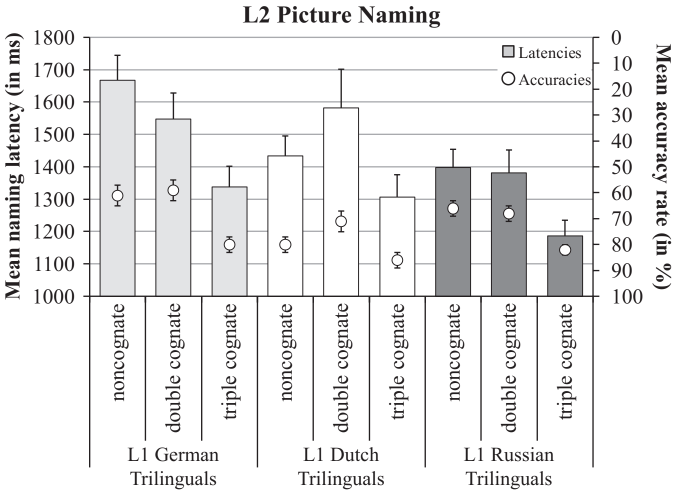

Figure 1. Naming latencies (y-axis) and accuracy rates (z-axis) for L2 picture naming (Experiments 3.1–3.3).

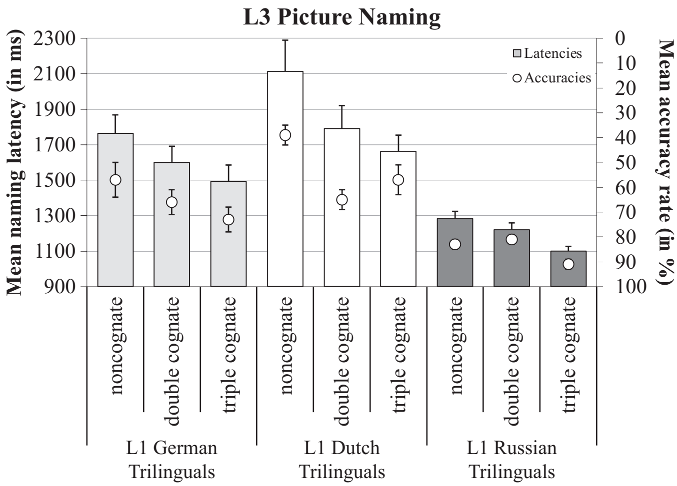

Figure 2. Naming latencies (y-axis) and accuracy rates (z-axis) for L3 picture naming (Experiments 3.1–3.3).

environment, there is stronger cross-language activation in L2 naming when all three languages are co-activated by the stimulus (triple cognate) than if only two languages are co-activated (double cognates). In L3 naming, triple cognates were named faster than non-cognates, and triple cognates and double cognates were named more accurately than L2 non-cognates. This could be interpreted as L2 English activation in L3 Dutch naming being less prominent, possibly mirroring an effect of the active daily usage of Dutch paired with the generally strong activation of L1 German. Also, one could assume that the L2 in these participants has not yet reached the proficiency threshold to exert a strong influence on L3 language production, while being immersed in the L3 does affect L3 picture naming. In an attempt to shed more light on the effect of immersion, in Experiment 2 a group of L1 Dutch trilinguals with the same three languages at their disposal were tested. In contrast to the Experiment 1 participants, these participants were living in an L1 environment, thus non-immersed in their L3. Hence, although both groups of trilinguals were university students at the same Dutch university, and spoke the same three languages, the trilinguals tested in Experiment 1 were immersed in their L3, whereas the trilinguals tested in Experiment 2 were immersed in their L1.

Experiment 2 – non-L3-immersed same-script trilinguals naming in L2 and L3

Method

Participants. Twenty-six female Dutch–English–German trilinguals, enrolled in the Faculty of Social Sciences at Radboud University, Nijmegen, the Netherlands, took part in the experiment. They received course credits for their participation. Their ages ranged from 18.2 to 24.7 years ($M = 19.8$, $SD = 1.8$). The participants had all been born in the Netherlands, had had 8.1 years of English instruction ($SD = 1.7$) and 5.2 years of German instruction ($SD = 1.4$) at secondary school. They rated themselves highly proficient in speaking Dutch, and more proficient in English than in German (*Mean difference* = 0.9; $t(25) = 5.89$, $p < .001$). Participants also completed the proficiency measures outlined in Experiment 1. Results are displayed in Table 1. The scores indicate that participants were more proficient in L2 English than in L3 German, $t(25) = 14.16$, $p < .001$.

Materials. The materials consisted of two sets of experimental stimuli: one for the L2 English and one for the L3 German picture naming task.

The 60 L2 English naming stimuli, identical to those used in Experiment 1, consisted of 20 cognates between L1, L2, and L3 (triple cognates), 12 cognates between Dutch and English (L1–L2 double cognates) and English and German (L2–L3 double cognates), and 28 non-cognates. The L3 German picture naming materials consisted of 60 black-on-white line drawings of common objects (Székely et al., 2004; see Appendix B). There were 18 cognates between L1, L2, and L3 (triple cognates), 16 cognates between Dutch and German (L1–L3 double cognates) and English and German (L2–L3 double cognates), and 26 non-cognates. The three word types did not differ significantly in log frequency (Baayen et al., 1993), word length, visual complexity, and name agreement, (Székely et al., 2003), all p values > .20, save visual complexity in L2 English (see *Materials* section in Experiment 1). Table 2 presents the mean word characteristics for the stimuli sets.

Apparatus and procedure. The apparatus and procedure used were the same as in Experiment 1.

Results and discussion

The data were analyzed as in Experiment 1.

Naming in L2 English. In L2 naming, trials associated with voice-key failures (4.4% triple cognates, 8.3% double cognates, and 8.7% non-cognates), incorrect responses, and outliers (0.6% triple cognates, 2.8% double cognates, and 2.4% non-cognates) were excluded from the RT analysis. Using the same cut-off points as in Experiment 1, 14 participants were dropped from the L2 English naming data analysis. Even though their accuracies on the L2 naming task were above threshold, we excluded their data in the L2 naming analyses because they performed below the accuracy threshold in their L3 German naming. This left 12 participants.

The naming latency analysis yielded a significant effect of word type, $F1$ (2,22) = 5.55, MSE = 40,919, $p = .011$, $\eta_p^2 = .34$; $F2$ (2,57) = 5.13, MSE = 58,878, $p = .005$, $\eta_p^2 = .15$. The post hoc analysis yielded significantly shorter RTs for triple cognates than double cognates ($p1 = .024$, $p2 = .003$) and non-cognates ($p1 = .002$, $p2 = .05$). Double cognates and non-cognates did not differ significantly ($p1 > .25$, $p2 > .10$).

The ANOVA on the accuracy data showed a significant effect of word type by participant only, $F1$ (2,22) = 9.04, MSE = 80, $p < .001$, $\eta_p^2 = .45$; $F2$ (2,57) = 1.55, $p = .11$. The post hoc analysis showed significantly higher accuracy rates for triple cognates than double cognates ($p1 = .009$, $p2 = .09$) and non-cognates ($p1 = .028$, but $p2 > .20$); non-cognates were named marginally significantly more accurately than double cognates ($p1 = .06$, but $p2 > .20$). Figure 1 displays naming latencies and accuracy rates.

Naming in L3 German. In L3 naming, trials associated with voice-key failures (4.2% triple cognates, 4.3% double cognates, and 1.2% non-cognates), incorrect responses, and outliers (0.4% triple cognates, 0.9% double cognates, and 0.7% non-cognates) were excluded from the RT analysis. Using the same cut-off points as in Experiment 1, the same 12 participants included in the analysis of the L2 English naming task were included, and 42 of the 60 original items remained for the L3 German analysis.

The L3 naming latency analysis yielded a significant effect of word type, $F1$ (2,22) = 6.92, MSE = 93,411, $p = .003$, $\eta_p^2 = .39$; $F2$ (2,39) = 3.80, MSE = 212,932, $p = .016$, $\eta_p^2 = .16$. The post hoc analysis yielded significantly faster naming latencies for triple cognates than non-cognates

($p1 = .017$, $p2 = .04$), and for double cognates than non-cognates ($p1 = .028$, $p2 = .016$). Triple cognates and double cognates did not differ significantly (both p values > .30).

The L3 accuracy data also revealed a significant effect of word type, $F1$ (2,22) = 7.81, MSE = 284, $p = .002$, $\eta_p^2 = .42$; $F2$ (2,39) = 5.03, MSE = 555, $p = .006$, $\eta_p^2 = .21$. The post hoc analysis yielded significantly higher accuracy rates for triple cognates than non-cognates ($p1 = .025$, $p2 = .06$), and for double cognates than non-cognates ($p1 < .001$, $p2 = .005$). Triple cognates and double cognates did not differ significantly ($p1 > .40$, but $p2 = .07$). Figure 2 displays naming latencies and accuracy rates.

The results from Experiment 2 yielded significantly shorter naming latencies and higher accuracies for triple cognates than for double cognates and non-cognates in L2 naming, which is in line with the results from Experiment 1. In L3 naming, triple cognates and double cognates were named faster and more accurately than non-cognates. The results obtained with L1 Dutch trilinguals, who had never been immersed in an L3 German environment, indicate that L3 only exerted sufficient co-activation in L2 naming to facilitate naming significantly when stimuli were cognates across all three languages. In L3 naming, the participants' performance showed a pattern in which both triple cognates and double cognates lead to co-activation that resulted in significant cognate facilitation compared to non-cognates. Thus, triple cognates and double cognates had similar effects in L3 naming, whereas in L2 naming they differed. This pattern of results suggests that in L2 naming both the stronger L1 and the weaker L3 are co-activated to speed up naming triple cognates compared to non-cognates, indicating that even the much less-developed L3 seems to exert enough influence to have a significant effect during language production. In L3 naming, however, triple cognates had no significantly stronger effect than did double cognates. A possible explanation is that L1 and L2 have higher baseline activation than L3, which in these participants had not yet reached the proficiency threshold to exert more influence in L3 language production. One could assume that this may also be linked to the fact that these participants were not immersed in their L3, in contrast to the participants in Experiment 1.

To further explore effects of immersion in L3 on language co-activation, and to examine to what extent cognate effects would emerge in bilinguals whose languages have different scripts, we tested L3-immersed and different-script L1 Russian trilinguals in Experiment 3.

Experiment 3 – different-script trilinguals naming in L2 and L3

Method

Participants. Twenty-eight female Russian–English–German trilinguals, enrolled in the English department at Goethe University, Frankfurt, Germany, volunteered to take part in the experiment. Their ages ranged from 23.6 to 32.4 years ($M = 26.5$, $SD = 2.2$). All participants had been born in Russian-speaking countries. They had had English instruction for 10.3 years ($SD = 1.9$) and had lived in an English-speaking environment for an average of 0.2 years ($SD = 0.4$). They had German instruction for 5.5 years ($SD = 2.3$), most of which after their arrival in Germany, and had been living in Germany for a period of 6.5 years ($SD = 3.2$); the mean age of arrival was 20.1 ($SD = 3.9$). The L1 Russian trilinguals rated themselves highly proficient in speaking Russian, and equally proficient in both English and German, $t(27) = 1.70$, $p > .10$. Participants also completed the X_Lex in English and the lexical decision tasks in L2 English and L3 German (see Table 1 for results). The participants' lexical decision task scores in English and German did not differ significantly, $t(27) < 1$.

Materials. The materials consisted of two sets of experimental stimuli: one for the L2 English and one for the L3 German picture naming task.

For the picture-naming task, one-hundred-and-twelve black-on-white line drawings of common objects were selected (Székely et al., 2004). The L2 English materials consisted of 18 cognates between L1 Russian, L2 English, and L3 German (triple cognates), 19 L1–L2 and L2–L3 cognates (double cognates), and 19 non-cognates. The L3 German picture naming materials entailed 18 triple cognates, 18 L1–L3 and L2–L3 double cognates, and 18 non-cognates (see stimuli list in Appendices C and D).

The three types of stimuli, in English and in German, were matched on frequency (CELEX database, Baayen et al., 1993), word length, name agreement, visual complexity (Székely et al., 2004), and imageability (Lahl, Goeritz, Pietrowsky, & Rosenberg, 2009), all p values >.10. Table 2 presents the mean word characteristics for the stimuli sets.

Apparatus and procedure. The apparatus and procedure used were the same as in Experiments 1 and 2, the only difference being that in both language conditions, the three experimental blocks were made up of two blocks of 19 stimuli and one block of 18 stimuli.

Results and discussion

The data were analyzed as in Experiments 1 and 2.

Naming in L2 English. Trials associated with voice-key failures (8.4% triple cognates, 8.0% double cognates, and 7.1% non-cognates), incorrect responses, and outliers (1.3% triple cognates, 2.3% double cognates, and 3.2% non-cognates) were excluded from the RT analysis. Using the same cut-off points as in Experiments 1 and 2, none of the participants and items had to be dropped from both L2 English and L3 German naming data analyses.

The naming latency data analysis revealed a significant effect of word type, $F1\ (2,54) = 14.84$, $MSE = 26{,}228$, $p < .001$, $\eta_p^2 = .36$; $F2\ (2,53) = 3.10$, $MSE = 52{,}996$, $p = .027$, $\eta_p^2 = .11$. The post hoc analysis yielded significantly shorter RTs for triple cognates than double cognates ($p1 < .001$, but $p2 > .20$) and non-cognates ($p1 < .001$, $p2 = .032$), while double cognates and non-cognates did not differ significantly ($p1 > .40$, but $p2 = .06$).

The L2 English accuracy data analysis showed a significant effect of word type by participants, $F1\ (2,54) = 31.27$, $MSE = 65$, $p < .001$, $\eta_p^2 = .54$, which was only marginally significant by items, $F2\ (2,53) = 2.08$, $MSE = 480$, $p = .068$, $\eta_p^2 = .07$. The post hoc analysis showed significantly higher accuracy for triple cognates than for double cognates ($p1 < .001$, but $p2 > .15$) and non-cognates, ($p1 < .001$, $p2 = .06$); this data pattern mirrors the RT analysis. Double cognates and non-cognates did not differ significantly (both p values > .40). Figure 1 displays naming latencies and accuracy rates.

Naming in L3 German. In L3 naming, trials associated with voice-key failures (15.1% triple cognates, 10.4% double cognates, and 12.7% non-cognates), incorrect responses, and outliers (0.6% triple cognates, 2.1% double cognates, and 3.4% non-cognates) were excluded from the RT analysis.

The naming latency data revealed a significant effect of word type, $F1\ (2,54) = 17.78$, $MSE = 13{,}833$, $p < .001$, $\eta_p^2 = .40$; $F2\ (2,53) = 4.74$, $MSE = 24{,}103$, $p = .007$, $\eta_p^2 = .15$. The post hoc analysis yielded significantly shorter naming latencies for triple cognates than double cognates ($p1 < .001$, $p2 = .025$) and non-cognates ($p1 < .001$, $p2 = .008$), while double cognates and non-cognates did not differ significantly ($p1 > .15$, $p2 > .40$).

The L3 German accuracy data revealed a significant effect of word type, $F1$ (2,54) = 12.73, MSE = 59, $p < .001$, $\eta_p^2 = .32$; $F2$ (2,53) = 2.58, MSE = 126, $p = .043$, $\eta_p^2 = .09$. The post hoc analysis yielded significantly higher accuracy rates for triple cognates than double cognates ($p1 < .001$, $p2 = .05$) and non-cognates ($p1 < .001$, $p2 = .07$), while double cognates and non-cognates did not differ significantly (both p values > .40). Figure 2 displays naming latencies and accuracy rates.

The different-script L1 Russian trilinguals' performance in L2 and L3 naming showed significantly shorter naming latencies and higher accuracy rates for triple cognates than for double cognates and non-cognates. These results indicate that in these participants, who at the time of the experiment were immersed in the L3 German environment, there is cross-language activation of their L1 Russian, L2 English, and L3 German both in L2 naming and L3 naming. This suggests an equally high baseline activation of L2 and L3, possibly mirroring both the active usage of English and German as languages of instruction at university and the active usage of German (along with Russian) in personal interactions inside and outside of university. These participants have thus reached and overcome possible thresholds in their L2 and L3 to allow these languages to exert influence on the other languages and thus for cross-language activation to take place. Again, while cross-language activation in bilinguals from their L1 on L2 or L3 has been shown in multilinguals with a wide variety of L2 and L3 proficiency levels, the L2 or L3 only exerts influence on the L1 if sufficient L2 and/or L3 proficiency has been reached (Costa et al., 2000; Poarch & Van Hell, 2012; Van Hell & Dijkstra, 2002).

Overall analyses of Experiments 1–3

To address the predictions made in the first section concerning the impact of immersion and relative language proficiencies in L2 and L3 on the ease (and thus the speed) of lexical access and cross-language activation, two additional analyses were conducted on the overall naming latencies and on the cognate effect magnitudes.

Firstly, the participant groups' overall L2 and L3 picture naming latencies were compared to assess whether immersion and language proficiency would modulate speed of access to L2 and L3, speeding up naming for those immersed and/or those with higher relative language proficiency in contrast to those participants non-immersed and less proficient. To test this, the collapsed overall picture naming latencies in L2 (English) and in L3 (Dutch, German, Russian) as an index of relative ease of lexical access, the accuracy scores in the L2 and L3 lexical decision tasks and the self-ratings for L2 and L3 as measures for L2 and L3 proficiencies, length of L2 and L3 instruction, and length of L2 and L3 immersion were correlated. L2 naming latencies correlated with none of these factors. L3 naming latencies, in contrast, correlated with length of immersion in L3 ($r = -.67$, $p < .001$), with length of instruction in L3 ($r = -.24$, $p < .05$), and with L3 self-rating scores ($r = -.76$, $p < .001$).

Subsequent multiple regression analyses were performed on the naming latencies in L3, with length of immersion in L3, length of L3 instruction, and L3 self-rating scores as predictors. The regression analysis showed that 44.5% of the variance in the L3 naming latencies was accounted for by length of immersion in L3 and 16.6% by the L3 self-rating scores ($F(2,49) = 38.51$, $p < .001$); adding length of L3 instruction did not significantly increase the variance accounted for. This means the longer the participants had been immersed in L3 ($B = -26.65$, $\beta = -.26$, $p < .05$) and the higher their self-rated L3 proficiency ($B = -309.69$, $\beta = -.58$, $p < .001$) the faster they named pictures in L3.

Secondly, to assess which of the variables may have had a modulating effect on cross-language activation as indexed by the cognate effect magnitudes, the magnitudes of the cognate facilitation effect in L2 picture naming (English) and L3 picture naming (Dutch, German, Russian) and the same set of variables used above were correlated (see Table 3 for cognate effect magnitudes in L2 and L3 naming). The correlation analyses showed no significant correlations for the cognate effect magnitudes in L2 with any of the factors. In contrast, the triple cognate effect and the double cognate effect in L3 naming correlated with length of immersion in L3 ($r = -.32$, $p < .01$ and $r = -.33$, $p < .01$, respectively) and with L3 proficiency ($r = -.43$, $p < .01$ and $r = -.34$, $p < .01$, respectively).

Subsequent multiple regression analyses were performed on the triple cognate effect and on the double cognate effect in L3 naming, with length of immersion in L3 and L3 proficiency as predictors. The regression analysis showed that 10.3% of the variance in the triple cognate effect magnitude in L3 naming was accounted for by length of immersion in L3 and 8.2% by L3 proficiency ($F(2,49) = 5.58$, $p < .01$). This means the longer the participants had been immersed in L3 ($B = -28.10$, $\beta = -.32$, $p < .05$) and the higher their L3 proficiency ($B = -184.87$, $\beta = -.41$, $p < .05$), the smaller the triple cognate effect magnitude in L3 picture naming. The regression analysis for the double cognate effect magnitude showed that 11.1% of the variance was accounted for by length of immersion in L3 ($F(1,50) = 6.23$, $p < .05$) and 11.9% by L3 proficiency ($F(1,50) = 6.73$, $p < .05$). This means the longer the participants had been immersed in L3 ($B = -29.42$, $\beta = -.33$, $p < .05$), and the higher their L3 proficiency ($B = -158.91$, $\beta = -.34$, $p < .05$), the smaller their double cognate effect magnitude in L3 picture naming.

The results from these analyses indicate that both length of immersion and self-assessed proficiency are the best predictors for speed of lexical access and retrieval in L3 naming and for the cognate effect magnitudes in L3 naming. Particularly the magnitudes of both the triple cognate facilitation effect and the double cognate facilitation effect were significantly modulated by length of immersion in the L3 and self-assessed L3 proficiency. It seems thus that immersion in L3 exerts influence in L3 naming across the three groups of participants that differs from the influence it exerts in L2 naming.

General discussion

The present study provides a unique contribution to the literature in that it examines three groups of trilinguals who differed in relative language proficiency and immersion experience. The goal of this study was to study triple and double cognate effects in these three groups of trilinguals and to shed light on whether during language production cross-language activation is modulated by relative language proficiency and immersion experience in adult trilinguals who had sustained and substantial input in three languages. The findings indicate that in trilinguals, the immersion experience and relative proficiency potentially affect cross-language activation of non-target languages during L2 and L3 picture naming. The results are in line with earlier findings of cognate facilitation in bilinguals by Costa et al. (2000), Hoshino and Kroll (2008), and Poarch and Van Hell (2012), now extended to same- and different-script trilinguals in various L3-immersion settings.

In line with earlier research on word recognition in trilinguals (cf. Lemhöfer et al., 2004; Van Hell & Dijkstra, 2002), the results obtained in this study show cross-language activation of three languages during picture naming. As in the Lemhöfer et al. study, but extended to language production, the cognate facilitation effect in the present study accumulated over languages in that cognates across three languages yielded more facilitation than cognates across only two languages in both same- and different-script trilinguals. This was found consistently, however not always significantly, for all groups of trilinguals during L2 naming. Such an effect can only be accounted for by assuming that all three languages, irrespective of script, were involved during the process of retrieval and production.

The same-script German–English–Dutch trilinguals in Experiment 1 showed an L2 naming performance pattern in which triple cognates were processed significantly faster than double cognates and non-cognates. In L3 naming, in contrast, triple cognates were processed significantly faster than non-cognates only, which we tentatively interpret as L2 English exerting less influence in these speakers than L3 Dutch, the language in which they were immersed. This view is supported by the accuracy data in which there is a similar pattern with significant facilitation for double cognates over non-cognates. Overall, the participants' performance could be assumed to reflect the amount of exposure more so than relative language proficiencies. In Experiment 2, the same-script Dutch–English–German trilinguals displayed an L2 naming performance pattern in which facilitation became evident with triple cognates only, while in L3 naming, the triple cognates and double cognates facilitated naming significantly. This pattern might be a reflection of lack of exposure to L3 German and relatively higher L2 English proficiency. In Experiment 3, the Russian–English–German trilinguals showed similar naming performances in L2 and L3, both in terms of latencies and accuracy rates, which parallels their relatively balanced language proficiencies in L2 English and L3 German, as well as regular language exposure to both languages. In these speakers, in L2 and L3 naming, facilitation became evident when all three languages were involved.

How can the observed cognate facilitation effects be explained? The language co-activation view explains the cognate facilitation effect by postulating that cognate words receive higher activation from all languages involved, whereas non-cognates only receive activation from their dominant language. Phonological and, to a lesser extent, orthographic overlap would then be at the base of the cognate facilitation effect. If both the target and the non-target languages are co-activated during word access, then the triple activation of identical or near-identical phonology and orthography would be sufficient to cause facilitation in naming such stimuli. Moreover, in bilingual speakers the links between the semantic system and the lexical nodes are stronger in the dominant language compared to the non-dominant language (cf. Kroll & Stewart, 1994). As a consequence, when bilinguals retrieve cognates during picture naming in the non-dominant language, strong activation of translation equivalents in the dominant language spread to the phonological level, which in turn facilitate the retrieval of the phonological segments in the non-dominant language. In other words, if one assumes that during word retrieval one conceptual representation is activated, and that pictures (denoting concrete words) have a large overlap in meaning in the languages of bilinguals and trilinguals (e.g., Laxén & Lavaur, 2009; Van Hell & De Groot, 1998), then the activation of a cognate's semantic representation should be stronger given that this activation has at its base not only one but two or possibly three language sources that provide phonological, orthographic, and semantic overlap.

Alternatively, in a cumulative frequency view (e.g., Strijkers, Costa, & Thierry, 2010), the cognate effect could simply be a word frequency effect that accumulates over time in multilinguals, given the repeated activation of a cognate's overlapping features irrespective of in which language the word is accessed. Non-cognates, which have no phonological and orthographic overlap, would conversely be rendered lower frequency words, while cognates would effectively be higher frequency words. This could then be at the base of the cognate facilitation effect being strongest for triple cognates than double cognates and non-cognates.

Finally, a learning-based explanation could also be drawn on to explain the cognate facilitation effect. In this view, pre-existing L1 memory representations are utilized during the learning of L2 and L3 words (e.g., De Groot & Keijzer, 2000). Because the orthography and phonology of L2 and L3 cognates are more similar to their L1 translations than those of non-cognates, learners are more inclined to directly map novel L2 and L3 cognates onto the existing L1 lexical-semantic representations during learning. This results in higher cross-language overlap of orthographic, phonological, and semantic codes for cognates than for non-cognates. The facilitation effects of double and triple cognates during lexical retrieval in picture naming should therefore reflect how extensively these cognates were mapped to the L1 lexical-semantic representations during learning and how strongly they are co-activated for production purposes. One would then expect triple cognates to possibly receive more co-activation than double cognates only if the triple cognate mapping was more extensive than double cognate mapping (see De Groot & Van Hell, 2005, for the integration of newly learned foreign language words). For non-immersed trilinguals, the fully overlapping integration of triple cognates may be less likely, which is a possible explanation for the participants' L3 naming performance in Experiment 2, in which the facilitation of triple cognates and double cognates over non-cognates did not differ significantly.

Irrespective of which specific account is more fitting, the pattern of the cognate effect obtained in this study indicates parallel co-activation of all the languages involved. We have shown that when trilinguals named pictures in one of their non-dominant languages not only did the dominant language exert an influence on the non-dominant languages, but also the second non-dominant language. Thus, the cognate facilitation found in bilingual picture naming (Costa et al., 2000; Hoshino & Kroll, 2008; Poarch & Van Hell, 2012) can be extended to trilingual picture naming. In trilinguals, not only the L1 exerts influence on L2 and L3, but, critically, the non-dominant languages learned later in life also exert influence on one another, as has been shown for syntax, lexicon, and phonology by, for example, De Angelis (2007), De Angelis and Dewaele (2011), and Jarvis and Pavlenko (2008). One could then also assume that both L2 and L3 should also exert influence on L1, which was borne out in the study by Van Hell and Dijkstra (2002) in recognition tasks in relatively proficient trilinguals and, more recently, in a picture naming study with bilingual and trilingual children (Poarch & Van Hell, 2012). Furthermore, the results obtained in the present study are in line with those in the picture naming study by Hoshino and Kroll (2008), who observed cognate facilitation for both different-script Japanese–English and same-script Spanish–English bilinguals, suggesting language co-activation of phonology even in different-script bilinguals, which is in line with the Russian–English–German trilinguals tested in Experiment 3.

To conclude, the results of the present experiments provide evidence for trilingual language activation irrespective of whether all three languages share the same script or whether one of the languages, in this case the L1, is of a different script. Furthermore, cross-language activation in trilinguals is modulated by their time spent immersed in the non-dominant languages and their usage frequencies, and their non-dominant languages' proficiencies. The activation levels of the non-dominant language(s) need to be sufficiently developed to allow for any cross-language activation that results in a cognate facilitation effect when naming in one of the non-dominant languages.

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Note

1. As we had well-founded predictions with respect to the direction of the cognate effect at the onset of this study, *p*-values throughout this manuscript are reported for one-tailed tests.

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Appendix A. List of L2 stimuli used in Experiments 1 and 2.

English (L2)	German (L1/L3)	Dutch (L1/L3)
Triple cognates		
apple	Apfel	appel
baby	Baby	baby
bench	Bank	bank
bus	Bus	bus
camel	Kamel	kameel
cat	Katze	kat
cow	Kuh	koe
crab	Krebs	krab
dinosaur	Dinosaurier	dinosaurus
dolphin	Delphin	dolfijn
door	Tuer	deur
dragon	Drachen	draak
king	König	koning
lamp	Lampe	lamp
palmtree	Palme	palm
pirate	Pirat	piraat
ring	Ring	ring
tiger	Tiger	tijger
penguin	Pinguin	pinguin

Appendix A. (Continued)

English (L2)	German (L1/L3)	Dutch (L1/L3)
Double cognates (with German)		
cap	Kappe	pet
carrot	Karotte	wortel
orange	Orange	sinaasappel
safe	Safe	kluis
Double cognates (with Dutch)		
bell	Klingel	bel
cake	Kuchen	cake
clock	Uhr	klok
envelope	Umschlag	envelop
fork	Gabel	vork
tennisracket	Tennisschläger	tennisracket
tent	Zelt	tent
toe	Zeh	teen
Non-cognates		
ant	Ameise	mier
bucket	Eimer	emmer
butterfly	Schmetterling	vlinder
closet	Schrank	kast
cloud	Wolke	wolk
coin	Muenze	munt
donkey	Esel	ezel
duck	Ente	eend
egg	Ei	ei
flower	Blume	bloem
glasses	Brille	bril
leaf	Blatt	blad
lemon	Zitrone	citroen
pencil	Bleistift	potlood
pig	Schwein	varken
pool	Schmimmbad	zwembad
present	Geschenk	cadeau
roof	Dach	dak
seal	Seehund	zeehond
shark	Hai	haai
shower	Dusche	douche
square	Viereck	vierkant
strawberry	Erdbeere	aardbei
teacher	Lehrer	leraar
towel	Handtuch	handdoek
train	Zug	trein
truck	Laster	vrachtwagen

Appendix B. List of L3 stimuli used in Experiments 1 and 2.

German (L3)	English (L2)	Dutch (L1)	Dutch (L3)	English (L2)	German (L1)
Triple cognates			Triple cognates		
Anker	anchor	anker	banaan	banana	Banane
Balkon	balcony	balkon	boek	book	Buch
Ball	ball	bal	clown	clown	Clown
Clown	clown	clown	hart	heart	Herz
Finger	finger	vinger	kaars	candle	Kerze
Fisch	fish	vis	kaas	cheese	Käse
Herz	heart	hart	kam	comb	Kamm
Kerze	candle	kaars	krokodil	crocodile	Krokodil
Kreuz	cross	kruis	kroon	crwon	Krone
Krone	crwon	kroon	kruis	cross	Kreuz
Loewe	lion	leeuw	ladder	ladder	Leiter
Nagel	nail	nagel	leeuw	lion	Loewe
Paket	package	paket	nagel	nail	Nagel
Sonne	sun	zon	raket	rocket	Rakete
Telefon	telephone	telefoon	schoen	shoe	Schuh
Tisch	table	tafel	tafel	table	Tisch
Traktor	tractor	traktor	telefoon	telephone	Telefon
Tuer	door	deur	vinger	finger	Finger
			voet	foot	Fuss
Double cognates			Double cognates		
Baum	tree	boom	trap	stairs	Treppe
Flasche	bottle	fles	vliegtuig	airplane	Flugzeug
Hund	dog	hond	vogel	bird	Vogel
Kette	chain	ketting	ananas	pineapple	Ananas
Koenigin	queen	koningin	boom	tree	Baum
Pferd	horse	paard	fles	bottel	Flasche
Schlange	snake	slang	ketting	chain	Kette
Schluessel	key	sleutel	koningin	queen	Koenigin
Tasche	bag	tas	paard	horse	Pferd
Treppe	stairs	trap	pincet	tweezers	Pinzette
Vogel	bord	vogel			
Frosch	frog	kikker	bot	bone	Knochen
Garten	garden	tuin	kasteel	castle	Burg
Geist	ghost	spook	peer	pear	Birne
Kaefig	cage	kooi	pen	pen	Kugelschrei
Kamera	camera	phototoestel	piano	piano	Klavier
Toilette	toilet	toilet	pompoen	pumpkin	Kuerbis
Non-cognates			Non-cognates		
Aufzug	elevator	lift	bureau	desk	Schreibtisch
Brett	board	plank	fiets	bicycle	Fahrrad
Briefmarke	stamp	postzegel	horloge	watch	Uhr
Dachboden	attic	zolder	jurk	dress	Keid

Appendix B. (Continued)

German (L3)	English (L2)	Dutch (L1)	Dutch (L3)	English (L2)	German (L1)
Fahrrad	bicycle	fiets	kikker	frog	Frosch
Fenster	window	raam	kip	chicken	Huhn
Gemaelde	painting	schilderij	konijn	rabbit	Kaninchen
Geschaeft	shop	winkel	krant	newspaper	Zeitung
Hose	pants	broek	laars	boot	Stiefel
Huhn	chicken	kip	lift	elevator	Aufzug
Kaninchen	rabbit	konijn	litteken	scar	Narbe
Karte	map	plattegrond	ouders	parents	Eltern
Kiste	box	doos	paddestoel	mushroom	Pilz
Kleid	dress	jurk	plank	board	Brett
Korb	basket	mand	plattegrond	map	Karte
Krawatte	tie	stropdas	postzegel	stamp	Briefmarke
Narbe	scar	litteken	raam	window	Fenster
Pfeife	pipe	pijp	rekenmachine	calculator	Taschenrech
Pilz	mushroom	paddestoel	riem	belt	Guertel
Stiefel	boot	laars	schilderij	painting	Gemaelde
Strasse	street	straat	staart	tail	Schanz
Teller	plate	bord	vuilnisbak	trashcan	Muelleimer
Tuete	bag	zak	winkel	shop	Geschaeft
Uhr	watch	horloge	tas	bag	Tuete
Zaun	fence	hek			

Appendix C. List of L2 stimuli used in Experiment 3.

English (L2)	German (L3)	Russian (L1)	Russian (L1) Cyrillic
Triple cognates			
banana	[Banane]	[ba'nan]	банан
cat	[Katze]	[kot]/['koschka]	кот/кошка
cow	[Kuh]	[karowa]	корова
cross	[Kreuz]	[krest]	крест
dinosaur	[Dinosaurier]	[dina's/zawr]	динозавр
dragon	[Drache]	[dra'kon]	дракон
flag	[Flagge]	[flag]	флаг
gorilla	[Gorilla]	[ga'rila]	горилла
kangaroo	[Känguru]	[kengu'ru]	кенгуру
lion	[Löwe]	[lev]	лев
nail	[Nagel]	['nogot]	ноготь
penguin	[Pinguin]	[pin'gvin]	пингвин
pirate	[Pirat]	[pi'rat]	пират
puzzle	[Puzzle]	[pazl]	пазл
rainbow	[Regenbogen]	['raduga]	радуга
rocket	[Rakete]	[ra'keta]	[ra'keta]
sun	[Sonne]	[`sontse]	солнце
toilet	[Toilette]	[tua'let]	туалет

(Continued)

Appendix C. (Continued)

English (L2)	German (L3)	Russian (L1)	Russian (L1) Cyrillic
Double cognates			
apple	[Apfel]	[‘jablako]	яблоко
baby	[Baby]	[mla’denets]	младенец
balloon	[Ballon]	[vaz’dushnyj schar]	воздушный шар
bear	[Bär]	[med’ved]	медведь
boat	[Boot]	[’lotka]	лодка
bottle	[Flasche]	[bu’tylka]	бутылка
butterfly	[Schmetterling]	[’babatschka]	бабочка
camel	[Kamel]	[wer’bljud]	верблюд
camera	[Kamera]	[fotoappa’rat]	фотоаппарат
carrot	[Karotte]	[mar’kofka]	морковка
ghost	[Geist]	[privi’denie]	привидение
pan	[Pfanne]	[skawa’rotka]	сковородка
parachute	[Fallschirm]	[para’schut]	парашют
piano	[Klavier]	[pia’nino]	пианино
priest	[Priester]	[swe’schennik]	священник
racket	[Schläger]	[ra’ketka]	ракетка
sweater	[Pullover]	[‘switär]	свитер
tank	[Panzer]	[tank]	танк
tent	[Zelt]	[pa’latka]	палатка
Non-cognates			
airplane	[Flugzeug]	[sama’löt]	самолёт
bell	[Klingel]	[zwanok]	звонок
belt	[Gürtel]	[re’men]	ремень
bicycle	[Fahrrad]	[velasi’ped]	велосипед
bucket	[Eimer]	[ved’ro]	ведро
cloud	[Wolke]	[’oblako]	облако
fence	[Zaun]	[za’bor]	забор
goat	[Ziege]	[ka’za]	коза
parrot	[Papagei]	[papu’gaj]	попугай
pear	[Birne]	[’gruscha]	груша
pen	[Kugelschreiber]	[’rutschka]	ручка
pencil	[Bleistift]	[karan’dasch]	карандаш
present	[Geschenk]	[pa’darok]	подарок
pumpkin	[Kürbis]	[’tykwa]	тыква
rabbit	[Kaninchen]	[’krolik]	кролик
strawberry	[Erdbeere]	[klub’nika]	клубника
truck	[Laster]	[gruza’wik]	грузовик
turtle	[Schildkröte]+	[tchere’paha]	черепаха
witch	[Hexe]	[’wedma]	ведьма

Appendix D. List of L3 stimuli used in Experiment 3.

German (L3)	English (L2)	Russian (L1)	Russian (L1) Cyrillic
Triple cognates			
Balkon	[balcony]	[bal'kon]	балкон
Bombe	[bomb]	['bomba]	бомба
Clown	[clown]	['kloun]	клоун
Delphin	[dolphin]	[del'fin]	дельфин
Gitarre	[guitar]	[gi'tara]	гитара
Kaktus	[cactus]	['kaktus]	кактус
Krone	[crown]	[ka'rona]	корона
Maske	[mask]	['maska]	маска
Maus	[mouse]	[mysch]	мышь
Palme	[palm]	['palma]	пальма
Papagei	[parrot]	[papu'gaj]	попугай
Rose	[rose]	[`roza]	роза
Telefon	[telephone]	[tele'fon]	телефон
Tiger	[tiger]	[tigr]	тигр
Traktor	[tractor]	['traktor]	трактор
Vulkan	[volcano]	[vul'kan]	вулкан
Zebra	[zebra]	[zebra]	зебра
Double cognates			
Anker	[anchor]	['jakor]	якорь
Ball	[ball]	[mjatsch]	мяч
Bank	[bench]	[ska'mejka]	скамейка
Bus	[bus]	[af'tobus]	автобус
Daumen	[thumb]	[bal'shoj 'palets]	большой палец
Dusche	[shower]	[dusch]	душ
Esel	[donkey]	[a'söl]	осёл
Kamm	[comb]	[ras'tschöska]	расчёска
Karte	[ma	['karta]	карта
Kartoffel	[potato]	[kar'toschka]	картошка
Kerze	[candle]	[swe'tscha]	свеча
König	[king]	[ka'rol]	король
Leiter	[ladder]	['lesnitsa]	лестница
Ritter	[knight]	['rytsar]	рыцарь
Schwein	[pig]	[svin'ja]	свинья
Strauß	[ostrich]	['straus]	страус
Teller	[plate]	[ta'relka]	тарелка
Tisch	[table]	[stol]	стол
Tür	[door]	[dver]	дверь
Windmühle	[windmill]	['melnitsa]	мельница
Non-cognates			
Baum	[tree]	['derewo]	дерево
Dach	[roof]	['kryscha]	крыша
Ente	[duck]	['utka]	утка

(Continued)

Appendix D. (Continued)

German (L3)	English (L2)	Russian (L1)	Russian (L1) Cyrillic
Fenster	[window]	[ak'no]	окно
Fledermaus	[bat]	[letutschaja]	летучая мышь
Gabel	[fork]	['wilka]	вилка
Kissen	[pillow]	[pa'duschka]	подушка
Knochen	[bone]	[kost]	кость
Knopf	[button]	['pugavitsa]	пуговица
Korb	[basket]	[kar'zina]	корзина
Pferd	[horse]	['loschad]	лошадь
Pilz	[mushroom]	[grib]	гриб
Pinsel	[brush]	['kistotchka]	кисточка
Schildkröte	[turtle]	[tschere'paha]	черепаха
Schmetterling	[butterfly]	['babatschka]	бабочка
Tasse	[cup]	['tschaschka]	чашка
Tüte	[bag]	[pa'ket]	пакет
Zug	[train]	['poezd]	поезд