Visual recognition of cognates and interlingual homographs in two non-native languages

Evidence from Asian adult trilinguals

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Previous studies on bilingual visual word recognition have been mainly based on European participants, while less is understood about Asian populations. In this study, the recognition of German-English cognates and interlingual homographs in lexical decision tasks was examined in the two non-native languages of Cantonese-English-German trilinguals. In the L2 English task, cognates were reacted to faster and more accurately than their matched non-cognates, while in the equivalent L3 German task, no cognate facilitation effect was found. However, cognate facilitation effects on response time and accuracy were observed in another L3 German task including cognates and interlingual homographs. The study suggests that Asian trilinguals access L2 and L3 in a language non-selective manner, despite their low proficiency in the recently acquired L3. Meanwhile, lexical processing in a non-proficient L3 is to a great extent affected by multiple contextual factors.

Keywords: multilingualism, bilingualism, lexical decision task, cognates

1. Introduction

Cognates and interlingual homographs (IHs) have received intense attention in bilingualism research, the former having similar spellings and meanings (e.g. German-English pair: *Bier* 'beer' – *beer*), and the latter having the same spelling but different meanings (e.g. German-English pair: *Tag* 'day' – *tag*) in two languages. One of the most fundamental questions is: when bilinguals see such a word in one language, would they simultaneously activate its orthographically similar counterparts in another language? Although there are studies supporting the

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language-selective view that expects bilinguals to completely shut off one of their two languages and be unaffected by the non-target language when processing cognates and interlingual homographs (Caramazza & Brones, 1979; e.g. Scarborough, Gerard, & Cortese, 1984), more studies suggest that bilinguals activate both of their languages when seeing such words (e.g. Dijkstra & Van Heuven, 2002; Lemhöfer & Dijkstra, 2004; Peeters, Dijkstra, & Grainger, 2013; Poarch & Van Hell, 2012). The processing of cognates and interlingual homographs is typically examined in lexical decision tasks (LDTs), which require bilinguals to judge whether a letter string is a real word in one of their languages. Many studies found that bilinguals were quicker and more accurate in processing L1–L2 cognates compared with non-cognate control words, and this was referred to as the 'cognate facilitation effect' (Dijkstra, Grainger, & Van Heuven, 1999; Dijkstra & Van Heuven, 2002; Lemhöfer & Dijkstra, 2004; Peeters et al., 2013). In comparison, interlingual homographs were often reacted to more slowly and less accurately than their matched monolingual control words were (Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Van Heuven, Schriefers, Dijkstra, & Hagoort, 2008), which was referred to as the 'interlingual homograph inhibition effect'. These cognate and interlingual homograph effects indicate that both readings of the cognates/interlingual homographs are at play during word recognition and therefore bilinguals' two languages are activated in parallel. Meanwhile, it is noticed that cognate and interlingual homograph effects are not always constant and their directions can be influenced by factors like lexical frequency (Dijkstra et al., 1998; Peeters et al., 2013), the number of orthographic neighbors (Van Heuven, Dijkstra, & Grainger, 1998), language proficiencies of the bilinguals (Brenders, Van Hell, & Dijkstra, 2011; Kroll, Sumutka, & Schwartz, 2005; Poarch & Van Hell, 2012), stimulus composition (Dijkstra et al., 1999, 1998) and task demands (Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010).

The recognition of cognates and interlingual homographs can be accounted for by various theories of the bilingual lexicon. Psycholinguistic models generally converge on a stage-by-stage lexical selection process that involves a lexical and a conceptual level, no matter how many languages a person speaks (Levelt, Roelofs, & Meyer, 1999). Different from the monolingual word recognition models, bilingual models need to formulate the lexical representations from two languages. In nearly all major bilingualism models, bilinguals' two languages are linked in various ways. For example, Kirsner, Lalor and Hird (1993) believe that words are organized by morphology instead of languages, so both the English words *marry, marriage,* and *married* and the French words *marier* and *marriage* will have one shared morphological representation in the mind of English-French bilinguals (Kirsner et al., 1993). Based on a series of visual word recognition experiments, the well-cited Bilingual Interactive Activation (BIA) model (Dijkstra et al., 1998) also organizes lexical items from two languages in an integrated lexicon. Lexical items in BIA are linked with excitatory and inhibitory connections at the feature, letter, word, and language levels. The later BIA+ model incorporates semantics, phonology and task schema (Dijkstra & Van Heuven, 2002) while maintaining the assumption of an integrated lexicon.

Unlike bilingual studies, cognate recognition by trilinguals is examined only by a small number of studies on European language speakers (Lemhöfer, Dijkstra, & Michel, 2004; Poarch & Van Hell, 2014; Szubko-Sitarek, 2011, 2015; Van Hell & Dijkstra, 2002). For example, the study by Van Hell and Dijkstra (2002) found that trilinguals who were proficient in all of their three languages showed a triple cognate facilitation effect when processing in their L1. In that study, Dutch – English – French trilinguals performed a word association task and a lexical decision task in their L1, Dutch. In both tasks, subjects showed shorter RTs for L1–L2 cognates than for non-cognate controls. At the same time, the trilinguals who were highly proficient in their L3, French, were also faster in reacting to L1–L3 cognates than to control words. Note that lexical processing of the L2 and L3 by trilinguals could be different from that of the L1 and L2 by bilinguals, as the L1 is suggested to be qualitatively different from later acquired languages (Aparicio et al., 2012; Aparicio & Lavaur, 2016). Aparicio and Lavaur (2016) conducted L2 and L3 LDTs on French-English-Spanish trilinguals using a masked priming translation paradigm. They found translation priming effects in both LDTs, but only when the prime belonged to participants' dominant L1. Relatedly, the ERP recording of French-English-Spanish trilinguals performing a semantic categorization task found that L1 words generated earlier N400 peak amplitudes than L2 and L3 words (Aparicio et al., 2012). Thus, due to the special status of the L1, the processing of a native language and a non-native language (L1 and L2) can be different from that of two non-native languages (L2 and L3). Therefore, findings in bilingual L1 and L2 processing may not be applicable to trilingual L2 and L3 processing.

The influence of cognates can be from a native to a non-native language, and vice versa. For example, influence from a native language to a non-native language was observed in the L3 German LDT by Lemhöfer, Dijkstra, and Michel (2004), where Dutch – English – German trilinguals showed L1–L3 and L1–L2–L3 cognate facilitation effects in L3 lexical processing. Similarly, Szubko-Sitarek (2011) found that Polish-English-German unbalanced trilinguals, who were advanced in L2 English and pre-intermediate/intermediate in L3 German, reacted faster to L1–L2–L3 cognates than non-cognates in the L3 LDT, suggesting an influence from L1 to L3. Cognate effects from a non-native language to a native language were supported by Bice and Kroll (2015) on English-Spanish bilinguals. The study observed reduced N400 effects for English-Spanish cognates during the L1 English LDT, showing influences from L2 Spanish to L1 English. These findings supported mutual interactions between languages in the mind of bilinguals and multilinguals.

Until now, evidence for parallel activation of two languages has been mostly gathered from studies on bilingual L1 and L2 processing (e.g. Brenders et al., 2011; Caramazza & Brones, 1979; Dijkstra & Van Heuven, 2002; Kroll et al., 2005; Van Heuven et al., 1998). As discussed earlier, the mental representation of two non-native languages might not be the same as that of a native and a non-native language. However, the processing of two non-native languages per se did not receive due attention in the past. Among the few studies that involved trilingual participants, the topic of non-native language processing was just discussed briefly (e.g. Lemhöfer et al., 2004; Szubko-Sitarek, 2011; Van Hell & Dijkstra, 2002). Also, participants in those studies were European trilinguals speaking typologically related languages. There are large numbers of Asian trilinguals who speak typologically dissimilar languages with unbalanced proficiencies. Little is known about the lexical processing of non-native languages by these Asian trilinguals. Our study approaches this issue by testing trilingual speakers with L1 Cantonese, L2 English and L3 German. This group differs from the participants of previous studies because trilinguals in this study were proficient in their L1 and L2 but not in their L3, while their typologically similar L2 and L3 are substantially different from their L1. Will there be extensive interactions between L2 and L3 lexicons because of typology, or very limited interactions because of the larger proficiency disparity between the L2 and L3 than between the L1 and L2/L3? An examination of these trilinguals will allow us to extend the language selectivity discussion to a more diversified population.

This study examined the processing of L2–L3 cognates and interlingual homographs by comparing their response latency and accuracy with those of their matched non-cognate and non-homograph controls in three lexical decision tasks. Experiment 1 was an L2 English LDT with L2–L3 cognates as the critical stimuli. The experiment was completed by a Cantonese-English-German trilingual group as well as a Cantonese-English bilingual group. Since bilinguals had no L3 German knowledge, they should not react to cognates and non-cognates differently in the L2 task. Therefore, if cognate facilitation effects were found in the trilingual group but not in the bilingual group, it should be due to the parallel activation of L2 and L3 lexicons rather than the stimuli themselves. Having established cognate facilitation effects in L2 processing, the processing of cognates was explored again in the L3 in two German LDTs, which were completed by trilinguals only. Cognates were tested with different stimuli lists and on different trilingual participants in two L3 tasks to ascertain whether there were any cognate effects in L3 processing. Experiment 2 was a German equivalent of the first English experiment, examining the same cognate pairs as in the English task, while Experiment 3 tested another set of cognates plus interlingual homographs. The reason for including both types in Experiment 3 was to prevent a type II error, because in real life trilinguals should encounter both cognates and interlingual homographs at the same time, and an earlier study found that interlingual homograph effects disappeared when the stimuli list excluded cognates (Dijkstra et al., 1998). Finally, as cognate/interlingual homograph processing was suggested by previous studies to be influenced by cross-linguistic orthographic similarity of cognates (Dijkstra et al. 2010), lexical frequency (Dijkstra et al., 1998; Peeters et al., 2013) and language proficiency (Brenders, Van Hell & Dijkstra, 2011), these factors were included in the data analysis. The results will be discussed with reference to the BIA+ model (Dijkstra & Van Heuven, 2002).

2. Experiment 1 – Cognates in an L2 English-only LDT

2.1 Methods

2.1.1 *Participants*

An L2 English LDT was administered to 21 Cantonese-English-German trilingual participants (Female = 11, Male = 10, mean age = 22.3 years, range = 20–26) and 21 Cantonese-English bilingual controls (Female = 11, Male = 10, mean age = 21.6 years, range = 20–27). Both groups of participants were native Cantonese-speaking university students born and raised in Hong Kong, a bilingual society where Cantonese is the dominant spoken language and English is widely used in official documents, public signs, and as a language of instruction in schools. Thus, most of the participants learned their L2 English as early as kindergarten and continued to be exposed to English often. Their mean age of L2 English acquisition was 3.0 ($SD = 0.92$) years old and the average English test score was equivalent to IELTS 6.9 ($SD = 0.51$, range = 5.5–8.0). Trilinguals and bilinguals did not differ significantly in ages of L2 English acquisition, $t(40) = -0.28$, $p = .783$, $d = -0.09$, or in their L2 proficiencies measured by IELTS scores, $t(40) = -0.15$, $p = .883$, $d = -0.05$. The trilingual participants were additionally taking German VI courses in The Chinese University of Hong Kong, the level of which was confirmed by their native German teachers to be equivalent to A2-B1 (beginning to intermediate) in the Common European Framework. L3 proficiency was not objectively measured in scores as the trilinguals had not taken any public examinations on German proficiencies, but their L3 German was weaker than their L2 English due to the lack of immersion experience and the limited length of studying and exposure. The trilinguals had learned German for six courses through bi-weekly, 1.5-hour language lessons. They reported themselves to have spent an average of only 0.52 hours outside the classroom on L3-related activities such as reading German newspapers or watching German television. Table 1 shows the self-reported ratings of language proficiencies on a seven-point Likert scale (1 = very low, 7 = perfect) for reading, speaking, comprehension and writing skills. L2 scores were around five and the L1 scores were around six to seven, showing that participants were quite confident about their bilingual ability, while the trilinguals gave relatively lower scores to their L3, indicating that they perceived their L3 as the weakest language. All participants had normal or corrected-to-normal vision.

Table 1. Means (and standard deviations) of proficiency ratings by participants in Experiment 1 on a seven-point scale (1 = very low, 7 = perfect)

Group	Language	Speaking	Comprehension	Reading	Writing
Trilingual	L1 Cantonese	6.27 (0.77)	6.80 (0.40)	6.53 (0.62)	6.00 (1.41)
	L2 English	5.05 (1.13)	5.76 (0.81)	5.61 (0.84)	4.80 (0.91)
	L3 German	3.23 (1.34)	3.47 (0.85)	3.80 (0.95)	3.19 (0.91)
Bilingual	L1 Cantonese	6.12 (0.56)	6.91 (0.87)	6.54 (0.73)	6.01 (0.99)
	L2 English	5.00 (0.81)	5.69 (0.72)	5.30 (0.98)	4.68 (0.78)

2.1.2 *Materials*

The test items consisted of 70 real English words (35 English-German cognates and 35 non- cognate controls) and 70 pseudo English letter strings. The English-German cognates in this study also included both identical cognates (e.g. *region – Region* 'region') and non-identical cognates (e.g. *product – Produkt* 'product'). The non-identical cognates were presented in English orthography. For example, in the English-German cognate pair *product – Produkt*, only *product* was used in this task. Thus, all cognates in this experiment were real English words that required positive responses. The non-cognate controls were 'pure English words' which differed obviously from their German translation equivalences in orthography. Levenshtein Distance (LD) was used to quantify the difference between two character strings (Levenshtein, 1966). The larger the LD, the more different the two strings will be. LD could be understood as the minimal number of insertions, deletions or substitutions required to change one word into the other. For instance, the LD between *Produkt* and *product* is one, as the word *product* could be derived from *Produkt* by changing one letter (from *k* to *c*). We calculated the LD between English-German cognate pairs, as well as between non-cognate stimuli and their German translation equivalents. T-tests showed that the LDs of cognates ($M = 0.66$, $SD = 0.80$) were significantly smaller than those of non-cognate control words ($M = 5.54$, $SD = 2.39$) in this experiment, $t(68) = -10.43$, $p < .001$, $d = -12.49$, demonstrating that the cognate stimuli exhibited higher degrees of cross-linguistic overlap than non-cognate controls. Frequency values, word lengths, and orthographic neighbor counts were retrieved from N-Watch (Davis, 2005). Non-cognates and cognates were matched on a one-to-one basis in terms of the number of letters, lexical frequency and the number of orthographic neighbors. For instance, the cognate *gold* (4 letters, 9 neighbors, 87.99 per million words) was matched with the non-cognate *rise* (4 letters, 9 neighbors, 85.03 per million words). Paired t-tests revealed no significant differences between cognates and non-cognates on lexical frequency, $t(34) = 0.15$, $p = .88$, $d = 0.04$, or number of orthographic neighbors, $t(34) = 1.45$, $p = .15$, $d = 0.35$, and non-cognates had exactly the same word length as cognates. As a stimulus check, reaction times documented in the English Lexicon Project (Balota et al., 2007) for the stimuli were retrieved, and paired t-tests did not show significant differences between the those of cognates ($M = 630$ ms) and of non-cognates ($M = 611$ ms), $t(34) = 1.77$, $p = .09$, $d = 0.41$. The non-words were pseudo English words that were created by changing one or two letters of real English words. Each pseudo word was matched with each real word in length. A summary of stimuli parameters is provided in Table 2.

Table 2. Mean frequencies (per million), mean numbers of orthographic neighbors, and mean numbers of letters of stimuli used in three LDT experiments

	Word type	Frequency	No. of neighbors	No. of letters
Exp1	Cognate	315.31 (722.11)	2.60 (3.37)	5.60 (1.60)
	Non-cognate controls	336.96 (815.43)	2.94 (3.52)	5.60 (1.60)
	Pseudo English			5.60 (1.60)
Exp2	Cognate	357.25 (981.82)	3.23(3.38)	5.66 (1.62)
	Non-cognate controls	354.87 (969.67)	3.60(3.11)	5.63 (1.56)
	Pseudo German			5.62 (1.55)
Exp3	Cognate	141.10 (275.87)	5.06 (5.06)	5.06 (1.25)
	Non-cognate controls	149.17 (302.65)	5.31 (5.03)	5.06 (1.25)
	IH	228.85 (435.60)	9.34 (4.52)	4.06 (0.84)
	Non-IH controls	209.78 (352.47)	8.56 (3.70)	5.06 (0.84)
	Pseudo German			4.53 (1.17)

2.1.3 *Procedure*

After consenting procedures, participants were seated comfortably about 60 cm from a computer screen. The letter strings were presented in 18-point Arial letters in white against a black background in pseudo-random order using E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). All letters were in uppercase to avoid the unwanted influence of orthography in the upcoming German tasks, as German capitalizes every noun while English does not. Participants were firstly presented with written instructions in English asking them to judge whether the letter string they saw was a real English word by pressing Z and M buttons with their left and right index fingers as quickly and as accurately as possible. The Z and M buttons for positive and negative responses were counterbalanced across participants to rule out the handedness factor. In each experiment, trials were preceded by a practice block of five items and an accuracy of 80% in the practice block was required to proceed to the main task.

Each trial was preceded by a fixation cross in the center of the screen for 800 ms followed by a blank screen for 300 ms and then the target letter string, which was presented for maximally 5000 ms or until participants gave a response. Then there was another blank screen for 300 ms after which the next trial began. Participants completed Experiment 1 (140 trials) plus Experiment 3 (136 trials), with a break between the experiments. After completion, participants filled in a language background questionnaire and received a nominal payment for participation.

2.2 Results

Out of the raw dataset, trials with RTs shorter than 200 ms or longer than two and a half standard deviations above the participant's mean were considered as outliers and were excluded from the analyses. This resulted in deletion of 0.4% of cognates, 3.1% of non-cognates and 4.9% of pseudo English words for the trilingual data, and 0.5% of cognates, 1.4% of non-cognates and 3.7% of pseudo English words for the bilingual control data. Cognates and non-cognates were deleted pairwise because the matching was done one by one. One non-cognate item (i.e. *comfort*) and its corresponding cognate (i.e. *product*) were deleted from analysis because the non-cognate was later discovered to be ill-designed. The analysis also excluded

Table 3. Reaction times (ms) and error rates (%) for tested stimuli in three experiments

	Cognate		Non-cognate control		IH		Non-IH control	
	RT	Error	RT	Error	RT	Error	RT	Error
L2 English (Exp 1)								
– Trilingual	683 (95)	0.7 (1.7)	746 (131)	3.4 (7.5)	–	–	–	–
– Bilingual	745 (178)	5.3 (6.6)	720 (178)	5.3 (6.1)	–	–	–	–
L3 German (Exp 2)	947 (453)	18.9 (15.7)	932 (453)	9.3 (12.2)	–	–	–	–
L3 German (Exp 3)	914 (337)	7.9 (10.9)	1057 (441)	19.8 (11.3)	965 (411)	13.0 (10.9)	932 (398)	15.8 (13.9)

Note. Reaction times (RTs) were in milliseconds. Error rates were in percentages. Standard deviations were in parentheses.

one participant and two pairs of cognate – non-cognate items (i.e. *wolf* – *trim* and *semester* – *specimen*) with an overall accuracy of 50% or below. Analyses of variances were performed on the reaction times (RTs) of correct responses in participant analysis (F1) and item analysis (F2). All RT analyses were performed on the raw reaction times and logarithmic (log) reaction times. As the two types of analyses did not yield different results, only log-transformed RT statistics are reported (the same applies to all three experiments). Logistic regressions were performed on error analyses. The means and standard deviations of RTs and error rates of all tested stimuli types are summarized in Table 3.

2.2.1 *RTs*

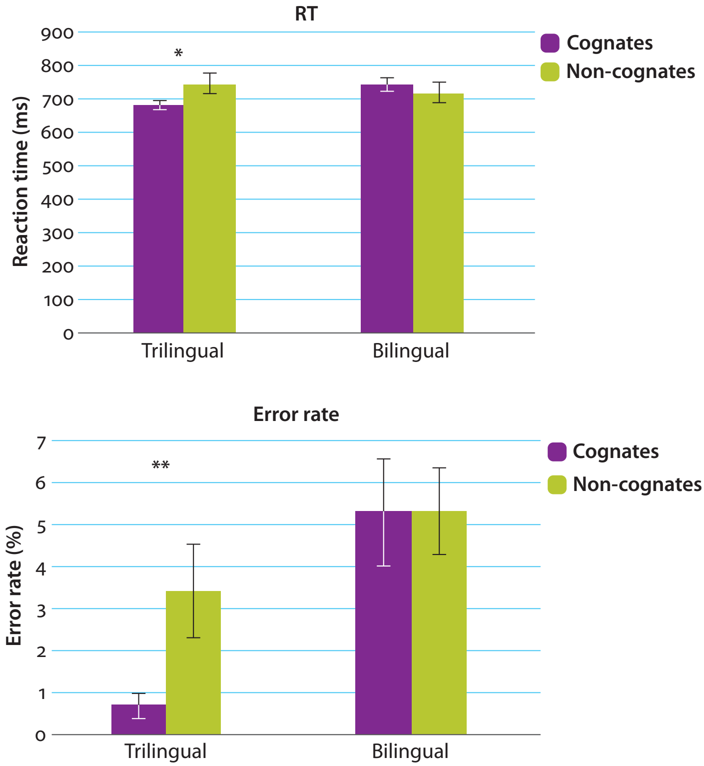
As the LDT was about L2 English and L3 German, cognate effects were expected in the trilingual group but not in the bilingual control group. Figure 1 shows mean RTs for cognates and non-cognates of the trilingual group and bilingual control group. Overall, the mean RTs to real English and pseudo English words were 716 ms and 994 ms for trilingual group, and 732 ms and 956 ms for bilingual control group. Trilinguals reacted faster to cognates ($M = 683$ ms) than to non-cognates ($M = 746$ ms), corresponding to a cognate facilitation effect on response latency. By comparison, the difference between RTs to cognates ($M = 745$ ms) and to non-cognates ($M = 720$ ms) was smaller in the bilingual control group.

In the by-subject analysis (F_1), an analysis of variances was conducted on each subject's mean RTs of the correct responses with Cognate Status (cognate vs. non-cognate) as the within-subject factor, and Group (trilingual vs. bilingual) as the between-subject factor. In the by-item analysis (F_2), an analysis of variances was conducted on each item's mean RTs of the correct responses with Cognate Status (cognate vs. non-cognate) as the between-item factor due to item-by-item matching, and Group (trilingual vs. bilingual) as the within-item factor. There was a significant main effect of Cognate Status on RT, $F_1(1, 39) = 11.71$, $p = .001$, $\eta^2 = .02$; $F_2(1, 64) = 3.32$, $p = .07$, $\eta^2 = .03$, and a Cognate Status × Group interaction effect on RT, $F_1(1, 39) = 11.30$, $p < .001$, $\eta^2 = .02$; $F_2(1, 64) = 4.83$, $p < .05$, $\eta^2 = .01$. The effect of Group on RT was marginal, $F_1(1, 39) = 2.91$, $p = .07$, $\eta^2 = .07$; $F_2(1, 64) = 3.21$, $p = .08$, $\eta^2 = .005$. Post-hoc pairwise comparison was done with the R package 'lsmeans' using the Tukey method (Lenth Russell V., 2016). Overall, cognates were reacted to faster than non-cognates, $p(F_1) = .001$, $p(F_2) = .07$. In particular, trilinguals responded faster to cognates than non-cognates, $p(F_1) < .001$, $p(F_2) = .07$, whereas bilingual controls' RTs did not differ between cognates and non-cognates, $p(F_1) = .99$, $p(F_2) = .78$. Meanwhile, the RTs to cognates were shorter in the trilingual group than in the bilingual control group, $p(F_1) = .06$, $p(F_2) = .03$, while RTs to non-cognate controls did not show a group difference, $p(F_1) = .77$, $p(F_2) = .99$. As predicted, in the L2 English-only task, trilinguals reacted faster to English-German cognates, while bilingual controls did not, given that bilinguals had no knowledge of German.

2.2.2 *Error rates*

Figure 1 shows the average cognate and non-cognate error rates of participants' in the trilingual group and the bilingual control group. Data analyses were performed on all responses participants gave in the LDT. The mean error rate to real English and pseudo English words was 2.0% and 15.0% for trilinguals, and 0.5% and 12.7% for bilinguals. Trilinguals' error rates on cognates (0.7%) were lower than non-cognates (3.4%), while bilingual controls' error rates on cognates (5.3%) and non-cognates (5.2%) did not differ significantly.

A binomial logistic regression model was built on Error (wrong vs. correct) with Cognate Status (cognate vs. non-cognate) and Group (trilingual vs. bilingual). Group × Cognate Status interaction was included to validate the stimuli. The



a.

b.

Figure 1. Comparison between bilinguals' and trilinguals' reaction times (RTs) and error rates in Experiment 1

model was significant [$\chi^2(3) = 44.49$, $p < .001$, $R_L^{\,2} = 0.05$, $R_{CS}^{\,2} = 0.02$, $R_N^{\,2} = 0.05$]. It showed a significant cognate facilitation effect on error rates for the trilingual group, in that trilinguals were 6.21 times more likely to make errors on non-cognates than on cognates ($ß = 1.82$, $SE = 0.48$, $z = 3.76$, $p < .001$). In comparison, the bilingual control group did not show significant differences in the odds of making errors on cognates and on non-cognates ($ß = 0.39$, $SE = 0.23$, $z = 1.65$, $p = .09$), which was as expected since the bilinguals had no knowledge of German. This confirmed that the cognate facilitation effect in the trilingual group was not due to internal characteristics of the words tested in the task.

2.3 Discussion

Experiment 1 replicated the typical cognate facilitation effect in the two non-native languages of trilinguals. For the trilingual participants, English-German cognates were responded to faster and more accurately than non-cognate control words. Since cognate effects were absent from the bilingual controls, the facilitation effects in trilinguals should not be caused by inherent properties of stimulus words. Therefore, this L2–L3 cognate advantage manifested a parallel activation of the non-target L3 and the target L2, which was what a language non-selective access view would predict. Although the participants were L2 English speakers who acquired English in early childhood and used English frequently, their L2 English lexical processing could still be influenced by the L3 German that was incompletely acquired in adulthood. This pattern of a lately acquired language influencing an early acquired language corroborates the bilingual study by Bice and Kroll (2015), where the lately acquired L2 was observed to impact bilinguals' early acquired L1.

The result of L2 processing being affected by L3 leads to the next question: is the reverse also true? In order to answer this question, the L2 English LDT was translated into L3 German in Experiment 2 and was tested on another group of Cantonese-English-German trilingual participants.

3. Experiment 2 – Cognates in an L3 German-only LDT

3.1 Methods

3.1.1 *Participants*

Participants of the German LDT were 20 trilinguals (Female = 10, Male = 10, mean age = 22.8 years, range = 21–27) with the same language background as the trilinguals in Experiment 1. Participants of Experiment 1 and 2 were different individuals to minimize confounds of practice effects, as the first two experiments were nearly identical except for the conducting language. The mean age of L2 English acquisition was 3.6 years old (SD = 0.59) and the average IELTS score was 6.85 (SD = 0.58, range = 6.0–7.5). They did not differ significantly from participants in Experiment 1 in ages of L2 English acquisition, $t(38.45) = 1.11$, $p = .27$, $d = 0.35$, or in IELTS scores, $t(39) = -0.46$, $p = .65$, $d = -0.15$. They also came from the German VI course, with similar L3 learning experiences and proficiencies as participants of Experiment 1. On average, 0.61 hours were spent each week on extra-curricular German-related activities by this group. Their self-rated language proficiencies are shown in Table 4. Participants of Experiment 1 and 2 did not differ in L2 proficiency ratings of speaking, $t(39) = -0.01$, $p = .99$, $d = 0.002$, comprehension, $t(39) = -0.01$, $p = .91$, $d = 0.03$, reading, $t(39) = -0.01$, $p = .92$, $d = 0.03$, or writing, $t(39) = -0.03$, $p = .98$, $d = 0.01$, nor in L3 proficiency ratings of speaking, $t(39) = 0.25$, $p = .81$, $d = 0.08$, comprehension, $t(39) = -0.68$, $p = .49$, $d = 0.21$, reading, $t(39) = -0.011$, $p = .91$, $d = 0.06$, or writing, $t(39) = 0.20$, $p = .85$, $d = 0.04$.

Table 4. Means (and standard deviations) of proficiency ratings by participants in Experiment 2 on a seven-point scale (1 = very low, 7 = perfect)

	Speaking	Comprehension	Reading	Writing
L1 Cantonese	6.25 (0.74)	6.79 (0.54)	6.55 (0.62)	6.01 (0.92)
L2 English	5.05 (1.12)	5.80 (1.32)	5.65 (1.01)	4.80 (0.98)
L3 German	3.15 (0.79)	3.65 (0.73)	3.75 (0.94)	3.15 (1.24)

3.1.2 *Materials and procedures*

The stimuli list in this experiment contained 35 German-English cognates, 35 non-cognate control words and 70 pseudo German letter strings. Cognates came from the pairs tested in Experiment 1. The difference was that the first experiment presented English members of the cognate pairs, while the second one presented German members of the pairs. Higher degrees of cross-linguistic overlap were exhibited by cognates than by non-cognates, as the Levenshtein Distances of cognates (M = 0.66, SD = 0.80) were significantly lower than those of controls (M = 5.65, SD = 2.09), $t(39.60) = 10.43$, $p < .001$, $d = 2.49$. Pseudo words were derived by changing one or two letters of real German words. The L3 words were confirmed as learned vocabulary for German VI students by two native German teachers who taught the participants. Also, the participants did not report having encountered unfamiliar German vocabulary in the post-experiment interview. Numbers of letters, frequency values, and numbers of orthographic neighbors counts were retrieved from the CLEARPOND corpus (Marian, Bartolotti, Chabal, & Shook, 2012). The same matching method in Experiment 1 was used here for German-English cognates, non-cognate controls and pseudo German words (Table 2). The procedure was the same as that in Experiment 1 except that there was no control group or group comparison. As in Experiment 1, all letters were capitalized. None of the stimuli used in Experiment 2 contained special German letters that might give orthographic cues to participants. There were a total of 140 trials.

3.2 Results

Similar to the first experiment, outliers with RTs shorter than 200 ms or longer than two and a half standard deviations above the participant's mean were trimmed, which constituted 2.2% of cognates, 3.1% of non-cognates and 6.6% of pseudo words. Two participants and one pair of cognate – non-cognate items (i.e. *Plan* 'plan' – *Zehn* 'ten') with error rates equal to or higher than 50% were excluded

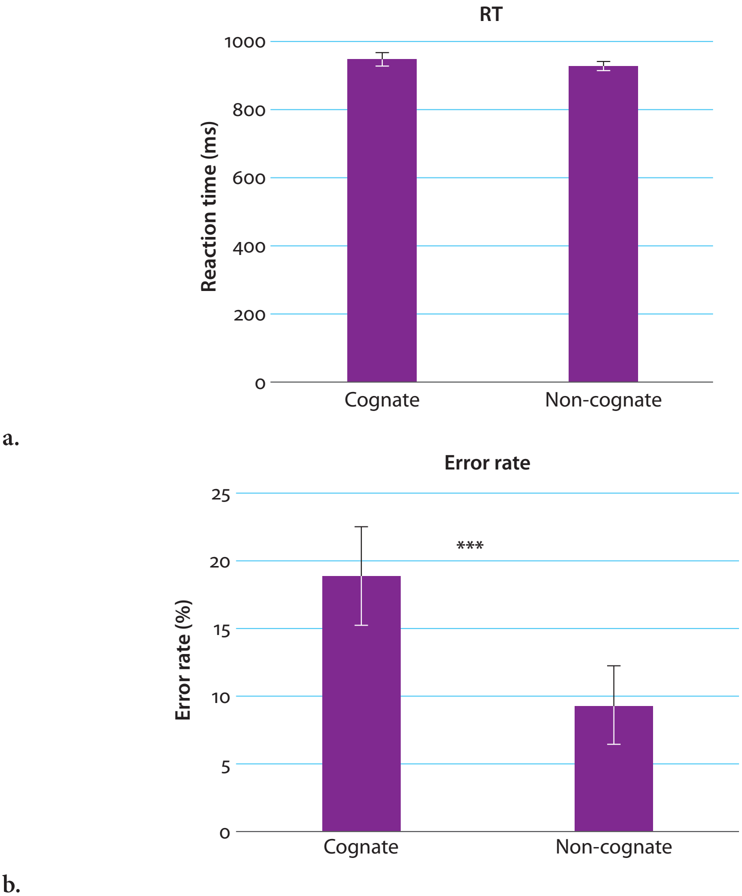


Figure 2. Comparison of reaction times (RTs) and error rates between cognates and non-cognates in Experiment 2

from analyses. Each participant's mean RTs of correct responses on cognates and non-cognates were calculated, and then compared by a two-tailed t-test. Error data were analyzed by a binomial logistic regression analysis as errors were categorical in nature. RTs and error rates of cognates and non-cognates were shown in Table 3 and Figure 2.

3.2.1 *RTs*

The mean RTs to real German and pseudo German words were 966 ms and 1265 ms. The difference between RTs to cognates ($M = 947$ ms) and RTs to non-cognate control words ($M = 932$ ms) did not reach statistical significance, $t(17) = 1.05$, $p = .31$, $d = 0.24$.

3.2.2 *Error rates*

The mean error rates to real German and pseudo German words were 11.0% and 21.2%. Cognates had higher error rates (19.4%) than non-cognates (9.3%). The binomial logistic regression model [$\chi^2(1) = 20.44$, $p < .001$, $R_L^2 = 0.04$, $R_{CS}^2 = 0.03$, $R_N^2 = 0.06$] on Error (wrong vs. correct) with Cognate Status (cognate vs. non-cognate) as the factor suggested that trilinguals were 2.34 times more likely to make mistakes on cognates than on non-cognates ($ß = 0.85$, $SE = 0.19$, $z = 4.39$, $p < .001$). In other words, cognates elicited more incorrect responses in the German LDT than non-cognates did, which was contrary to the prediction from the bilingualism literature.

3.2.3 *Post hoc analyses*

Since there seemed to be a counterintuitive cognate inhibition effect, further exploration into stimuli design was sought in order to understand such a result. It was noticed that among the cognates in Experiment 2, 14 of them were identical cognates sharing the same spelling in German and English, while 16 of them were non-identical cognates that differed in one or two letters in the two languages. As identical and non-identical cognates might show different patterns in LDTs (Dijkstra et al., 2010), this orthographic factor was assessed in a post hoc analysis.

The mean error rate was 26.1% ($SD = 0.26$) for identical cognates and was 10.3% ($SD = 0.22$) for non-identical cognates. The mean error rate was 9.54% ($SD = 0.08$)) for non-cognates that were paired with identical cognates, and was 8.95% ($SD = 0.82$) for non-cognates paired with non-identical cognates. Logistic regressions were performed on Error (wrong vs. correct) with Cognate Status (cognate vs. non-cognate), Cognate Type (identical vs. non-identical) as factors. The model that included both factors and their interaction [$\chi^2(3) = 38.24$, $p < .001$, $R_L^2 = 0.04$, $R_{CS}^2 = 0.04$, $R_N^2 = 0.06$] revealed a significant interaction effect of Cognate Type × Cognate Status on Error, $ß = 1.10$, $SE = 0.34$, $z = 3.18$, $p = .001$, but no significant effect of Cognate Status or Cognate Type, $p = .63$. The model that excluded the interaction [$\chi^2(2) = 27.92$, $p < .001$, $R_L^2 = 0.03$, $R_{CS}^2 = 0.03$, $R_N^2 = 0.04$] found significant main effects of Cognate Status ($ß = 0.53$, $SE = 0.17$, $z = 3.17$, $p < .01$) and Cognate Type ($ß = 0.68$, $SE = 0.17$, $z = 4.03$, $p < .001$) on Error. The likelihood ratio test suggested that the removal of the interaction terms significantly reduced model fit, $\chi^2(1) = 11.18$, $p = .001$, so the first model with interaction gave a better account for the data. Results from the first model indicated that the cognate effect on error rate data in Experiment 2 was confounded by whether the cognate had identical or non-identical orthographies in German and English. Then, two logistic regressions on Error with Cognate Status were run separately for identical and non-identical cognate items. Results showed that identical cognates had significantly more errors than their matched non-cognate controls, $ß = 0.98$, $SE = 0.22$, $z = 4.03$, $p < .001$, while non-identical cognates and their matched non-cognate controls did not differ significantly in error rates, $ß = -0.12$, $SE = 0.26$, $z = -0.48$, $p = .06$. Although the pattern was still inconsistent with the assumption that cognates should be responded to more accurately, it supported our speculation that identical and non-identical cognates were reacted to differently in the task.

3.3 Discussion

Contrary to our prediction, the L3 task did not find a cognate facilitation effect. Firstly, no cognate facilitation effect was observed in RTs. Participants reacted to cognates and non-cognates with similar latencies. Secondly, there was an unconventional cognate inhibition effect on error rates. Further analysis revealed that this inhibition effect was only present in identical cognates.

The question that ensued was why there was an inhibition effect on identical cognates. Is it possible that the participants were not proficient enough in L3, so they got confused because those identical cognates were real words in both the target language (German) and the non-target language (English)? For example, when participants saw an identical cognate *Hand*, they were supposed to give a positive response because it is a real German word. However, since *Hand* is also an English word, the most unbalanced participants who were not proficient in German would have probably first recognized it as an English word due to their higher English proficiency, after which they realized that it should also be a German word as well. They would need to suppress the English reading to give the correct answer, so they might have made more errors on identical cognates like *Hand* due to the cognitively demanding task of inhibiting a non-target language. In fact, this was what participants should do in a language decision task, rather than in a lexical decision task. A language decision task asks participants to decide whether a word is in language A or language B, and cognate inhibition is the expected result of language decision tasks (Dijkstra et al., 2010). Turning to learners with more balanced L2 and L3 proficiencies, the word *Hand* should have immediately activated their German lexicon and there would be no need to suppress an earlier activated non-target language. Thus, our hypothesis was that less proficient L3 learners would show a stronger cognate inhibition effect because of the ambiguity of language membership of identical cognates.

In order to test this hypothesis, the participants should be divided into two proficiency groups to begin with, but the proficiency factor could not be examined because the participants all came from the same proficiency level with almost the same L3 learning experience. Initially, we tried to use the L3 self-reported proficiency scores as proficiency measurements, but none of them showed any sensible correlation with the experiment results. Also, as participants' self-ratings were similar to each other, these scores might not precisely reflect the proficiency variation within the trilingual group. Then, we took an alternative by considering those who did well (measured by accuracy in Experiment 2) in the LDT as high performers, based on the premise that higher performance should go hand in hand with higher language abilities, and this generalization could be drawn from the fact that participants performed better in equivalent LDTs conducted in their more proficient L2 (Experiment 1) than in their less proficient L3 (Experiment 2). Thus, participants' accuracies in correctly identifying pseudo words in Experiment 2 were used as landmarks for performance, in that higher accuracies indicated higher performances. The cognate inhibition effect (CIE) on the accuracy of each participant was obtained by subtracting the non-cognate error rate from the cognate error rate of that person. The higher the CIE, the stronger cognate inhibition effect a participant exhibited. As shown in Figure 3 and by the Pearson correlation test, there was a strong and significant negative correlation between CIE and participants' accuracies on identifying pseudo words, $r = -0.94$, $p < .001$. This pattern indicated that low performers exhibited larger cognate inhibition effects than high performers. Since cognate inhibition only applied to identical cognates, this result indicated that low performers were influenced by identical cognates from the non-target language, as hypothesized earlier. The difference between low and high performers in LDTs was also evidenced in the bilingual study by Brenders and colleagues (2011), where the beginning L2 learners, but not the proficient bilinguals, showed a cognate inhibition effect on RT. Therefore, it was suggested that the low-proficiency participants were likely to be confused by the lexical ambiguity in identical cognates.

Experiment 2 did not find a cognate facilitation effect for the L3 German task, and this was contrary to predictions based on the bilingual literature. Our analyses suggested that there might be confusion among participants which resulted in this pattern. To consolidate cognate effects (or lack thereof) in the L3, German-English cognates were tested again in another L3 LDT with a different stimuli composition in Experiment 3.

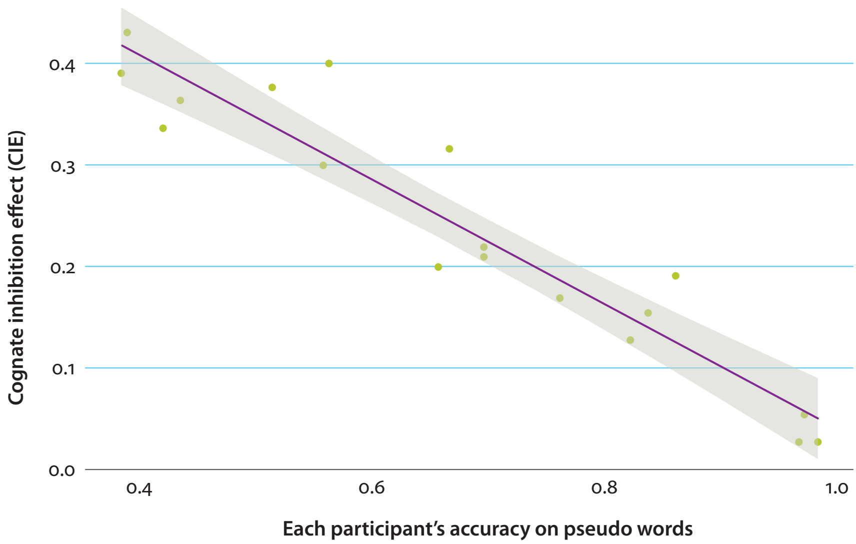


Figure 3. Correlation between the cognate inhibition effect and the overall performance of each participant

4. Experiment 3 – Cognates and interlingual homographs in an L3 German-only LDT

4.1 Methods

Trilingual participants of Experiment 1 and Experiment 2 took part in Experiment 3, resulting in 41 participants (Female = 21, Male = 20, mean age = 22.7 years, range = 20–27). The stimuli contained a new set of 16 German-English cognates matched with 16 non-cognate control words, 18 German-English interlingual homographs matched with 18 non-interlingual homograph controls, as well as 68 pseudo German words. Non-cognates were designed the same way as in Experiment 2, and the Levenshtein Distances of non-cognates ($M = 5.06$, $SD = 1.08$) were significantly higher than that of cognates ($M = 1.00$, $SD = 0.86$), $t(43.72) = 13.16$, $p < .001$, $d = 3.15$. Cognates in Experiment 3 and Experiment 2 did not differ significantly in lexical frequencies, $t(49) = 0.85$, $p = .40$, $d = 0.26$. Interlingual homographs could be found in both German and English vocabulary, while the non-interlingual homographs were German word forms non-existent in

English vocabulary. Frequency values, word lengths, and orthographic neighbor counts were retrieved from CLEARPOND (Marian et al., 2012). The matching of stimuli (see Table 2) and experimental procedures were the same as the first two experiments and there were a total of 136 trials.

4.2 Results

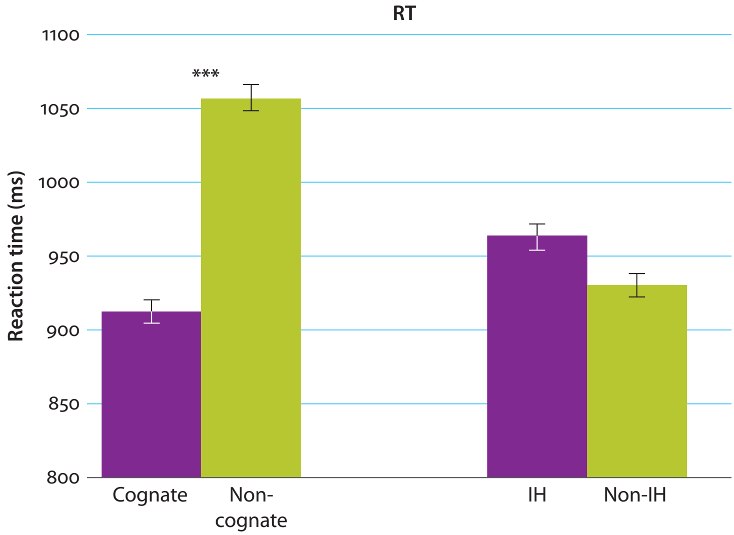
The same 50% cut-off threshold was applied to trials in Experiment 3, resulting in a rejection of data from four participants, one interlingual homograph – non-homograph pair (*Herd* 'stove' – *Tuch* 'scarf'), and one cognate – non-cognate pair (*Tag* 'day' – *zur* 'to'). Outliers included 3.0% of cognates, 1.9% of non-cognates, 2.2% of interlingual homographs, 1.9% of non-interlingual homographs, and 4.3% of pseudo German words. T-tests and logistic regressions were applied to examine RT and error data. The RT and error rates are shown in Table 3 and Figure 4.

4.2.1 *RTs*

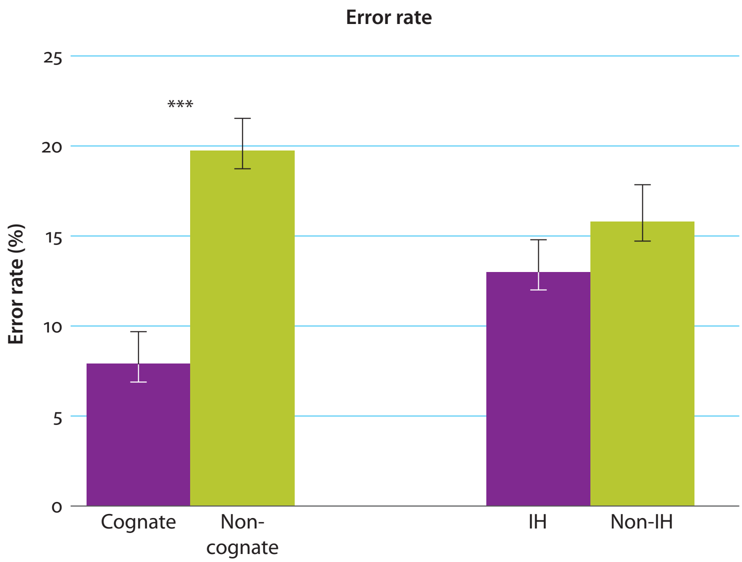
The mean RTs to real German and pseudo German words were 967 ms and 1129 ms. In contrast to Experiment 2, cognates (M = 914 ms) were responded to faster than non-cognate words were (M = 1057 ms), exhibiting a cognate facilitation effect of 143 ms, $t(36) = 6.06$, $p < .001$, $d = 0.9$. The mean RTs to interlingual homographs (M = 965 ms) and non-interlingual homographs (M = 932 ms) did not amount to a significant interlingual homograph effect, $t(36) = -7.14$, $p = .47$, $d = 0.12$.

4.2.2 *Error rates*

The mean error rates to real German and pseudo German words were 14.1% and 16.9%. The mean error rates to cognates and non-cognates were 7.9% and 19.8%, and to interlingual homographs and non-interlingual homographs were 13.0% and 15.8%. Binomial logistic regression [$\chi^2(1) = 41.28$, $p < .001$, $R_L{}^2 = 0.04$, $R_{CS}{}^2 = 0.03$, $R_N{}^2 = 0.06$] on Error (wrong vs. correct) with Cognate Status (cognate vs. non-cognate) as the factor suggested that the odds of errors on cognates were 76.44% lower than that of cognates ($ß = -1.09$, $SE = 0.18$, $z = -6.13$, $p < .001$), so cognates were responded to with higher accuracy. Error rates for interlingual homographs and non-interlingual homographs were 17.4% and 15.1%, respectively. The binomial logistic regression model on Error (wrong vs. correct) with Interlingual Homograph Status (interlingual homograph vs. non-interlingual homograph) as predictor was not significant [$\chi^2(1) = 0.09$, $p = .76$, $R_L{}^2 = 0$, $R_{CS}{}^2 = 0$, $R_N{}^2 = 0$], suggesting that interlingual homographs and non-interlingual homographs did not differ significantly in error rates.



a.



b.

Figure 4. Comparison of reaction times (RTs) and error rates between cognates and non-cognates and between interlingual homographs (IHs) and non-interlingual homographs (non-IHs) in Experiment 3

4.3 Discussion

In the second L3 task testing on both cognates and interlingual homograph, cognates were responded to faster and more accurately than non-cognates words were, but interlingual homographs and non-interlingual homographs did not differ significantly in either RTs or error rates. Note that interlingual homographs were homographic forms which may have different frequency values in the L2 and L3, and the relative frequency of the two readings has been suggested to affect the processing of IHs (Dijkstra et al., 1998). However, the relative frequency factor could not be addressed in this study because the majority of interlingual homograph stimuli used did not have discrepant frequencies in the two languages. 90% of IHs in the experiment had L2 and L3 readings that were either frequent or infrequent. Excluding such words, the remainder did not allow for statistical tests because of the relatively small data set. Nevertheless, we did observe that interlingual homographs with high-frequency reading in the non-target language appeared to be difficult for participants. For examples, interlingual homographs like *Ton* with low frequency in the target L3 and high frequency in the non-target L2 had a high mean RT of 1053 ms, which was well above the 965 ms mean RT of all interlingual homographs.

5. General discussion

In the LDTs we tested the processing of cognates and interlingual homographs in L2 and L3 on a group of beginning-to-intermediate L3 German learners speaking English as their L2. In Experiment 1, German-English cognates were reacted to significantly faster and more accurately than pure English control words were in the L2 English task. By comparison, the bilingual control group did not show any cognate effect in the same L2 task. In Experiment 2, the German version of the first experiment, no cognate effect was found. In Experiment 3, another German LDT integrating both cognates and interlingual homographs, the German-English cognates were responded to faster and with fewer errors than German non-cognates were, while interlingual homographs and their matched non-interlingual homograph controls did not differ significantly in either response latency or accuracy.

Cognate facilitation effects on RT and error rate data in Experiments 1 and 3 lend support to a language non-selective approach to trilingual L2 and L3 processing. Bilingualism literature has provided at least two explanations for the cognate facilitation effect. The cumulative frequency approach assumes that identical cognates in two languages share a single mental representation, and that cognates are more easily processed because bilinguals encounter cognates more often than other words in one language (De Groot & Nas, 1991; Sánchez-Casas, Davis, & García-Albea, 1992). Another viewpoint, taken by the BIA+ model (Dijkstra & Van Heuven, 2002), believes that cognates activate the same semantics and the meaning overlap facilitates language processing (Van Hell & De Groot, 1998). This approach takes both identical and non-identical cognates into consideration and predicts that partial orthographic overlap will also send activation to the semantics. The second approach is more applicable to the present study because we did not intentionally use only identical cognates in the stimuli, and an overall cognate facilitation effect was found in Experiments 1 and 3 which included both types of cognates. During the processing of L2–L3 cognates, the partial or full orthographic overlap activates the shared semantics in both the target and the non-target languages from bottom-up, and the activation of semantics accelerates processing speed and enhances processing accuracy.

Language dominance influences the processing of L2–L3 cognates, but in a way that is different from the generalizations in previous behavioral studies. The cognate facilitation effect is commonly thought to be stronger in tasks conducted in a non-dominant language than in a dominant language (Lemhöfer & Dijkstra, 2004; Poarch & Van Hell, 2012, 2014). During the processing of a non-dominant language, the dominant language is likely to remain active and spread activation to the non-dominant language. Thus, a stronger language is more likely to influence a weaker language than in the opposite direction (Kroll et al., 2005). It is proposed by Van Hell and Dijkstra (2002) that a high proficiency level is required for a weaker language to have significant effects on a stronger language. However, the L2 LDT in Experiment 1 demonstrates that a much weaker L3 could also influence a stronger L2. In fact, under certain circumstances, it possible for even a limited foreign language experience to influence cross-linguistic activation patterns (Van Hell & Poarch, 2014). At the time of the study, participants were still learning the L3 in classroom settings in order to pass exams, so their memory of the L3 could be fresh and strong enough to influence a proficient L2. Despite the lack of behavioral data supporting backward influence from a weak language to a strong one, recent ERP studies showed the effects of an L2 on an L1 in cognate processing (e.g. Bice & Kroll, 2015; Midgley, Holcomb, & Grainger, 2011). In particular, Bice and Kroll (2015) suggested that L2 learners' stronger L1 was influenced by the weaker L2 even at early learning stages. This bilingual pattern is consistent with the current study in which trilinguals' stronger L2 was affected by their weaker L3 in the L2-only task. Apart from this, selecting L2 and L3 lexical items and selecting L1 and L2 lexical items in LDTs are not exactly the same, and therefore phenomena common to bilinguals might not be found in trilinguals. Firstly, trilinguals' L2 may not be as highly activated or deeply entrenched as bilinguals' L1 and thus be more vulnerable to cross-linguistic influence from another language. Also, there could be an

'L2 status' factor (Williams & Hammarberg, 1998) playing a role, in that trilinguals categorize L2 and L3 as their 'non-native languages' and thus are more likely to exhibit transfers between L2 and L3. Additionally, as English and German are typologically more similar than Cantonese and English or Cantonese and German, mutual influences could happen extensively in these two non-native languages. These factors all contribute to a backward influence from a weak L3 to a strong L2.

Interestingly, a cognate facilitation effect was observed in the second German LDT (Experiment 3) but not in the first German LDT (Experiment 2). Several explanations were explored. One possibility is that the inclusion of interlingual homographs in Experiment 3 improved participants' performance on cognates, but this is unlikely because recent studies found the opposite pattern. For instance, the mixing of cognates and interlingual homographs resulted in inhibition effects of cognates in Dutch-English bilingual children (Brenders et al., 2011). Also, studies on Dutch-English bilingual adults showed that the presence of real Dutch words in English LDTs cancelled out the canonical cognate facilitation effect (Poort & Rodd, 2017; Poort, Warren, & Rodd, 2016). Since interlingual homographs are real words in the non-target language, they could remind participants of the two interpretations of cognates and cause participants' confusion in figuring out a correct response. Thus, the inclusion of interlingual homographs should reduce, instead of enhance, the cognate facilitation effect, which is contrary to the results in Experiment 3.

Another possibility is a practice effect, for 20 out of the 37 participants in Experiment 3 had previously completed Experiment 2, as both were L3 lexical decision tasks. However, the t-test showed that participants who previously took Experiment 2 did not have significantly shorter RTs than those previously took Experiment 1, $t(35) = 0.31$, $p = .75$, $d = 0.10$. Meanwhile, the analysis on cognate effect changes between Experiment 1 and 2 takers did not support the practice account. The factor of Previous Session (participated in Experiment 1 vs. participated in Experiment 2) × Cognate Status interaction was added into ANOVAs and binomial regression analyses of RT and error data of Experiment 3. For the RT analysis, the effect of Previous Session × Cognate Status interaction was not significant, $F(1, 70) = 0.11$, $p = 0.74$, $\eta^2 < 0.0015$, whereas for the error rate analysis, adding the factor of Previous Session × Cognate Status interaction did not significantly improve model fit, $\chi^2(1) = 1.43$, $p = .23$, meaning that cognate facilitation effects were found in the two groups of participants alike. Summarizing the results, participants who previously took Experiment 2 did not change in their strategies of using cross-linguistic overlap to facilitate German-English cognate recognition in the subsequent Experiment 3. Therefore, a practice effect should not be an important factor contributing to different cognate effects in the two German LDTs. However, due to the fixed orders of Experiment 2 and Experiment 3, a practice confound could not be completely avoided. To rule out a practice effect, future research with a new group of Experiment 3 takers is needed.

The third explanation is inspired by Dijkstra and colleagues (1998), who pointed out that a shift in performance strategy could happen during the course of the experiments. According to the Language Mode theory (Grosjean, 2001), bilinguals can move from a 'monolingual mode' (predominantly activating one language) to a 'bilingual mode' (activating two languages) in different contexts. It is speculated that all of the participants in Experiment 3 were tuned to an English-German 'bilingual mode' after the completion of Experiment 1 or Experiment 2 that had elicited dual language activation. If both non-native languages were active in the last session (Experiment 3), a cognate effect would become more likely. Indeed, the exceptionally high error rates of identical cognates in Experiment 2 were not observed in Experiment 3, showing that the participants might no longer be confused by the ambiguity of such words. The effects of global context and experimental block on bilingual language activation were also supported by an ERP study conducted in the L2 of German-English bilinguals (Elston-Güttler, Gunter, & Kotz, 2005). In the study, participants who previously watched an L1 German movie exhibited semantic priming effect in the processing of German-English homographs in the first block only. Similarly, the divergent findings in the two L3 German tasks of the present study underscore the importance of contextual factors in the processing of L2–L3 cognates.

Frequency is another potential confound leading to different findings in the two L3 tasks. Mean frequency values in Table 2 seem to suggest that the cognates used in Experiment 2 were more frequent than those in Experiment 3. To examine this issue, Frequency was added as a continuous variable to the original logistic regression models on cognate error rates. For both experiments, the new models with Frequency and Cognate Status as predictors [Experiment 2: $\chi^2(2) = 31.9$, $p < .001$, $R_L{}^2 = 0.09$, $R_{CS}{}^2 = 0.05$, $R_N{}^2 = 0.12$; Experiment 3: $\chi^2(2) = 57.9$, $p < .001$, $R_L{}^2 = 0.06$, $R_{CS}{}^2 = 0.05$, $R_N{}^2 = 0.09$] found a significant effect of Frequency (Experiment 2: $ß = -0.03$, $SE = 0.001$, $z = -2.11$, $p < .05$; Experiment 3: $ß = -0.02$, $SE = 0.005$, $z = -3.23$, $p < .01$), and still a significant effect of Cognate Status (Experiment 2: $ß = 0.95$, $SE = 0.32$, $z = 2.92$, $p < .01$; Experiment 3: $ß = -1.08$, $SE = 0.18$, $z = -5.93$, $p < .001$) on error rates. However, adding Frequency × Cognate Status interaction did not increase the models significantly [Experiment 2: $\chi^2(1) = 2.16$, $p = .14$; Experiment 3: $\chi^2(1) = -2.58$, $p = .10$). The insignificant interaction effects indicated that Frequency could not account for the difference in error rates between cognates and non-cognates in the two experiments. In other words, lexical frequency did not significantly affect either the cognate inhibition effect in Experiment 2, or the cognate facilitation effect in Experiment 3. Therefore, frequency does not seem to be the main reason for the different results in the two LDTs.

The cognate facilitation in the second L3 task (Experiment 3) was expected, while patterns in the first L3 task (Experiment 2) were not typical. It was suspected that the absence of cognate facilitation effects in Experiment 2 was an artifact caused by participants' limited proficiency, which took a toll on their cognitive resources and led to non-target performance strategies. First of all, when the cognitive resources were occupied in tasks conducted in a weak L3, participants might not be able to use semantics to facilitate cognate processing. The relationship between working memory and cognate performances was explored in another study using translation tasks (Kroll, Michael, Tokowicz, & Dufour, 2002). In that study, L2 learners with lower working memory benefited more from cognates than L2 learners with higher working memory, which suggested that leaners with lower working memory relied more on forms, while learners with higher working memory relied more on concepts. L2 learners in that study resemble trilinguals in the current study. Low-performing trilinguals focused more on forms than concepts, and thus failed to use the conceptual overlap to accelerate lexical retrieval. Meanwhile, too much attention on word forms made low performers confused by ambiguous, identical cognates, so they misidentified such words as non-German words. As discussed in the post hoc analysis of the results in Experiment 2, incorrect responding strategies were likely used by these participants, who were essentially using language decision task strategies to perform an LDT, resulting in cognate inhibition effects. In addition, seeing cognates which were also real English words, trilinguals might grow too cautious and attempt to consciously suppress the non-target L2 English as a whole, as trilinguals tend have a higher metalinguistic awareness than bilinguals do (O Laoire, 2005). The suppression of L1 during L2 processing was also observed in the ERP study by Bice and Kroll (2015), which found that learners showed a non-canonical N400 for cognates in L2 LDTs. Based on the assumption that the N400 reflected processing difficulty, the study indicated that some learners inhibited L1 during L2 processing and made cognates harder, instead of easier to retrieve.

Mechanisms in the BIA+ model (Dijkstra & Van Heuven, 2002) could be pursued to explain the inhibitory effect in identical cognates. In the BIA+ framework, an inhibitory mechanism plays an essential role in visual word recognition: L3 cognates with their orthographically similar L2 cross-linguistic partners are simultaneously activated from bottom-up, and a top-down inhibitory mechanism is needed to suppress the non-target language competitors in order to make a correct decision. On the one hand, the low performers with limited cognitive resources were not very adept at top-down inhibition. On the other hand, the identical cognates raised processing difficulties by presenting real L2 words in an L3 task. Therefore, the low performers showed interference instead of facilitation from L2 when encountering identical cognates. The relation between cognitive ability and cognate effect was also discussed in a few other studies comparing older and younger bilingual adults (Logan & Balota, 2003; Siyambalapitiya, Chenery, & Copland, 2009). Siyambalapitiya and colleagues (2009) found a cognate inhibition effect in the cross-linguistic condition of a repetition priming task in older bilinguals and suggested that their poor inhibition ability was the reason for slower lexical access. Similarly, Logan and Balota (2003) observed that those with poor cognitive ability have difficulties in selecting close lexical competitors. The low performers in this study are analogous to those older bilinguals with limited controlling abilities.

In contrast to the cognate effects, no interlingual homograph inhibition effect was found. Given the finding that interlingual homographs and non-interlingual homographs were reacted to with similar RTs and accuracies, such a result could not directly prove a parallel activation of German and English representations during the processing of interlingual homographs. The null effect for interlingual homographs is unsurprising because various studies have shown that the IH effect was more unsteady than the cognate effect. For example, Von Studnitz and Green (2002) found inhibition effects for interlingual homograph words compared with one language controls, but another study with Spanish-English bilinguals (Gerard & Scarborough, 1989) did not observe any interlingual homograph effects. It was observed that interlingual homograph effects were more likely when the interlingual homographs had low frequency in the reading of the target language and high frequency in the reading of the non-target language (Dijkstra, Timmermans, & Schriefers, 2000; Dijkstra et al., 1998). Since such interlingual homographs only constituted less than 10% of IHs in this study, Experiment 3 did not provide the best situation to elicit an interlingual homograph effect. The null effect of interlingual homographs did not indicate that the L2 was not activated, as there was a cognate facilitation effect in the same task. In case of interlingual homograph processing, participants might have activated their L3 lexicon highly enough to immediately cut off the activation of the L2 lexicon, so that the bottom-up activation from the shared orthography did not reach the higher semantic level. By comparison, in cognate processing, the shared orthography and semantics in cognates promoted parallel activations of both L2 and L3 lexicons, which converged on the semantic level. The absence of an interlingual homograph effect and the presence of a cognate effect suggest that shared semantics might be more important than a shared orthography for one lexicon to influence another.

6. Conclusion

Our study found evidence for parallel activation of L3 and L2 lexicons during visual word recognition in a group of Asian trilinguals who were acquiring an L3 in adulthood. Despite the trilinguals being less proficient in their L3 than in their L2, there was still an observable cognate facilitation effect from the L3 to L2. Therefore, the mechanism of processing L2 lexical items should remain malleable over the lifespan, and it is possible for a recently acquired language, even with limited proficiency, to influence the processing of a proficient L2 acquired in childhood. In addition to this flexibility over time, these Asian trilinguals also demonstrated greater variability in lexical processing compared with the bilingual and trilingual population tested earlier. Whether or not lexical overlaps in L2 and L3 show facilitative or inhibitory effects is largely determined by interactions of multiple factors such as language dominance, stimuli composition, orthographic similarity, performance strategy in a task, typological proximity between languages, and individual variations on language proficiency. Future studies are needed to tease apart these interactions in order to better understand trilingual non-native language processing.

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