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Unbalanced Trilinguals' Cognate Processing in L2 in Isolation and in Sentence Context

Evidence from behavioral and eye-movement studies

Abstract: While studies on bilinguals' cognate processing have commonly examined the cognate facilitative effect as well as its influencing factors, research on trilinguals' processing of cognates has been insufficient, and the results of existing studies have been inconsistent. The study presented here aimed to investigate how L2–L3 cognates can influence unbalanced trilinguals' L2 word recognition both in isolation and in sentence context and examined how word classes could modulate the effect. In a lexical decision task, unbalanced Chinese–English–German trilinguals were required to read cognate and noncognate nouns and verbs in isolation. No cognate effect was observed. In an eye-monitored sentence-reading task, participants were asked to read the target cognates and noncognates embedded in low-semantic-constraint sentence contexts. A cognate inhibition effect was observed in nouns, but only in gaze duration, an early-stage measure. Moreover, an uncommon noun processing disadvantage over verbs was observed in both experiments. Results were discussed in relation to language-learning experiences, language-membership ambiguity, and the concreteness effect.

Keywords: Chinese; English; German; word class; lexical processing

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1 Introduction

In the domain of bilingualism, researchers have been focusing on the processing of cognates for years. The term "cognates," in psycholinguistics, refers to words that have both overlapping forms and similar meanings across languages, such as German *Hand* and English *hand*. Previous studies have shown that cognates are processed faster than noncognates (i.e., words that do not share forms with their translation), which is referred to as the "cognate facilitation effect." This is often regarded as evidence for language-nonselective lexical access; that is, when bilingual or multilingual speakers see a word, the lexical representations in both the target language and the non-target language(s) are activated.

Cognate facilitation effect has been commonly observed in word recognition in isolation (e.g., Comesaña et al. 2015; Dijkstra et al. 1999; Lemhöfer et al. 2008; Peeters et al. 2013; Schwartz et al. 2007) and in sentence reading (e.g., Dijkstra et al. 2015; Duyck et al. 2007; Libben and Titone 2009; Van Assche et al. 2009; van Hell and de Groot 2008). The facilitation not only happens from one's first language (L1) to the second language (L2) but also appears from the weaker L2 to the stronger L1 (Titone et al. 2011; Van Assche et al. 2009; van Hell and Dijkstra 2002). Furthermore, researchers have identified a series of factors that can modulate the cognate effect, including formal similarity (Comesaña et al. 2015; Dijkstra et al. 2010), word frequency (Miwa et al. 2014; Peeters et al. 2013), word concreteness (van Hell and de Groot 1998), word classes (Bultena et al. 2013, 2014; Van Assche et al. 2013), language proficiency (Nakayama et al. 2013; Schwartz and Kroll 2006), and task demands (Bultena et al. 2014; Dijkstra et al. 2010). Researchers have also formulated theories to account for bilingual cognate processing, such as the Bilingual Interactive Activation (BIA) model (Dijkstra and van Heuven 1998) and the later BIA+ model (Dijkstra and van Heuven 2002).

Compared with bilingual recognition studies, however, how trilinguals recognize cognates has only been probed by a small number of studies (Lemhöfer et al. 2004; Lijewska and Chmiel 2015; Poarch and van Hell 2014; Szubko-Sitarek 2015; Zhu and Mok 2020), some of which focused on comparing "double" and "triple" cognates. For example, Lemhöfer et al. (2004) carried out a lexical decision task in participants' third language (L3) to compare L1–L3 cognates with L1–L2–L3 triple cognates. Results showed that participants' responses to L1–L3 cognates were faster than those to control words, and the triple cognates were processed even faster. Szubko-Sitarek

(2015) took this a step further by not only replicating the triple cognate effect but also exploring the "reversed" cognate facilitation. In the experiments, Szubko-Sitarek conducted a lexical decision task in L1 in which participants with different L3 proficiency levels responded to L1–L2–L3 cognates, L1–L3 cognates, and L1 controls. It was revealed that, although later-acquired, L2 and L3 could indeed facilitate L1 processing, with L3 only playing a minor role in the process.

Following the line of research on the reversed cognate effect in trilingual word processing, a few studies further explored whether L3 could facilitate the word processing in L2. When trilinguals' L2 and L3 are both nonnative languages, it is reasonable to assume that when they read in L2, cognate facilitation works differently from when bilinguals read in L1, their native language. However, the results of such studies varied. For example, Lijewska and Chmiel (2015) asked Polish–German–English trilinguals to translate L2–L3 cognate words of English into their L1 and L2. Although the participants were highly proficient in their L2, the results showed that the cognate facilitation effect was only found in L3–L1 translation, but not in L3–L2. More recently, Zhu and Mok (2020) examined how L2–L3 cognates could influence isolated word recognition in both L2 and L3. Cantonese–English–German trilinguals participated in lexical decision tasks in both L2 and L3. They found that L2 word recognition was facilitated by L3, but L3 word recognition was only facilitated when the stimulus list contained both L2–L3 cognates and interlingual homographs. This was inconsistent with the results of bilingual studies in which generic cognate facilitation from L1 to L2 was observed and with those of previous studies on how mixed stimulus lists influence cognate effect (e.g., Poort and Rodd 2017; Vanlangendonck et al. 2020). Considering the limited research and mixed results of the L3 to L2 cognate effect, more evidence is needed in terms of how a foreign language learned later might affect the processing of a foreign language learned earlier.

The study presented here aimed to address whether trilinguals' L2 word recognition could be facilitated by their L3 lexical knowledge by investigating how trilinguals process L2–L3 cognates. We were also interested in how this process could be influenced by the word class. In Experiment 1, we conducted a lexical decision task in which Chinese–English–German trilinguals' reaction times were recorded when they judged L2–L3 cognate nouns and cognate verbs in English. In Experiment 2, we embedded the words in sentence contexts to investigate whether context could influence L2 word recognition. The eye-tracking method was adopted to collect eye-movement measures regarding different stages of lexical processing.

2 Experiment 1: Word recognition in isolation

2.1 Method

This experiment adopted a 2 (Cognate Status: cognate, noncognate) × 2 (Word Class: noun, verb) within-subject factorial design using the lexical decision paradigm. Participants' responses and reaction times to the stimuli were collected.

2.1.1 Participants

For Experiment 1, 27 Chinese–English–German trilinguals were recruited from the School of German Studies at Beijing Foreign Studies University. The participants signed written consents and were paid for the experiment. The data of three participants were excluded from the analysis because their overall accuracy rates in the task were lower than 70%. The remaining 24 participants included 11 males and 13 females, with a mean age of 20.2 years old ($SD = 1.75$). All participants were right-handed and had normal or corrected-to-normal vision.

The participants completed language-background questionnaires in which they were required to fill in their past language-learning experiences and to rate their own proficiency in Chinese, English, and German. The results are summarized in Table 1. All participants spoke Chinese as their native language, learned English as a part of their education for an average of 12 years ($SD = 3.57$), and learned German after learning English and had been studying German as a full-time major at their current university, which was reflected in their AoAs and years of formally learning L2 and L3 (see Table 1). Paired samples *t* tests revealed that the ratings of their Chinese proficiency were significantly higher than those of their English and German in all aspects (reading, listening, speaking, writing, and overall proficiency, all ps < 0.001), and the ratings of their English and German proficiency did not differ significantly in any aspect (all ps > 0.1). This showed that the participants' L2 and L3 were weaker than their mother tongue, but did not differ significantly from each other. To sum up, the participants were all unbalanced trilinguals whose proficiency levels in their second and third languages were not as high as that of their first language.

Table 1: AoAs, years of language education, and proficiency ratings (on a seven-point scale) in Experiment 1

Rating	L1 (Chinese)	L2 (English)	L3 (German)
AoA	—	6.42 (1.84)	17.04 (2.35)
Years of formal education	—	12.04 (3.57)	3.26 (2.86)
Self-assessed proficiency			
Reading	6.42 (0.93)	4.88 (1.23)	4.75 (1.26)
Listening	6.46 (0.72)	4.29 (1.71)	3.92 (1.50)
Speaking	6.17 (1.01)	4.00 (1.69)	4.17 (1.55)
Writing	5.79 (1.06)	4.50 (1.35)	4.25 (1.33)
Overall	6.13 (0.74)	4.46 (1.38)	4.25 (1.36)

Note: Standard deviations are presented in parentheses. $n = 24$.

2.1.2 Materials

The stimuli in Experiment 1 consisted of 96 words: 24 English–German (L2–L3) cognates, 24 English (L2) control words, and 48 nonwords.

The real words were all English words; half were nouns, and half were verbs. None of the real words had an L3 translation equivalent that was an English–German interlingual homograph. Considering that we were going to embed the target words into sentence contexts, we paired cognates with noncognates. The cognates were verified using Van Orden's (1987) similarity measure, which is a measure ranging from 0 to 1 that represents the orthographic similarity between two words, with 1 representing that the two words were identical. The similarity measures of nouns and verbs were calculated in slightly different ways. Since the infinitive forms of all German verbs are suffixed with *-(e)n* while English verbs are not (e.g., English *start* vs. German *starten*), the inherent difference between English and German verbs is greater than that of nouns. Thus, the root forms of German verbs were used to calculate the similarity measure for verbs. The similarity measures are reported in Table 2. We conducted a four-level univariate analysis of variance (ANOVA) and pairwise comparison to compare the similarity measures across levels. Results showed that similarity measures for cognates were significantly higher than those of noncognates (ps < 0.001). Similarity measures did not differ across noun/verb cognates or noun/verb noncognates (ps > 0.1).

We also controlled other factors that could influence lexical processing. The word lengths ranged from 3 to 9 characters, and the numbers of syllables ranged from 1 to 4. The log frequencies of the English targets and their German equivalents were retrieved from WebCelex (Baayen et al. 2001). Frequencies were obtained by word class (i.e., if a word could belong to multiple word classes, only the frequency of its noun or verb reading was obtained). Neighborhood sizes of the target words were calculated using the “Toolbox” function of WebCelex (Baayen et al. 2001). We also conducted rating studies to collect statistics on semantic similarity, familiarity with English targets and their German counterparts, and the concreteness of the target words. All ratings were conducted by Chinese–English–German trilinguals who did not participate in the formal experiment. The statistics are presented in Table 2. The results of the four-level univariate ANOVAs showed that there were no significant differences between levels for word lengths, numbers of syllables, log frequencies of English targets and German counterparts, neighborhood sizes, semantic similarity ratings, familiarity ratings with English targets and German counterparts, or concreteness (all ps > 0.1).

Table 2: Means of lexical characteristics of the target words

Lexical Characteristics	**Noun**		**Verb**	
	Cognate	**Noncognate**	**Cognate**	**Noncognate**
Van Orden’s similarity measure	0.85 (0.14)	0.14 (0.08)	0.77 (0.18)	0.13 (0.09)
Word length	6.00 (1.71)	6.17 (1.47)	5.50 (1.62)	5.83 (1.90)
Number of syllables	1.92 (0.90)	2.00 (0.95)	1.83 (1.03)	1.83 (0.57)
Log frequency of English targets	1.89 (0.48)	2.05 (0.19)	2.01 (0.42)	2.02 (0.31)
Log frequency of German translation equivalents	1.62 (0.61)	1.92 (0.45)	1.58 (0.52)	2.02 (0.54)
Neighborhood size	3.08 (4.31)	2.58 (4.06)	6.58 (6.16)	4.75 (5.53)
Semantic similarity rating	6.43 (0.29)	6.40 (0.24)	6.46 (0.17)	6.26 (0.25)
Familiarity with English targets	6.54 (0.27)	6.71 (0.18)	6.40 (0.36)	6.48 (0.32)
Familiarity with German translation equivalents	6.66 (0.33)	6.62 (0.25)	6.44 (0.38)	6.30 (0.48)
Concreteness	4.25 (1.42)	4.16 (1.91)	3.96 (0.84)	4.24 (0.63)

Note: Standard deviations are presented in parentheses.

The 48 nonwords were generated with WordGen (Duyck et al. 2004) using the heuristic method (i.e., creating nonwords by changing one letter in a real word). The nonwords were matched with target words regarding word lengths item by item. Furthermore, six noncognate words (three nouns and three verbs) and six nonwords were selected for use in practice trials. None of the 12 words was used in the formal experiment.

In order to differentiate nouns from verbs, all target words were presented in a minimally disambiguating context (Bultena et al. 2013). In Bultena et al.'s (2013) study, to guarantee that nouns and verbs could be distinguished, nouns were presented with *the, a(n)*, or *this* and verbs with *we, you*, or *they*. Despite being an effective method, the way the researchers presented the verb could have caused unwanted syntactic processing when participants read them. Therefore, in this experiment, all nouns were presented with the definite article *the* and verbs with the infinitive marker *to*. Nonwords were presented in the same way: Half were presented with *the*, and the other half with *to*.

2.1.3 Procedures

Participants were seated in a normally lit testing booth about 60 cm from a screen. They read written instructions on the screen while listening to oral instructions from the experimenter prior to the task. Instructions were provided in Chinese (L1). Participants were instructed to determine whether the presented series of letters was a real English word or was a nonword as accurately and quickly as possible and to respond by pressing either the leftmost or the rightmost button of a Chronos response device (Psychology Software Tools) with their index fingers. The key–response correspondence was counterbalanced: Half of the participants pressed the left button for real words and the right button for nonwords, while the other half had a reversed setting. The LEDs above the two used buttons on the Chronos were lit white throughout the experiment to remind the participants of the buttons to press.

Stimuli were presented in black lowercase 32-pt Arial letters against a light gray background using E-Prime 3.0 (Psychology Software Tools). The procedure of one trial is shown in Figure 1. Each trial started with a cross fixation ("+") at the center of the screen for 500 ms, followed by a blank screen for another 500 ms. Then a target word or a nonword was presented at the center until the participant responded or a timeout of 2000 ms was reached. The intertrial interval was 1000 ms. Stimuli were presented in a pseudorandom order in which no more than three words or nonwords appeared in a row.

Participants first familiarized themselves with the experiment through the 12 practice trials and then finished the formal experiment. After the experiment, they were required to fill out the language-background questionnaire. Participants received their rewards when they finished the entire session. A complete experiment session took around 30 minutes.

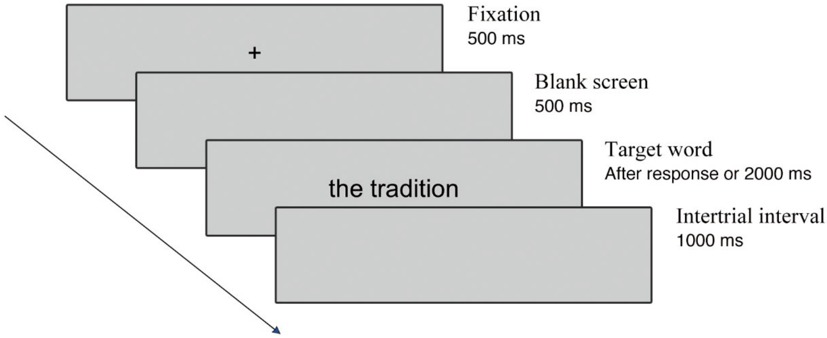

Figure 1: Trial sequence in Experiment 1

2.2 Results

Out of the raw dataset, the data of three participants were excluded due to accuracy lower than 70%. A cognate item (i.e., *salad*) and its paired noncognate (i.e., *fruit*) were removed from the analyses because the cognate item was later found to be ill-designed. For all the trials of real words, trials with reaction times (RTs) outside 3 SDs from all the trials' mean were treated as outliers and excluded, which resulted in the removal of 1.63% of the trials.

We analyzed the error rates and the RTs of all correct real word trials using ANOVAs with IBM SPSS Statistics (Version 26). Means and standard deviations are presented in Table 3.

Table 3: Reaction times (in ms) and error rates (in percentages) in Experiment 1

Level	**RT**		**Error rate**	
	M	**SD**	***M***	**SD**
Noun cognate	649	109	3.03	6.92
Noun noncognate	629	100	1.98	4.78
Verb cognate	616	103	2.78	6.35
Verb noncognate	616	105	0.35	1.70

Note: RTs are rounded to the nearest millisecond.

The analysis of error rates showed no significant main effect of Word Class, $F(1, 23) = 1.61$, $p = 0.22$, $\eta_p^2 = 0.065$; there was also no significant main effect of Cognate Status, $F(1, 23) = 1.44$, $p = 0.25$, $\eta_p^2 = 0.059$. No interaction was detected either, $F(1, 23) = 0.83$, $p = 0.37$, $\eta_p^2 = 0.035$. These results showed that the error rates did not differ significantly across conditions. The results of RTs, on the other hand, revealed a significant main effect of Word Class, $F(1, 23) = 9.41$, $p = 0.005$, $\eta_p^2 = 0.29$. The effect of Cognate Status was not significant, $F(1, 23) = 1.91$, $p = 0.18$, $\eta_p^2 = 0.077$. The interaction was not significant either, $F(1, 23) = 1.43$, $p = 0.24$, $\eta_p^2 = 0.059$. Figure 2 shows the mean RTs for all four conditions.

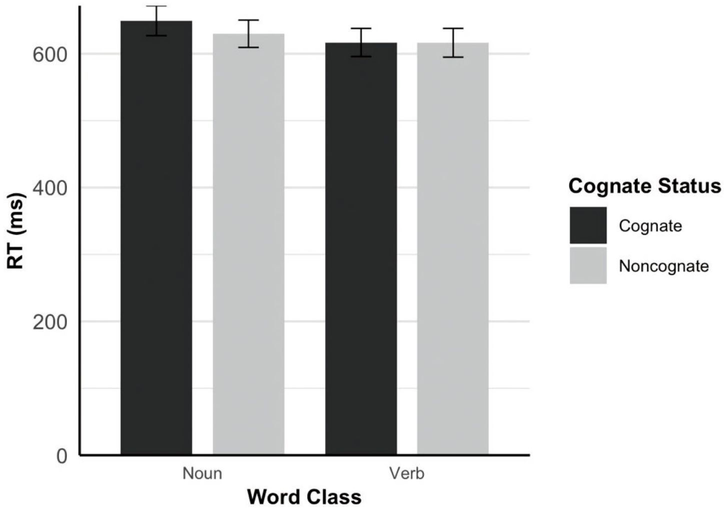

Figure 2: RTs (in ms) of different conditions in Experiment 1
Note: Error bars show standard errors.

2.3 Discussion

Experiment 1 failed to observe the cognate facilitation effect that had been observed in previous bilingual research. Although this was inconsistent with most past studies on cognates, it is comparable to the results of Lijewska and Chmiel's (2015) study. In their study, they did not observe cognate facilitation when participants were required to translate L3–L2 cognates into L2. This was explained by the weak conceptual link between L3 and L2: the participants learned L3 through L1, so L3 words had established stronger semantic links to their L1 translation equivalent than to the L2 ones. When an L3–L2 cognate was presented, activation could not travel from L3 to L2 representations, leading to a lack of cognate facilitation effect. This could account for the absence of the cognate facilitation effect in the current experiment. Because the participants learned the two foreign languages separately, they had little experience working with both languages and, therefore, demonstrated weak links between the L2 and L3 representations.

Another explanation for the phenomenon is related to task demand. Dijkstra et al.'s (2010) study focused on how different requirements of tasks may influence the cognate effect. Dutch–English bilinguals performed a lexical decision task, a language decision task, and a progressive demasking task in English in which they read cognates and noncognates with various levels of form overlap. In the lexical decision task, a common cognate facilitation effect did appear. However, in the language decision task, a cognate inhibition effect was observed instead of a facilitative one, and in the progressive demasking task, there was no significant effect of orthographic similarity. The different cognate effects appearing in the different tasks were accounted for by the lexical competition of cognate representations. As a localist connectionist model would suggest, the representations of cognates are linked to the respective language-membership nodes. In the language decision task, cognate processing was not facilitated by the coactivation of the lexical or semantic nodes but was inhibited by the competition between the language-membership nodes. In our study, although we conducted a lexical decision task, we postulate that the task might have involved language decisions. Since both languages involved in the experiment were foreign languages and the participants had relatively low proficiency in them compared with their L1, it is possible that for participants to decide whether the presented string was a real word or not involved judging whether the string was from L2 or L3, even though this was not explicitly stated in the task instruction.

This view was also supported by Zhu and Mok's (2020) study on Cantonese–English–German trilinguals' cognate recognition, in which they observed a cognate facilitation effect from L3 to L2 but not from L2 to L3 in lexical decision tasks. The participants lived in Hong Kong SAR, where they were exposed to their L2 (English) early and had been using it on a daily basis in their social lives and education, while their L3 was learned at university through biweekly courses. When the researchers explained the lack of cognate facilitation from L2 to L3, they argued that, due to participants' low proficiency level in L3, when participants see an L2–L3 cognate, their representation in L2 was activated first and had to be suppressed to perform the judgment in L3. In our experiment, the participants had comparable proficiency levels in both English and German, and neither was used extensively in their daily life. The ambiguity of language membership affected the process of lexical decision and therefore resulted in the absence of the cognate facilitation effect.

This postulation also made us question whether having a language context (e.g., in a language-unambiguous sentence context) could allow us to see cognate effects, leading us to the attempt to embed the words in sentence contexts in Experiment 2.

3 Experiment 2: Word recognition in sentence contexts

3.1 Method

This experiment adopted a 2 (Cognate Status: cognate, noncognate) × 2 (Word Class: noun, verb) within-subject factorial design. Different from the design in Experiment 1, words were not presented in isolation but in sentence contexts.

3.1.1 Participants

For Experiment 2, 21 Chinese–English–German trilinguals were recruited from the School of German Studies at Beijing Foreign Studies University. All of them were students majoring in German. They took part in the experiment in exchange for a small fee, and all signed written consents before the experiment. None of them took part in the first experiment. The data of three participants were removed from further analysis due to tracking problems, leaving 18 participants (4 males and 14 females). Their ages ranged from 18 to 23 years old ($M = 20.39$, SD = 1.33). All of them were right-handed and had a normal or corrected-to-normal vision.

All participants also completed the language-background questionnaires. Similar to those in Experiment 1, all participants spoke Chinese as their native language and learned English and German afterwards. The questionnaire data are reported in Table 4. Paired samples t tests revealed that the ratings of their Chinese proficiency were significantly higher than those of their English and German in all aspects (all ps < 0.001), and the ratings of their English and German proficiency did not differ significantly in any aspect (all ps > 0.1), which showed that the participants' L2 and L3 proficiencies were weaker than that in their native language, but that both had reached a similar proficiency.

Table 4: AoAs, years of language education, and proficiency ratings (on a seven-point scale) in Experiment 2

Rating	L1 (Chinese)	L2 (English)	L3 (German)
AoA	–	6.44 (2.55)	17.06 (2.44)
Years of formal education	–	11.39 (3.24)	3.38 (2.11)
Self-assessed proficiency			
Reading	6.72 (0.57)	4.94 (1.00)	5.11 (1.13)
Listening	6.89 (0.32)	4.83 (1.25)	4.89 (1.32)
Speaking	6.39 (0.98)	4.33 (1.50)	4.78 (1.35)
Writing	6.44 (0.70)	4.22 (1.31)	4.61 (1.29)
Overall	6.50 (0.71)	4.67 (1.19)	4.78 (1.26)

Note: Standard deviations are presented in parentheses. $n = 18$.

3.1.2 Materials

The same 24 English–German cognates and 24 control words used in Experiment 1 were used as target words. To embed the target words into sentences, 48 sentence contexts were constructed. Each sentence context contained a cognate–noncognate pair. The sample sentences used in Experiment 2 are presented in Table 5. Participants read 48 critical sentences in the experiment; cognate and noncognate targets were counterbalanced across versions.

Table 5: Sample stimuli of Experiment 2

Word type	Sentence context	Target word (German equivalent)
Noun		
Cognate	The speaker introduced the *problem* to the audience.	*problem (Problem)*
Noncognate	The speaker introduced the *research* to the audience.	*research (Forschung)*
Verb		
Cognate	The businessman is going to *study* the annual report tomorrow morning.	*study (studieren)*
Noncognate	The businessman is going to *receive* the annual report tomorrow morning.	*receive (empfangen)*

Note: Target words are shown in *italics* in the table. When presented to participants, no words were italicized.

All sentence contexts were declarative sentences, consisting of 7 to 13 words (M = 9.90, SD = 1.53, see Table 6). No significant difference in word count was found between those containing nouns and those containing verbs, $t(46) = 0.65$, $p = 0.61$. In all sentence contexts, the target words appeared in verb-object constructions in a sentence-middle position. They were never the first or the final word of a sentence. All target words appeared in the morphologically simplest form: nouns were all singular, and verbs appeared as plural forms of present tense or infinitives.

To control the semantic clue provided by the sentence context, all sentences were assured of having low semantic constraints. In other words, the target words were not predictable from the sentence contexts. To match semantic constraints across levels, a cloze probability test was conducted. In the test, participants were asked to provide an English noun or verb to fill a blank at the target word position to complete the sentence contexts (e.g., *The speaker introduced the ________ to the audience*.). Half of the sentences were rated by 60 participants, and the other half were rated by another 80 raters. All raters were native speakers of Chinese and had learned English as a second language. As expected, the cloze probabilities of the target words were very low (see Table 6) and did not differ significantly across conditions, $F(3) = 0.31$, $p = 0.82$. No target words had a cloze probability higher than 0.15, nor did any sentence context have an alternative completion option that reached a cloze probability higher than 0.50.

Table 6: Characteristics of the sentence contexts

Characteristics	**Noun (n = 24)**		**Verb (n = 24)**	
	Cognate	**Noncognate**	**Cognate**	**Noncognate**
Word count	9.75 (1.60)		10.04 (1.49)	
Target word cloze probability	0.03 (0.04)	0.03 (0.05)	0.03 (0.04)	0.02 (0.03)

Note: Standard deviations are presented in parentheses.

As noncritical stimuli, 48 filler sentences were constructed. These filler sentences were also declarative sentences, consisting of no cognate nouns or verbs (except unavoidable auxiliaries) and no target words. The filler sentences contained 7 to 13 words (M = 10.10, SD = 1.55) and had no significant difference from the target sentences in terms of word counts, $t(94) = 0.66$, $p = 0.58$. Of the filler sentences, half were followed by a comprehension question that could be answered with "yes" or "no." The questions were simple and were created to ensure that participants were reading carefully (e.g., *She arrived late today due to the heavy rain.* Question: *Did she arrive on time?*).

Half of the questions required the answer "yes" and the other half "no." Another four practice sentences were also created in line with the fillers for the practice session, and one of them contained a comprehension question.

All sentences (both critical and filler sentences) were proofread by a native speaker of English to ensure they were natural and free from grammatical mistakes. Some sentences were slightly modified after being proofread.

3.1.3 Procedures

The experiment was administered in an eye-tracking laboratory. Eye-movement data was collected using a desktop-mounted EyeLink 1000 Plus eye tracker system (SR Research, Ontario, Canada). A chinrest was fixed 60 cm from the display to minimize participants' head movement.

Participants first read instructions provided in Chinese, in which they were told that they were expected to read silently at a normal speed and to answer any question that followed. They were also informed to try to avoid any head movement during the experiment. Then, participants went through a nine-point calibration prior to the experiment.

The experiment started with four practice trials. Then, all 96 sentences were presented in a pseudorandom order, with each sentence appearing once. Sentences containing target words of the same condition never followed one another. A complete procedure of a trial is shown in Figure 3. Each trial started with a drift correction, which required participants to look at a circular fixation point located on the left side of the screen where the sentence began. Then, a sentence was presented on the screen. Participants' eye movements were recorded during the presentation of the sentence. When participants finished reading the sentence, they could press the space bar to continue. As mentioned above, half of the filler sentences (n = 24) were followed by comprehension questions. Questions were presented starting with a bold "Q" and responses were recorded when participants pressed "F" or "J" on the keyboard. When the question was answered, the participant would be directed to the next trial.

During the experiment, participants always read with both eyes; however, eye movements were recorded in monocular mode from the left eye only. The sampling rate was set at 1000 Hz. Rest was provided to participants when needed.

All sentences and questions were aligned to the left. Each was presented in a single line in black lowercase 24-pt letters using Arial against a light gray background. The target words took up visual angles ranging from 1.34° to 3.82°.

After completing the experiment, participants were asked to fill out the language-background questionnaire. Rewards were given after the completion of the whole session, which took around 40 minutes.

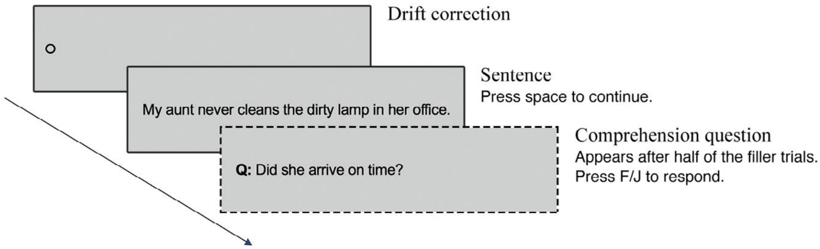

Figure 3: Trial sequence in Experiment 2

3.2 Results

To analyze the results of eye-tracking, areas of interest (AOIs) were first selected. The AOIs of this experiment were chosen to cover the target words, and fixations in these areas were analyzed. Eye-tracking measures were selected in accordance with previous studies and reviews (Bultena et al., 2014; Duyck et al., 2007; Libben and Titone, 2009; Rayner, 1998). Both early- and late-stage eye-tracking measures were analyzed in the study. Early-stage measures included first fixation duration and gaze duration; late-stage measures included regression-path duration and total reading time. Definitions for the above-mentioned measures are listed in Table 7. Early-stage measures are believed to reflect initial lexical access, while late-stage measures are assumed to reflect higher-order processes relating to semantic integration.

Table 7: Definitions of the eye-tracking measures

Stage	Measure	Definition
Early	First fixation duration	The duration of the first fixation in the AOI during the first passage through it.
	Gaze duration	The sum of all fixation durations starting from the first landing in the AOI until the first moving off from it.
Late	Regression-path duration	The sum of all fixation durations starting from the first landing in the AOI until the first landing on the right of the AOI.
	Total reading time	The sum of all fixation durations in the AOI in the given trial.

Of all the participants, one participant was excluded from further analyses due to visible misalignment in eye-movement data. The data of two more participants were excluded due to the data loss caused by excessive blinking. The remaining participants had a high percentage of accurate answers to the comprehension questions (M = 96.06, SD = 3.34), indicating that all participants read the sentences carefully. The sentences containing the word pair *salad–fruit* were excluded from the analysis due to ill design. Furthermore, 4.05% of the trials were removed due to skipping, and 2.08% of the trials were excluded because the total reading time lay outside 3 SDs from the mean.

All eye-tracking measures were analyzed in IBM SPSS Statistics (Version 26). The descriptive statistics of all four eye-tracking measures across all four conditions are reported in Table 8 and shown in Figure 4.

Table 8: Eye-tracking measures (in ms) in Experiment 2

Level	FFD		GD		RPD		TRT	
	M	**SD**	***M***	**SD**	***M***	**SD**	***M***	**SD**
Noun cognate	255	44	358	84	404	113	543	188
Noun noncognate	256	30	326	47	400	87	554	201
Verb cognate	234	40	308	56	360	89	503	180
Verb noncognate	254	47	330	63	360	89	503	182

Note: Reading measures are rounded to the nearest millisecond. FFD = first-fixation duration; GD = gaze duration; RPD = regression-path duration; TRT = total reading time.

A series of 2 (Word Class: noun vs. verb) × 2 (Cognate Status: cognate vs. noncognate) repeated measures ANOVAs were performed for all eye-tracking measures. Statistics for the ANOVAs are presented in Table 9. For first fixation durations, the analysis revealed a significant main effect of Word Class, $F(1, 17) = 4.61$, $p = 0.047$, $\eta_p^2 = 0.21$, showing that nouns were read more slowly than verbs. The effect of Cognate Status was marginally significant, $F(1, 17) = 3.81$, $p = 0.068$, $\eta_p^2 = 0.18$; cognates were read slightly faster than noncognates. There was no interaction between Word Class and Cognate Status. On the other hand, gaze duration displayed a different pattern: There was still a main effect of Word Class, $F(1, 17) = 8.61$, $p = 0.009$, $\eta_p^2 = 0.34$; however, Word Class and Cognate Status showed an interaction, $F(1, 17) = 9.94$, $p = 0.006$, $\eta_p^2 = 0.37$. Pairwise comparisons revealed that there was a significant difference between the gaze durations for cognate nouns and noncognate nouns, $p = 0.031$, indicating that cognate nouns were read more slowly than noncognate nouns. The difference between cognate and noncognate verbs, however, was not significant, $p = 0.098$.

For late-stage reading measures, the main effect of Word Class was marginally significant in regression-path durations, $F(1, 17) = 3.73$, $p = 0.070$, $\eta_p^2 = 0.18$, and significant in total reading times, $F(1, 17) = 6.25$, $p = 0.023$, $\eta_p^2 = 0.27$. Cognate Status showed no significant effect on either measure, nor did the interaction between the two factors.

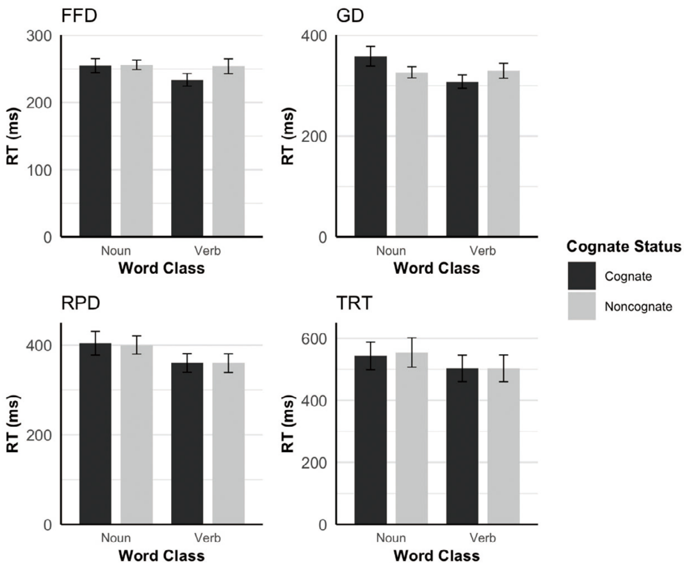

Figure 4: Eye-tracking measures for different levels in Experiment 2
Note: FFD = first-fixation duration; GD = gaze duration; RPD = regression-path duration; TRT = total reading time. Error bars show standard errors.

Table 9: The results of ANOVAs for the eye-tracking measures

Measure	**Effect**	**d*f***	***F***	η_p^2
First fixation duration	Word Class	(1, 17)	4.61^{*}	0.21
	Cognate Status	(1, 17)	$3.81^{\dagger}$	0.18
	Interaction	(1, 17)	2.85	0.14
Gaze duration	Word Class	(1, 17)	8.61^{**}	0.34
	Cognate Status	(1, 17)	0.27	0.02
	Interaction	(1, 17)	9.94^{**}	0.37
Regression-path duration	Word Class	(1, 17)	$3.73^{\dagger}$	0.18
	Cognate Status	(1, 17)	0.02	0.00
	Interaction	(1, 17)	0.02	0.00

Measure	Effect	df	F	η_p^2
Total reading time	Word Class	(1, 17)	6.25*	0.27
	Cognate Status	(1, 17)	0.10	0.04
	Interaction	(1, 17)	0.10	0.01

Note: $^{\dagger}p < 0.10$. $^{*}p < 0.05$. $^{**}p < 0.01$.

3.3 Discussion

In this eye-tracking experiment, we noticed different patterns for early-stage and late-stage measures. For gaze duration, there was a cognate inhibition effect for nouns that was inconsistent with the findings of most previous bilingual studies, while no cognate effect was observed in late-stage reading measures. A rare inhibition effect was found in Dijkstra et al.'s (2015) Experiment 2. In the experiment, Dutch–English bilinguals read Dutch cognates and noncognates in both English and Dutch contexts in a lexical decision task. They found cognate inhibition effects when the cognates were read in Dutch low-constraint sentences and in English sentences. The researchers explained that although the L1 sentence context could not activate the English cognate reading through language cues, the L2 reading of the cognate was suitable for the semantic expectations and was thus activated in parallel with the possible L1 candidates and led to the inhibition effect.

In our experiment, the language-membership ambiguity might have also contributed to the early-stage inhibition. When reading a sentence with low semantic constraint in L2, the L3 reading of the cognate could have been activated as well during early lexical access, since the participants had comparable proficiency levels in L2 and L3; however, the activation was later suppressed by the language cue further provided by the sentence context. This explains why no cognate effect was observed in regression-path duration and total reading time.

Verbs showed no cognate effects in this experiment. Previous studies (Bultena et al. 2013, 2014; van Hell and de Groot 1998) suggested that verb processing requires more effort and could particularly affect verb processing in L2. Bultena et al. (2013) argued that, due to the morphological and syntactic complexity and more language-specific use of verbs, when L2 representations are mapped onto L1 representations during learning, L2 noun representations are more easily mapped onto L1 than L2 verbs. Therefore, in sentence contexts where morphological and syntactic information were abundant, it might have been difficult for participants to activate verb representation in another language despite the form overlap, and hence no cognate effect appeared.

4 General discussion

4.1 Cognate effect in two foreign languages

Unlike most of the previous studies on bilingual and trilingual cognate effects, no cognate facilitation effect was observed in the present study. Past studies have used cognate effects as evidence for language-nonselective lexical access as well as supporting models such as the BIA+ model (Santesteban and Schwieter 2020), so the lack of cognate facilitation in the current study may seem to suggest that language-nonselectivity does not apply to trilingual speakers. However, we believe that the results do not necessarily disprove language-nonselective access in trilingual speakers. Instead, this could have been due to the weaker link between L2 and L3 representations, since both were foreign languages, or due to the possible language-membership ambiguity that had to be resolved in lexical processing. A few studies that we mentioned earlier (e.g., Lijewska and Chmiel 2015; Zhu and Mok 2020) also suggested that when both the L2 and L3 of a trilingual are foreign languages, the two languages may not function in the same way as a bilingual's L1 and L2. Dijkstra (2003) also suggested that as multilinguals still access their mental lexicon in a language-nonselective manner, they may exploit nonlinguistic and linguistic contexts to help modulate the recognition process. Therefore, such results have important implications for extending bilingual models (such as the BIA+ model) to account for multilingual processing: The multiple languages of a multilingual speaker may not possess an equal position in their mental lexicon, and the connections between two foreign languages may be weaker than those between a foreign language and a native language.

Several confounding factors may have prevented us from understanding how a trilingual's two foreign languages interact. The first one is proficiency. Bilingual studies have suggested that L2 proficiency may modulate cognate effects (Bultena et al. 2014; Libben and Titone 2009), as having different levels of proficiency means different degrees of relative activation of L1 and L2 representations. For bilinguals, we can easily generalize the relative proficiencies of the two languages (either balanced or unbalanced). For trilinguals, however, it becomes much more difficult. In Zhu and Mok's (2020) study, participants were most proficient in their L1, were less proficient in their L2, and had the lowest proficiency level in L3. In Lijewska and Chmiel's (2015) study, participants had reached a near-native level in their L2 and had a higher-intermediate level in L3. In the study presented here, both participants' L2 and L3 had reached an intermediate level. Different relative language proficiency levels of participants in these studies might have led to the discrepancy in the results.

In addition, past studies have suggested that AoA could also modulate cognate effects (Lijewska 2020). For example, Titone et al. (2011) have found that cognate facilitation effect was stronger when L2 was acquired earlier in life. Since both L2 and L3 in the current study were not acquired simultaneously, it is also possible that such factors had impacts on the results of study presented here.

Another interfering factor may be related to language experience and use. Past research on multilingualism has focused on how new lexical knowledge is organized in the mental lexicon in relation to that of existing languages (Szubko-Sitarek 2015). It has been proposed that new lexical input may be integrated into a typologically nearer language (Rothman 2015) or may automatically detect and connect to a place with the largest overlap in existing lexical representations (Hall 2002). As Lijewska and Chimel's (2015) study claimed, participants' having learned L3 with the help of L1 may have led to a stronger conceptual link between L1 and L3 representations. It is also reasonable to assume that how a third language is acquired determines how the representations of the three languages are organized and hence affects cognate processing in the two foreign languages.

4.2 Noun and verb processing

A very curious phenomenon that we consistently observed through Experiments 1 and 2 was the fact that nouns were processed more slowly than verbs. This was reflected in the significant main effect of Word Class that was found in the RTs in Experiment 1 and in three out of four of the reading measures in Experiment 2. However, this is contradictory to the noun processing advantage that has been found in the past studies (for a review, see Vigliocco et al. 2011). In particular, the finding in this study is different from what was found in past bilingual studies on cognate processing and word class (Bultena et al. 2013, 2014; Van Assche et al. 2013; van Hell and de Groot 1998).

The question that emerged was why a noun processing disadvantage was observed in the current study. This could be caused by the interplay between the word class effect and the concreteness effect. In Bultena et al.'s (2014) eye-tracking study in which Dutch–English bilinguals read English nouns and verbs in sentence contexts, an overall noun processing advantage was found. However, as reported in the study, they failed to match the concreteness between noun targets and verb targets; noun targets were significantly more concrete (Bultena et al. 2014: 1221). Therefore, the noun processing advantage that they observed could have been caused by the difference in concreteness between the two word classes.

Another piece of evidence came from van Hell and de Groot's (1998) study. In their study, Dutch–English bilinguals performed word association tasks for cognates and noncognates in all directions between Dutch and English. In the study, the grammatical class (noun vs. verb) and concreteness (concrete vs. abstract) of the target words were manipulated diagonally. In the response-time analysis, there was a three-way interaction between stimulus language, grammatical class, and concreteness. We noticed from the data that when the bilinguals' second language was involved in the task, the association latencies of abstract nouns were larger than those of concrete verbs and abstract verbs, except when the participants produced associations to English noncognates in Dutch. This data suggested that abstract nouns could be particularly difficult for bilingual speakers to process, probably even more difficult than verbs, which we usually believe to be more abstract.

In the study presented here, to match concreteness across levels, the stimulus list used in the experiments included more abstract nouns than usual (e.g., *problem, argument, belief, safety*). The very existence of these abstract nouns may be the reason that led to the noun disadvantage. Therefore, future research should address the interaction between word class and concreteness in bilingual (and multilingual) word processing by providing more evidence from diagonal manipulation of the two factors.

5 Conclusion

This study examined Chinese–English–German trilinguals' lexical processing when reading L2–L3 cognates in their L2. In the experiments, L2–L3 cognates did not facilitate the word processing in L2. The absence of a cognate facilitation effect may have been caused by weaker links between the two foreign languages or by competition between language memberships.

Moreover, we observed an uncommon noun processing disadvantage, which we believe to be related to the interplay between word class and concreteness as factors influencing lexical access. Future studies are expected to further explore how individual factors (e.g., proficiency, AoA, amount of usage) and other lexical factors (e.g., concreteness) modulate trilingual speakers' cognate processing.

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