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ORIGINAL ARTICLE

Limitations of the cognate effect: How second language proficiency and stimulus frequency modulate adolescent learners' word recognition

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Abstract

To examine cross-linguistic influences during bilingual lexical processing, a word type frequently used is cognates (i.e., translation equivalents with an overlap in form and meaning, such as English-German *tomato-Tomate*). Cognates have been found to be processed faster and more accurately than translation equivalents without such overlap (i.e., noncognates, such as English-German *potato-Kartoffel*). This *cognate facilitation effect* (CFE) is considered evidence for language co-activation in bilinguals and has been studied mostly in children and adults. The aim of the current study was to examine this effect in a more heterogeneous group of adolescent L2 learners and explore its potential modulation by L2 proficiency and stimulus frequency. For this purpose, 68 L1 German low-intermediate learners of L2 English participated in an English lexical decision task on cognate and noncognate words. Notably, CFEs could not be replicated in this group of learners. However, further analysis revealed that word recognition was modulated by both participants' L2 English proficiency and target word frequency. The results of the present study add to the literature on modulating factors of the CFE, expand them to a population of early second language learners, and underline the need for future research on factors influencing cross-linguistic activation.

Keywords: cognates; cross-linguistic influence; language comprehension; lexical decision; L2 proficiency; second language processing; word frequency

Introduction

Research on bilingual language processing has yielded ample evidence that multilingual speakers cannot simply switch off one language while using the other. With regard to the mental lexicon of multilingual speakers, this means that both conceptual representations and word forms from multiple languages are stored and processed in a language non-selective system (Kroll et al., 2014). In order to gain a

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deeper understanding of the mechanisms underlying language non-selective lexical access in bilinguals, researchers in this field often focus on lexical items that are similar in both meaning and form across languages. Such lexical items are called *cognates* and can be described more precisely as translation equivalents that share the same or similar orthographic and/or phonological form as well as meaning across two or more languages (e.g., English *tomato* and German *Tomate*). Previous research on bilingual lexical processing has found ample evidence that bilinguals process cognate words generally faster and more accurately than noncognate words, which are translation equivalents without a form overlap (e.g., English *potato* and German *Kartoffel*). This processing advantage of cognates over noncognates is referred to as the *cognate facilitation effect* (CFE) and casts light on the organization of the bilingual mental lexicon. More specifically, it is considered evidence that languages in the bilingual lexicon interact with each other in an interconnected system (Dijkstra et al., 2010). The CFE is a robust finding in both adults and children (see Lijewska, 2020, and Squires et al., 2020, for reviews); however, it is comparatively less researched in the intermediate age group of adolescents. Nevertheless, teenagers are a particularly interesting target group for research on second language processing. As the lexical retrieval system of children has not yet reached maximum efficiency, children usually exhibit slower performance on lexical tasks in contrast to adults (Jescheniak et al., 2006). Lexical retrieval efficiency of adolescents, however, remains unclear for the most part, and there is only a limited number of studies on adolescent lexical processing: For morphological first language (L1) processing, more specifically morphological decomposition during visual word recognition, there is evidence that younger adolescents' (12- to 13-year-olds) result patterns resemble the ones of 7- to 9-year-old children more, while older adolescents' (16- to 17-year-olds) patterns resemble adults more (Dawson et al., 2018). Thus, adolescence can be considered an inflection period in lexical processing and morphological decomposition, in particular. Analogously, Ben-Shachar et al. (2011) found evidence that age affects the processing of visual word stimuli by demonstrating that, during childhood and adolescence, cortical sensitivity to visually presented L1 words enhances with increased age. In terms of second language (L2) processing, adolescents are likely characterized by lower L2 proficiency compared to adults, given that adolescents have received comparatively less language instruction at school up to this point. At the same time, though, most adolescents differ fundamentally from younger children in that they are on the verge of being comparatively more exposed to English outside school via, for instance, social media or media in general. An increase in extramural English exposure, in turn, typically correlates with an increase in proficiency (Sundqvist, 2009). In addition, adolescents do not only differ from children in terms of their more developed lexical retrieval systems and their increased L2 exposure, but also in their general cognitive development. Developmental studies have shown that cognitive control, also referred to as executive function (EF), gradually strengthens in adolescence (see Best & Miller, 2010, for a review). As previous research has found that cross-language activation during bilingual language processing is modulated by EF (e.g., Mercier et al., 2014, for evidence in adults; Gastmann & Poarch, 2022, for children), a different degree of EF in adolescents may, in turn, lead to altered language control during linguistic processing compared to children or adults.

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Accordingly, in a study by Iniesta et al. (2024), adolescents exhibited a greater efficiency in language control compared to children.

Overall, adolescents are in a stage of development in which they are becoming increasingly cognitively mature, are exposed to more and more English outside of school, expanding their vocabulary, and thus further developing their language skills. However, it can be assumed that there are interindividual differences between adolescents in the pace of development and, consequently, greater variability in second language proficiency. Thus, the present study aims to fill the gap between child and adult L2 research by exploring the impact of lexical information from the native-language on word recognition in a second language and, in particular, to what extent the CFE occurs in a more heterogeneous group of adolescent low-intermediate L2 learners.

Language co-activation from childhood to adulthood

The CFE is one of the most robust demonstrations of the language non-selective access hypothesis: For cognates, word forms from both languages are co-activated in an integrated lexicon due to their form overlap, which then boosts lexical activation of both the target word and its translation equivalent. For instance, if an L1 German learner of L2 English is presented with the English word *tomato*, the overlap in both form and meaning with the German word *Tomate* boosts the activation and lexical retrieval of *tomato* and consequently facilitates L2 lexical processing. This language non-selective lexical access in bilinguals is also represented in computational models such as the BIA+ model (Dijkstra & Van Heuven, 2002) and Multilink (Dijkstra et al., 2019). According to these models, any given lexical input automatically activates several other lexical nodes depending on their similarity with the input. For cognate words, both the input word and its form-similar translation equivalent in another language would be activated, resonating between their form and meaning representations, and finally converging on one shared semantic node. Consequently, this overlap in form and meaning boosts lexical retrieval. Noncognate processing, however, is limited to the overlap in semantic representation(s). As for cognates, meaning is activated from both lexical nodes, activation spreads comparatively faster — in contrast to the processing of noncognates, which relies on activation from only one lexical node. Hence, knowledge of another language does not facilitate noncognate processing as it does for cognates.

Such a facilitatory effect of cognate words has been found in different tasks and across modalities. Adult bilinguals have shown cognate facilitation in production tasks not just across different scripts (Hoshino & Kroll, 2008) but also in trilingual speakers (Poarch & Van Hell, 2014). Similarly, cognate facilitation has been found in adult bilinguals' comprehension, for instance, in lexical decision (Bultena et al., 2013; Dijkstra et al., 2010). Furthermore, the effect of cognate facilitation seems to be gradual in that it increases with greater form overlap across translation equivalents (Dijkstra et al., 2010; Vanlangendonck et al., 2020). Moreover, CFEs have not only been observed in L2 but also in L1 processing (Van Hell & Dijkstra, 2002), although usually exerting stronger effects on L2 processing (for evidence in L1 vs. L2 picture naming, see Costa et al., 2000, and Poarch & Van Hell, 2012). While the aforementioned studies have examined cognate processing solely in

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isolation, other studies have found cognate facilitation in sentence reading (Bultena et al., 2014; Van Assche et al., 2011) and also in written sentence production (Woumans et al., 2021).

Whereas most studies on cognate processing have focused on (mostly comparatively highly proficient) adult speakers, research with younger language users has increased in recent years. Poarch and van Hell (2012), for instance, found bidirectional (i.e., from L1 to L2 and vice versa) CFEs in 5- to 8-year-old children's picture naming, emerging in the non-dominant language of L1 German learners of L2 English, German–English bilinguals, as well as German–English–Language X trilinguals, and also in the dominant language of the bilinguals and trilinguals, respectively. Other studies have also demonstrated a CFE in children's comprehension: In a visual world picture-word recognition task, Gastmann and Poarch (2022) found such a facilitative effect for cognates in the accuracies, reaction times (RTs), and eye movements of 4- to 6-year-old L1 German learners of L2 English. Furthermore, they found that noncognate processing was facilitated by enhanced non-verbal cognitive control skills in contrast to the processing of cognates. Bosma and colleagues (2019) tested 5- to 8-year-old Dutch–Frisian bilingual children's receptive vocabulary and found a gradual CFE that was modulated by the degree of overlap across translation equivalents (but note that Gastmann & Poarch, 2022, did not find an effect of overlap in early L2 learners). In a recent study, Koutamanis et al. (2024a) examined cross-language activation in simultaneous bilingual Dutch–Greek children with varying degrees of Dutch exposure. They reported CFEs for both production (Greek picture naming) and comprehension (Greek auditory lexical decision); however, these effects manifested themselves differently in the two tasks. For picture naming, the results yielded a classic main effect of cognate status, with cognate pictures being named faster than noncognate pictures. For lexical decision, the results revealed that cognate and noncognate processing was modulated by Dutch exposure, with stronger cognate facilitation in the accuracies of children with more Dutch exposure and thus Dutch dominance. More balanced or more Greek-dominant children, however, showed the opposite pattern, with lower accuracies for cognates than noncognates, although to a lesser extent. Moreover, there was no effect of cognate status on children's lexical decision times. Results for another lexical decision experiment by Koutamanis et al. (2024b) with Dutch–German bilingual children revealed a CFE in RTs but, interestingly, no such finding in accuracies. Conversely, in a lexical decision experiment with German–English bilingual third graders, Schröter and Schroeder (2016) found evidence for cross-language activation through cognates in both accuracies and RTs for English and similarly in RTs for German. In summary, it can be concluded that previous findings from cognate processing in young learners are somewhat mixed. In production, there has been evidence that children exhibit a strong CFE — although this may be related to overall slower latencies compared to adults, which, in turn, allows for a greater time window in which language co-activation may be observed (Poarch & Van Hell, 2012). For comprehension studies, however, the findings from bilingual language processing in children seem to be more mixed, with diverging evidence for cognate facilitation, cognate inhibition, and null findings.

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Looking at the variety of studies on cognate processing altogether, it is striking that research focusing on the age group between (young) children and adults, namely adolescents, is considerably underrepresented. To our knowledge, there are only three psycholinguistic studies that explored cognate processing in adolescents. In a picture naming study, Iniesta et al. (2024), using behavioral measures and event-related potentials (ERP), found CFEs during second language production in both 11- to 12-year-old children and 15- to 16-year-old adolescents. Specifically, cognates elicited higher accuracy rates, faster response times, and reduced N400 negativity than noncognates. For first language production, a CFE was only reflected in the N400 component. Interestingly, children exhibited greater N200 amplitudes for cognates than noncognates during L1 production, while adolescents showed no such difference, demonstrating more efficient language control patterns in adolescents. They conclude that, while language co-activation appears independent of the learners' developmental stage, language control seems to hinge on maturation of frontal brain regions. For language co-activation during word comprehension, Duñabeitia and colleagues (2016) found a CFE in a translation recognition task with Spanish–Basque bilinguals aged between 8 and 15 years. Critically, the effect was stronger in younger children compared to older children. The authors argue that the decrease in the influence of cross-language similarity may be due to both increased exposure to print, resulting in more automated reading, and a stronger language control system in older children. In contrast, Brenders and colleagues (2011) found cognate facilitation in L2 English lexical decisions of L1 Dutch fifth, seventh, and ninth graders. Analyses on the interaction of cognate status and age group remained non-significant, suggesting constant cognate effects across age groups. Although the results of Duñabeitia et al. and Brenders et al. seem to differ at first glance, it should be noted that the participants in Duñabeitia and colleagues' study were more balanced bilinguals from birth, whereas Brenders and colleagues' participants were L2 learners with significantly less L2 exposure.

Modulating factors of language co-activation

Although the CFE seems to be a very robust finding, particularly in adult speakers, previous studies have also revealed modulating factors that may conceal or even revert cognate facilitation under certain conditions. A main finding from previous research is that the processing of cognates is largely influenced by stimulus list composition. Studies have found that the presence of identical cognates has a major influence on the occurrence and strength of the CFE with identical cognates promoting facilitation (Arana et al., 2022) and that in stimuli lists including non-target language words from the participants' other language, cognate effects might vanish (Poort & Rodd, 2017) or even become mirrored inhibition effects (Vanlangendonck et al., 2020). Both Poort and Rodd (2017) and Vanlangendonck and colleagues (2020) argue that a mixed-language stimulus context enhances response competition. In a single-language context, target words need to be assessed based on their general word status, and perceived target language items are instinctively categorized as "word-like," resulting in a "yes"-press. In a dual-language context, however, non-target language words induce competition in participants' decision making as the participants not only have to decide whether the target word

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is an existing word but also whether it is a word from a specific language. Thus, for cognate words, response competition may be increased due to their dual-language representation. Similar to stimulus list composition, word frequency can likewise modulate cognate and noncognate processing. In an ERP study, Peeters and colleagues (2013) found a frequency effect with overall better performance for high-frequent compared to low-frequent words. With regard to cognate and noncognate processing, they found stronger cognate effects in lower-frequent words than higher-frequent ones. Additionally, they demonstrated that not only the frequency of the target word but also the frequency of the non-target reading of the translation equivalent affected cognate processing.

While these modulating factors reside in the choice of stimuli or their combination with potential competitors within a specific task, interindividual differences between participants can also have an impact on (L2) lexical processing. One main determinant that has been explored in previous studies is language proficiency. Previous research has found greater CFEs in the less dominant language than in the dominant one (for evidence in adults, see Costa et al., 2000; for evidence in children, see Koutamanis et al., 2024b, Poarch & Van Hell, 2012, Robinson Anthony et al., 2022). Similarly, previous studies have demonstrated that individual differences in L2 proficiency may impact cross-linguistic activation during second language processing (see Van Hell & Tanner, 2012, for a review). In two studies focusing on L2 sentence reading, both Bultena et al. (2014) and Pivneva et al. (2014) found that cognate facilitation was greater with reduced L2 proficiency. In a recent study by Krogh (2022), L1 Danish L2 English bilinguals performed several visual lexical decision tasks in their L1 and their L2 with a pure or mixed-language stimulus list design applied. Strikingly, no CFE occurred in the L2 pure language condition. However, post hoc analysis on the impact of L2 proficiency in the pure L2 context revealed a CFE in the lower-proficient learners' RTs, but no such effect in the higher-proficient group. Recently, similar null findings for L2 cognate processing have been observed in a study by Gastmann and colleagues (2025). Participants were L1 German advanced learners of L2 English who performed an L2 English visual lexical decision task, with accuracies being high across the board, corroborating the participants' advanced L2 proficiency. Although cognate and noncognate accuracies only differed by 1%, analyses yielded a moderate CFE for the participants' decision accuracies. For RTs, however, analyses did not reveal an effect of cognate status. The authors speculate that these null effects for RTs were either due to the overall high frequency of the target stimuli, which may have disguised any effects of cognate status (also see Peeters et al., 2013), or due to the participants' overall high L2 proficiency, possibly leading to ceiling effects also reflected in the overall high accuracies. While most of these findings have been demonstrated in adults, few(er) studies have looked at proficiency effects on child L2 processing. In a study with 10- to 13-year-old Dutch primary school students, De Wilde and colleagues (2020a) examined the impact of word-related variables on L2 word learning in learners from a wider range of L2 proficiency. They concluded that word-related variables such as cognateness and lexical frequency contribute differently to word learning depending on the learners' L2 proficiency. More specifically, lower-proficient learners relied more on similarity between translation equivalents in the form of cognates than higher-proficient learners did.

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Additionally, higher-proficient learners exhibited a stronger L2 frequency effect (i.e., greater knowledge of high- than low-frequent words). Consequently, the work by De Wilde and colleagues not only shows that there are differences in L2 processing in terms of proficiency within a group of child L2 learners, but it also demonstrates that modulating factors of L2 processing can certainly interact with each other.

The present study

While several studies have looked at potential modulating factors of cognate and noncognate processing in adults, few(er) have focused on the modulation of cross-linguistic influences during word recognition in younger second language learners. Against this backdrop, the present study's first aim is to investigate cross-language activation in a so far under-researched group of adolescent less proficient learners. For this purpose, the current study tests the lexical decision task by Gastmann and colleagues with a population of L1 German low-intermediate learners of L2 English between 12 and 14 years. Due to the assumed greater variability in proficiency among these adolescent learners, it can be presumed that they also exhibit greater variance in their vocabulary size and, consequently, in their knowledge of low-frequency words, than in contrast to a more homogeneous group of adult students as tested by Gastmann et al. (2025). Since word-related variables contribute differently to language processing and, consequently, possibly linguistic co-activation depending on the learners' proficiency (De Wilde et al., 2020a), it was decided to further look at the interaction of potential modulating factors. One word-related variable that has been studied extensively in the past is lexical frequency (see Brysbaert et al., 2018, for a review). However, it has only been studied a little in relation to cognate and noncognate processing (but see Peeters et al., 2013). Relatedly, in their discussion of the lexical decision results, Gastmann and colleagues point to stimulus word frequency possibly accounting for a modulation of cognate and noncognate processing, presuming that overall high lexical frequency might have overshadowed cognate effects. Consequently, the present study's secondary research question aims to investigate the impact of lexical frequency on L2 word recognition in relation to individual differences in learner proficiency.

The following predictions were made with regard to cross-linguistic influences during L2 word recognition and their potential modulation:

First, we assume that computational models such as the BIA+ model (Dijkstra & Van Heuven, 2002) and Multilink (Dijkstra et al., 2019) can also be applied to a younger learner population, as evidenced in previous studies (Bosma et al., 2019; Brenders et al., 2011; Duñabeitia et al., 2016; Gastmann & Poarch, 2022; Koutamanis et al., 2024a; Koutamanis et al., 2024b; Poarch & Van Hell, 2012; Schröter & Schroeder, 2016). Therefore, we predict that the enhanced activation for cognate words due to their dual-language overlap facilitates their processing, resulting in a CFE in accuracies in line with Gastmann and colleagues (2025).

Second, we predict that this activation boost will also be transferred to the participants' RTs. Thus, in contrast to the null effects in RTs found by Gastmann and colleagues, this study's lower-proficient learner group should exhibit a CFE with this

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measure due to their generally weaker language skills. This prediction is analogous to the findings from lexical decision by Krogh (2022), who demonstrated CFEs only in the less-proficient learner group. We suggest that her findings can be transferred to a younger population of adolescent learners, as previous studies have also identified proficiency effects on younger learners' word processing (see Poarch & Van Hell, 2012, for greater CFEs in children's non-dominant language).

Third, we assume that cognate and noncognate processing will be affected by both L2 proficiency and lexical stimulus frequency. We predict that, for relatively lower-proficient learners within our sample, cognate facilitation will be stronger (see De Wilde et al., 2020a; Krogh 2022). Furthermore, we expect CFEs to be more pronounced for less frequent items (Peeters et al., 2013).

Methods

Participants

A total of 68 adolescent L1 German speakers participated in this study. They were all learners of L2 English and were recruited from grades 7 and 8 of secondary schools in the area of Dortmund, Germany. They participated voluntarily and received a compensation of 15 Euros for their participation. Five participants had to be excluded due to additional exposure to English at home (2), incorrect task administration (2), or vision problems (1). The remaining 63 participants (35 female, 28 male) were between 12 and 14 years old and had, on average, started learning English in primary school at the age of 6. They were low-intermediate learners of English with an English proficiency ranging approximately between levels A2 and B1 of the Common European Framework of Reference for Languages (CEFR) according to the state curriculum (see Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen, 2019). Twenty-six of them were raised bilingually with a language other than German or English. These bilinguals either rated German as their more proficient language or rated both languages as (almost) equally proficient. Both children and their parents filled in a background questionnaire based on the Language and Social Background Questionnaire (LSBQ; Anderson et al., 2018), assessing the children's language learning history, self-rated proficiencies, English use, and social background. To assess the participants' language proficiencies, they were administered the LexTALE (Lemhöfer & Broersma, 2012) for German and a shortened version of the standardized Peabody Picture Vocabulary Test (PPVT III A; Dunn & Dunn, 1997) for English.[1] Note that the children's use of English and their score in the PPVT were positively correlated ($r(61) = .33$, $p = .008$). Participant information is summarized in Table 1. Informed consent was secured from both children and their parents, and ethical approval was granted by the Ethics Committee of TU Dortmund University (ethics vote no. GEKTUDO_2022_39).

Materials

The experimental stimuli were taken from Gastmann et al. (2025) and consisted of 160 letter strings, including 80 words and 80 nonwords. The words comprised 40 cognates and 40 noncognates between German and English that were assumed to be

Table 1. Participant characteristics ($n = 63$)

	M	*SD*	Range
Age (years)	13.4	0.7	12.0 – 14.8
Age of English acquisition (years)	6.4	1.4	1.5 – 9.5
English use[a]	3.7	1.3	1.8 – 6.4
German proficiency (GE LexTALE)[b]	76.3	9.2	56.3 – 92.5
English proficiency (PPVT)[c]	0.82	0.1	0.58 – 0.97
Parents' education[d]	3.4	0.7	2.0 – 5.0

[a]English use was aggregated across five situations (with family, with friends, at school, using media such as movies and reading, on social media) on a 10-point rank scale (ranging from 1 = *I do not use English in these situations at all.* to 10 = *I exclusively use English in these situations.*)
[b]Mean percentage of correct responses per words and nonwords.
[c]The participants were presented with the first 72 items (sets 1-6) of the PPVT III A. The score represents the rate of correct answers with a maximum score of 72.
[d]Parents' level of education as a proxy for socioeconomic status (SES) on a 5-point rank scale (1 = *no school-leaving qualification*, 2 = *GCSE*, 3 = *higher education entrance qualification*, 4 = *university degree*, 5 = *doctoral degree*), collapsed across both parents.

familiar to 7th and 8th graders, according to a screening of typical English textbooks that are commonly used in this group of learners. Cognates and noncognates were matched on length, number of syllables, English orthographic and phonological neighborhood size (English Lexicon Project; Balota et al., 2007), as well as frequency in English (SUBTLEX-US log10; Brysbaert & New, 2009) and German (SUBTLEX-DE log10; Brysbaert et al., 2011). Independent sample *t*-tests yielded no significant difference between conditions (all $ps > .15$), and English and German word frequencies were highly correlated ($r(78) = .86, p < .001$) as illustrated in Figure 1. Additionally, normalized orthographic Levenshtein distance (Levenshtein, 1966; Schepens et al., 2012) was calculated for cognates and noncognates as a proxy for overlap between languages. Cognates and noncognates differed significantly ($p < .001$), with cognates exhibiting greater overlap than noncognates. Word characteristics are displayed in Table 2.

The additional 80 pseudowords were generated by selecting 80 English nouns (unidentical to the target words) and by changing one letter in each word. It was ensured that the newly created nonwords neither existed in German nor English and followed the rules of English orthography and phonotactics. Nonwords and words were exactly matched on length and number of syllables (both $p = 1$). Stimuli, data, and the analysis script used in this study can be accessed via OSF (https://osf.io/e8352).

Procedure

Participants performed a visual English lexical decision task, which was programmed in OpenSesame (version 3.3.11; Mathôt et al., 2012) and took roughly seven minutes. The participants were tested individually in the laboratory, and they were seated approximately 60 cm from the screen. The participants' task was to decide as quickly and accurately as possible whether the word on the screen

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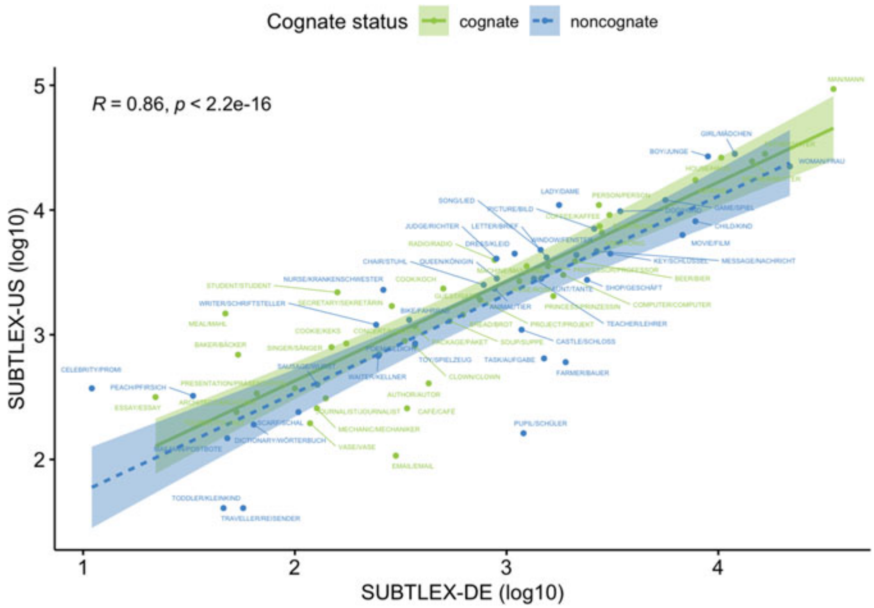

Figure 1. Correlation between German and English SUBTLEX (log 10) word frequency by cognate status.

was an existing English word or not by pressing one of two designated buttons on a MilliKey MH-5 button box. The stimuli were presented in white ink (#FFFFFF), 40 px Arial font, all capitals, on a black background (#000000) at the center of the screen. Each trial was initiated with a 500-ms fixation cross in the middle of the screen. The target stimulus followed and remained on screen until a button was pressed or 3000 ms had elapsed. The experiment consisted of four experimental blocks of 40 items each, and after the first three experimental blocks, the participants were able to take a short self-timed break. Prior to the actual experimental blocks, participants performed a ten-trial practice round to familiarize themselves with the task. Stimuli were presented in a different randomized order per participant, and no feedback regarding their response was provided.

Additionally, participants performed several other tasks, not all of which are reported in this paper. The order of tasks was as follows: (1) Lexical decision task, (2) Flanker task, (3) a self-paced reading experiment, (4) German LexTALE, (5) English PPVT, (6) forward and backward digit span task, (7) questionnaire, (8) Stroop Arrows task. In total, each session took approximately 90 minutes, with sufficient time for breaks if needed.

Results

Analyses on accuracy rates and reaction times (RTs) were performed in R (version 4.4.0; R Core Team, 2024), and only responses to words were analyzed. For the sake of completeness, mean accuracy rates and RTs for nonwords are reported in Table 3. One noncognate item (EN: *pupil*) had to be removed due to its homonymity with

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Table 2. Stimuli characteristics for target words

	Cognates (n = 40)		Noncognates (n = 40)	
	M	*SD*	*M*	*SD*
Length	5.98	2.02	5.38	1.66
No. of syllables	1.90	0.84	1.68	0.80
SUBTLEX-US (log10)	3.26	0.68	3.24	0.72
SUBTLEX-DE (log10)	2.79	0.76	2.90	0.77
Orthographic neighbors	4.39	4.84	3.78	4.25
Phonological neighbors	8.92	10.94	8.50	8.37
Normalized Levenshtein distance	0.75	0.24	0.16	0.15

Table 3. Mean accuracies (proportions) and reaction times (in milliseconds) by condition

	Accuracy	RTs
Cognates	0.91 (0.06)	808 (138)
Noncognates	0.88 (0.09)	799 (139)
Nonwords[a]	0.86 (0.10)	1005 (218)

Note: Standard deviations are in parentheses.
[a]Nonword accuracies and RTs were not analyzed and are only included for completeness.

both a noncognate translation (*Schüler:in*) and a cognate one (*Pupille*) in German. For the accuracy analysis, RTs below 200 ms were coded as false alarms (n = 2). For the RT analysis, incorrect button presses and extreme RTs above 2500 ms (n = 58 [0.66%]) were excluded. Note that this procedure deviates from Gastmann et al. (2025), who trimmed RTs at 2000 ms, as it was assumed that the less-proficient L2 learners in the current study would require more time in their decision making. Visual inspection of RT distributions confirmed this assumption. Table 3 lists the accuracy rates and RTs for the respective conditions. Note that the adolescents' overall error rates were higher (cognates: 9%, noncognates: 12%) than those of the adult learners in Gastmann et al. (2025; cognates: 1%, noncognates: 2%), corroborating our assumption of an overall lower L2 proficiency of the present study's population.

With the aid of *lme4* (Bates et al., 2015) and *lmertest* (Kuznetsova et al., 2017), accuracy and RT data was analyzed using (generalized) linear mixed-effects regressions. To analyze the effect of cognate status on participants' accuracies and RTs, cognate status was sum-coded (cognate = 1, noncognate = −1) and entered as a fixed effect into the models. To identify the maximal converging random effect structure, the "order" function in the *buildmer* package was used for both mixed-effect models (Voeten, 2021). Effect sizes were calculated with the *effectsize* package (Ben-Shachar et al., 2020). For accuracies, generalized linear mixed-effects analysis

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Table 4. Model outputs for cognate status (cognate vs. noncognate) after 'buildmer' model optimization

	Accuracy				Reaction times			
	Estimate	*SE*	*z*		Estimate	*SE*	*t*	
(Intercept)	3.11	0.21	15.06	***	818.38	21.74	37.65	***
Cog_stat	0.16	0.18	0.89		−0.68	13.94	−0.05	
	Formula: Accuracy ~ 1 + Cog_stat + (1 | Stimulus) + (1 | Participant)				Formula: RT ~ 1 + Cog_stat + (1 | Stimulus) + (1 | Participant)			

yielded no effect of cognate status (ß = 0.16, $SE = 0.18$, $z = 0.89$, $p = .373$, $d = 0.22$). Likewise, linear mixed-effects analysis of RTs revealed no effect of cognate status either (ß = −0.68, $SE = 13.94$, $t = -0.05$, $p = .961$, $d = -0.01$). Table 4 displays the detailed model output.

To further investigate the modulating role of language proficiency and lexical frequency on L2 word recognition, we added the participants' PPVT score as a measure of their L2 proficiency and the SUBTLEX-US (log 10) frequency as a measure of English word frequency of the target stimuli into our analysis. As the frequency of English target nouns and that of their German translation equivalents were highly correlated (see Figure 1), it was decided to only look at the role of English frequency. Again, (generalized) linear mixed-effects analyses were conducted, and the maximal converging random effect structure was identified using the "order" function in the *buildmer* package (see above, for a similar procedure). Mixed-effect logistic regressions were run with the fixed effects cognate status (sum-coded), English word frequency (scaled and centered), and English proficiency (scaled and centered), as well as their interactions. The result patterns of the mixed-effects models are visualized in Figure 2 for accuracies and in Figure 3 for RTs, and detailed model output is displayed in Table 5.

For accuracies, generalized linear mixed-effects analysis yielded main effects of English word frequency (ß = 0.89, $SE = 0.15$, $z = 6.02$, $p < .001$, $d = 1.52$), and English proficiency (ß = 0.34, $SE = 0.12$, $z = 2.80$, $p = .005$, $d = 0.71$). The model yielded no interaction between any of the fixed effects. As illustrated in Figure 2, a word frequency effect (see Brysbaert et al., 2018, for a review) could be replicated with higher-frequent items being responded to more accurately compared to lower-frequent items. Additionally, lower-proficient learners had overall lower accuracies. Although descriptively, lower-proficient learners were more accurate on cognates than noncognates on lower-frequent items, the three-way interaction was statistically not significant (ß = 0.13, $SE = 0.09$, $z = 1.48$, $p = .139$, $d = 0.37$).

For RTs, linear mixed-effects analysis revealed a main effect of English word frequency (ß = −79.53, $SE = 11.05$, $t = -7.20$, $p < .001$, $d = -1.83$), a two-way-interaction between cognates status and word frequency (ß = 28.71, $SE = 9.63$, $t = 2.98$, $p = .003$, $d = 0.76$), as well as a three-way interaction of cognate status, word frequency, and L2 proficiency (ß = −7.57, $SE = 3.57$, $t = -2.12$, $p = .034$, $d = -0.54$). To further explore the two-way interaction, subset analyses were

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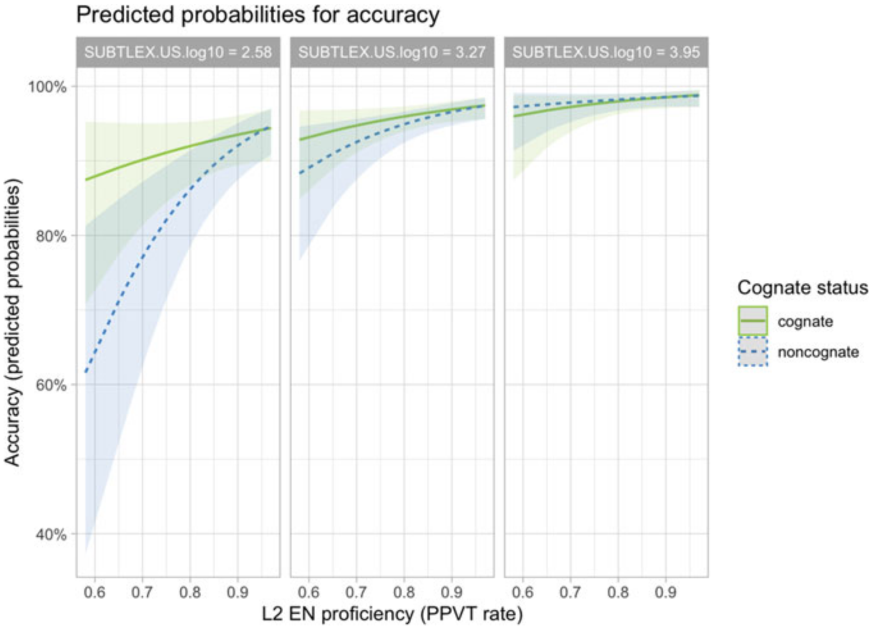

Figure 2. Interaction between cognate status, English word frequency, and L2 English proficiency on the predicted probabilities for accuracy. *Note.* English word frequency was treated as a continuous predictor in the model. For illustrative purposes, we followed the convention by Cohen and Cohen (1983) and Aiken and West (1991) and plotted the effect of frequency on the predicted values for accuracies by displaying them for the mean frequency (3.27) as well as one standard deviation below (2.58) and above (3.95) the mean. The figure was created with the R package sjPlot (Lüdecke, 2024).

conducted based on a median split for English frequency (see Table S1 in the Supplementary Materials). These analyses revealed a significant two-way interaction between cognate status and item frequency in the lower frequency range, indicating a CFE for lower-frequent items (ß $= 42.50$, $SE = 18.33$, $t = 2.32$, $p = .020$, $d = 0.59$). For higher-frequent items, however, no interaction between cognate status and word frequency was found (ß $= 3.99$, $SE = 9.03$, $t = 0.44$, $p = .659$, $d = 0.11$). As illustrated in Figure 3, a CFE was found only in lower-frequent items and was stronger in lower-proficient learners. Interestingly, the effect seemed to reverse in higher-frequent items with cognates being processed slower than noncognates, particularly in lower-proficient learners. The three-way interaction for RTs was followed up by separate subset analyses for cognates and noncognates (see Table S2 in the Supplementary Materials). These subset models revealed a main effect of word frequency on both cognate (ß $= -51.07$, $SE = 14.81$, $t = -3.45$, $p < .001$) and noncognate (ß $= -106.31$, $SE = 14.68$, $t = -7.24$, $p < .001$) latencies, although inducing a stronger effect on noncognate RTs ($d = -1.84$) compared to cognate RTs ($d = -0.88$). The subset models yielded neither a main effect of L2 proficiency nor an interaction between proficiency and word frequency.

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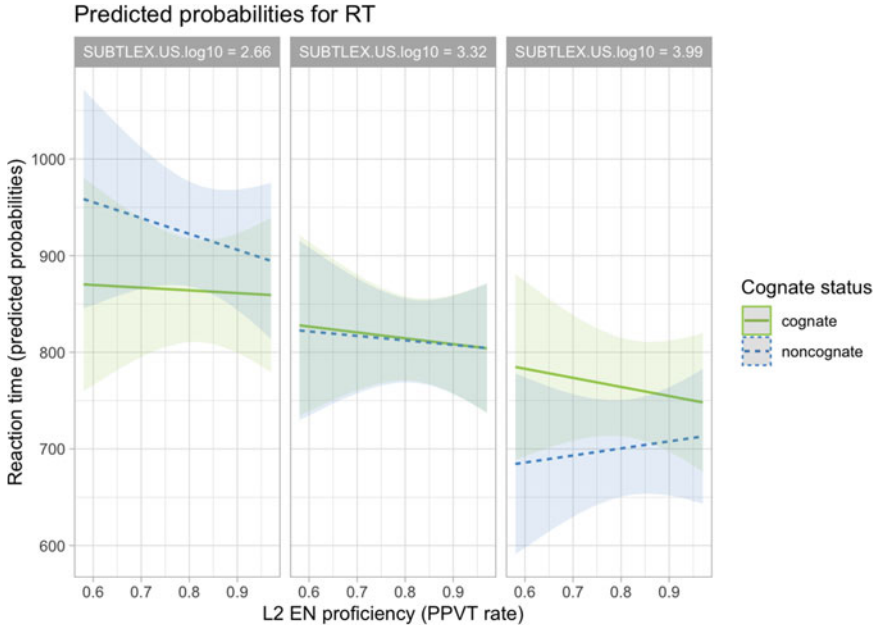

Figure 3. Interaction between cognate status, English word frequency, and L2 English proficiency on the predicted probabilities for reaction time. *Note.* English word frequency was treated as a continuous predictor in the model. For illustrative purposes, we followed the convention by Cohen and Cohen (1983) and Aiken and West (1991) and plotted the effect of frequency on the predicted values for accuracies by displaying them for the mean frequency (3.32) as well as one standard deviation below (2.66) and above (3.99) the mean. The figure was created with the R package sjPlot (Lüdecke, 2024).

Discussion

The aim of the present study was to examine the extent to which cross-linguistic influences occur during L2 word recognition in a more heterogeneous group of low-proficient adolescent learners of English. More specifically, the present study investigated whether the adolescents' lexical decision performance was modulated by the cognate status of the target words. Furthermore, the study aimed to explore the impact of interindividual L2 proficiency differences and target word frequency on cognate and noncognate processing. To our knowledge, this is the first study that has inspected adolescents' lexical decision performance in relation to both their L2 proficiency and the impact of word frequency on L2 lexical comprehension.

With regard to our first and second predictions, assuming cognate facilitation in both the participants' decision accuracies and latencies, CFEs could, however, not be replicated in either accuracies or RTs. This is remarkable and contradicts previous findings in lower-proficient L2 learners from similar age groups (Brenders et al., 2011; Duñabeitia et al., 2016). We had assumed to detect a distinct CFE by building on Gastmann and colleagues' lexical decision task with a group of learners with comparatively lower L2 proficiency. However, testing a different group of learners might not have been sufficient to account for individual differences in L2 proficiency. Hence, the PPVT score was used to assess potential interindividual differences induced by proficiency within this group of young learners.

Table 5. Model outputs analysis after 'buildmer' model optimization

	Accuracy				Reaction times			
	Estimate	*SE*	*z*		Estimate	*SE*	*t*	
(Intercept)	3.11	0.17	18.35	***	811.64	19.53	41.55	***
Cog_stat	0.11	0.14	0.77		1.06	9.91	0.11	
EN_freq	**0.89**	**0.15**	**6.02**	***	**−79.53**	**11.05**	**−7.20**	***
EN_prof	**0.34**	**0.12**	**2.80**	**	−5.32	17.10	−0.31	
Cog_stat x EN_freq	−0.16	0.14	−1.13		**28.71**	**9.63**	**2.98**	**
Cog_stat x EN_prof	−0.07	0.09	−0.79		−0.76	3.63	−0.21	
EN_freq x EN_prof	−0.08	0.09	−0.88		4.27	6.46	0.66	
Cog_stat x EN_freq x EN prof	0.13	0.09	1.48		**−7.57**	**3.57**	**−2.12**	*
	Formula: Accuracy ∼ 1 + EN_freq + EN_prof + Cog_stat + EN_prof:Cog_stat + EN_freq:Cog_stat + EN_freq:EN_prof + EN_freq:EN_prof:Cog_stat + (1 + EN_prof | Stimulus) + (1 + EN_freq | Participant)				Formula: RT ∼ 1 + EN_freq + EN_prof + EN_freq:EN_prof + Cog_stat + EN_freq:Cog_stat + EN_prof:Cog_stat + EN_freq:EN_prof:Cog_stat + (1 + EN_freq + Cog_stat | Participant) + (1 | Stimulus)			

Note: Significant effects in bold.

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Regarding our third prediction, the influence of L2 proficiency and stimulus frequency on cognate and noncognate processing, main effects of word frequency and L2 proficiency on decision accuracies were found. Higher-proficient learners were overall more accurate, and the decision accuracies for higher-frequent items were at the ceiling.

For RTs, the analysis revealed a main effect of word frequency, an interaction of frequency and cognate status, and a three-way interaction of frequency, cognate status, and L2 proficiency. It is not entirely clear what induced the three-way interaction, as the two-way interaction between proficiency and frequency did not reach significance in separate subset analyses for cognates and noncognates. However, looking at Figure 3, it appears that for the lower frequency range, there is a CFE, whereas in the higher frequency range, this pattern seems to be mirrored towards a cognate inhibition effect. Both opposing effects seem to be stronger for the lower-proficient group and attenuated for participants with higher L2 proficiency. These results, some of which replicate previous findings and some of which contrast with existing research, are discussed in more detail below.

The significant main effect of word frequency in both accuracy and RT data replicates the well-established word frequency effect, which pertains to higher-frequent items being processed faster and more accurately than lower-frequent ones (Brysbaert et al., 2018). In the present study, this generally applies to both cognate and noncognate items and similarly holds for all participants regardless of their L2 proficiency. The findings confirm that the word frequency effect is a decisive factor influencing lexical processing, as has been observed in numerous studies on lexical processing in both monolingual and bilingual speakers (e.g., Cop et al., 2015) as well as word learning in child L2 learners (De Wilde et al., 2020a). Thus, it is widely acknowledged that, whereas higher word frequency speeds up processing, the efficiency of word processing decreases in the lower-frequency range. Interestingly, it is precisely in this lower-frequency context that the cognate status of words seems to play a crucial role. Similar to findings by Peeters and colleagues (2013), who found that word frequency modulates cognate and noncognate processing to a different extent, the present study found a significant interaction between cognate status and item frequency. This interaction was carried by a CFE for lower-frequency words, with lower-frequent cognates being processed faster than lower-frequent noncognates, as evident from the subset analyses. According to the BIA+ model (Dijkstra & Van Heuven 2002), L2 words are characterized by lower resting level activations in contrast to L1 words from similar frequency ranges. Thus, the BIA+ assumes greater word frequency effects for the L2 than for the L1 (also see Duyck et al., 2008, for similar evidence). As cognate words share form overlap with the L1, and the L1 is thus co-activated, resting level activations should be higher for cognate words compared to noncognate words with similar frequencies. For noncognate words, however, L2 learners can only make use of their L2 knowledge. Accordingly, the present study corroborates the BIA+ model's assumption of greater word frequency effects for the L2, as subset analyses revealed a stronger main effect of word frequency on noncognate RTs than on cognate latencies. It is possible that for cognates, the overlap with the L1 already facilitated processing to such an extent that word frequency became a less determining factor. Consequently, cognateness seems to mitigate the effect of word frequency.

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Another possible explanation for the facilitated processing of cognates, particularly in the lower frequency range, may be found in the *cumulative frequency hypothesis* (e.g., Winther et al., 2021). It argues that bilinguals encounter cognate words generally more often due to their form overlap across languages, thus increasing the frequency of these words. For the present study, this would mean that low-frequent cognates are not so low-frequent after all due to their dual-language representation. Although some studies support this hypothesis (Lemhöfer et al., 2004; Winther et al., 2021), others argue that cognate facilitation is not just a consequence of cumulative frequency, but rather a result of special representations of cognates in the bilingual mental lexicon (Peeters et al., 2013; Van Hell & Dijkstra, 2002). Since it has not yet been fully established whether cognate facilitation can be explained by their cumulative frequency, and this study cannot provide any clear conclusions either, further investigation is required.

With regard to the impact of language proficiency, previous studies have established that cognate processing can, in fact, be modulated by L2 proficiency (e.g., Bultena et al., 2014). Similarly, in the present study, there was a significant three-way interaction between cognate status, word frequency, and learners' proficiency, which may at least in part have been carried by CFEs in lower-frequent items increasing with lower L2 proficiency. This is in line with the outcomes of Krogh (2022), who found cognate facilitation in lower-proficient adult L2 learners' lexical decision times but not in higher-proficient L2 learners. Similarly, De Wilde et al. (2020a) demonstrated that the effect of form similarity through cognateness was stronger in lower-proficient children than in higher-proficient children. At the same time, the present study's results contrast with the findings of Brenders and colleagues (2011; Experiment 1) in a population of child and adolescent L2 learners. The authors found a CFE in learners' L2 lexical decisions that was not modulated by L2 proficiency. Nevertheless, when interpreting these results, it should be noted that Brenders and colleagues compared three groups regarding their proficiency based on their academic year and did not — unlike this study — use a continuous proficiency measure to assess for differences within or across these groups. Regarding the present study's findings, however, lower-proficient learners seemed to have profited more from cross-linguistic form overlap with the L1 than higher-proficient learners did. Due to their greater L2 proficiency, the higher-proficient learners, in contrast, may have relied less on their L1 and possibly reached ceiling effects. Such ceiling effects are particularly apparent in the accuracy results. While accuracy scores were generally high for both cognates and noncognates, they were even higher in the more-proficient learners as also indicated by the main effect of proficiency, suggesting that the activation boost from the L1 translation equivalent cannot further enhance performance and thus reached ceiling (similar to the results by Koutamanis et al., 2024b, who also found ceiling effects in children's lexical decision accuracy).

From Figure 3, however, it becomes apparent that it cannot be ascertained whether the significant three-way interaction in RTs is driven by (1) a CFE in lower-proficient learners' response times to lower-frequent items, (2) a possible cognate inhibition effect in lower-proficient learners' response times to higher-frequent items, or, in fact, (3) a combination of the two effects. Nevertheless, both effects — whether facilitatory or inhibitory in nature — support the assumption of an

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integrated bilingual lexicon with language non-selective processing (as also concluded by Koutamanis et al., 2024a, who similarly observed a co-occurrence of facilitation and inhibition effects). The three-way interaction suggests that several influencing factors on the word and participant level are interrelated and may affect the processing of cognates and noncognates to a different extent. While the CFE is in line with previous research, and similarly, the influence of L2 proficiency and target word frequency are consistent with findings from earlier studies, the apparent inhibition effect in higher-frequent items is rather exceptional and should therefore be interpreted with caution. While most lexical decision studies have found CFEs, there are a few exceptions to this. For example, Vanlangendonck and colleagues (2020) found that a mixed-language stimulus list context (i.e., adding L1 words as "no"-responses to an L2 lexical decision task) turned facilitatory cognate effects into mirrored inhibition effects. Similarly, Brenders and colleagues (2011; Experiment 3) found cognate inhibition effects in children's L2 lexical decisions when adding false friends (i.e., words that share form overlap across languages but differ in their meaning) to the stimulus list. These findings, however, cannot be mapped to the current study's results as the context of the experiment was purely L2 English. The stimuli were presented in a single-language stimulus list context, and the experiment neither included any English pseudowords that were actual German words nor false friends. In the recent study by Koutamanis and colleagues (2024a) mentioned above, facilitation effects in simultaneous Greek–Dutch bilingual children's lexical decision latencies could not be replicated, and there were diverging results for accuracies. While cognates facilitated word recognition in the children's non-dominant language, they seemed to inhibit word recognition in the children's more dominant language (also see Broersma et al., 2016, for findings of both cognate facilitation and inhibition in picture naming). While these findings seem to be partially analogous to the present study's descriptive findings in the accuracies (i.e., more accurate responses to lower-frequent cognates than lower-frequent noncognates in lower-proficient learners), Koutamanis and colleagues' results cannot be mapped to the present study's findings in RTs, where inhibition effects in the higher word frequency range seemed to arise particularly in lower-proficient learners, that is, learners who were even less dominant in English. This inhibition effect in higher-frequent items is, however, much more attenuated in higher-proficient learners (similarly to the CFE in lower-frequent items), therefore approximating the results reported by Krogh (2022), who found no cognate effect in higher-proficient learners' lexical decision times at all (see also Andras et al., 2022, for no cognate facilitation in highly proficient bilinguals' auditory L2 word comprehension).

Altogether, while previous studies suggested that cognate inhibition effects may be attributed to stimulus list composition (Brenders et al., 2011; Vanlangendonck et al., 2020) or language dominance (Koutamanis et al., 2024a), these accounts cannot be extrapolated to the present study's findings of inhibition effects arising in lower-proficient learners' response times to higher-frequent items. A possible explanation could be that this effect is caused by word-level characteristics. Looking at the experimental items retrospectively, we detected high-frequent noncognates that could also be interpreted as cognates between English and German, such as *lady*, *queen*, or *song*, which are in fact often used as borrowings in German. With increased frequency, the more likely it is that such words are borrowed, and

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particularly younger speakers tend to use English words like *song* as borrowings in their everyday use. Such alleged noncognates might have thus shared form and meaning representations for both German and English, which then sped up processing of these items. While this might explain enhanced processing of noncognates, it does, however, not explain why noncognates outperformed cognates in the higher-frequency range.

Another potential modulating aspect that also resides on the lexical level is the measure of word frequency chosen in the present study. While SUBTLEX frequencies are a commonly used measure in linguistic and psychological research and have been found to predict lexical processing much better than many predecessor measurements (Brysbaert & New, 2009), one could ask whether this measure is truly representative of the word frequency of adolescent second language learners in this case. Previous studies have already raised concerns that word frequency is subject to individual differences, particularly influenced by language exposure (Monaghan et al., 2017; also see Brysbaert et al., 2018, for a review of the word frequency effect and its potential modulations). Similarly, we argue that American film and television subtitles might in fact not be representative for (1) this age group and (2) word frequency in an L2. Besides, in the school context, adolescent L2 learners are mostly exposed to English through extramural exposure such as (social) media and/or gaming (De Wilde et al., 2020b). Thus, future studies examining the role of word frequency in lexical processing should try to take participants' individual word frequencies into account by, for instance, applying familiarity ratings and using these individual measurements of word frequency as a predictor for lexical processing.

Conclusion

Overall, the present study's findings support the assumption of language non-selective processing in an integrated bilingual lexicon and extend the existing body of research on bilingual lexical processing in adolescent second language learners. By providing evidence for cross-linguistic transfer during L2 word recognition in adolescent learners, the current study bridges the gap between lexical processing research in bilingual children and in adults. More specifically, our findings show that during L2 visual word recognition, cognate and noncognate processing was modulated by both the participants' L2 proficiency and the frequency of the English target words. In general, the results indicated that the processing of both cognates and noncognates was sensitive to word frequency, with faster and more accurate decisions for higher-frequent items. Interestingly, cognateness seemed to attenuate this effect with less pronounced frequency effects for cognates compared to noncognates. While for lower-frequent items, the dual-language representations of cognates sped up processing, they seemed to slow down processing in higher-frequent items, in contrast to noncognates. Although participants benefitted more from cognateness in the low-frequency range than in the higher frequency range, the present study's findings nevertheless suggest that during cognate recognition, both the L2 target word as well as its L1 translation equivalent become co-activated. In addition, and in line with previous research, these observed effects were more

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pronounced in lower-proficient learners, suggesting that less advanced learners rely more on their L1 than more advanced learners do.

All in all, the present study's findings demonstrate that, despite the robustness of the CFE, various influencing factors — whether at the word level or the participant level — can interact with this effect and also with each other. Thus, future studies need to further delve into a more profound understanding of the underlying mechanisms during L2 word recognition and modulating factors of cognate processing, more specifically. Further research should therefore aim to investigate the impact of item and participant characteristics as well as task and modality demands on bilingual word recognition. Consequently, further research is necessary to explore the synergy of cognate status and word frequency and whether cognate effects arise due to cumulative frequency or their unique representation in the mental lexicon. Finally, the present study on adolescent L2 processing underlines the importance of taking individual differences in language proficiency into account, which may often be particularly pronounced at this developmental stage. Future studies should therefore further investigate cross-linguistic activation in second language processing, not only in young adults and children but also across the entire life span.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0142716425100374

Replication package. Stimuli, data, and the analysis script used in this study can be accessed via https://osf.io/e8352.

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Competing interests. The authors declare none.

Note

1 Note that the original PPVT norming guidelines (i.e., taking certain age ranges into account) were adapted to the computation of raw scores. Given that the PPVT is a receptive vocabulary measure that was originally designed for monolingual speakers, the standardized norming guidelines are not applicable to the present study's second language learner population (see De Wilde et al., 2020a, for a similar procedure).

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