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ORIGINAL ARTICLE

Shared representations in cognate comprehension and production: An online picture naming and lexical decision study with bilingual children

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Abstract
The cognate facilitation effect, a classic example of cross-language interaction in the bilingual lexicon, has mostly been studied in adults. We examined the extent to which such effects occurred in simultaneous bilingual children's word processing, to what extent these were modulated by language dominance, and to what extent this differed between comprehension and production tasks. Simultaneous bilingual Dutch-Greek children, ranging from Dutch-dominant to Greek-dominant, performed auditory lexical decision and picture-naming tasks in an online experiment. Cognate facilitation effects emerged in both tasks but manifested themselves differently. In lexical decision, there was an interaction effect with language dominance in accuracy, while in picture naming there was a main effect in reaction times. These findings suggest that, similar to what has been found for adults, simultaneous bilingual children have an integrated lexicon, in which both languages are interactively connected. Effects may differ as a combined result of factors such as comprehension versus production and individual differences in language dominance. Importantly, despite such differences, our results show that cognate effects emerge across tasks and across a range of individual children's language dominance, indicating that shared representations within the bilingual lexicon are accessed during both word comprehension and production.

Keywords: Simultaneous bilingual children; cognates; cross-linguistic influence; comprehension; production

Highlights

- Bilingual children from two countries performed two online tasks involving cognates
- Cognate facilitation emerged in both auditory lexical decision and picture naming

- Cognate effects point toward shared meanings and co-activated form representations
- Task demands affect how cognate effects manifest and how they interact with dominance

Introduction

Children who grow up with multiple languages can sometimes use their knowledge of one language while processing their other language. For example, Dutch-Greek bilingual children may find a Dutch word like *xylofoon* "xylophone" easier to process than a Dutch word like *doedelzak* "bagpipes," aided by their knowledge of Greek. Unlike *doedelzak* /ˈdudəlzɑk/, which translates to *γκάιντα* /ˈgai̯da/ in Greek, *xylofoon* is a Dutch-Greek cognate, that is, a word whose translation equivalents are pronounced very similarly: /ksiloˈfon/ in Dutch and /ksiˈlofono/ in Greek. Situations in which cognates are processed more quickly or with more ease than other words—the so-called cognate facilitation effect—provide important insights into how the bilingual lexicon is organized and accessed. Specifically, such examples illustrate how the two languages in a bilingual lexicon are not stored and processed independently from each other but are represented in a shared system with interactions between the languages. This view is supported by extensive research on bilingual adults (see e.g., Dijkstra & van Heuven, 2018, for a review). However, much less research has focused on the lexicon of simultaneous bilingual children. In the present study, we test to what extent the cognate facilitation effect is indeed obtained in simultaneous bilingual children. More specifically, we examine to what extent such effects are observed under different circumstances, by considering cognate comprehension and production in bilingual children with varying levels of language dominance.

Organization of and access to the bilingual lexicon

Bilingual adults

In the generally accepted view of the bilingual lexicon, the two languages are combined in an integrated lexicon that is accessed in a language-nonselective manner, that is, words from both languages may be activated at all times (e.g., Dijkstra & van Heuven, 2002, 2018). This assumption has several consequences for lexical processing in bilinguals. Because words from both languages are represented in a shared system, they can become co-activated during processing when they overlap enough in their semantic, phonological, and/or orthographic representations. For example, cognates such as the Dutch *ballon* /baˈlɔn/ "balloon" and Greek *μπαλόνι* /baˈloni/ "balloon" are assumed to have a shared semantic representation across languages and to share sub-lexical phonological representations for several phonemes (/b/, /a/, /l/, etc.); see Figure 1. When a cognate word is presented to a Dutch-Greek bilingual, activation is assumed to converge towards the same semantic and sub-lexical representations, leading to strong co-activation of both cognate members.

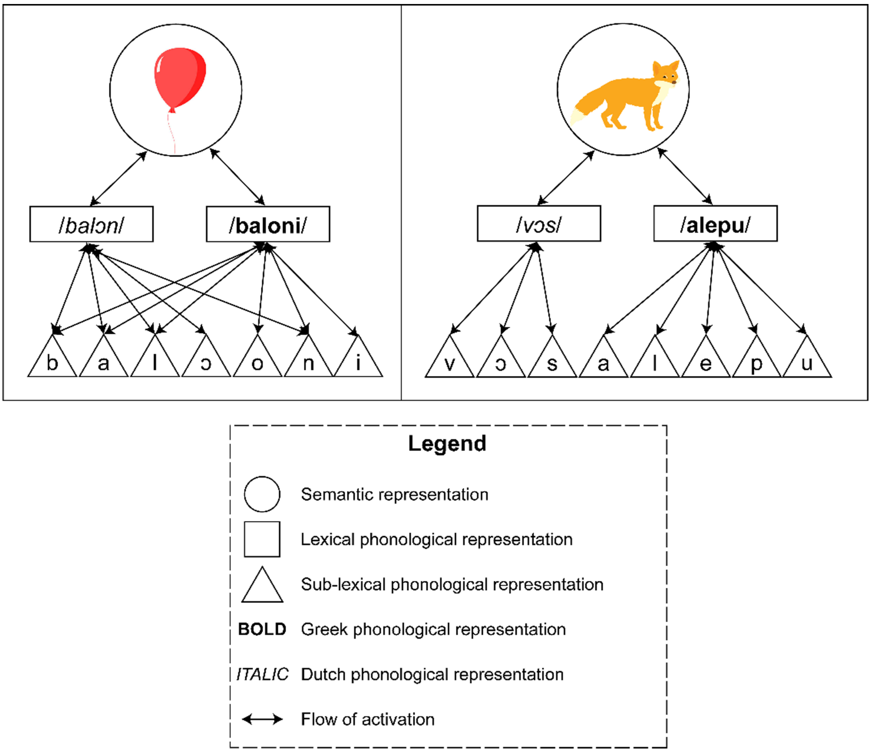

Figure 1. Representation and flow of activation in an integrated Dutch-Greek bilingual lexicon of a cognate (left: ballon—μπαλόνι “balloon”) and a noncognate translation pair (right: vos—αλεπού “fox”).

This is explained by interactive models of bilingual word processing, such as the Bilingual Interactive Activation plus (BIA+) model (Dijkstra & van Heuven, 2002). According to this model, a word that is presented to a bilingual activates all word forms that are similar to this input word, irrespective of the language they belong to. This activation resonates (i.e., flows back and forth) between form and meaning representations. As a result, in the case of cognates, activation spreads between translation equivalents via both shared semantic and sub-lexical representations. In contrast, co-activation of translation equivalents without form overlap (like Dutch *vos* /vɔs/ “fox” and Greek *αλεπού* /aleˈpu/ “fox”) would be limited to convergence at the semantic level (Dijkstra et al., 2019; Dijkstra & van Heuven, 2002; Shook & Marian, 2013); see Figure 1. The stronger resonance between cognate members induces a faster activation and recognition of cognates relative to noncognates.

Importantly, the relative strength of co-activation of languages may depend on a bilingual’s language dominance. Variation in dominance is typically accounted for in processing models in terms of language exposure. According to BIA+ (Dijkstra & van Heuven, 2002) and Multilink (Dijkstra et al., 2019), for example, language exposure affects the ease with which a representation in the lexicon is activated: More exposure to a word in a language leads to a higher resting-level of activation for that word, which in turn leads to faster activation and a stronger influence on the

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processing of other words. Many empirical studies with bilingual adults have found cognate effects to be stronger in a non-dominant language than in a dominant (usually native) language, in which cognate effects are usually smaller or even absent (e.g., Muntendam et al., 2022; van Hell & Dijkstra, 2002; van Hell & Tanner, 2012).

To the extent that the same flow of activation is assumed to take place between the same representations in production and in comprehension (see e.g., Menenti et al., 2011; Pickering & Garrod, 2013; Zwitserlood, 1994), cognate facilitation effects are predicted to occur in both modalities (e.g., Dijkstra & van Heuven, 2018). Within the lexicon itself, the main difference between comprehension and production lies in which representation is activated first. In (auditory) cognate comprehension, sub-lexical phonological representations are activated based on the input. The sub-lexical representations activate corresponding word forms, including the two translation equivalents, which themselves both activate their shared semantic representation. In cognate production, a semantic representation is activated first. From there, the two corresponding word forms (i.e., the translation equivalents) are activated and in turn their (partially overlapping) sub-lexical phonological representations. In both modalities, the resonating activation increases the activation levels of the two co-activated word forms, leading to faster cognate comprehension and production than noncognate comprehension and production. Indeed, studies with bilingual adults have found cognates to be processed more quickly and/or more accurately in both comprehension (e.g., Dijkstra, 2005; Dijkstra et al., 2010; Lemhöfer et al., 2004) and production (e.g., Costa et al., 2000; Hoshino & Kroll, 2008; Kroll et al., 2006).

In sum, in comprehension and production the same representations are accessed in the lexicon, although this access may involve different processes depending on the modality involved. Further processing of the information from the lexicon may also differ depending on the specific situation. Experimental tasks that are used to investigate such processes therefore place different demands on the language user. This can influence word processing in general and cognate facilitation effects in particular. The BIA+ model (Dijkstra & van Heuven, 2002) accounts for differences in task demands by implementing a separate Task/Decision subsystem, which takes input from the lexicon and creates a task-appropriate response. For example, in lexical decision, a commonly used comprehension task, the Task/Decision subsystem takes an activated word form and its meaning as input to decide whether the word requires a "yes"-response (for real words in the target language) or a "no"-response (for non-words or words from the non-target language). This is quite different from a task-appropriate response in picture naming, a commonly used production task. In picture naming, after a meaning and its corresponding word forms have been activated, the target language word form needs to be selected and phonologically encoded, and articulatory processes need to be set in motion. So while the same representations are assumed to be activated in the lexicon in production and comprehension, they are processed differently by the Task/Decision subsystem.

Studies have found that the factors that play a role in word processing may differ between comprehension and production tasks (see e.g., de Groot et al., 2002; Ferrand et al., 2011). Importantly, this includes cognate status (e.g., de Groot et al., 2002; Dijkstra et al., 2010; Poort & Rodd, 2017). For example, de Groot et al. (2002) observed asymmetrical cognate effects (that is, cognate effects only in a non-dominant language) in lexical decision and symmetrical cognate effects (i.e., cognate effects in

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both languages) in word naming. In other words, interactions between modality and dominance effects may affect empirical outcomes.

In sum, models of the bilingual lexicon assume that the two languages are represented in an integrated system, which is accessed in a language-nonselective manner, and in which activation spreads between connections during lexical processing. Cognates are processed with more ease than noncognates as a result of shared semantic and sub-lexical representations and activation resonating between these representations. The strength of such cognate facilitation is influenced by language dominance and is subject to specific task demands. The empirical evidence for models of the bilingual lexicon is largely based on research involving bilingual adults. As we will see in the next section, there is a small but growing body of evidence pointing to a similar integrated lexicon in simultaneous bilingual children, although it is not yet clear to what extent the role of modulating factors is the same as in adults.

Simultaneous bilingual children

An important question for bilingual child research, as for bilingual adult research, is whether the bilingual lexicon is integrated and if representations are shared. Children and adults not only differ in chronological age but also typically in age of acquisition: Although most studies with adults focus on late second language learners, for bilingual children both languages are acquired more or less simultaneously, while they are both still developing. As such, empirical research needs to establish to what extent bilingual word processing is similar between these groups.

Studies on cognate processing in bilingual children have made use of several spoken word production and (visual) comprehension tasks. For example, Poarch and van Hell (2012) conducted picture-naming tasks with simultaneous German-English bilingual children between 4.9 and 8.2 years old. When the picture was named with a cognate word, it was named more accurately and more quickly than when it was a noncognate control word. These cognate facilitation effects were found in both languages. Schröter and Schroeder (2016) found similar effects in an orthographic lexical decision task with simultaneous and early German-English bilingual children (third graders with a mean age of 7.65 years): Children responded more accurately and more quickly to cognates than to noncognates. Although the accuracy effect was only significant in English, reaction time effects appeared in both languages, similar to Poarch and van Hell (2012). In other studies, the degree of orthographic overlap between translation equivalents was manipulated on a continuous scale. More similar (i.e., cognate-like) translation equivalents were processed more quickly in Frisian (but not Dutch, as discussed below) sentence reading by Dutch-Frisian bilingual children between 9 and 12 years old (Bosma & Nota, 2020) and in Spanish-to-Basque and Basque-to-Spanish translation recognition by Spanish-Basque bilingual children between 8 and 15 years old (Duñabeitia et al., 2016). In a receptive Frisian vocabulary test, the form-similarity of translation equivalents affected the performance of Dutch-Frisian bilingual children between 5 and 8 years old (Bosma et al., 2019). The findings from these various cognate processing studies all support the hypothesis of an integrated bilingual lexicon in children.

In addition to these cognate production and visual word comprehension studies, there have been auditory comprehension studies examining the bilingual child's lexicon. These were often focused on between-language lexical priming rather than cognate processing. In lexical priming, two (related) words are presented in sequence whilst participants' processing is monitored. A priming effect is obtained when properties of the first word (i.e., the prime) influence the processing of the second word (i.e., the target), for instance when they are semantically related. Such a priming effect is taken as evidence for connections between representations in the lexicon, so when words from different languages prime each other, this is evidence that they are represented in a shared system in which representations from both languages are interconnected. In simultaneous bilingual toddlers, lexical priming studies (all involving noncognates) have found evidence for connections between (noncognate) words with partial phonological overlap from different languages (Von Holzen & Mani, 2012) as well as semantically related words (Floccia et al., 2020; Jardak & Byers-Heinlein, 2019; Singh, 2014) and translation equivalents (Floccia et al., 2020; Von Holzen & Mani, 2012). Recently, similar between-language phonological and translation priming effects have been found in older bilingual children (Koutamanis et al., 2023b). In line with the findings from cognate processing studies, these between-language priming effects with noncognates are in support of models of an integrated bilingual lexicon in children.

Many of the aforementioned studies included some measure of language dominance. For example, in their cognate production study, Poarch and van Hell (2012) found differences between child second language learners, who were more dominant in their first language, and simultaneous bilinguals, who were more balanced. For simultaneous bilinguals, effects emerged in both languages, but for child second language learners, effects were found only in the weaker language (i.e., children's second language). Similarly, in sentence reading, Bosma and Nota (2020) found cognate effects in simultaneous Frisian-Dutch bilingual children only in Frisian, which was the language to which they had had less exposure in reading, and Bosma et al. (2019) found stronger cognate facilitation for children with less exposure to the target language at home than for children with more exposure to the target language. For between-language lexical priming, Singh (2014) only found effects from simultaneous bilingual toddlers' dominant language to their non-dominant language (where dominance was operationalized in terms of exposure). In contrast, other priming studies, which were highly similar in design, found no such dominance effects (Floccia et al., 2020; Jardak & Byers-Heinlein, 2019; Koutamanis et al., 2023b). In sum, although there is evidence for dominance playing a similar role in the bilingual child's lexicon and lexical processing as in adults, there are inconsistencies among studies requiring more research.

Unlike language dominance, modality- or task-related factors and their influence on cognate processing have rarely been considered in simultaneous bilingual child research. Many studies have included multiple participant groups or multiple outcomes (e.g., accuracy and reaction times), but not multiple tasks. This lack of triangulation not only decreases comparability between child and adult studies but also makes it unclear to what extent findings within child research are generalizable across comprehension and production and, due to possible interactions between task- and participant-related factors (as in de Groot et al., 2002), across children with different degrees of language dominance.

Present study

To test the extent to which the two languages in bilingual children's lexicon interact similarly across comprehension and production and across children varying in language dominance, we conducted two cognate processing tasks with the same group of Dutch-Greek simultaneous bilingual children. This is a population that is not often studied and thus contributes to diversity in the field of psycholinguistics and bilingualism research (see e.g., Bylund et al., 2023; Kidd & Garcia, 2022; Singh et al., 2023). The tasks were chosen to increase comparability with adult studies, namely (auditory) lexical decision, a commonly used comprehension task in adults (e.g., Lagrou et al., 2011; Muntendam et al., 2022), and picture naming, a commonly used production task in child and adult studies (e.g., Costa et al., 2000; Hoshino & Kroll, 2008; Poarch & van Hell, 2012). We used auditory lexical decision rather than visual lexical decision to avoid effects of children's literacy skills unrelated to dominance and to avoid effects of having two different alphabets. In both tasks, we measured accuracy as well as reaction times.

Participants were Dutch-Greek simultaneous bilinguals, aged between seven and eleven years old. To secure a sample of children whose dominance patterns varied, we included children living in the Netherlands and children living in Greece. As both tasks were conducted in Greek, language dominance was measured in terms of relative language exposure to Dutch. This operationalization allowed us to test the predictions following from the BIA+ model (Dijkstra & van Heuven, 2002) and Multilink (Dijkstra et al., 2019), namely that more exposure to a language leads to more influence of that language on word processing in the other language.

We assumed that models of the bilingual lexicon based on adult studies are also applicable to the lexicon of bilingual children—specifically, we assumed that activation spreading between shared sub-lexical and semantic representations in the lexicon leads to cognate facilitation in both comprehension and production. We predicted cognate facilitation effects in both lexical decision and picture naming, in accuracy as well as in reaction times, in line with earlier studies with children (Bosma et al., 2019; Bosma & Nota, 2020; Duñabeitia et al., 2016; Poarch & van Hell, 2012; Schröter & Schroeder, 2016) and adults (e.g., Costa et al., 2000; Dijkstra et al., 2010; Hoshino & Kroll, 2008; Lemhöfer et al., 2004), although the way cognate effects manifest in different tasks may differ (de Groot et al., 2002).

In addition, we predicted cognate facilitation effects to be modulated by language dominance in both tasks. Specifically, in line with the BIA+ model (Dijkstra & van Heuven, 2002) and Multilink (Dijkstra et al., 2019), we assumed that the more dominant a language is in the lexicon, the more influence it exerts over the other language. As a consequence, we predicted stronger cognate facilitation effects for children who received more exposure to the non-target language Dutch, as has been found in several studies with children (Bosma et al., 2019; Bosma & Nota, 2020; Poarch & van Hell, 2012; Singh, 2014) and adults (Muntendam et al., 2022; van Hell & Dijkstra, 2002; van Hell & Tanner, 2012).

Because of COVID-19-related restrictions, testing could not take place face-to-face, and all tests in this study were conducted remotely via an online testing platform. These kinds of psycholinguistic experiments have not yet often been conducted remotely, especially not with children, which poses some challenges. For example, as will be discussed under Data Exclusion, online testing can result in noisier data than face-to-face testing. At the same time, if successful, online testing also provides important possibilities. For example, by testing remotely, the present study can provide insights into the robustness of any cognate facilitation effects under different circumstances. In addition, it facilitates the inclusion of children from different countries (see also Supplementary Materials for our learnings from testing remotely).

Method

Participants

Participants were 27 Dutch-Greek bilingual children (15 girls, 12 boys), aged between 7.1 and 10.8 years old ($M = 9.0$, $SD = 1.2$), living either in the Netherlands ($n = 22$) or in Greece ($n = 5$). All children had received substantial exposure to both Greek and Dutch, defined as minimally half a day per week, since before the age of three and for the majority ($n = 21$) since birth. Three children had received substantial input (i.e., more than half a day a week) to a language other than Dutch or Greek, but this was much earlier in their lives, namely until age four ($n = 2$) or age two ($n = 1$), at least 5 years prior to testing. All children had at least one parent who had completed (applied[1]) university, indicating a higher socio-economic status.

Of the children living in the Netherlands ($n = 22$), all children had acquired Greek from at least one parent or caregiver in their home environment. In some cases ($n = 8$), both parents were native speakers of Greek and had migrated to the Netherlands at a later age (for instance, for work or studies); for most ($n = 12$), one parent was a native speaker of Greek and the other a native speaker of Dutch. For two children, one parent was raised bilingually themselves, while the other parent was Dutch. In addition to receiving input from family members, several children ($n = 10$) attended heritage language classes in Greek. Of the children living in Greece ($n = 5$), four had one parent who was a native speaker of Dutch and one who was a native speaker of Greek. In one case, both parents were native speakers of Greek, but the family had lived in the Netherlands for four years. One parent was fluent in Dutch and (still) mostly spoke Dutch to the child. All five children also attended heritage language classes in Dutch.

Table 1 summarizes children's scores on a range of background variables: working memory (Dutch version of Alloway Working Memory Assessment: Forward and Backward Digit Span Tests; Alloway, 2012), Dutch lexical proficiency (LITMUS Cross-linguistic Lexical Task; Haman et al., 2015; van Wonderen & Unsworth, 2021), Greek lexical proficiency (adaptation of Greek Child Action and Object Test; Kambanaros et al., 2013), and Dutch and Greek syntactic proficiency (LITMUS Sentence Repetition Task; Marinis & Armon-Lotem, 2015). In addition, we measured children's current relative language exposure (Bilingual Language

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Table 1. Overview of participant characteristics

Background variable	*M*	*SD*	Range
Working memory[a]:			
– Forward digit span test score	93	14	61–127
– Backward digit span test score	98	11	74–114
Dutch proficiency:			
– Lexical proficiency score	76%	17%	26%–96%
– Syntactic proficiency score	70%	25%	10%–100%
Greek proficiency:			
– Lexical proficiency score	60%	25%	5%–92%,
– Syntactic proficiency score	21%	22%	0%–75%
Percentage of Dutch exposure	60%	23%	14%–95%

[a]Scores are standard scores, with possible scores ranging from 47 to 153.

Table 2. Correlations between proficiency scores and exposure

	1	2	3	4	5
1. Percentage of Dutch exposure	—				
2. Dutch lexical proficiency score	0.75***	—			
3. Dutch syntactic proficiency score	0.65***	0.85***	—		
4. Greek lexical proficiency score	−0.78***	−0.38	−0.34	—	
5. Greek syntactic proficiency score	−0.71***	−0.47*	−0.34	0.79***	—

* $p < .05$. ** $p < .01$. *** $p < .001$.

Experience Calculator; Unsworth, 2013). The resulting percentage reflects how much of children's language exposure around the time of testing was in Dutch compared to Greek. Table 2 shows how the various proficiency and exposure measures are correlated. All proficiency measures correlated moderately or strongly with language exposure. Dutch lexical proficiency and Dutch syntactic proficiency correlated strongly with each other, as did Greek lexical proficiency and Greek syntactic proficiency. Dutch lexical proficiency was weakly correlated with Greek syntactic proficiency.

Participant information, stimulus lists, data, and analysis scripts for this study can be retrieved from https://osf.io/k2xw6/.

Materials

Lexical decision

The lexical decision stimuli consisted of 108 Greek words and 108 pseudowords. The real words were nouns selected from word lists for young Dutch children (Dunn et al., 2005; Mulder et al., 2009; Schlichting & Lutje Spelberg, 2002; Zink &

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Lejaegere, 2002) and translated into Greek, with a reported age of acquisition (AoA) below 8;0 (Brysbaert et al., 2014).[2] The pseudowords were taken from Revithiadou and Lengeris (2016).

The real words included 36 Greek words which were cognates with Dutch, 36 matched noncognate Greek words, and 36 Greek filler words. The noncognates were matched to the cognates based on frequency (Dimitropoulou et al., 2010), AoA (Brysbaert et al., 2014), concreteness (Brysbaert et al., 2014), onset phoneme category, and length (in syllables) ($ps > .05$). The fillers were non-matched noncognate words, meaning that they could differ from the cognates on these features.

Items were divided into eight blocks: four consisting of 30 items (five cognates, five matched noncognates, five fillers, and 15 pseudowords) and four of 24 items (four cognates, four matched noncognates, four fillers, and 12 pseudowords). Each block was preceded by four practice items (one cognate, one noncognate, and two pseudowords), except for two 30-item blocks, which were preceded by twelve practice items (three cognates, three noncognates, and six pseudowords). These two blocks were each administered as the first block in a testing session (see Procedure).

Block-internal stimulus order was pseudorandomized for each participant, with no more than two subsequent trials from the same condition. All individual stimulus order lists were checked manually for form or meaning overlap between subsequent trials, to avoid unwanted interactions with phonological or semantic priming. In addition to the matching between cognates and noncognates, we also checked that the different blocks and sessions did not differ from each other in terms of cognate frequency, AoA, concreteness, onset phoneme category, and length ($ps > .05$).

All (pseudo)words were recorded by a female native speaker of Greek.

Picture naming

The picture-naming stimuli consisted of 144 full-color drawings, depicting various objects. The (Greek) target words corresponding to these pictures (36 cognates, 36 matched noncognates, and 72 fillers) were selected from the same sources as the lexical decision task, but different words were used in the two tasks. Similar to the lexical decision items, all picture-naming target words had a reported AoA below 8;0. An additional criterion for picture naming was that the target words were imageable, which was less important for lexical decision. Related to imageability, the cognates selected for picture naming were more concrete than the cognates selected for lexical decision ($p < .05$), whereas the cognates did not differ between the two tasks on frequency, AoA, onset phoneme category, and length ($ps > .05$).

Within the picture-naming task, cognates and matched noncognates were matched using the same criteria as in the lexical decision task, meaning they did not differ from each other on frequency, AoA, concreteness, onset phoneme category, and length ($ps > .05$).

Pictures were selected from Multipic (Duñabeitia et al., 2018) and Rossion and Pourtois (2004), complemented with clip-art images in similar styles if no suitable option was available. All pictures were pre-tested for naming consistency by adult native speakers of Greek and adapted if necessary.

The 144 pictures were divided over four blocks of 36 items, each containing nine items with cognates as target words, nine with matched noncognates as target words, and 18 fillers. Each block was preceded by four practice items: two cognates and two noncognates. Block-internal stimulus order randomization and block matching were performed in the same way as in the lexical decision task.

Procedure

All children were tested individually, while at home, over two sessions one to three weeks apart. Testing took place online using Radboud Online Linguistic Experiment Generator (ROLEG), an in-house online platform. After signing informed consent forms, caregivers received a link to access the experiments via a browser. They were instructed to help the child set up, but leave the room as soon as the experiment was running. Instructions for all tasks were embedded in short animation videos shown in the experiments. An experimenter was also present via a video call to give feedback and additional instructions where needed.

The two sessions were conducted by two different experimenters. Because the data in this study were collected as part of a larger project into not only cognate effects, dominance, and modality but also language context, the experimenters spoke different languages: The experimenter in the first session was a native speaker of Greek and the experimenter in the second session was a native speaker of Dutch. The target language of the main tasks in both sessions was Greek. The instructional videos used the same language as the experimenter of the session. However, because of the relatively small Dutch-Greek sample and relatively high data loss (see Data Exclusion), language context was ultimately not included in the present study. Information on how we checked for potential confounds with language context is given under Language Context.

Stimuli were distributed across sessions, each containing four lexical decision blocks and two picture-naming blocks. A lexical decision trial started with a 50 ms beep and 250 ms pause[3], after which the item was played. Participants responded by pressing a key on their keyboard: For real Greek words, a key on the side of their dominant hand had to be pressed, and for pseudowords, a key on the side of their non-dominant hand had to be pressed. These keys were labeled by the children's caregivers with stickers, as instructed by the experimenter: a smiley face for real words and a frowny face for pseudowords.[4] A new trial started after a keypress. Accuracy and reaction times (RTs) were recorded in ROLEG.

A picture-naming trial also started with a 50 ms beep sound, followed by a 250 ms pause. Subsequently, the image appeared on the screen for participants to name in Greek. After 2000 ms, the image disappeared and a new trial started. Accuracy and RTs were obtained from audio recordings (see Scoring), which were made on a separate recording device in the participant's home.

To increase children's engagement and motivation, the tasks were embedded in an overarching story, told through the instructional videos. There were two stories: In one story, an inventor was trying to fix a talking robot, and in the other, aliens were trying to speak with an astronaut who visited their planet. In the lexical decision blocks, children were asked to check if the robot or alien was saying words correctly in Greek, and in the picture-naming blocks, their task was to teach the robot or alien new Greek words. Which story was told in which session was counterbalanced between participants. Proficiency tasks and other background tasks were administered between the blocks containing the main tasks and were also embedded in the overarching story. Greek proficiency tests were administered in the first session, where the experimenter spoke Greek, and Dutch proficiency tests were administered in the second session, where the experimenter spoke Dutch. Each testing session lasted approximately 60–70 minutes.

Scoring

While accuracy and RTs were automatically recorded for the lexical decision task, the picture-naming data were scored manually. Audio recordings of the picture-naming task were annotated by a native speaker of Greek, who labeled the onset of the beeps, which served as auditory markers of stimulus onset, and of the participants' responses in Praat (Boersma & Weenink, 2022). The time between beep onset and response onset was the RT. A subset of data (10% of participants) was annotated by a second scorer. Inter-rater reliability was 0.82, indicating excellent agreement between the scorers (Hallgren, 2012).

Picture-naming accuracy was based on transcriptions from the same scorers, following a lenient scoring scheme and a strict scoring scheme. Lenient scores were used in accuracy analysis and for participant and target word exclusion in RT analysis; strict scores were used for RT analysis (see Analysis and Data Exclusion). In the lenient scoring scheme, a response was scored as correct if it contained the target word or a derived form such as a plural or diminutive.[5] Late responses, after the beep indicating the start of the next trial, were also scored as correct under the lenient scoring scheme. Cognates that were pronounced in the non-target language (e.g., *kangoeroe* /ˈkɑnɣəru/ instead of *καγκουρό* /kaŋɡuˈɾo/) were coded as "other," that is, they were excluded from lenient accuracy scores. In the strict scoring scheme, false starts and late responses were scored as incorrect, as well as non-target language pronunciations of cognates.

Analysis

Accuracy scores and RTs of both tasks were analyzed separately. Accuracy was analyzed with mixed effects logistic regression models, and RTs were analyzed with linear mixed effects models, using the glmer and lmer functions respectively from the lme4 package version 1.1-27.1 (Bates et al., 2015). RTs were log-transformed, approaching a normal distribution (Baayen & Milin, 2010). In the RT models, p-values were obtained using Type 2 conditional F-tests with Kenward-Roger approximation for degrees of freedom as implemented in the Anova function of the package car (Fox & Weisberg, 2019). Orthogonal sum-to-zero contrast coding was applied to *Cognate Status*. *Percentage of Dutch Exposure* was mean-centered.

All models contained the predictors *Cognate Status* and *Percentage of Dutch Exposure*, interactions between these predictors, and random intercepts for *Participant* and *Target Word*. Random slopes were not included, as this led to convergence issues. Next, task-related covariates, known to influence response outcomes (e.g., Lemhöfer et al., 2008), namely *Trial Number, Previous Trial Accuracy*, and *Previous Trial logRT,* were added to the models in a stepwise manner as a control. Only those covariates that significantly improved the model were included, as was established through Likelihood Ratio Tests using the Anova function in the base package (R Core Team, 2020).

Results

Data exclusion

Lexical decision

Lexical decision data were available for all 27 children. First, responses with RTs below 700 ms or above 2200 ms were excluded from both accuracy and RT analysis. This resulted in exclusion of 9.5% of all responses or 8.3% of correct responses. The rate of exclusions may be higher than what is typically considered normal, due to the testing circumstances. We chose relatively strict limits based on visual inspection of the data, to counteract the noisiness of the raw data: Stimuli were presented online, with timing differences depending on participants' computer and internet connection. As such, responses that were visibly faster or slower than the majority were deemed more likely to reflect measurement errors. Next, participants with accuracy scores below 80% on pseudowords were excluded ($n = 5$), as this indicated that they had a bias for "yes"-responses. For RT analysis only, we excluded participants with accuracy scores below 80% on cognates and matched noncognates ($n = 5$) and items with mean accuracy below 80% ($n = 13$, six cognates). Item exclusion did not affect the matching between cognates and noncognates (ps $> .05$). Next, for RT analysis, all remaining incorrect responses were excluded. Finally, for both accuracy analysis and RT analysis, we calculated mean RTs per participant per testing session based on their remaining trials and excluded responses above or below 2.5 SD of this participant mean (1.9% for accuracy analysis; 2.1% for RT analysis), leaving a total of 1322 trials in the final dataset for accuracy analysis and 827 trials for RT analysis.[6]

Picture naming

Because we did not receive audio recordings from all children, picture-naming data were available for 23 out of the 27 tested children. For the accuracy analysis, data was excluded for children who responded in fewer than 50% of trials ($n = 12$), because it was not clear if these low response rates were caused by technical issues, by lack of understanding the task, or by lack of knowing the word. As such, these children's accuracy rates based on given responses may be misleading. This left a total of 695 trials in the final dataset for accuracy analysis.

For the RT analysis, we first excluded responses from all 23 available participants if RTs were faster than 1300 ms or slower than 2800 ms. This resulted in exclusion of 16.7% of correct trials. Similar to lexical decision, data exclusion was based on visual inspection of the data, for the same reasons. A further complication for this task was that the RTs were calculated using audio recordings made on different devices and under different circumstances, which may have inflated the rate of measurement error. While this meant that for this task in particular, there was likely a loss of statistical power, we prioritized careful consideration of the data and filtering out as much noise as possible over maximizing the number of observations. After excluding individual data points, participants with (lenient) accuracy scores below 70% of their given responses on cognates and matched noncognates were excluded from analysis ($n = 4$), as well as items with mean (lenient) accuracy below 50% of given responses ($n = 4$). Item exclusion did not affect the matching between cognates and noncognates ($ps > .05$). Next, all remaining responses that were incorrect under the strict scoring scheme were excluded. Finally, we calculated mean RTs per participant per testing session based on their remaining trials and excluded responses above or below 2.5 SD of this participant mean (0.4%), leaving 486 trials in the final dataset for RT analysis.

Language context

Because we collapsed data from two sessions that differed in language of communication (language context), the data were checked for potential confounds. Specifically, after excluding data following the criteria outlined above, we checked whether potential effects of *Percentage of Dutch Exposure* or *Cognate Status* may be confounded with the effects of language context. For *Cognate Status*, there were no differences between the number of included observations per condition per context (lexical decision accuracy: $\chi^2(1) = 0.17, p = .68$; lexical decision RTs: $\chi^2(1) = 1.19, p = .27$; picture-naming accuracy: $\chi^2(1) = 0.001, p = .97$; picture-naming RTs: $\chi^2(1) = 0.42, p = .52$). As such, we had no reason to believe that potential effects of *Cognate Status* would be confounded with any language context effects.

Regarding *Percentage of Dutch Exposure*, we found differences between the two contexts in the number of observations included per child (lexical decision accuracy: $\chi^2(21) = 74.09, p < .001$; lexical decision RTs: $\chi^2(16) = 32.33, p = .009$; picture-naming accuracy: $\chi^2(10) = 35.05, p < .001$; picture-naming RTs: $\chi^2(18) = 48.13, p < .001$). Because the number of observations per child differed between the contexts, we then checked whether the average *Percentage of Dutch Exposure* differed between contexts by performing additional t-tests. These revealed no differences between contexts in terms of *Percentage of Dutch Exposure* for lexical decision accuracy ($t(1311) = -0.41, p = .68$), lexical decision RTs ($t(787.41) = -0.55, p = .58$), and picture-naming RTs ($t(404.21) = -1.31, p = .19$). As such, we had no reason to believe that potential effects of *Percentage of Dutch Exposure* would be confounded with language context. In picture-naming accuracy, however, average *Percentage of Dutch Exposure* was lower in the single-language context, where the experimenter spoke Greek, than in the dual-language context, where the experimenter spoke Dutch ($t(690.63) = -3.22, p = .001$). Because of this difference, we repeated the analysis for picture-naming accuracy including *Language Context* as a covariate. This did not change the general outcomes for *Percentage of Greek Exposure* or *Cognate Status* (see Appendix in comparison with Picture-Naming Results). Hence, there is no evidence that any effects of these predictors stemmed from our manipulation of language context. Note that this does not mean that language context did not affect cognate effects or dominance effects, but we did not investigate this in the current study (see

Table 3. Mean lexical decision accuracy and reaction times in milliseconds (standard deviations between parentheses) per condition, for children with higher and lower percentages of Dutch exposure

	Accuracy	Reaction times
Cognates	0.86 (0.35)	1206 (260)
– Higher Dutch exposure	0.86 (0.35)	1205 (239)
– Lower Dutch exposure	0.86 (0.35)	1208 (278)
Noncognates	0.86 (0.34)	1203 (288)
– Higher Dutch exposure	0.80 (0.40)	1204 (276)
– Lower Dutch exposure	0.92 (0.26)	1203 (299)

Table 4. Parameter estimates and significance tests of accuracy and reaction times in the lexical decision task

	Accuracy				Reaction times				
					Parameter estimates		Significance tests		
Predictor	*B*	*SE*	*z*	*p*	*B*	*SE*	*F*	*df*	*p*
(Intercept)	2.574	0.264	9.765	<.001	7.075	0.022			
Cognate status	−0.232	0.390	−0.594	.552	0.007	0.016	0.174	1,56.2	.678
Percentage of Dutch Exposure	−2.247	0.790	−2.843	.004	0.037	0.094	0.146	1,14.9	.707
Percentage of Dutch Exposure x Cognate status	3.412	0.851	4.011	<.001	0.029	0.062	0.218	1,764.2	.641

Koutamanis et al., 2023a, for a similar study on language context, which found interactions between dominance and context).

Lexical decision results

Descriptive lexical decision results per condition for children with higher and lower percentages of Dutch exposure (based on a median split, for illustrative purposes) are presented in Table 3.

The best-fitting models for accuracy and RTs on the lexical decision task are presented in Table 4. The accuracy analysis revealed a main effect of *Percentage of Dutch Exposure*, as well as an interaction between *Cognate Status* and *Percentage of Dutch Exposure*. As illustrated in Figure 2, *Percentage of Dutch Exposure* had a stronger effect on noncognate accuracy than on cognate accuracy. As such, the more Dutch-dominant children were, the stronger the cognate facilitation effect that emerged. For more balanced or Greek-dominant children, accuracy on cognates was lower than accuracy on noncognates.

The RT analysis revealed no significant effects.

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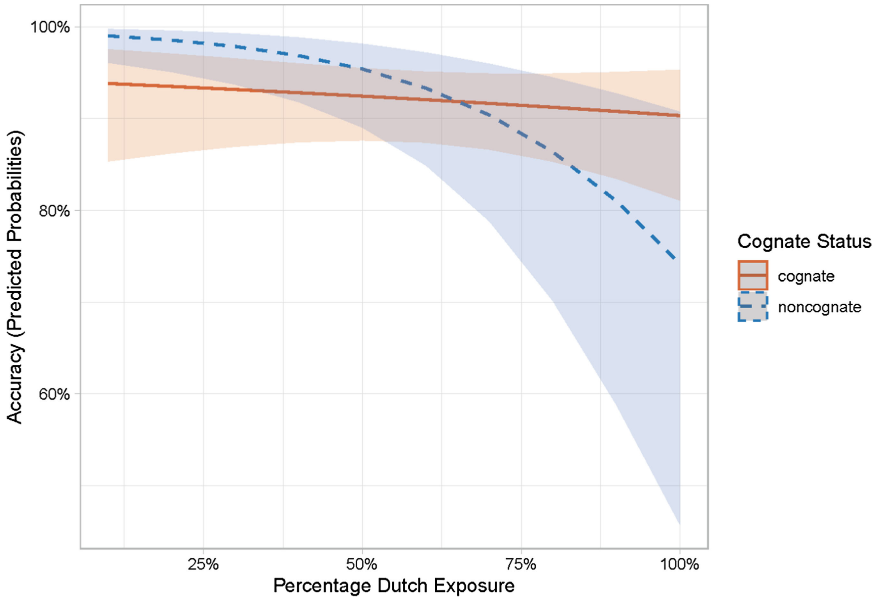

Figure 2. Interaction effect between Percentage of Dutch Exposure and Cognate Status on the predicted probabilities for accuracy.

Picture-naming results

Descriptive picture-naming results per condition for children with higher and lower percentages of Dutch exposure (based on a median split, for illustrative purposes) are presented in Table 5.

The final models for the picture-naming data are presented in Table 6. The accuracy analysis revealed a main effect of *Percentage of Dutch Exposure*: As illustrated in Figure 3, children responded more accurately if they received less Dutch (i.e., more Greek) exposure. The RT analysis revealed a main effect of *Cognate Status*, where cognates were named more quickly than noncognates, as illustrated in Figure 4.

Discussion

In this study, we investigated to what extent cognate facilitation effects were robust across modalities (comprehension vs. production), in children with differing degrees of language dominance, speaking a language combination (Dutch-Greek) that has not often been examined. We aimed to build upon earlier evidence for an integrated lexicon in simultaneous bilingual children, by testing for effects of co-activation of cognate members in both comprehension and production, in tasks with different task demands, while taking individual differences in language dominance into account.

Primary-school-aged Dutch-Greek simultaneous bilinguals performed two Greek cognate processing tasks, namely a comprehension task (an auditory lexical decision task) and a production task (a picture-naming task). As predicted, cognates were processed with more ease than noncognate control words in both tasks, although these cognate effects manifested themselves in different ways. In comprehension,

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Table 5. Mean picture-naming accuracy and reaction times (standard deviations between parentheses) per condition, for children with higher and lower percentages of Dutch exposure

	Accuracy	Reaction times
Cognates	0.87 (0.33)	1945 (342)
– Higher Dutch exposure	0.79 (0.41)	1927 (347)
– Lower Dutch exposure	0.94 (0.25)	1967 (335)
Noncognates	0.85 (0.36)	2071 (337)
– Higher Dutch exposure	0.70 (0.46)	2053 (340)
– Lower Dutch exposure	0.93 (0.25)	2084 (335)

Table 6. Parameter estimates and significance tests of accuracy and reaction times in the picture-naming task

	Accuracy				Reaction times				
					Parameter estimates		Significance tests		
Predictor	*B*	*SE*	*z*	*p*	*B*	*SE*	*F*	*df*	*p*
(Intercept)	2.536	0.471	5.386	<.001	7.586	0.023			
Cognate status	0.353	0.511	0.691	.489	−0.058	0.019	9.523	1,62.4	.003
Percentage of Dutch Exposure	−4.484	1.723	−2.602	.009	−0.040	0.095	0.206	1,16.2	.656
Percentage of Dutch Exposure x Cognate status	2.070	1.576	1.314	.189	−0.028	0.056	0.252	1,448.6	.616

there was an effect in accuracy, in interaction with children's language dominance. In production, cognate facilitation emerged in reaction times and we found no influence of children's language dominance, although there was a main effect of dominance on accuracy in both tasks. In the next sections, we first discuss our findings separately for each modality, before comparing the results and demands of the two tasks.

Cognate comprehension

Our findings for children's accuracy on the auditory lexical decision task were largely in line with our hypotheses. Overall, accuracy was higher for children with less Dutch (i.e., more Greek) exposure. The correlations between exposure and Greek lexical proficiency in this study (see Table 2) suggest that children with more Greek exposure had larger Greek lexicons, and Greek words had higher resting-level activation, in line with BIA+ (Dijkstra & van Heuven, 2002) and Multilink (Dijkstra et al., 2019). Importantly, for Dutch-dominant children, language exposure and cognate status interacted as predicted by these models: Dutch-dominant children responded more accurately to cognates than to noncognates, and this cognate

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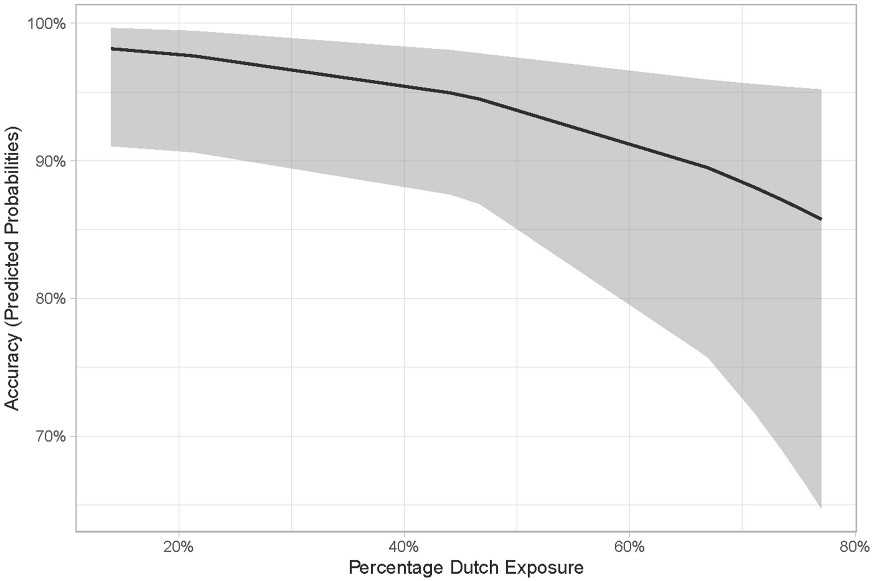

Figure 3. Main effect of Percentage of Dutch Exposure on the predicted probabilities for accuracy.

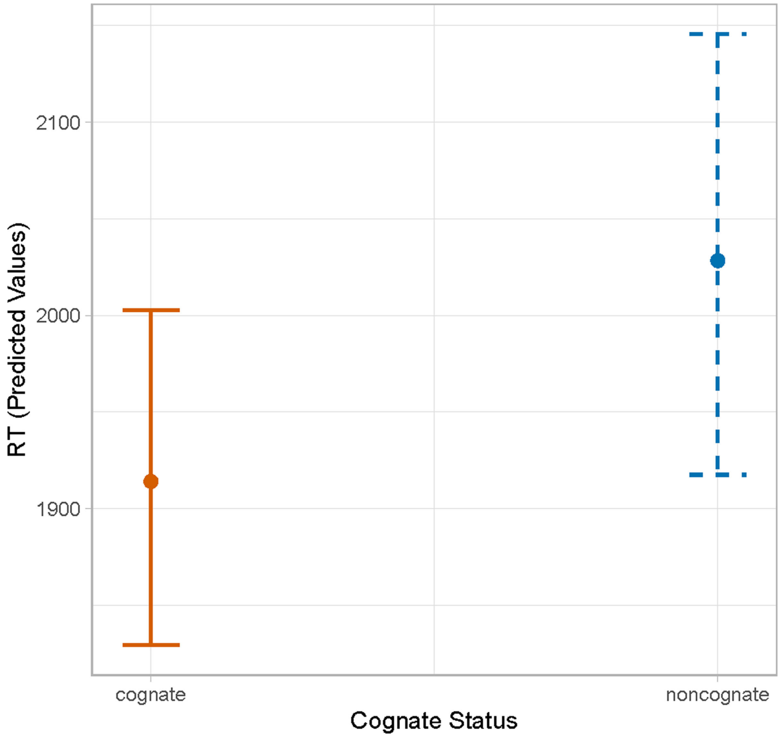

Figure 4. Main effect of Cognate Status on the predicted values for RTs.

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facilitation effect increased with the percentage of Dutch exposure. This indicates that they were able to use their Dutch knowledge in a Greek comprehension task and suggests that shared sub-lexical and semantic representations lead to increased activation of cognate word forms. Specifically, it suggests that both the Greek target word form representation and the Dutch translation of the target word became co-activated because of their correspondence to the auditory input. The Greek target was further activated by activation resonating from the Dutch word form via their shared sub-lexical and semantic representations, leading to more accurate comprehension. Importantly, the higher the resting-level activation of Dutch words, the more easily these words became (co-)activated and the more influence they exerted during the processing of Greek words. This resulted in stronger cognate facilitation, similar to previous studies on bilingual children (Bosma et al., 2019; Bosma & Nota, 2020; Poarch & van Hell, 2012; Singh, 2014) and adults (e.g., Muntendam et al., 2022; van Hell & Dijkstra, 2002; van Hell & Tanner, 2012).

In contrast, more balanced or Greek-dominant children tended to respond less accurately to cognates than to noncognates. Although cognate effects found in previous studies are generally facilitatory, negative cognate effects may also occur (see e.g., Broersma et al., 2016, for a discussion). It is likely that both word forms become co-activated in a similar manner as in cognate facilitation, but that this leads to negative effects under certain circumstances. For example, Brenders et al. (2011) argue that negative cognate effects may be caused by inhibition at the Task/Decision subsystem of the lexicon. In their lexical decision study with child second language learners, Brenders et al. (2011) found negative cognate effects triggered by the presence of false friends, that is, words that share their forms but not their meanings across languages. Apparently, the processing of such ambiguous word forms led to competition between responses, which extended to the processing of cognates. Broersma et al. (2016) also found negative cognate effects in a picture-naming study conducted in Welsh with English-Welsh bilingual adults, but only for English-dominant bilinguals. They proposed that both facilitatory processes and competition take place during cognate processing, which may lead to inhibitory effects depending on task-specific aspects and/or participants' language dominance. Although the negative effects in our study occurred in lexical decision and not in picture naming, the general explanation by Broersma et al. (2016) is in line with our findings, as negative effects only occurred in one task and only for a subset of participants based on their dominance.

Negative effects have also been found in studies examining between-language interactions in morphosyntax. For example, in a study by van Dijk (2021) and van Dijk et al. (2022), Turkish-Dutch simultaneous bilingual children processed ambiguous sentences, whose preferred interpretation differed between Dutch and Turkish. In Dutch sentence processing, the more Turkish-dominant children were, the more they inhibited the Turkish-like interpretation. In our study, similar competition and inhibition processes appear to have occurred, possibly caused by language distance. Like Dutch and Turkish (in van Dijk, 2021; van Dijk et al., 2022; see also Muntendam et al., 2022) or English and Welsh (in Broersma et al., 2016), Dutch and Greek are not closely related and do not share many cognates. As such, Dutch-Greek children do not often directly benefit from their Dutch lexical knowledge when processing Greek and may generally inhibit responses triggered by the activation of Dutch representations (see also Green & Abutalebi, 2013; Radman et al., 2021; see Peleg et al., 2020, for a similar

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reasoning regarding dominance and language distance effects). This response inhibition would then result in similar behavior as in Brenders et al. (2011).

In sum, in lexical decision, cognate effects emerged either as facilitation in accuracy (in children's non-dominant language) or as inhibition (in children's more dominant language). Both types of effects suggest that, in cognate comprehension, the two similar word forms become active and interact with each other. The consequences of this interaction depend on the children's language dominance, but both facilitatory and inhibitory cognate effects are likely to result from an integrated lexicon with language-nonselective processing. In contrast to accuracy, children's reaction times revealed no cognate facilitation effects. The differences between accuracy and reaction times in this study may be explained as a combined consequence of participant sample characteristics and modality—a point we return to after our discussion of the picture-naming results.

Cognate production

Corroborating our findings from lexical decision accuracy, cognate effects emerged in picture-naming reaction times: In trials where children named the picture correctly, they did so more quickly when it was a cognate than when it was a noncognate. This is in line with our hypotheses and with previous child studies (e.g., Poarch & van Hell, 2012) and adult studies (e.g., Costa et al., 2000; Hoshino & Kroll, 2008). The finding of cognate effects in both comprehension and production modalities supports the assumption of an integrated bilingual lexicon being accessed in each of them. In addition to the cognate effect, as in lexical decision, there was a main effect of language dominance on picture-naming accuracy: The more Greek-dominant children were, the more often they correctly named the picture, indicating that increased Greek exposure led to a more developed Greek vocabulary and higher resting levels of activation of Greek words in the lexicon.

Contrary to our predictions, and differently from what we found for comprehension, we found no influence of language dominance on the cognate facilitation effect. In addition, there were no cognate effects in picture-naming accuracy, unlike in previous studies (e.g., Poarch & van Hell, 2012). We discuss the differences between lexical decision and picture naming regarding dominance effects and regarding accuracy and reaction time effects in the next section.

Comparison between production and comprehension

The finding of cognate effects across two quite different tasks in both comprehension and production, with different items, suggests that such effects are robust in the simultaneous bilingual child's lexicon, similar to the (usually late sequential) bilingual adult's lexicon. Nevertheless, there were differences between the outcomes for comprehension and production, even though they were conducted with the same participants and contained comparable target words. It is possible that some differences in outcomes, especially for the role of language dominance, stem from differences in statistical power as a result of differences in rates of data loss. In addition, however, the observed differences in outcomes for comprehension and production may be due to general modality effects and/or specific task demands.

An important difference between comprehension and production is to what extent a fully specified mental representation of an item is required in order to respond successfully. A “good enough” representation of a word form will often still result in correct comprehension, but not in correct production—a difference that is exaggerated in the lexical decision task and picture-naming task. For example, if a participant does not know if the Greek word for “fox” is /aleˈpu/ or /aneˈpu/, they would likely still be able to respond correctly to it in lexical decision, whereas in a task like picture naming, the word must be produced completely and correctly. As such, for the picture-naming task, we only analyzed trials in which a response was given, and only responses with target-like pronunciation were scored as correct. For these well-acquired words, accuracy was high (see Table 5), possibly not leaving much room for further improvement: Additional activation coming from cognate translation equivalents was not found to have a significant effect on accuracy. Although it was found to affect RTs, the lack of interaction with dominance again suggests that there was not enough room to further improve processing speed.

Our lexical decision results, on the other hand, provide insight into the processing of a wider range of words. It is likely that not all Greek target words were equally familiar to the children and consequently not all responses were equally certain, especially as, on average, the children in our sample had higher proficiency scores and received more exposure in Dutch than in Greek (see Table 1). As such, there was more space for additional activation from cognate translation equivalents to improve accuracy, depending on individual differences in dominance. In addition, it is likely that the final dataset for lexical decision was statistically more powerful than the final dataset for picture naming.

In principle, we would have expected the same processes as in lexical decision accuracy to have an effect on children’s lexical decision RTs, as in, for example, Brenders et al. (2011), but we found no significant effects in our study. Interestingly, differences between outcome measures have been found in previous studies as well. For example, in their lexical decision with German-English bilinguals, Schröter and Schroeder (2016) found differences between accuracy and reaction time patterns in German, which was the societal and likely dominant language, but not in English. Their findings suggest that language dominance modulated the extent to which cognate effects occurred in accuracy or in RTs. Our findings further suggest that such differences may be modulated by both dominance and comprehension or production modality, in line with de Groot et al. (2002).

These complex interactions between modality and more specific task-related factors, on the one hand, and sample characteristics, on the other, also potentially explain inconsistent findings regarding language dominance from previous studies with simultaneous bilingual children. In addition to differences between participant samples, whether dominance effects occur may be the result of differences in stimuli, comprehension versus production, and exact task demands.

Strengths and limitations

Although we used a large number of items in both tasks in the present study, our sample size was limited and the fact that data was collected online unfortunately contributed to further data loss (see Supplementary Materials for our more detailed

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and more practical learnings from remotely testing bilingual children's word processing). This likely affected the findings in this study, especially with respect to individual differences in language dominance—as a result, these findings need to be interpreted with care. In addition, although data was collected in two language contexts, the high data loss meant that we were unable to examine the role of language context in cognate processing in this study. Future studies with larger samples are needed to investigate the role of language dominance and language context in cognate processing (see e.g., Koutamanis et al., 2023a, who found that dominance and context may indeed interact in their influence on the cognate effect).

Despite its limitations, remote testing had one crucial advantage, namely that it allowed us to target a broader range of language dominance by including children from different countries. This was especially important given the relatively small and underrepresented population tested here (see e.g., Bylund et al., 2023; Kidd & Garcia, 2022; Singh et al., 2023). Furthermore, our successful use of online testing with bilingual children highlights the potential such methods have in facilitating large-scale international collaborations (in line with the work of e.g., Visser et al., 2022). The finding that there were cognate effects in these less-controlled testing circumstances furthermore provides important insights into the robustness and generalizability of cognate effects in bilingual children.

Related to the generalizability of cognate effects, this study included a combination of languages that are not very closely related, thereby showing that similar cognate effects can occur as have been found in previous studies with more closely related languages, such as German and English (e.g., Poarch & van Hell, 2012; Schröter & Schroeder, 2016). Still, Dutch and Greek are related (as both are Indo-European languages) and share a certain number of cognates, which may affect the extent to which cognate effects occur. Indeed, Koutamanis et al. (2024) found that language distance can influence the strength (but not necessarily the occurrence) of cognate effects. Future studies may further investigate cognate effects in languages which are related to each other to differing degrees.

Another limitation of this study is that it cannot distinguish the general effects of modality (comprehension vs. production) from the effects of specific task demands. That is, as we included only one comprehension task and one production task and these involved quite different demands, it is not clear whether our findings for comprehension and production generalize to all comprehension and production tasks, respectively, or whether they may differ between tasks in the same modality. Future studies should include multiple cognate comprehension or production tasks which place different demands on the language user to be able to tease apart the effects of modality in general from the effects of specific tasks.

Altogether, our findings show that the interplay between co-activation in the bilingual child's lexicon and task and/or modality is a promising avenue for further research. Future (replication) studies with larger samples, possibly through international collaborations, and/or more controlled lab settings, are needed to reach a more detailed understanding of the interplay between item (e.g., cognate) effects, dominance effects, context effects, modality effects, and task effects in the simultaneous bilingual child's lexicon.

Conclusion

The present findings support models of an integrated bilingual lexicon with language-nonselective access in a similar way to what has been found for bilingual adults and in line with an emerging body of evidence with bilingual children. The present study therefore builds on evidence from earlier toddler, child, and adult studies, suggesting that simultaneous and sequential bilinguals do not have qualitatively different lexicons and showing that bilinguals have an integrated lexicon at multiple—and possibly all—stages of development. In such a lexicon, activation resonates between shared (sub-lexical) form and meaning representations, resulting in cognate effects in both comprehension and production.

The present study is one of the few child studies looking into such effects in simultaneous bilingual children speaking less closely related languages, testing for cognate effects in auditory comprehension, and including both cognate comprehension and production. Our results suggest that, similar to what has been found for adults, the manifestation of cognate effects is task-sensitive, that is, modality (comprehension vs. production) and/or specific task demands influence whether effects emerge in accuracy or reaction times and to what extent they are affected by dominance. Importantly, despite such differences, our results show that cognate effects emerge across tasks and across a range of individual children's language dominance, indicating that shared representations within the integrated bilingual lexicon are accessed during both word comprehension and production.

Replication package. Participant information, stimulus lists, data, and analysis scripts for this study can be retrieved from https://osf.io/k2xw6/.

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Competing interests. The authors declare none.

Notes

1 The Netherlands distinguishes universities of applied sciences, which offer higher professional education, and research universities, which traditionally offer more research-oriented education. Both are considered higher education.

2 This large-scale AoA database only includes Dutch words. Although using Greek translations does not account for phonological aspects that may affect word acquisition, semantic and cultural aspects are likely relatively well accounted for, as most children were growing up in the Netherlands.

3 Exact timing differed depending on participants' computer and Internet connection.

4 An anonymous reviewer suggested that smiley- and frowny-faced labels may be associated with positive and negative emotions, and this may have influenced our results. While further research is necessary to assess this possibility in more detail, we note that previous lexical decision studies with children have used similar labels (see e.g., Haebig et al., 2015; Hein & Kauschke, 2022; Quémart & Maillart, 2016). A meta-analysis by Jones and Brandt (2018) briefly discusses the use of smileys in the context of methodological variation, but it is not clear whether any emotional effect would be expected.

5 For two matched noncognates, the target word was changed post hoc. Because the intended target word was never produced, but many children used a synonym, the synonym was scored as correct. A third matched noncognate was swapped with a filler, because the picture was unclear to most children. These changes did not affect matching between cognates and matched noncognates.

6 The full dataset as well as the script for data exclusion are available on https://osf.io/k2xw6/.

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Appendix

Parameter estimates and significance tests of accuracy in the picture-naming task, with Language Context as a covariate.

	Accuracy			
Predictor	*B*	*SE*	*z*	*p*
(Intercept)	2.542	0.472	5.384	<.001
Cognate status	0.354	0.511	0.693	.488
Percentage of Dutch Exposure	−4.499	1.726	−2.607	.009
Language context	0.109	0.503	0.217	.828
Percentage of Dutch Exposure x Cognate status	2.087	1.578	1.323	.186

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