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Brief Report

Orthographic processing in balanced bilingual children: Cross-language evidence from cognates and false friends

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ABSTRACT

We investigated whether beginning bilingual readers activate orthographic as well as semantic representations in both of their languages while reading in one of them. Balanced bilingual third graders who were learning to read concurrently in German and English completed two lexical decision tasks, one in each language, including cognates, false friends, and matched control words. Results showed a processing advantage for cognates over controls in both languages, indicating that the facilitation effect is driven by the level of balanced language proficiency rather than by experience with print. Except for lower accuracy scores in German, false friends did not differ in their processing from controls, pointing to the presence of semantic-to-orthographic feedback already in the beginning of reading acquisition. Confirming assumptions by the bilingual interactive activation plus (BIA+) model as well as the revised hierarchical model (RHM), findings suggest that in their strategy to resolve orthographic ambiguity, balanced bilingual children are more comparable to bilingual adults than to child second-language (L2) learners.

Introduction

A large body of research on word recognition in bilinguals has shown that words that are orthographically identical across languages, so-called interlingual homographs, are processed differently

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compared to words that exist in one language only (e.g., Caramazza & Brones, 1979). Whereas cognates, which also share their meaning across languages, have repeatedly been found to facilitate lexical processing (e.g., Lemhöfer & Dijkstra, 2004), orthographically identical words that differ in meaning between languages, referred to as false friends, have been reported to cause null or even inhibitory effects (e.g., Dijkstra, Van Jaarsveld, & Ten Brinke, 1998). This has been taken as evidence that lexical access in bilinguals is language nonselective and based on an integrated lexicon, causing cross-language activation of orthographic as well as semantic representations during word recognition. The majority of findings, however, are based on data of balanced bilingual adults or individuals who differ in their proficiency between languages, such as second-language (L2) learners. Yet, little is known about the development of lexical access in balanced bilingual children and whether findings on cognates and false friends generalize to earlier stages of reading acquisition.

The bilingual interactive activation plus (BIA+) model (Dijkstra & Van Heuven, 2002) postulates that bilinguals have a single orthographic lexicon, which contains nodes for words in both languages that compete with one another for selection. The visual presentation of a word leads to the coactivation of orthographic and associated phonological representations in both languages, which in turn activate semantic representations and language nodes. Because activation can also flow backwards through this system, one way to account for the cognate facilitation effect is the involvement of semantic-to-orthographic feedback (Lemhöfer & Dijkstra, 2004). On this view, cognates are believed to have two orthographic entries that share a semantic representation. On simultaneous activation of the two orthographic entries, the activated semantic representation, in turn, sends feedback to the orthographic level and, thus, amplifies its activation. This way, in one of the two languages, the entry of a cognate will reach its activation threshold sooner than the entry of a noncognate. Orthographic entries of false friends, on the other hand, are connected to separate semantic representations. One possible explanation for them being recognized neither faster nor more accurately relative to controls is that their benefit in activation on the orthographic level is annulled or even reversed by the resulting competition of different semantics (Jared, Cormier, Levy, & Wade-Woolley, 2012).

It has been shown, however, that these effects depend on the level of language proficiency. Cross-language studies found cognate facilitation primarily in bilinguals' L2 (i.e., their less proficient language) but not in their first language (L1). Dijkstra and Van Heuven (2002) accounted for this finding by proposing a temporal delay of L2. Based on the assumption that frequently used words have a high resting level of activation, and that words with a high resting level need less input to become activated, it is argued that the reading of a word in (the more frequently used) L1 is activated faster than in (the less frequently used) L2. With respect to cross-language interference, the temporal delay hypothesis postulates that responses to L2 readings can be affected by the earlier available L1 readings but not vice versa. This view is in line with the revised hierarchical model (RHM; Kroll & Stewart, 1994), which assumes that bilingual memory organization consists of two independent lexicons (L1 and L2) and an integrated conceptual system (CS). Whereas L1 and L2 are lexically linked to each other, initially there is a direct connection only between CS and L1. Because the link between CS and L2 will first develop during L2 acquisition, learners need to derive meaning in L2 via their L1. With growing proficiency in L2, this dependency will diminish until eventually both links are equally strong. Accordingly, effects due to semantic-to-orthographic feedback should arise only in individuals who are proficient enough in their L2 to be affected by different semantics. Evidence confirming this theory was provided by van Hell and Dijkstra (2002) when conducting research on trilingual adults, who showed cognate facilitation in L1 if the proficiency in their weaker language(s) was relatively high. The authors concluded that a certain level of proficiency in the weaker language(s) is required for effects to become noticeable in an L1 context.

Yet, it is not known whether it is merely the level of language proficiency or also the amount of experience with print that drives interference effects in bilinguals. This, however, is of crucial importance for research with children, especially when focusing on effects that have been found only in adults so far. Most studies on word recognition in bilingual children focused on L2 learners, and only two of these studies used online tasks to explore the impact of interlingual homographs. Jared and colleagues (2012) asked third graders learning to read simultaneously in English (L1) and French (L2) to name cognates, false friends, and interlingual homophones. They found that children reading in their L2 made fewer errors naming cognates and interlingual homophones than controls but were less accurate in naming false friends. Interestingly, in children's L1, this inhibition for false friends was the only significant effect. Likewise, conducting a lexical decision task (LDT) with primary school students in Dutch (L1) and English (L2), Brenders, van Hell, and Dijkstra (2011) observed an advantage for cognate processing exclusively in students' L2 and only if presented without false friends. The authors explained the absence of cognate facilitation in connection with false friends in terms of a greater susceptibility to stimulus list composition in beginning learners of an L2. They proposed that L2 learners and more proficient bilinguals rely on different strategies to resolve orthographic ambiguity problems during word recognition. In accordance with the RHM, L2 learners may focus more on spelling than on meaning and, thus, become confused more easily. More proficient bilinguals, on the other hand, may pay more attention to meaning and make use of semantic coactivation to solve ambiguity, speeding up their responses. The question, however, is what the case would be for bilinguals who are already proficient speakers but still beginning readers. If language proficiency rather than experience with print is the crucial factor for strategy use, children who are equally proficient in both of their languages, unlike those learning an L2, should not differ from bilingual adults in their performance on cognates and false friends.

To the best of our knowledge, there is no study on the orthographic processing of interlingual homographs in balanced bilingual children. To fill this gap, we investigated beginning bilingual readers of German and English using both languages on a daily basis. We hypothesized that cognate facilitation would occur in both languages, which would serve as evidence that the cognate advantage arises as a function of the level and balance of language proficiency and irrespective of the amount of participants' experience with print. Second, assuming that high proficiency would lead to semantic coactivation in both languages, we expected that, in contrast to L2 learners, balanced bilingual children would show cognate facilitation despite being presented with false friends. This would indicate a strategy to solve lexical ambiguity that is similar to that of bilingual adults. Furthermore, if this strategy use was the same in both languages, the processing of cognates and false friends should not differ between German and English.

Method

Participants

To ensure that children had been exposed to print as equally as possible in both languages, participants were recruited from a bilingual school in Berlin in which the language of instruction was 50% German and 50% English. A total of 46 third graders (21 female, M_{age} = 7.65 years, SD = 0.48) participated in the study, which was conducted during regular school hours and comprised two sessions, each lasting 45 min. At the time of testing, children had received 2 years of formal reading instruction in each language.

In the first session, participants completed a questionnaire on their language background and social demographics. All children reported to use both languages equally on a daily basis and to have normal or corrected-to-normal vision. Whereas 27 children stated to have acquired both languages simultaneously from birth, 12 reported to have learnt German and 7 to have learnt English first. All of them, however, indicated to have acquired the respective other language very early in life, with the majority of them before the age of 3 years. Regarding the language they mostly spoke at home, 14 children reported to use both languages equally, whereas 18 indicated to speak more German and 14 to speak more English at home. Despite deviating language backgrounds, all children proved to be fluent speakers of German and English upon entering school, which was part of the admission requirement of the bilingual school.

We assessed nonverbal intelligence by administering the Culture Fair Test (CFT) 20-R (Weiß, 1998). Participants did not differ from the norm for monolinguals of the same age group (sample: M = 5.04, norm sample: M = 5.4, t < 1, p = .31). Receptive vocabulary was measured in German using the CFT 20-R Vocabulary Test (Weiß, 1998) and in English using the British Picture Vocabulary Scale (Dunn & Dunn, 2009). Both tests consisted of multiple-choice items that required participants to select the closest matching equivalent for a given target word. The mean percentiles were 30.0 (SD = 21.6) for German and 26.4 (SD = 20.9) for English. As is often reported for bilingual children's vocabulary knowledge

(Bialystok, Luk, Peets, & Yang, 2010), scores were lower than the monolingual norm. Yet, results were comparable in German and English ($t < 1$, $p = .42$), which indicated equal vocabulary knowledge in both languages. We also assessed children's word and pseudoword reading fluency in each language through computerized speed reading tests, which require participants to name single words and pseudowords as fast as possible. We used the Salzburger Lese- und Rechtschreibtest (SLRT; Moll & Landerl, 2010) in German and the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) in English. Unfortunately, the SLRT does not provide age- but only grade-corrected norms. So, given that the start of formal reading instruction in Germany differs from the United Kingdom, where children start schooling on average a year younger, we ensured chronological age by using grade 3 norms for the SLRT and grade 4 norms for the TOWRE. We also averaged over participants' word and pseudoword performance in each test to compensate for differences in stimuli characteristics between the languages. The comparison of mean percentiles in German ($M = 54.5$, $SD = 29.4$) and English ($M = 53.4$, $SD = 24.1$) indicated equal reading fluency in both languages ($t < 1$, $p = .85$).

Stimulus materials

We selected 64 interlingual homographs (targets) that ranged in length between 3 and 8 letters and had a Levenshtein distance between languages of no more than 2 ($M = 0.3$, $SD = 0.6$); that is, their spelling in German and English differed by a maximum of two letters or their positions (e.g., *Adresse* vs. address). Half of the targets were identical in meaning (cognates), and half of them differed in meaning between German and English (false friends). Taking into account language-dependent differences in word frequency distributions, cognates and false friends were matched as closely as possible for length and normalized lemma frequency per million. Frequency measures were taken from the childLex database for German (Schroeder, Würzner, Heister, Geyken, & Kliegl, 2014) and the TASA (Touchstone Applied Science Associates) corpus for English (Zeno, Ivens, Millard, & Duvvuri, 1995), both solely based on children's literature. In each language, targets were matched with 64 controls on length and frequency (all $ts < 1$). All item characteristics are given in Table 1. To keep the stimulus material as homogeneous as possible across language conditions, all control words were translation equivalents. For a complete list of targets and controls, see the Appendix.

Pseudowords were constructed from targets for each language separately using the multilingual pseudoword generator Wuggy (Keuleers & Brysbaert, 2010), which controlled for language-specific characteristics such as sub-syllabic structure and transition frequencies. For each language, targets were randomly assigned to two lists. Each list consisted of 16 cognates and 16 false friends plus their corresponding controls and noncorresponding pseudowords. Within languages, targets did not differ

Table 1
Mean lengths and frequency characteristics for words.

	Cognates	False friends
Length		
Targets	4.50 (0.92)	4.38 (1.29)
German controls	4.53 (0.92)	4.44 (1.16)
	$t(62) = 0.14$, $p = .89$	$t(62) = 0.20$, $p = .84$
English controls	4.59 (1.39)	4.72 (1.33)
	$t(62) = 0.32$, $p = .75$	$t(62) = 1.05$, $p = .30$
German frequency		
Targets	36.28 (48.33)	49.66 (81.02)
German controls	34.66 (44.58)	41.78 (66.27)
	$t(62) = -0.14$, $p = .89$	$t(62) = -0.43$, $p = .67$
English frequency		
Targets	129.28 (135.87)	66.79 (121.92)
English controls	129.91 (135.04)	51.75 (65.29)
	$t(62) = 0.02$, $p = .99$	$t(62) = -0.61$, $p = .54$

Note. Standard deviations are in parentheses.

across lists in length and frequency (all *t*s < 1). List assignment to the two languages was counterbalanced between participants.

Procedure

Participants performed two LDTs: one in German and one in English. The experiment was conducted using IBM-compatible laptops that recorded reaction times (RTs) automatically while participants used the keyboard to respond. Items were presented in Courier New font on a 15-inch TFT screen in white 28-point letters on a black background. Children were instructed to decide whether or not a presented letter string formed a correct word in German (German LDT) or in English (English LDT), and asked to perform as quickly and accurately as possible. Following language-specific spelling conventions, nouns were capitalized in German but not in English. To further boost the level of activation of the target language, the language of instruction was English during the English LDT and was changed to German for the German LDT.

For each language, participants completed a practice block with 4 trials. Words and pseudowords were randomly assigned to three blocks of 46 items each. Each trial began with the presentation of a fixation cross for 500 ms, followed by another 500 ms until the item appeared, which remained on screen until a response was given. The order of tasks was counterbalanced across participants.

Results

Accuracy scores and RTs were analyzed for words only using mixed-effects models (Baayen, Davidson, & Bates, 2008) as implemented in the *lme4* package (Version 1.0–4; Bates, Maechler, Bolker, & Walker, 2013) in *R*. RT data were logtransformed and analyzed using a linear model, whereas accuracy data were logit transformed and analyzed using a generalized linear model with a binomial link function. Items and participants served as random effects, whereas Language (German vs. English), Word Status (targets vs. controls), and Target Type (cognates vs. false friends) were modeled as fixed effects. Effect contrasts were estimated using the general linear hypotheses test generated with the *multcomp* package (Hothorn, Bretz, Westfall, Heiberger, & Schuetzenmeister, 2014).

As usually observed for word recognition in more transparent orthographies, accuracy was higher for German than for English (German: $M = 92.1\%$, $SE = 1.2\%$; English: $M = 86.7$, $SE = 1.9\%$), $\chi^2(1) = 14.1$, $p < .001$. For the RT analysis, incorrect trials and trials that deviated more than 2.5 standard deviations from either the participant or item mean were discarded, accounting in sum for 18% of the raw data. Overall, words were processed faster in German than in English (German: $M = 1470$ ms, $SE = 120$; English: $M = 1576$ ms, $SE = 121$), $\chi^2(1) = 9.6$, $p < .01$.

Table 2 contains the model mean results for cognates, false friends, and controls in both languages. We calculated two contrasts within each language to estimate the effect of Word Status for both

Table 2
Mean accuracy and RTs for words in German and English.

	Accuracy (% correct)		Reaction time (ms)	
	Cognates	False friends	Cognates	False friends
German				
Targets	95 (1.3)	85 (3.1)	1184 (76.3)	1288 (83.2)
Controls	93 (1.7)	91 (2.1)	1281 (82.6)	1304 (84.1)
Effect	2	−6*	−97*	−16
English				
Targets	95 (1.4)	79 (4.0)	1226 (79.1)	1403 (90.9)
Controls	89 (2.5)	78 (4.1)	1344 (86.9)	1411 (91.6)
Effect	6**	1	−118*	−8

Note. Standard errors are in parentheses.
* $p < .05$.
** $p < .01$.

Target Types as well as two contrasts for the interaction between Language and Word Status for each Target Type, that is, German cognates/false friends over controls versus English cognates/false friends over controls. In the following, their effects are presented separately.

Cognates

Although in German there was a tendency for cognates to be processed more accurately than controls, post hoc contrasts did not show an effect for accuracy ($z = 1.24$, $p = .22$). For RTs, however, there was evidence for cognate facilitation ($z = -2.00$, $p < .05$). In English, accuracy scores ($z = 2.69$, $p < .01$) as well as RTs ($z = -2.32$, $p < .05$) revealed a processing advantage for cognates over controls. The Word Status × Language interaction did not reach significance for either accuracy or RTs, indicating that cognates were processed similarly in German and English.

False friends

In German, post hoc contrasts showed inhibition for false friends for accuracy ($z = -2.00$, $p < .05$) but not for RTs ($z = -0.31$, $p = .76$). In English, neither accuracy scores ($z = 0.13$, $p = .90$) nor RTs ($z = -0.15$, $p = .88$) revealed processing differences between false friends and controls. There was no interaction for Word Status × Language for either accuracy or RTs, suggesting no difference between German and English in the processing of false friends.

Discussion

The current study was conducted with two aims in mind. By comparing cognate processing in both languages of balanced bilingual children, we wanted to investigate whether facilitation occurs as a function of equal language proficiency and irrespective of experience with print. Upon including false friends in the stimulus material, we further aimed to study the presence and use of semantic-to-orthographic feedback during the early stages of the bilingual lexicon. Overall, results provide clear evidence for the cross-language activation of orthographic as well as semantic representations during word recognition in beginning bilingual readers, confirming assumptions by the BIA+ model on an integrated lexicon. In contrast to previous studies on bilingual children, we could show cognate facilitation in both languages when controlling for equally high proficiency. Given that a cognate advantage for word recognition in an L1 context has been found only for fluent trilingual adults so far (van Hell & Dijkstra, 2002), this serves as evidence that the cognate effect depends primarily on the level and balance of language proficiency and occurs irrespective of the amount of participants' experience with print. This finding indicates that from the very beginning of reading acquisition, lexical access in balanced bilinguals is highly language non-selective in nature.

The lack of facilitation for false friends points to the presence of semantic-to-orthographic feedback during the early stages of the bilingual lexicon. We concur with the view of Jared and colleagues (2012) that a potential reason for the null effect for false friends lies in their two competing semantic entries in the mental lexicon. Similar to cognates, the form overlap of false friends first leads to an activation advantage on the orthographic level. In contrast to cognates, however, this activation benefit is then annulled by the activation disadvantage on the semantic level. Because this was the case in both languages, we further interpreted our findings in line with the RHM, proposing that semantic co-activation occurred in German as well as in English because in both languages participants' links to the conceptual system were equally strong. Moreover, the fact that there was an effect for cognates despite their presentation with false friends shows that participants were able to benefit from this semantic coactivation rather than becoming confused. In comparison with the L2 learners investigated by Brenders and colleagues (2011), balanced bilingual children seem to be less susceptible to stimulus list composition, resembling adult bilinguals in their performance on lexical decision tasks. Their strategy to deal with the lexical ambiguity of cognates generalized across languages, serving as further evidence that balanced bilinguals rely on a single integrated word recognition system when learning to read.

Despite equal proficiency and exposure to print in both languages, children recognized words overall faster and more accurately in German than in English. One way to explain this finding would be the fact that participants were recruited in a German-speaking environment and that, despite reporting equal use of both languages on a daily basis, they were slightly more exposed to German. Another explanation would be in line with the orthographic depth hypothesis (Katz & Frost, 1992). Accordingly, reading acquisition would be easier in orthographically shallow German than in opaque English because of its more consistent mapping between letters and sounds. Both approaches would explain the processing advantage for German, and could further be the reason why accuracy scores for false friends showed an inhibition effect in German but not in English. In accordance with findings by Jared and colleagues (2012), who also observed inhibition for false friends solely in children's L1, we concluded that an effect for false friends arises only when their processing is fast. Assuming that the disadvantage for false friends is due to semantic competition, and that lexical access includes semantic processing, an inhibition effect would occur the more likely the faster the word is lexically accessed. The speed of lexical access, in turn, increases with reading proficiency. Although there were no significant differences between languages in children's vocabulary, reading fluency, and exposure to print, German words could have benefited from their more transparent letter–sound mapping or their higher subjective frequency due to German being the dominant language environment. Lastly, we also need to take into account the limitations of interlanguage comparisons, which are a great challenge for every cross-linguistic study. Especially when using tests that are sensitive to reading age or linguistic characteristics, which naturally differ between different languages, performance comparability needs to be treated with caution.

In sum, we could provide evidence that balanced bilingual children show a facilitation effect for cognates in both of their languages, solving lexical ambiguity by making use of semantic coactivation even when being presented with homographs that both share and differ in semantics. Our results on orthographic processing after controlling for participants' proficiency in both languages hint at why previous studies did not find cognate facilitation in L1 contexts. Because the majority of research on bilingualism is carried out on individuals who have a dominant language, data are likely to reveal an effect of L1 on L2 processing but not the other way around. It also seems likely that the effect of stimulus list composition on cognate processing diminishes with increasing proficiency in participants' weaker language. Further research is needed to verify the impact of balanced bilingualism on orthographic processing by replicating the experiment with different languages as well as with participants who have more (or even less) experience with print. Although bilingual language proficiency is rarely equally balanced in nature, the data we have provided are essential for the development of a word recognition model that can account for bilingual reading acquisition. Particularly in light of the increasing number of children learning to read concurrently in two languages, this seems to be a notable goal for future research.

Appendix

Targets and their controls for LDTs in both languages.

German LDT

Cognates

Adresse, Arm, Ball, Banane, Bank, Bus, Butter, Film, Form, Gold, Hunger, Kaktus, Kamel, Knie, Land, Musik, Name, Nase, Nest, Pause, Plan, Post, Ring, Rose, Salz, Sand, Sport, Start, Sturm, Tiger, Wind, Wolf

Cognate controls

Musiker, Fuß, Papa, Schere, Haut, Rad, Mittag, März, Jahr, Bahn, Diener, Rakete, Bohne, Grad, Boden, Kampf, Hund, Hals, Tüte, Decke, Dame, Hemd, Bein, Löwe, Dach, Loch, Nebel, Vogel, Monat, Ziege, Meer, Eule

False friends

Angel, Art, Bad, Boot, Brand, Brief, Direktor, Dose, Fabrik, fast, Gas, Gift, hell, Herd, Hose, Hut, Kind, Lack, Mist, Mode, Note, Rat, Rock, sensibel, Stapel, Stern, Stock, Strand, Tag, Ton, Wall,

(*continued on next page*)

Wand

False friend controls

Welpe, Seite, Eis, Rand, Bauch, Glück, Publikum, Pilz, Ritter, weit, Uhu, Käse, böse, Esel, Kino, Hof, Geld, Affe, Möwe, Witz, Lied, Ohr, Mond, flüssig, Ferien, Fahne, Waffe, Löffel, Bild, Tor, Laub, Wahl

English LDT

Cognates

address, arm, ball, banana, bank, bus, butter, film, form, gold, hunger, cactus, camel, knee, land, music, name, nose, nest, pause, plan, post, ring, rose, salt, sand, sport, start, storm, tiger, wind, wolf

Cognate controls

musician, foot, dad, scissors, skin, wheel, noon, march, year, train, servant, rocket, bean, degree, floor, fight, dog, neck, bag, ceiling, lady, shirt, leg, lion, roof, hole, fog, bird, month, goat, sea, hate

False friends

angel, art, bad, boot, brand, brief, director, dose, fabric, fast, gas, gift, hell, herd, hose, hut, kind, lack, mist, mode, note, rat, rock, sensible, staple, stern, stock, strand, tag, ton, wall, wand

False friend controls

pup, page, ice, border, belly, luck, audience, fungus, knight, wide, owl, cheese, evil, mule, cinema, court, cash, ape, gull, pun, song, ear, moon, liquid, holiday, flag, weapon, spoon, image, gate, leaves, choice

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