CHAPTER 3

Can learning explain cognate effects in bilingual comprehension and production?

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Most theories of bilingual word recognition and production assume parallel, on-line activation of both languages, even in one-language contexts. A considerable amount of the evidence for parallel activation comes from the study of translation equivalents with similar form and meaning across two languages (cognates), which bilinguals process differently to translation equivalents with no form similarity across languages (non-cognates). The on-line account has been queried by Costa et al. (2017), who suggest that the cognate effect can be explained by learning: on-line cross-talk during second language acquisition would lead to different representations for cognates compared to non-cognates in the bilingual mental lexicon. In this chapter, we focus on these two hypothesised origins of the cognate effect and consider the extent to which cognate effects can be explained by learning and on-line activation.

How do a bilingual's languages affect each other?

Bilinguals often find themselves in situations where only one of their languages is understood. In these one-language contexts, to what extent does their other (non-target) language affect processing in the (target) language in use? A considerable amount of relevant research on this question in bilingual language processing has focused on lexical access – that is, how word representations in the bilingual mental lexicon are accessed. The general orthodoxy is that lexical representations across languages are activated in parallel, meaning that activation is not constrained to only one language when a word's meaning is accessed. This view, termed the language non-selective hypothesis (Beauvillain & Grainger, 1987), is captured in theoretical models of bilingual language production (Costa et al., 1999; Dijkstra et al., 2019) and comprehension (Dijkstra et al., 2019; Dijkstra & van Heuven, 1998, 2002). A contrasting view is the language selective hypothesis (Gerard & Scarborough, 1989), in which activation of lexical candidates is restricted to the target language.

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One way that has been used to test how a bilingual's languages affect each other is to look at the processing of words that have similar form and meaning in the two languages, namely cognates. Cognates are translation equivalents that also overlap considerably in written and/or spoken form across two languages (e.g., *hospital*, which has the same spelling and meaning in Spanish and English). The overlap in form may be partial, as with non-identical cognates (e.g., the Spanish word *gato* is cognate with English *cat*), or complete, as with identical cognates (e.g., *hospital* above). If bilinguals process cognates differently to control words (matched on frequency, length, etc.) that do not share form with their translation equivalents (such as Spanish *mesa* – 'table'), it suggests that the two languages of a bilingual speaker influence each other in some way. But the exact nature of such influences, and how they contribute to the patterns observed in cognate processing, can be difficult to identify.

Below, we consider two hypotheses about the source of activation of cognates relative to non-cognates.[1] The first, which is widely accepted and assumes language non-selectivity, involves the on-line co-activation of representations from both languages in the bilingual mental lexicon. In other words, when a cognate word is processed, parts of its representations in both languages become active. The second hypothesis about the source of cognate activation is due to the manner in which they are learned and subsequently represented in the mental lexicon. This hypothesis assumes that cognates are represented differently from translation equivalents that do not overlap in form and is compatible with both selectivity and non-selectivity. In other words, cognate words are represented differently because their shared form and meaning cause them to be learned differently. If so, then cognates are likely to be processed differently to cross-linguistically unrelated words. The present chapter discusses cognate processing in a second language (L2) in light of these two hypotheses, on-line activation and learning, to better understand the role each of them plays in accounting for cognate effects.

We first review theoretical assumptions and models of bilingual lexical processing and how they explain consistent findings of a cognate facilitation effect (e.g., Costa et al., 2000) (Section 2). These findings have shown that bilinguals process cognates faster than non-cognates, and this processing difference is not observed in monolinguals. This facilitated processing is standardly explained by on-line activation. We then discuss an account explaining cognate effects in terms of how cognates are learned and represented. Next, we consider the predictions of a learning account for cognate processing in various one-language tasks (i.e.,

1. By non-cognates we mean translation equivalents that are unrelated in form. We do not focus on special cases such as false friends (interlingual homographs/homophones), that is, words that are related in form but unrelated in meaning.

in this context, tasks where only the L2 is used) in comprehension and production (Section 3). The predictions are discussed along with empirical findings of cognate effects to assess the extent to which these findings can be explained by learning. Based on the evidence we review, we argue that cognate effects are consistent with a learning account, but also with an on-line activation account and that the findings from cognate processing are not sufficient to distinguish between the accounts.

Explanations of the cognate facilitation effect

Studies of L2 lexical production and comprehension consistently find that processing is facilitated for cognates relative to words that are unrelated to their translation in form. This effect holds for different behavioural tasks, such as picture naming (e.g., Costa et al., 2000), lexical decision (e.g., Dijkstra et al., 1999), priming (de Groot & Nas, 1991), and reading (e.g., Duyck et al., 2007; Libben & Titone, 2009). The effect has also been found in studies using neurophysiological methods, such as ERP (Strijkers et al., 2010; Midgley et al., 2011). The degree of cross-linguistic form overlap correlates with the size of the effect. For instance, greater orthographic overlap leads to larger facilitation effects in general, whereas greater phonological overlap leads to larger facilitation only for (orthographically) identical cognates (Dijkstra et al., 2010). The facilitation effect is also modulated by language proficiency: for instance, Schwartz and Kroll (2006) found that bilinguals with a higher L2 proficiency elicited smaller cognate facilitation. Below, we first review how cognate effects have been interpreted in terms of on-line co-activation of two languages in models of bilingual lexical processing. We then discuss how the effects can be explained by learning, based on an account of cross-linguistic effects by Costa et al. (2017) and use this to consider the extent to which empirical data supports this account. Lastly, we discuss the implications of our theoretical analysis for further research on cognate processing.

On-line parallel activation

Many researchers assume that cognate effects are an indicator of the on-line, simultaneous activation of lexical representations across languages. The rationale is that the activation of cognate words originates from two sources rather than one, unlike non-cognates, thereby aiding the process of lexical retrieval. As an example, consider the Spanish-Catalan cognate gato (Catalan: *gat* – 'cat') used by Costa et al. (2000) to explain the activation process in production: If the cognate is produced in Spanish, both the Spanish and Catalan lexical representations are activated simultaneously, starting at the conceptual level. When this activation spreads to the phonological level, the phonemes /g/, /a/, and /t/ receive activation from two sources (i.e., the lexical representations in the two languages), which eases phonemic selection. In the case of non-cognate production, for example *mesa* – 'table' in Spanish (Catalan: *taula*), the lack of overlap between phonological segments leads to smaller activation of the phonemes and by consequence, no facilitation.

In reading comprehension, cognate facilitation has been interpreted as an 'orthographic-semantic priming effect' (Dijkstra et al., 2010, p. 286). Here, the idea is that the overlapping representations of a cognate's orthography and semantics are co-activated. For instance, in Dutch-English bilinguals, seeing a cognate such as *tomato* in English activates both its English and Dutch orthographic representations *tomato* and *tomaat*, respectively. This activation flows from the two sources at the orthographic level to the semantic level and feeds back to the orthographic level, resulting in a higher level of activation of a cognate compared to non-cognates. This account is supported by the experimental results of Dijkstra and colleagues: they found a strong increase in cognate facilitation (measured by lexical decision times) going from orthographically near-identical to identical cognates.

This idea may be better conveyed in terms of a quantitative model where these assumptions are implemented. MULTILINK is a recent, localist-connectionist computational cognitive model of bilingual (written) word recognition and production proposed by Dijkstra et al. (2019). It integrates the assumptions of two models: the Bilingual Interactive Activation model (BIA/BIA+: Dijkstra & Van Heuven, 1998; Van Heuven et al., 1998; Dijkstra & Van Heuven, 2002), a computational model of bilingual word recognition, and the Revised Hierarchical Model (RHM: Kroll & Stewart, 1994), a theoretical model of lexical and conceptual representation in bilingual memory. Because MULTILINK goes beyond these earlier models with regards to simulations of cognate processing, we sketch out its assumptions below.

MULTILINK assumes language non-selective activation of words stored in an integrated lexicon, meaning that the representations of word candidates relating to an input word are co-activated and compete across languages. Its standard architecture is shown in Figure 1. An input word (indicated by the blue underscore at the bottom of Figure 1) activates orthographic representations (green underscores in Figure 1) in the model's lexicon to an extent that depends on their usage frequencies and orthographic overlap (measured by normalised Levenshtein distance) between the input and stored word representations. Phonological representations are activated directly (via orthography) and indirectly (via semantics). In the case of Dutch-English bilingual processing, if a cognate such as *tomato* is presented as input to the model, co-activation of the orthographic representations *tomato* and *tomaat* occurs. They both activate their shared semantic representation, and then the semantic and orthographic representations together activate the phonological representations they are linked to. Compared to a non-cognate input word, the co-activation leads to a quicker increase in activation of the concept, which in turn results in earlier and stronger feedback to the orthographic (recognition) or phonological (production) output representations. According to MULTILINK, resonance between the representations at the orthographic and semantic levels is the driving force of cognate facilitation. The results of Dijkstra and colleagues' simulations correlate with findings from experimental studies that use Dutch-English L2 lexical decision tasks (Dijkstra et al., 2010; Vanlangendonck et al., 2020) and word naming (Dijkstra et al., 2019). Thus, MULTILINK predicts that cognates would elicit shorter reaction times (RTs) than non-cognates.

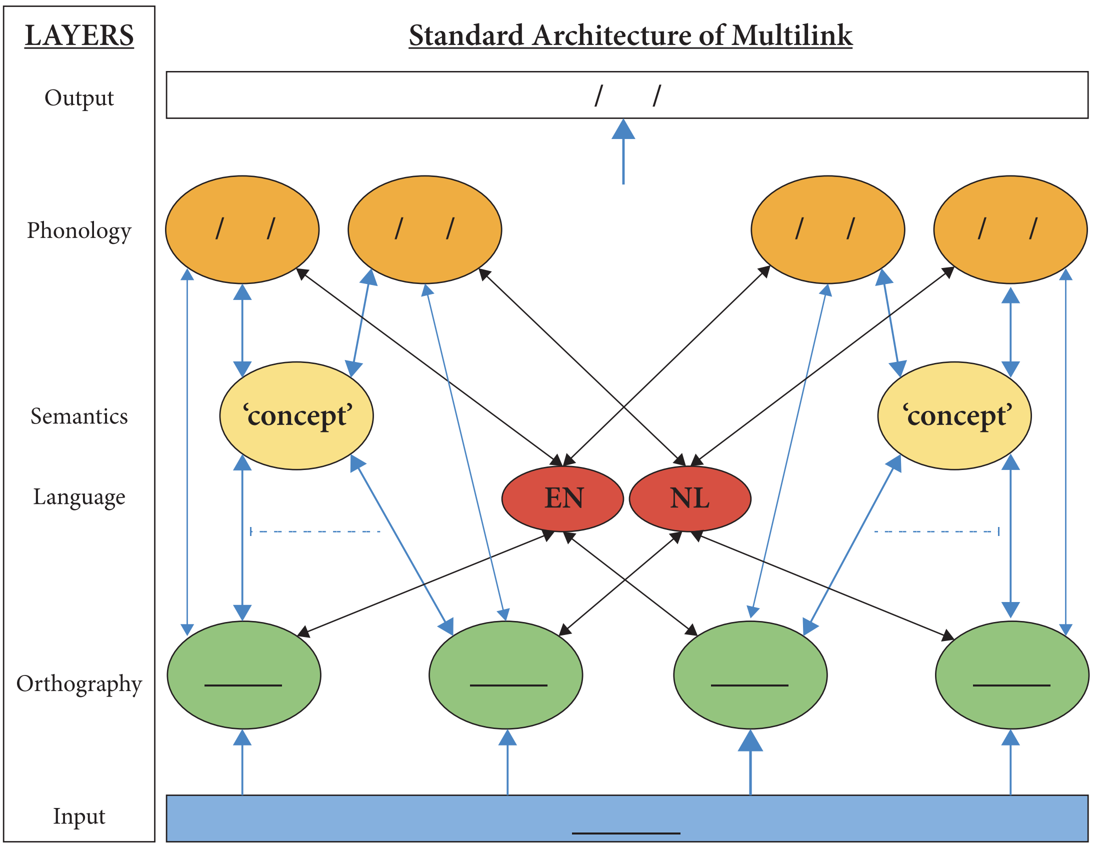

Figure 1. Architecture of the symbolic lexical network of the MULTILINK model. All activation flows bidirectionally as it is an interactive model. The output is dependent on task. Reprinted from Dijkstra et al. (2019)

Cognate effects in light of learning

The on-line accounts of Costa and his colleagues (Costa & Caramazza, 1999; Costa et al., 1999, 2000) and Dijkstra et al. (2010, 2019) have provided a fairly orthodox explanation of cognate effects in production and comprehension. Other proposals have relied less on simultaneous, on-line activation and have considered the nature of cognate representations as the driving mechanism of the effects instead. Below, we sketch out one account of how the representations of cognates in the mental lexicon may lead to their facilitated processing based on a proposal from Costa, Pannunzi, Deco, and Pickering (2017).

The idea that the way cognates are learned may contribute to their facilitated processing has been suggested by several authors, such as Costa et al. (2006, p. 143), de Groot (2010, p. 247) and Dijkstra et al. (2012, p. 69). Costa et al. (2017) proposed a model of how the process of learning a second language may explain findings attributed to on-line parallel activation of lexical entries across two languages. Their hypothesis accounts for how the L2 lexical structure emerges in relation to various observations of cross-linguistic effects. For instance, in an ERP experiment by Thierry and Wu (2007), Chinese-English bilingual participants performed semantic relatedness judgments on semantically related and unrelated word pairs (e.g., *train* and *ham*) whose translations were either form-related in Chinese (*huo che* and *huo tui*, respectively) or not form-related. A reduced N400 amplitude was found for the form-related word pairs compared to those words with no relationship in Chinese. This reduction in the N400 amplitude applied irrespective of semantic relatedness. An English monolingual control group did not show this effect, whereas a monolingual Chinese control group showed a reduced amplitude (in addition to behavioural priming effects as measured by accuracy and RTs, which was not observed in the bilingual group) for form-related pairs of Chinese words.

Thierry and Wu (2007) interpreted their findings as a result of on-line activation of translation equivalents during processing. In contrast, the explanation of Costa et al. (2017) is that, during learning, the native language structure is carried over to the emerging structure of the L2 because of on-line co-activation of the languages. Thierry and Wu's results could thus be explained by the proposal that when learning the English word *train*, a Chinese learner activates its L1 translation *huo che* through semantics, which activates its form-related neighbour *huo tui* ('ham'). This in turn activates the L2 representation *ham*. Because *train* activates *ham* in this manner, a connection is developed between them. The resulting L2 structure thus has 'traces' of the L1. With increasing proficiency and automaticity, parallel activation is gradually restricted. When sufficient proficiency is reached, the co-activation of native language representations may cease, but the connection between *train* and *ham* remains in the L2 English mental lexicon.

Oppenheim et al. (2018) criticised some aspects of the learning account in a response to Costa et al. (2017). They queried whether the link between form-related (and semantically unrelated) L1 words is likely to survive when new (semantic) associations between words that co-occur in the L2 are encountered. For instance, they asked what happens when Chinese-English bilinguals learn valid and useful within-L2 associations, such as associating *ham* with *cheese*. They argued that the differences in the strength of the connections between co-activated words should be reflected in the magnitude of the observed effect of (L1) form overlap. Of course, Costa et al. do not agree with this proposal – in their account, strong connections are caused by both the within-language relationships and by the relationship that has been established as a consequence of between-language transfer. Note also that the model of Costa et al. provides just one possible learning-based account of Thierry and Wu's results. For example, it is also possible that co-activation persists in proficient bilinguals, but that it occurs only in two-language contexts. Alternatively, co-activation might always occur, but it is too limited or too slow to explain Thierry and Wu's findings.

The learning account of Costa et al. (2017) assumes two mechanisms for word learning in a second language: Phonological (or orthographic) forms are linked to semantic concepts via spreading activation (i.e., activation spreads between related representations) and Hebbian learning (i.e., representations that are activated together develop a connection). These mechanisms contribute to the inheritance of the L1 organisation of lexical items in the emerging L2 lexicon. When accounting for cognate facilitation as a learning effect, it is of course necessary to assume that activation flows between languages during learning, just as it continues to do in the on-line activation account. In other words, co-activation of words and their translations occurs during learning. But once a sufficiently high level of proficiency is attained, non-target language representations cease to be activated. Consequently, this leads to different representations for cognates than non-cognates in bilingual lexical memory. The representations of cognate words are "enhanced" such that they are more accessible than non-cognates, which is why their processing is (typically) easier and faster. If this hypothesis is correct, it means that a cognate word is represented similarly to a higher-frequency word. That is, it has a stronger representation and therefore requires less evidence to reach a threshold for identification (Morton, 1979). To put it differently, in order to successfully recognise or produce a cognate word, its representations require less activation compared to non-cognates. Crucially, on-line activation between L1 and L2 occurs during learning, but may be shut off after a sufficient proficiency is attained – either completely, with no co-activation at all, or partly, such that co-activation is restricted, for instance, to very early (sub-lexical) stages of word recognition (a 'language-independent encoding process prior to language-specific lexical access'; Gerard & Scarborough, 1989, p. 312).

Studies investigating the acquisition of cognate words are consistent with this account, as cognate words have been found to be easier to learn and less prone to be forgotten (de Groot & Keijzer, 2000; Lotto & de Groot, 1998; Tonzar et al., 2009; de Vos et al., 2019). For example, de Groot and Keijzer (2000) asked experienced L2 learners to learn made-up translations of L1 words in a new pseudo-language. Testing participants one week after training, they found that these pseudo-cognates (with 40–75% overlap with the paired L1 word) are easier to learn and less susceptible to being forgotten than non-cognates (with no overlap). Similar results have been found up to six months after training with German-Dutch cognates (de Vos et al., 2019). These findings suggest that the strengths of representation may differ for cognates vs. non-cognates, at least early in L2 acquisition. Their findings suggest that processing differences between cognates and non-cognates may be due to learning. Of course, the ease of learning cognates might reflect on-line activation during the initial stages of acquisition, which is compatible with the on-line activation account.

As an interim summary, the main differences between the two accounts are the following. An on-line account explains cognate effects in terms of activation as a cognate is processed. In contrast, a learning account explains them in terms of the representation of cognate words in the mental lexicon. In the latter case, cognate facilitation occurs because less activation is required from the input for successful recognition of a cognate, compared to non-cognates. Of course, a hybrid account is also possible, with cognate effects being due to a combination of on-line activation and learning.

A theoretical review of cognate effects in bilingual processing

We now review evidence of cognate effects, explaining the results in terms of the two accounts discussed above. We argue that both accounts are able to interpret the empirical findings, and the research carried out so far on cognate processing does not allow us to distinguish between the two accounts. The effects seen in cognate processing are influenced by many factors, such as the presence of a sentence context and the predictability of a cognate, the cognate's word class, the degree of form overlap between cognates, and the L2 proficiency of the bilingual. We consider each of these and review studies on bilingual comprehension and production separately below. Our focus is on tasks that do not require overt translation, or where the stimuli are not mixed between L1 and L2, as such tasks would induce a dual-language mode, in which different patterns of word activation may be observed overall (Wu & Thierry, 2010).

Cognate processing in isolation

In the learning account, a cognate word would in general behave the way a higher-frequency word does in monolingual speakers, because of its enhanced representation caused by learning (Costa & Pickering, 2019). As such, for cognate words processed in isolation (without a sentence context), the predictions are that both recognition and production times are facilitated compared to matched non-cognate control words. This difference between cognate and non-cognate processing should not be observed in monolinguals. If the hypothesis is correct, we expect that cognates (vs. non-cognates) should show the same patterns as have been observed for higher-frequency (vs. lower-frequency) words, for example relating to the time-course of processing. The cognate effect should appear early in processing, for instance, on first fixation and first pass durations in eye-tracking, and as early as 140 ms after stimulus onset in an ERP study (Sereno et al., 1998). On this account, it is not due to on-line effects but due to the distinctive properties of cognate words enabling them to develop stronger representations compared to non-cognates in memory during learning. Note that the on-line account also predicts that cognate processing is facilitated relative to non-cognates. However, in this case the facilitation is caused by on-line activation rather than higher resting level of activation, and in this case, it is unclear whether the effect would be similar to a frequency effect.

Comprehension

Visual word recognition

It is consistently found that bilinguals make faster lexical decisions for cognates than non-cognates: Using highly fluent Dutch-English bilinguals, Dijkstra et al. (1998) found significantly faster RTs for (orthographically) identical cognates compared to control words (a 25 ms effect). Similar results have been obtained with identical French-English cognates (Peeters et al., 2013) and with phonologically similar different-script Japanese-English cognates (Miwa et al., 2014). Dijkstra and colleagues interpret their findings as evidence of on-line activation of the cognate form in the non-target language, which combines with activation of the cognate form in the target language to increase the activation of the cognate's semantic representation. They attribute the cognate effect to the higher activation of the cognates' partially shared semantic representation. In other words, both the activated target and non-target orthographic representations of the cognate contribute to the activation of its meaning. The authors further hypothesise that this convergent activation at the semantic level sends strong feedback to the orthographic level. They argue that to properly evaluate hypotheses about language selectivity and non-selectivity in lexical access, levels of representation require a distinction between form (orthography) and content (semantics). According to the authors, lexical access is non-selective at both these levels. The distinction between form and content is useful in demonstrating the differences between on-line accounts and the learning account. The latter is compatible with the assumption that lexical access is language-selective throughout or is non-selective at the early stages of processing, possibly only at the form level. The facilitation observed in the lexical decision experiments discussed above could be due to the higher activation of cognates than non-cognates and would thus be compatible with the learning account as well as with the on-line account.

Interestingly, further studies have found that the magnitude of cognate effects is larger for identical cognates than non-identical cognates (Dijkstra et al., 1999; Duyck et al., 2007). In L2 English lexical decision, Dijkstra et al. (2010, Experiment 1) found that RTs decreased with increased orthographic similarity between a cognate and its translation. The effect was largest for identical cognates, which also benefited from phonological similarity with their translation equivalents. The authors' explanation is that identical cognates elicit the largest co-activation and that the two representations of non-identical cognates inhibit each other, as seen by the reduction in facilitation when form overlap decreases. From a learning perspective, the smaller facilitation for non-identical cognates could be explained by the idea that the amount of cross-talk between languages during L2 word acquisition may vary depending on the degree of form overlap. Non-identical cognates may thus show a smaller effect because their cross-linguistic relationship is less salient than the relationship of identical cognates, leading them to be learnt less well.

Cognate effects have also been found when the relationship across two languages is not so salient. For example, cognates across Arabic and Hebrew are written differently because of their markedly different orthographies, although they still overlap in phonology. Degani et al. (2018) used such words to explore whether non-selective language co-activation occurs across orthographies. In a one-language semantic priming study, Arabic-Hebrew bilinguals judged whether two visually presented words in their L2 Hebrew were related in meaning. When primed with a word related in meaning to the target word, participants were more accurate and marginally faster at responding if the prime was an Arabic-Hebrew cognate than if it was a non-cognate. This study demonstrates that cognate effects persist even when strong language membership cues are present in the absence of overlap between orthographies (i.e., bottom-up effects from orthography are absent). The authors suggest that the degree of overlap between L1 and L2 representations (at any level of representation) may vary depending on the language pair and be dynamic over time for individual bilinguals. For instance, they suggest that increased L2 proficiency may result in L2 phonological representations that are more distinct from the L1 phonological representations (i.e., the pronunciation of L2 words becomes more native-like), and hence a decrease in sub-phonological similarity. This is a plausible way in which increased L2 proficiency could reduce cross-talk between languages, as suggested by the learning account (e.g., Costa et al., 2019).

An ERP study by Peeters et al. (2013) offers insight into how a cognate's frequencies of occurrence in the target and non-target languages affect its processing. In their study, late French-English bilinguals performed a lexical decision task in their L2 English. The critical target words were either orthographically identical cognates with high or low L1 and L2 frequencies (e.g., *assassin* which has a high frequency in French, but low frequency in English as its near-synonym *murderer* is more common), or L2-specific control words with high or low frequency. The RT data showed a significantly larger facilitation effect for cognates with low L2 frequency compared to those with high L2 frequency. Furthermore, cognates with high L1 frequency elicited faster RTs than cognates with low L1 frequency. The ERP data revealed a significant N400 effect of cognate status, with controls yielding a more negative-going wave (indicating more difficulties in processing) than cognates. A separate analysis on the cognate words revealed that the N400 effect of L2 frequency was longer (300–700 ms) and more widely distributed, whereas the (anterior) N400 effect of L1 frequency was shorter (400–500 ms). Additionally, cognates with low L2 frequency and high L1 frequency elicited a more negative N400 compared to cognates with high L2 frequency and low L1 frequency. The authors suggest that cognates with low L2 frequency benefit more from their L1 translation equivalents than high L2 frequency cognates. Based on these findings, and the assumption that both the L1 and L2 representations of a cognate are co-activated, Peeters et al. proposed that even though both the target and non-target language word frequencies of a cognate affects its processing, its frequency in the target language has a larger influence on processing than its frequency in the non-target language.

In an ERP study with similar design, Xiong et al. (2020) investigated the processing of visually identical Japanese-Chinese cognates, which can sound different across the two languages. Their Chinese-Japanese participants performed an L2 Japanese lexical decision task on two-character cognates and control words. Interestingly, in lexical decision times, the cognate effect was larger for cognates with low Japanese word frequency (52 ms, relative to a low-frequency non-cognate) than high Japanese frequency (28 ms, relative to a high-frequency non-cognate). Their ERP measures revealed a more negative early frontal waveform for controls than cognates, about 250 ms after word onset (FN250). Compared to cognates, control words elicited a larger negative amplitude in the central-parietal region about 400 ms after word onset (N400). However, in contrast to Peeters et al., the effects of L1 word frequency on cognate processing was only marginally significant in both the behavioural and ERP measures. The authors interpret cognate facilitation as a result of on-line co-activation. They suggest that the early FN250 effect may reflect co-activation of L1 and L2 orthographic representations at a pre-lexical level, as the FN250 is thought to reflect processing at the form-level (Holcomb & Grainger, 2006). This activation of the orthographic level then moves toward the semantic level, activating the meaning of the cognate word as reflected in the later N400 effect, leading to a facilitated recognition of cognates compared to controls. However, Xiong et al. conclude that further work is required to investigate the possibility of an interaction of pre-lexical phonological and semantic information contained in Chinese/Japanese characters.

If cognate effects instead are ascribed to learning, a possible explanation for the RT and ERP results of Peeters et al. (2013) of easier processing of cognates with high L2 frequency is that they are encountered more often during L2 learning, thus strengthening their L2 representations, which leads to easier processing. In contrast, a cognate with low L2 and high L1 frequency may be more difficult to process because it is mainly encountered during L1 learning. Its L2 representation is therefore not as prominent as for the words encountered often in the L2. The benefit of a high L1 frequency on processing could potentially be due to more cross-talk during learning (and, thus, enhanced representations) for cognates with high L1 frequency. The evidence from Xiong et al. (2020) of co-activation at an early, pre-lexical level is also compatible with a learning account that assumes non-selective activation early in lexical access. Furthermore, the larger amplitude of N400 for controls found in Peeters et al. and Xiong et al. could reflect a frequency effect, as the N400 has been found to be smaller for isolated words with high frequency compared to low-frequency words (Barber et al., 2004). This is consistent with the assumption of a learning account that cognates are processed more easily than non-cognates because cognates behave like high-frequency words due to their enhanced representation. We return to a discussion of the effect of word frequency in bilingual language processing below, but first we review whether cross-linguistic effects in visual word recognition differ from those observed in spoken word recognition.

Spoken word recognition

One potentially problematic study for a learning account of cognate effects is that of Blumenfeld and Marian (2007). They employed a visual world eye-tracking paradigm to record the eye-movements of German-English and English-German bilinguals, as well as English monolinguals, in spoken English word recognition. Participants were presented with four objects, which included (1) either an English-German cognate or a non-cognate as the target, and (2) either a similar sounding German competitor or a control item, plus two filler objects. Participants were asked in English to identify the object and click on it. When the target word was a non-cognate (e.g., *desk* – 'Pult' in German), there was no difference between the percentages of looks at competitor (e.g., *Deckel* – 'lid' in English) and control items in English-German bilinguals and also in the English monolinguals. In contrast, competitor items received significantly more looks than control items for German-English bilinguals than for both other groups. For cognate targets (e.g., *pianist* – 'Pianist' in German), English-German bilinguals behaved like German-English bilinguals, with the percentage of looks being significantly larger for competitor (e.g., *Pik* – 'spades' in English) than control items.

Blumenfeld and Marian's conclusion is that both languages are co-activated when proficiency (in the language of the competitor items) is high (in the case of German-English bilinguals) for both cognate and non-cognate targets, whereas co-activation of a less proficient language (in English-German bilinguals) does not always occur but can be "boosted" by cognate targets. However, it could be that a visual world paradigm activates dual-language mode: upon seeing an object, participants may activate the name of the object in their native language. If this is the case, then objects with cognate names, which have been argued to induce dual-language mode (Wu & Thierry, 2010), may activate the other language more than objects with non-cognate names. Therefore, it could be that the cognate stimuli activate the non-target language, which could explain the competition from form-related items in the non-target language.

Production

Cognate facilitation has also been found in language production, where bilingual speakers name pictures faster if their names in the two languages are cognates than if they are non-cognates (e.g., Costa et al., 2000; Hoshino & Kroll, 2008). In Costa et al. (2000), highly proficient Catalan-Spanish bilinguals and Spanish monolinguals named pictures in Spanish whose names were either non-identical cognates (e.g., *gato–gat*, 'cat') or non-cognates (*mesa–taula*, 'table'). One aim of the study was to test whether the phonology of non-selected lexical items would be activated. The authors found that Catalan-Spanish bilinguals produced cognate names faster than non-cognate names, whereas Spanish monolinguals named both types of pictures with similar latencies. Additionally, they found in a second experiment that the magnitude of the cognate effect depended on language dominance: non-dominant (Catalan) speakers elicited a larger effect compared to dominant (Spanish) bilinguals. They argued that cognates are facilitated because the phonological nodes receive activation from two sources (the selected target language nodes and the non-selected non-target language nodes), leading to a quicker selection of phonemes. With non-cognates, activation of the non-selected lexical node activates the non-target phonology, but since this is different from the target language phonology, there is no facilitation. According to Costa et al., the effect of language dominance on naming could be due to activation of phonological nodes from lexical nodes being greater in the dominant than the non-dominant language. This may be because activation is larger for the dominant compared to non-dominant language words (i.e., asymmetric activation), or because the connections between lexical and phonological nodes are stronger in the dominant than non-dominant language (difference in connection strength).

An alternative explanation for the origin of the cognate effects in naming, which does not assume on-line co-activation, was proposed by Costa et al. (2006). This idea involves differences in learning difficulty between cognates and non-cognates. Costa et al. argued, in line with the learning account, that cognates are learned more easily and more robustly than non-cognates. Additionally, if two alternatives are available, a cognate would be used more often during learning: 'a Spanish-English unbalanced bilingual may be more inclined to use the word "construct" ("construir" in Spanish) than the word "build" ("construer" in Spanish)' (Costa et al., 2006, p. 143). They argue that this learning advantage may lead to the advantage for the processing of cognates compared to non-cognates later in life.

Strijkers, Costa, and Thierry (2010) investigated the time-course of ERP correlates of the frequency effect and the cognate effect in overt picture naming (L1 and L2) in highly proficient bilinguals (Spanish-Catalan and Catalan-Spanish). They found that the ERPs of high vs. low target-language frequency words and cognate vs. non-cognate words were 'remarkably comparable': the ERPs of high-frequency items diverged from the ERPs of low-frequency items around 180 ms after picture presentation, with greater ERP amplitudes for low- compared to high-frequency items. A similar pattern was found in the cognate conditions, with non-cognates eliciting greater amplitudes than cognates, from around 190 ms after the target presentation in L1 and L2 naming. The authors suggest that cognate status and word frequency have a similar impact on naming latencies and that the cognate effect may be a frequency effect in disguise: The cross-linguistic form overlap of cognate translations leads to a strong activation of their lexical representations in both the target and the non-target language every time a cognate is encountered. This co-activation may only occur for cognates, or alternatively, is very weak for non-cognate translations. Because cognates are co-activated more often, this leads to a higher-frequency representation for cognates compared to non-cognates.

Although we agree with the conclusion that the cognate effect may be a frequency effect in disguise, we argue that the assumption of activation of non-target language lexical representations (i.e., beyond the sub-lexical activation of the shared phonological segments) every time a cognate is heard or uttered is not necessary. The similarities between word frequency effects and cognate effects observed here could be because both cognates and high-frequency words have easily accessible representations in memory (Costa & Pickering, 2019). The ease of lexical access could thus be ascribed to learning (although it is challenging to determine if and when this cross-talk ceases to occur: see, e.g., Costa et al., 2019, for a discussion), because cognates require a lower threshold of activation to be selected for production.

Another line of research on cognate processing deals with tip-of-the-tongue (TOT) states. These states occur when a failure of word retrieval associated with access to some features about a word (Brown & McNeill, 1966). Bilinguals experience TOT states more often than monolinguals (Gollan & Acenas, 2004). This effect has been found, for instance, in Hebrew-English bilinguals (Gollan & Silverberg, 2001) and in Spanish-English and Tagalog-English bilinguals (highly proficient or dominant in English) when tested in L2 English using a picture naming task (Gollan & Acenas, 2004). Interestingly, bilinguals performed similarly to monolinguals when presented with pictures whose names are cognates (Gollan & Acenas, 2004). In their discussion, Gollan and Acenas considered a possible explanation for cognate effects, which assumes a similar logic as the learning account discussed here: that cognates are 'better learned' than non-cognates due to the prominence of the cross-linguistic similarity, such that the similarity operates as a 'powerful retrieval cue' (p. 264).

Although Gollan and Acenas (2004) do consider this proposal, they at the same time suggest three problems with it. We believe these problems do not, in fact, challenge the learning account. First, they argue that the assumption that co-activation of lexical representations occurs during learning and then fails to occur (after learning) is similar to the cognate account of Costa et al. (2000), but without the ad-hoc assumption that co-activation ceases. However, we argue that it is not clear why the assumption of reduced or restricted co-activation with increased proficiency and automaticity should be problematic. Their second point is that because cognates are very common in many language pairs, their similarity is notable when they are first learned, but over time it is likely that this 'novelty' becomes less salient. Here, it is not clear why the similarities between cognates should become less salient over time. Thirdly, they point out that a clear mechanism for their observed effects is not provided by this account: for instance, it is unclear at which processing level the effect of cognate words' ease-of-learning would arise in accounts of TOTs. We argue that a learning account could offer a plausible resolution of these issues: since TOT states are thought to occur due to incomplete activation of lexical candidates (Meyer & Bock, 1992), cognates may be less likely to stay in this state because, according to the learning account, they require less activation for successful selection.

Cognates have also been found to affect articulation. Amengual (2012) tested different groups of Spanish-English bilinguals (both L1 Spanish and L1 English) in the naming of Spanish targets (e.g., *teléfono* – 'telephone' (cognate) or *teclado* – 'keyboard' (non-cognate)) in Spanish sentences (*Yo puedo decir …* – 'I can say …'). For all groups, although cognates were named faster than non-cognates, their voice onset times (VOT) were longer (more English-like, i.e., less native-like) compared to non-cognates. This difference was not found in a non-English speaking (Spanish-Catalan bilinguals) control group. In a similar study, Jacobs et al. (2016) tested different groups of English-Spanish bilinguals (classroom and immersion (intermediate proficiency) vs. advanced learners (high proficiency)). In the naming of cognate (e.g., *cable*) vs. non-cognate (e.g., *cabe*) targets (in isolation) in L2 Spanish, a difference between cognate and non-cognate VOT was only found in the classroom learners. Jacobs et al. ascribe the differences between the groups to the ability to inhibit the non-target language, rather than proficiency, as the advanced learners had significantly higher L2-proficiency than both the classroom and immersion learners, but the immersion leaners were "forced" to inhibit their L1 due to the immersion programme. From the perspective of an on-line account, it could be that on-line connections between representations are different depending on how learning occurred, which is why the effect is observed only in the classroom learners. However, the findings also agree with the assumption of a learning account that learning interacts with lexical representations: it could be that immersion learners are less affected by the activation of L1 representations during learning, which results in the ability to maintain native-like contrasts in the L2.

In summary, we have looked at different production and comprehension tasks and language pairs in which cognate facilitation has been observed. This facilitation is modulated by the degree of form overlap but is also present when the form overlap is missing in either phonology or orthography. Most of the findings are consistent with a learning account, although also with the full on-line activation account. Some may argue that when experimental word stimuli are processed one by one, the presence of identical or non-identical cognates could unintentionally encourage activation of the non-target language during their processing (Wu & Thierry, 2010; Comesaña et al., 2015). It is therefore important to consider how cognate effects manifest during sentence processing, as we do below.

Cognate processing in sentence contexts

When a word is processed in a sentence context, its predictability in the given sentence context influences its processing. The predictability of a target word (e.g., *book*) in a given sentence can be manipulated by biasing the preceding context (measured by Cloze probability) toward that word. The resulting sentences are referred to as semantically constraining (or high-constraint) sentences (e.g., *He went to the library to get a …*), where the probability of the target word *book* is high. These stand in contrast to low-constraint sentences (e.g., *He went to the shop to buy a …*) which are not biased toward one specific target word, so the context provides little information about the probability of the next word being *book*. Below, we discuss how processing of cognates in comprehension and production is affected by their predictability in a sentence context.

Comprehension

In monolingual reading times, the effects of predictability and frequency seem to be additive (Staub, 2015). That is, the effect of a word's frequency is not affected by its predictability in a given sentence, meaning that the effect of predictability is the same for high- and low-frequency words. Staub further concluded that this activation has an early effect on processing, either during the pre-lexical processing of features or at the earliest stages of lexical processing (i.e., letters or features).

Extending the effects of frequency and predictability to bilingual comprehension, and assuming that the mechanisms of predictive processing are similar for bilinguals (although bilinguals may predict more slowly or to a lesser extent in their L2 compared to native speakers (Martin et al., 2013; Ito et al., 2017, 2018)), what are the implications for cognate processing and predictability? According to the learning account, cognates receive additional activation during learning, just as high-frequency words do, so that both cognates and high-frequency words have a high resting level. Therefore, the effect of cognatehood may be the same as the effect of frequency – that is, the interaction between predictability and cognatehood may be additive. A learning account predicts that cognate effects on eye movements should therefore not be modulated by contextual constraint. An on-line account, exemplified by the predictions of the BIA+ model, assumes that linguistic context, such as semantic constraint, can directly affect activity in the word identification system through increased semantic activation feeding back to the orthographic level (Dijkstra & van Heuven, 2002; Van Assche et al., 2011). Thus, according to the BIA+ model, top-down information from semantic constraint may constrain the degree of non-selective access. However, because of the lack of a specific mechanism of how sentence context may influence lexical access (Schwartz & Kroll, 2006), the predictions for an on-line account are underspecified.

Libben and Titone (2009) examined how cognate processing is affected by semantic constraint in an eye-tracking study. Their highly proficient French-English bilinguals read L2 English sentences which were either highly or weakly semantically constraining toward identical cognates or their controls. The early eye-tracking measures, such as first fixation duration, gaze duration, and skipping rate, showed more rapid processing for cognates than controls in both low- and high-constraint sentences. For the later measures, such as go-past time and total reading time, cognate processing was facilitated only in low-constraint sentences. The study further found that bilinguals with higher L2 proficiency displayed smaller cognate facilitation effects than less proficient bilinguals. The authors suggest that semantic and orthographic pre-activation increase the lexical expectations of upcoming input (at the orthographic level). Because these lexical expectations are language-specific, lexical access is initially non-selective and becomes more selective at the later stages of comprehension. In another similar study with Dutch-English bilinguals, cognate facilitation in high-constraint sentences was found for both early and late measures (Van Assche et al., 2011, Experiment 2). Based on this result, Van Assche et al. argue that top-down semantic restrictions have a 'very limited influence' on lexical activation and that both the early and late stage of word recognition is non-selective.

Pivneva et al. (2014) ascribe the different findings of Libben and Titone (2009) and Van Assche et al. (2011) to the participants' L2 proficiency. They used the same stimuli and paradigm as Libben and Titone but tested less proficient French-English bilinguals, whose L2 proficiency was more similar to that of the bilinguals in Van Assche et al. Replicating Van Assche et al., cognate facilitation was found for both early (gaze duration) and late (total reading time) eye-tracking measures in high-constraint sentences, suggesting that cognate facilitation in high-constraint sentences is limited to early stages of processing only if the L2 proficiency is sufficiently high as in Libben and Titone's participants. Pivneva and colleagues suggest two reasons why proficiency should modulate effects of sentence constraint on cognate facilitation. The first is that less proficient bilinguals are less likely to use contextual information efficiently (e.g., Martin et al., 2013). The second is that divided L1 and L2 exposure may result in non-cognates being encountered less frequently overall by bilinguals (compared to cognates), such that cognate effects are driven by control words and not by cognates (Gollan et al., 2011; Titone et al., 2011). These explanations are consistent with a learning account, if one assumes that with increased exposure to the L2 the differences between the resting level activations of cognate and non-cognate words become smaller. However, they are also consistent with an on-line account where the smaller cognate effect associated with higher proficiency (i.e., changed relative proficiency between the L1 and L2) may be due to a reduced relative contribution of activation of non-target language forms (Bultena et al., 2014).

In order to better understand the effect of sentence context on language non-selectivity, Lauro and Schwartz (2017) compared the effect sizes from studies on cognate facilitation in high- and low-constraint sentence contexts in a meta-analysis. The analysis of studies on L2 processing revealed that overall, cognates are processed faster than non-cognates in both a high- and a low-constraint context, but that the effect is larger in low-constraint contexts. It was further found that task type modulates the magnitude of the effect. Cognate effects are stronger in tasks that require overt responses from participants, such as lexical decision, compared to experiments measuring more implicit behaviour, such as eye movements in reading. Lauro and Schwartz suggest that a sentence context alone does not contribute sufficient linguistic information to constrain lexical access to only one language, but that a semantically constraining sentence context can attenuate cross-linguistic lexical activation. They conclude that the extent to which the non-target language influences processing in the target language is dynamic, meaning that the activation of the non-target language changes during the time-course of lexical access (from recognising the word to integrating it with the semantic context) and during the comprehension of a sentence. This activation depends on comprehension demands and the availability of information allowing for a decision to make a response or to move on in a sentence.

Production

Lauro and Schwartz' (2017) meta-analysis included some language production studies, which we will now look at in more detail. In language production, an interaction between frequency and predictability has been found in L2 processing. For instance, Gollan et al. (2011) compared predictability and word frequency effects between comprehension and production. Spanish-English and Dutch-English bilinguals with different levels of L2 English proficiency named pictures (Experiment 1) or read words (Experiment 2, eye-tracking) embedded in high- or low-constraint sentences. The word frequency of the picture name was manipulated (high/low). An interaction between frequency and sentence constraint was found in naming, but not for any of the standard measurements (gaze duration, first fixation duration and total fixation times) in reading, confirming earlier findings from the monolingual domain in naming (Griffin & Bock, 1998) and reading (Staub, 2015). More specifically, semantic constraint reduced the size of the frequency effect in production, but not in comprehension. Thus, if one assumes a pure learning account, where cognate words are represented similarly to high-frequency words, a reduced cognate effect should also be observed when cognates are named in a highly constraining sentence context. As in comprehension, an online account also predicts that semantic constraint can modulate cognate effects through pre-activation of semantics in production. Yet, as we discuss above, due to the lack of a more specific mechanism of how this occurs in the BIA+, it is not clear whether the effects may be fully or only partially eliminated.

Schwartz and Kroll (2006) used an RSVP naming task to investigate cognate processing in sentences where the predictability of identical, or near-identical (e.g., *band–banda*) cognates was manipulated. In this task, Spanish-English bilinguals saw L2 English sentences which were rapidly presented one word at a time, and they had to name a target word out loud. A cognate facilitation effect, measured by naming latencies, was found only in low-constraint sentences (for both more proficient and less proficient bilinguals), but not in high-constraint sentences. Crucially, there was an interaction between constraint and cognate status, and cognate facilitation was eliminated in high-constraint sentences. In contrast, Starreveld et al. (2014) in their picture naming experiment with Dutch-English bilinguals found that production of (identical or non-identical) cognates in L2 sentences was facilitated in both high- and low-constraint contexts. They interpret these findings as evidence that co-activation occurs even when producing words in context. They explain cognate facilitation in terms of the model of Costa et al. (2000) model of cognate effects in language production, which we discussed in Section 2: the phonological segment receives activation from two sources rather than one, due to co-activation. The constraining semantic context pre-activates features of the upcoming word, and may even fully activate its semantic representation, such that the name of the picture is available before it occurs.

The findings from both studies discussed in the above paragraph (Schwartz & Kroll, 2006; Starreveld et al., 2014) can also be explained by a learning account. In production, frequency effects are modulated by sentence constraint (Gollan et al., 2011; Griffin & Bock, 1998). This could explain why Schwartz and Kroll (2006) observed no effect in the high-constraint condition. If a cognate word behaves like a higher-frequency word due to its representation, it could be that a strongly constraining sentence context modulates the facilitation caused by bottom-up effects, leading to smaller facilitation. Then why was a cognate effect observed in the high-constraint condition in Starreveld et al. (2014)? First, their data is not clear on whether sentence constraint significantly interacted with cognate status in L2 processing as the analysis was performed on pooled data from naming in L2 and L1. Second, reiterating a point we made in Section 3.1 about the visual world paradigm and dual-language mode, it could be that the naming of pictures (as opposed to written words as in Schwartz and Kroll's study) induces dual-language mode. Therefore, it could be that seeing and naming a cognate object activated its name also in the participants' L1. However, it is clear that further research is required to fully understand how cognate status interacts with sentence constraint in both production and comprehension, as the studies discussed here do not fully converge on their findings.

Discussion

In this chapter, we discussed how cognate facilitation effects can be accounted for by two different accounts, on-line co-activation of target and non-target languages vs. cognate learning. The first account assumes that the representations of cognate words are likely to be activated faster and to a higher degree than non-cognates during lexical access. This occurs because activation from the target and non-target representation of cognates converges at the semantic level, and results in feedback activation to the lexical representations. The second account assumes that cognate representations require less activation than non-cognates in order to be recognised or produced successfully. Here, the target and non-target readings of a cognate do not contribute to its facilitation during processing on-line, but rather they contribute during learning, such that cognates' representations become enhanced compared to non-cognates. This hypothesis is one way in which cognate effects can be accounted for in terms of their manner of learning and representation. It is similar to earlier but less exhaustive accounts which emphasize cognate learning and representation in memory when explaining cognate effects (Costa et al., 2006; de Groot, 2010; Dijkstra et al., 2012). The learning account finds support in studies showing that cognates are learned faster and retained for longer in memory, compared to non-cognates (de Groot & Keijzer, 2000; de Vos et al., 2019; Lotto & de Groot, 1998). We further reviewed other evidence of cognate processing to assess the extent to which this supports (or at least is consistent with) a learning account.

Results from studies of cognate processing in isolation (i.e., when cognates are processed without a sentence context) are consistent with both accounts, as both predict facilitation of cognates compared to control words. Perhaps the strongest form of evidence for a learning account is the finding of Strijkers et al. (2010) that cognates diverge from non-cognates at about the same time as highly frequent words diverge from words with low frequency in their ERP amplitudes. This suggests that the two effects may have the same origin, but whether on-line co-activation continues across the lifespan of a bilingual, or whether it is sufficient that co-activation is restricted to a learning phase (and to dual-language contexts) where the processing context often involves both languages, is yet an open question. It is also possible to combine the learning account with the assumption that co-activation of target and non-target languages continues to occur throughout the life of a bilingual. For instance, it may well be that initially, during comprehension, form-related neighbours across languages are briefly activated (Gerard & Scarborough, 1989). Whether the activation of the non-target language takes place continuously throughout the process of lexical access, and whether this always leads to the activation of the meaning of non-target translation equivalents, is unclear. However, future research could explore further how cognate status interacts with variables that are known to interact with word frequency, such as regularity (Sereno & Rayner, 2000), to examine whether the similarities between cognate and frequency effects are only superficial, or whether they reflect that similar mechanisms are driving the effects.

When cognates are processed in a sentence context, we saw less conclusive evidence of cognate facilitation if the context is semantically constraining. The existing findings also emphasised the role of L2 proficiency in cognate processing. A learning account provides a straightforward account of why cognate effects may be modulated by proficiency. Costa et al. (2019) hypothesised that increased proficiency and automaticity in the L2 may change the organisation of the bilingual mental lexicon (for instance through "unlearning", i.e., reducing the footprint of L1 on the L2), which may also lead to greater autonomy between a bilingual's languages. One of the strengths of a learning account is thus its focus on how learning interacts with lexical representations (Costa & Pickering, 2019) across different stages of bilingualism, which allows for flexibility when it comes to different aspects of bilingualism, such as language use. One way to investigate how learning interacts with lexical representations is to examine cognate effects in trilinguals. For example, if a Dutch-Spanish-English trilingual learns English in Dutch school, do they show stronger cognate effects between Dutch and English than Spanish and English?

Based on the evidence reviewed in this chapter, we argue, in line with Costa et al. (2006), that cognate effects are consistent with explanations and models that do not assume on-line co-activation. Although here we have focused on evidence from cognate processing in one-language contexts, and the evidence from cognate processing in isolation consistently shows cognate effects, investigations into how cognate facilitation is affected by, for instance, word frequency and sentence constraint are not conclusive, as the findings are compatible with both learning and on-line accounts. We further argue that cognate effects by themselves cannot prove that parallel activation always occurs during on-line processing. This is because, as suggested by Pivneva et al. (2014), it could be that the cognate effect is driven by the lower functional frequency of words unique to the L2. Further explorations of the role of L2 proficiency and L1 and L2 word frequencies are required to better understand cognate effects and their underlying mechanisms.

As mentioned by Costa et al. (2006), the processing of other types of words that are ambiguous with regard to which language they belong to, for instance false friends, may offer additional insight into language interaction. These words share form but not meaning across languages and could therefore help to tease apart the effects of cross-linguistic semantic and form processing. A comparison between the processing of cognates and false friends from the perspective of a learning account would therefore be necessary to draw better conclusions about how learning and co-activation affects processing on different levels of representation.

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