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Cross-linguistic influence in the bilingual lexicon: Evidence for ubiquitous facilitation and context-dependent interference effects on lexical processing

Review Article

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Abstract

For bilinguals, lexical access in one language may affect, or be affected by, activation of words in another language. Research to date suggests seemingly contradictory effects of such cross-linguistic influence (CLI): in some cases CLI facilitates lexical access while in others it is a hindrance. Here we provide a comprehensive review of CLI effects drawn from multiple disciplines and paradigms. We describe the contexts within which CLI gives rise to facilitation and interference and suggest that these two general effects arise from separate mechanisms that are not mutually exclusive. Moreover, we argue that facilitation is ubiquitous, occurring in virtually all instances of CLI, while interference is not always present and depends on levels of cross-language lexical competition. We discuss three critical factors – language context, direction, and modality of CLI – which appear to modulate facilitation and interference. Overall, we hope to provide a general framework for investigating CLI in future research.

1. Introduction

Most research used to build theories of lexical processing has been based on monolinguals. Research exploring language and cognitive processes in bilinguals has increased over the past three decades, revealing important insights including shared conceptual-semantic representations, automatic cross-language co-activation of lexical representations, non-selective lexical access, and cross-language lexical competition. Furthermore, the lexical system is highly dynamic, revealing cross-linguistic influence (CLI) in both directions and the ability to adapt to various contextual demands. In some cases CLI facilitates lexical processing, while in other cases it appears to interfere. This discrepancy has largely been ignored, in part because evidence for each phenomenon – facilitation and interference – often comes from disparate bodies of literature. Thus, it is currently unclear under what conditions cross-linguistic facilitation and interference are found and how to reconcile the appearance of these opposing forces across various experimental paradigms. In order to advance theories of bilingual lexical processing, these seemingly contradictory bodies of evidence need to be reconciled and placed within the broader theoretical context of bilingual lexical organisation.

We consider CLI to encompass any instance where lexical representations in one language – either as a result of retrieval (comprehension or production), passive exposure, or simple existence in the bilingual's lexicon – exert some effect on lexical access in another language. This definition may seem rather broad and possibly at odds with traditional conceptualisations of CLI. However, we feel that it enables generalisation of principles that have become ubiquitous in research on bilingualism to behavioural outcomes (facilitation and interference) observed across a wide range of contexts and experimental paradigms.

Although CLI may occur at multiple levels of language processing, in this review, we examine patterns of CLI at the level of lexical processing with the aim of establishing when, and under which conditions, CLI either facilitates or interferes with lexical access in the dominant and non-dominant language(s)[1]. We begin by exploring evidence of facilitation and interference CLI effects, drawing upon findings from both psycholinguistic and memory research. These two fields have developed in isolation from each other, with very little cross-talk between them (Mickan et al., 2019). Moreover, we attempt to contextualise the findings of our review within a broad theoretical framework, drawing on principles and predictions from formal models of bilingual language organisation.

Based on an extensive review of the literature, we argue that while interference effects have received a lot of attention, facilitation effects are much more widespread and, indeed, may represent the default form of CLI. At the core of this argument is the proposition that facilitation and interference are driven by separate but – importantly – not mutually exclusive mechanisms. We posit that facilitation is driven by automatic cross-language co-activation, a ubiquitous mechanism whereby lexical access in one language activates lexical representations in the other language, improving later accessibility of the co-activated representations. Importantly, the ubiquity of co-activation ought to confer some degree of facilitation during nearly all bilingual lexical processing contexts. Interference, by contrast, arises due to cross-linguistic competition which can occur as a result of co-activation. Unlike automatic co-activation, competition is not ubiquitous and only arises under certain contexts, and may be resolved through inhibition. We therefore argue that both facilitation and interference effects may occur simultaneously, with behavioral measures revealing the prevalence of one or the other depending on their relative contributions during lexical access.

To begin, we briefly outline three principles thought to underlie CLI: shared semantic representations, automatic lexical co-activation, and cognitive control processes in lexical selection. Following this, we separately review the evidence for cross-linguistic facilitative and interference effects and offer theoretical interpretations for each. We then discuss three critical factors which appear to modulate the nature and magnitude of CLI: language context, language direction, and modality. Finally, we conclude by discussing the dynamic nature of CLI.

The scope of this review may seem unusually broad, drawing on findings from a range of paradigms and experimental effects, which often have few commonalities among them. For example, much of the evidence concerning cross-linguistic facilitation comes from translation priming and simultaneous picture-word presentation paradigms, while interference effects are frequently reported in the context of language switching and language learning, as well as second-language immersion settings. Experienced readers may also note that these different paradigms were developed to tap entirely different features of the bilingual lexicon; for example, translation priming paradigms are mainly employed to investigate the architecture of the lexico-semantic system, while language switching paradigms were designed to tap control processes in lexical selection. How does one reconcile such disparate bodies of literature? We encourage readers to view these seemingly incompatible paradigms simply as different CONTEXTS which give rise to greater or lesser degrees of co-activation, competition, and inhibition. As we will elaborate below, many contexts give rise to co-activation but not competition – hence, they are naturally held up as robust examples of cross-linguistic facilitation. By contrast, paradigms that elicit high degrees of competition tend to produce interference. To understand how these processes co-occur, however, we compare results from these different paradigms based on the degrees of co-activation and competition that they are assumed to engender, while also recognizing the roles of certain influential factors (e.g., certain task demands that seem to drive variable degrees of competition). The advantage of this approach is that it offers generalizability across different bodies of research that report evidence of facilitation or interference – a primary goal of this review. Our approach is not intended to provide a framework for highly specific predictions about lexical access or the lexico-semantic architecture – that is the domain of more targeted bodies of research. Rather, it is intended to characterise, broadly, how facilitation and interference may co-occur in different contexts, considering overarching principles and mechanisms that are common to many theories of bilingual lexical access.

2. Principles underlying CLI

Numerous models of bilingual language organisation have been proposed over the past few decades. While the purpose of this review is not to evaluate specific models, we feel that many provide a useful lens with which to view the data on CLI. We draw on broad principles shared by models to interpret general effects. Three such principles are overlapping representations, automatic co-activation, and lexical competition and inhibition.

2.1. Overlapping representations

Although they possess two or more different lexicons, bilinguals are thought to have a single conceptual-semantic system with links to lexical representations in both languages. Prominent models of the lexical architecture of bilinguals incorporate (mostly) shared semantic representations (e.g., Dijkstra et al., 2019; Kroll & Stewart, 1994), an integrated lexicon, and some means of classifying lexical representations by language membership (e.g., Dijkstra & van Heuven, 2002; Green, 1998). Cognate words (such as *Bicicleta* and *Bicycle* in Spanish and English) have the most overlap across languages. In addition to largely overlapping meanings, they share orthographic and/or phonological forms, to a greater or lesser extent. Some researchers have suggested that cognates may have unique lexical representations. For example, if the bilingual lexicon is organized not by language but rather by morphological relatedness, cognates would share the same morphological representation in the mental lexicon despite having different language memberships (Lalor & Kirsner, 2001a, 2001b; Sánchez-Casas & García-Albea, 2005). By contrast, other researchers posit that in addition to shared semantics, cross-language overlap for cognates exists at the levels of sublexical and lexical phonology (Degani et al., 2018; Miwa et al., 2014). Some models of the bilingual lexicon, such as the Bilingual Interactive Activation+ (BIA+; Dijkstra & van Heuven, 2002) and Multilink (Dijkstra et al., 2019) models assume only shared semantic representations for cognates but separate morphemic and phonological representations.

2.2. Automatic co-activation

The presence of a shared conceptual-semantic system means that activation of a conceptual representation should activate all lexical items associated with that concept, in all languages. For example, upon viewing a picture of a table, a Spanish–English bilingual would experience co-activation of both of the object's associated lexical representations (*mesa* and *table*). Co-activation is observed even when a task is solely in one language, as well as when language-unique orthography ensures that the language cues only support the activation of one language (e.g., Degani et al., 2018). In addition to spreading activation from shared conceptual-semantic representations, activation may spread between lexical representations in both languages through direct connections between them (Kroll & Stewart, 1994). Lexical representations in each language then spread activation to their associated phonological and orthographic representations (e.g., Cop et al., 2017; Costa et al., 2000; Hermans, 2004). A good example of this can be found in cognates: cognate facilitation effects (see 3.1) are generally thought to be due to spreading activation from lexical representations in both languages to shared phonological forms (Costa et al., 2000). Since cognates have overlapping phonological/orthographic segments, these segments receive

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activation from both lexical representations, leading to quicker access of phonological forms for cognates than non-cognates (Costa et al., 2000; Strijkers et al., 2010). Interestingly, co-activation may occur exclusively on the basis of phonological and orthographic similarity, independent of shared semantics (e.g., Hameau et al., 2021).

An important related concept is the activation threshold. A word's activation threshold is thought to determine its accessibility, whereby words with lower thresholds are easier to access (Green, 1986, 1998; Paradis, 1993, 2007)[2]. Activation thresholds are highly dynamic: activating a word once will lower its threshold, making it more accessible on subsequent trials, while the thresholds of words that are not accessed gradually rise over time (Paradis, 1993). Thus, different words have different resting levels of activation, depending on factors such as frequency of use (Dijkstra et al., 2019). This principle has important implications for automatic co-activation: if activating a word in one language causes co-activation of its translation equivalent(s) in another, then the threshold of the translation equivalent(s) should also be lowered, making it more readily accessible on subsequent trials.

2.3. Lexical competition and inhibition

A popular view holds that, in many contexts, co-activated words in a non-target language may compete for lexical selection. This competition must therefore be resolved in order to select the desired target word. Consider the following example: if a Spanish–English bilingual engages in a Spanish picture naming task, viewing a picture of a table will cause parallel activation of all associated lexical representations (*mesa* and *table*). This creates conflict because *mesa* and *table* represent alternative possible responses. Therefore, competition posed by *table* must be overcome in order to successfully respond with *mesa*.

The idea of controlling interference from other languages has been widely applied to understanding a number of bilingual phenomena, including language attrition, slower word retrieval, language switching costs, and generalized cognitive advantages. A number of mechanisms have been proposed to mediate lexical selection in the presence of competition (see Finkbeiner et al., 2006; or Kroll et al., 2006 for reviews), though all are broadly concerned with cognitive control mechanisms that serve to increase the accessibility of words in the target language and/or reduce competition from words in a non-target language. Many accounts hold that this is achieved by regulating activation thresholds of words in either or both languages (Green, 1986, 1998; Paradis, 1993, 2007). A common view, stemming from Green's (1998) highly influential Inhibitory Control model, is that lexical competition is resolved through inhibition. Inhibition is a domain-general mechanism which, in this context, reduces the accessibility of non-target words, possibly by raising their activation thresholds, in order to facilitate selection of the desired target word.

According to Green (1998), inhibition may operate either proactively or reactively. With respect to proactive inhibition, bilinguals may indiscriminately inhibit all words in a non-target language in order to reduce any potential competition; this phenomenon is commonly referred to as global inhibition. Global inhibition may be regarded as a top-down process driven, at least in large part, by the speaker's intentions and expectations about upcoming demands on the language system (e.g., "I must name this picture in Spanish"), and is likely mediated by language identifiers that differentiate words in the target language from those in the non-target language. By contrast, reactive inhibition may serve to overcome (as opposed to prevent) competition from non-target words during lexical selection[3]. This so-called local inhibition may be applied selectively, at the level of individual representations. Thus, in order to successfully retrieve a target word such as *mesa*, the speaker would inhibit only activated competitors (e.g., *table*), while unrelated words (e.g., *university*) would not require inhibition. Critically, inhibition at any level should confer a latent cost to the inhibited word(s). If inhibiting a word raises its activation threshold, then that word should become less accessible on subsequent trials.

3. Cross-linguistic facilitation

3.1. Evidence for facilitation

The studies described in this section are presented in Table 1 for the reader's convenience. There is substantial evidence that speaking, knowing, or being exposed to words in one language can facilitate access to words in another language. Perhaps the most intuitive example of such facilitation comes from research on cognate processing. Cognates are easier to learn than non-cognates in both childhood (Bosch & Ramon-Casas, 2014; Gampe et al., 2021) and adulthood (Elias & Degani, 2022; Ghazi-Saidi & Ansaldo, 2017; Lotto & de Groot, 1998; Raboyeau et al., 2010). Cognates also tend to facilitate language processing: even when operating in a single language, cognates often show processing benefits, evidenced by faster and/or more accurate picture naming (Acheson et al., 2012; Costa et al., 2000; Hoshino & Kroll, 2008; Ivanova & Costa, 2008; Jacobs et al., 2016; Li & Gollan, 2021; Roberts & Deslauriers, 1999; Rosselli et al., 2014; Stadie et al., 1995; Strijkers et al., 2010), fewer tip-of-the-tongue states (TOTs; Gollan & Acenas, 2004), and faster responses on word reading (de Groot et al., 2002; Lalor & Kirsner, 2001b), word association (Degani et al., 2018; van Hell & de Groot, 1998; van Hell & Dijkstra, 2002), translation (de Groot, 1992), and lexical decision tasks (de Groot et al., 2002; Dijkstra et al., 1999; Lalor & Kirsner, 2001a; Lemhöfer & Dijkstra, 2004; Lemhöfer et al., 2004; Miwa et al., 2014). Moreover, sentences and longer texts containing cognate words are read more quickly and efficiently compared to texts with fewer or no cognates (Balling, 2013; Cop et al., 2017; Duyck et al., 2007; Van Assche et al., 2009, 2011). Cognates also appear to be resistant to forgetting: for example, immersion studies demonstrating first-language (L1) attrition have shown that while participants may struggle to recall lower frequency words, cognates still show robust retention, even if the cognate words are lower frequency (Ammerlaan, 1996; Hulsen, 2000). Interlingual homonyms, which are closely related to cognates, also show facilitatory effects. Interlingual homonyms (also known as "false cognates" or, colloquially, "false friends") are words in two languages that share phonological overlap ("homophones") or orthographic overlap ("homographs"), but no semantic overlap. Under certain task conditions, participants may respond more quickly to interlingual homographs (de Groot et al., 2000; Dijkstra et al., 1998; Lemhöfer & Dijkstra, 2004) and homophones (Haigh & Jared, 2007) than to control words.

Non-cognate translation equivalents also show cross-language facilitation. A large source of evidence here comes from research employing cross-language priming paradigms. In these experiments, participants are briefly shown a prime in one language (typically presented so rapidly that participants are not conscious of its presence) followed by a target word in a different language.

Table 1. Summary of studies showing behavioral evidence of cross-linguistic facilitation discussed in Section 3.1. Studies are organized alphabetically by Task / Test of lexical access. This table does not include reviews, meta-analyses, or studies reporting exclusively on neuroimaging results.

Task / Test of lexical access	Description of effect	Citations
Aloud word reading	Faster responses to cognates	de Groot et al., 2002; Lalor & Kirsner, 2001b
Confrontation naming	Advantage for words receiving treatment for aphasia in another language	Kohnert, 2004
Lexical decision	Faster responses to cognates and/or interlingual homonyms	de Groot et al., 2002; Dijkstra et al., 1999; Haigh & Jared, 2007; Lalor & Kirsner, 2001a; Lemhöfer et al., 2004; Lemhöfer & Dijkstra, 2004; Miwa et al., 2014
	Positive translation or homonym priming	Basnight-Brown & Altarriba, 2007; Chen et al., 2014; Cristoffanini et al., 1986; de Groot & Nas, 1991; Duñabeitia et al., 2009; Duyck & Warlop, 2009; Gerard & Scarborough, 1989; Gollan et al., 1997; Jiang, 1999; Kim & Davis, 2003; Lee et al., 2018; McPhedran & Lupker, 2021; Miwa et al., 2014; Nakayama et al., 2013, 2016; Voga & Grainger, 2007; Wang, 2013
Picture naming	Faster responses to cognates and/or interlingual homonyms	Acheson et al., 2012; Costa et al., 2000; Gollan & Acenas, 2004; Hoshino & Kroll, 2008; Ivanova & Costa, 2008; Jacobs et al., 2016; Li & Gollan, 2021; Roberts & Deslauriers, 1999; Rosselli et al., 2014; Stadie et al., 1995; Strijkers et al., 2010
	Cross-language repetition improves performance	Branzi et al., 2014; Misra et al., 2012; Runnqvist & Costa, 2012
	Knowing a phonological neighbor or morphological family member improves performance	Hameau et al., 2021; Mulder et al., 2015
	Knowing a translation equivalent improves performance	Gollan et al., 2005; Gollan & Acenas, 2004; Higby et al., 2020
	Superimposition of translation equivalent improves performance	Costa et al., 1999; Costa & Caramazza, 1999; Dylman & Barry, 2018; Giezen & Emmorey, 2016; Hermans, 2004; Roelofs et al., 2016
	Advantage for words receiving treatment for aphasia in another language	Edmonds & Kiran, 2006; Kiran & Roberts, 2010
Semantic decision	Faster responses to cognates	Degani et al., 2018; van Hell & de Groot, 1998; van Hell & Dijkstra, 2002
	Positive translation priming	Chen et al., 2014; Grainger & Frenck-Mestre, 1998; Kim & Davis, 2003; McPhedran & Lupker, 2021; Wang & Forster, 2010
	Knowing translation equivalent improved performance	Poulin-Dubois et al., 2018
Signing (ASL)	Facilitated lexical access during code-blending	Emmorey et al., 2012, Kaufmann & Philipp, 2017
Text reading	Faster / more efficient reading if text contains cognates	Balling, 2013; Cop et al., 2017; Duyck et al., 2007; Van Assche et al., 2009, 2011
Various tasks	Advantage for words receiving treatment for aphasia in another language	Lopez et al., 2022
Verbal fluency	Advantage for words receiving treatment for aphasia in another language	Goral et al., 2012

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Participants are usually required to make a lexical or semantic decision judgement. Participants tend to respond more quickly to targets that are primed by a translation equivalent compared to an unrelated word (Basnight-Brown & Altarriba, 2007; B. Chen et al., 2014; de Groot & Nas, 1991; Duñabeitia et al., 2009; Duyck & Warlop, 2009; Goral et al., 2001; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Lee et al., 2018; McPhedran & Lupker, 2021; Nakayama et al., 2016; Wang, 2013; Wang & Forster, 2010; see Wen & van Heuven, 2017 for a meta-analysis). Similarly, bilinguals name pictures more rapidly if the same picture was previously named in another language (Branzi et al., 2014; Misra et al., 2012; Runnqvist & Costa, 2012). Cross-language priming effects tend to be stronger for cognates (overlapping semantics, orthography, and phonology) than non-cognates (Cristoffanini et al., 1986; Gerard & Scarborough, 1989; Kim & Davis, 2003; Nakayama et al., 2013), and may even be observed across languages employing different scripts (overlapping semantics and phonology, but not orthography) (Greek–English: Voga & Grainger, 2007; Hebrew–English: Gollan et al., 1997; Korean–English: Kim & Davis, 2003; Japanese–English: Hoshino & Kroll, 2008; Miwa et al., 2014; Nakayama et al., 2012, 2013). Indeed, cognate primes are just as robust as within-language repetition primes (Davis et al., 2010). Interestingly, priming effects are generally more robust when primes are presented in the dominant language and targets in the non-dominant language than in the opposite direction (which we discuss in section 5.2). Facilitative co-activation is thought to underlie cross-language repetition priming effects whereby the prime word automatically co-activates its translation equivalent(s), which is then easier to process when it appears as the target (see section 3.2).

Another paradigm that reveals cross-language facilitation is simultaneous picture-word presentation. In this design, a picture of an object is presented with a word superimposed over it, and participants are typically instructed to name the pictured object and ignore the printed word. Picture naming (i.e, target word retrieval) is faster when the target word's translation is superimposed compared to an unrelated word or a non-word (Costa & Caramazza, 1999; Costa et al., 1999; Dylman & Barry, 2018; Giezen & Emmorey, 2016; Hermans, 2004; Roelofs et al., 2016). It should be noted that these studies used non-cognates, so the facilitation is not due to overlapping orthographic/phonological information, but rather must occur through the shared conceptual-semantics of the target word and its translation.

The evidence presented so far supports the idea that activation of a word in one language co-activates its translation equivalent(s) and facilitates subsequent processing of those translations. One might argue that the nature of these tasks induces automatic co-activation by virtue of participants being exposed to words in both languages (even if the primes are masked and thereby subconscious). However, automatic co-activation of translation equivalents can facilitate lexical processing even when a task is completed in a single language. In a clever "hidden repetition" paradigm, Chinese–English bilinguals made relatedness judgments on pairs of English words. Stimulus pairs that were unrelated in English (the target language), but whose translation equivalents were related orthographically or phonologically, elicited an electrophysiological brain response typical for semantic priming or lexical repetition, indicating facilitation of the target word (Thierry & Wu, 2007; Wu & Thierry, 2010; Zhang et al., 2011; but see Wen & van Heuven, 2018, who failed to replicate this effect). Additional evidence has been reported for morphological priming, which showed cognate facilitation effects even when the primes and targets were in only one language (Comesaña et al., 2018). Additional evidence of co-activation from single-language tasks has revealed cross-language effects of lexical frequency (Miwa et al., 2014), phonological neighbors (Hameau et al., 2021), and morphological family members (Mulder et al., 2015). Crucially, in all of these studies, participants completed the tasks in, and were exposed to, only one language; thereby eliminating any explicit effects of exposure to another language. These studies demonstrate that translation equivalents are automatically co-activated even when only one language is required for the task, and that this co-activation, by default, can facilitate lexical processing.

The facilitation that arises from co-activation is not limited only to experimental settings, but can also result in longer-term changes in lexical accessibility. For example, bilinguals name pictures in their dominant language more rapidly (Gollan et al., 2005; Higby et al., 2020) and experience fewer TOTs on these words (Gollan & Acenas, 2004) if they know an equivalent translation in their non-dominant language. Poulin-Dubois et al. (2018) showed that bilingual toddlers were better able to match words in one language to the correct picture if they knew the same word in another language, compared to words only known in one language. These studies suggest that cross-language connections can improve accessibility.

Cross-linguistic facilitation can also be seen in studies of code-blending, a bilingual language production phenomenon unique to bimodal bilinguals[4]. Unlike switching back and forth between two spoken languages, which tends to incur a processing cost (see section 4.1), research has shown that code-blending does not slow down lexical retrieval (Emmorey et al., 2012; Kaufmann & Philipp, 2017). For example, accuracy for low-frequency American Sign Language (ASL) signs improves when produced together with their English translations (Emmorey et al., 2012). Moreover, ASL–English bilinguals occasionally produce ASL signs when communicating with English monolinguals, as well as co-speech gestures that resemble properties of ASL (Casey & Emmorey, 2008; Weisberg et al., 2020). It is unlikely that the bilinguals intend to convey information with their use of signs (as they tend not to be iconic signs and thus would be uninterpretable by their interlocutors); rather, this example of code-blending suggests that the co-activation of English and ASL supported lexical access or other aspects of language production.

Lastly, unique evidence for cross-language facilitation can be found in neurodivergent bilingual individuals (e.g., those with aphasia[5] or Alzheimer's disease). Facilitative effects of cognates have been found in studies of these populations (Costa et al., 2012; Ferrand & Humphreys, 1996; Roberts & Deslauriers, 1999). Moreover, treatment for aphasia in one language has been shown to improve later retrieval for untreated translations of the words used for treatment (Edmonds & Kiran, 2006; Goral et al., 2012; Kiran & Roberts, 2010; Kohnert, 2004; Lopez et al., 2022). This suggests that cross-language co-activation can also benefit language recovery in bilinguals.

3.2. Interpretation of facilitation effects

Overall, it is clear that cross-linguistic facilitation is a robust and replicable phenomenon that has been demonstrated across a range of contexts. Based on the prevalence of automatic co-activation and the resulting improvements in lexical

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accessibility, we posit that facilitation takes place in virtually all cases of cross-linguistic influence. Importantly, this co-activation should lower the activation thresholds of both the selected words and their translation(s), resulting in subsequent ease of retrieval for both.

In the cases of translation priming and simultaneous picture-word presentation, exposure to the prime or distractor activates its lexical representation, which causes co-activation of its translation equivalent(s), either via shared conceptual representations or via direct lexical links (Kroll & Stewart, 1994). This has the effect of lowering the activation threshold of both the target and its translation equivalent(s), making the latter more readily accessible when a response is required (e.g., a recognition judgement or verbal response). Similarly, naming a word or picture in one language activates its translation equivalent(s), making the translation(s) more readily accessible when participants subsequently name the same item in another language. A similar interpretation may be applied to cross-language treatment effects for bilinguals with aphasia: treated words activate their (untreated) translation equivalents via co-activation, resulting in treatment gains in both the treated and untreated languages.

The "hidden repetition" effect and the observation that knowing words in one language facilitates access to their translation equivalent(s) reveals the long-term effects of co-activation, even in the absence of an experimental manipulation (Degani et al., 2011). Repeated co-activation of translation equivalents will lower their activation thresholds, resulting in modified resting activation levels.

Cognates tend to enjoy an even greater benefit of cross-linguistic co-activation than non-cognate translation equivalents. The ease with which cognates are retrieved and recognized is likely due to multiple sources: co-activation of shared semantics, shared phonological and/or orthographic representations, and morphological family members (Dijkstra et al., 2019; Lalor & Kirsner, 2001a; Mulder et al., 2015). By contrast, non-cognate translation equivalents benefit from shared semantics but not overlap of phonological, orthographic, or morphological representations. As such, the enhanced benefits conferred to cognates might be considered a result of the sum of co-activation across multiple levels of representation (Voga & Grainger, 2007). Indeed, facilitative cognate effects have been shown to scale with degree of phonological/orthographic/semantic overlap (Dijkstra et al., 2010; Mulder et al., 2015; but see Vanlangendonck et al., 2020), while interlingual homonyms also appear to benefit even in the absence of semantic overlap (Dijkstra et al., 1998; Haigh & Jared, 2007; Lemhöfer & Dijkstra, 2004).

Interestingly, orthographic overlap is not a requirement for observing cross-language facilitation, evidenced by facilitative effects of phonologically similar words across languages that employ different scripts (Gollan et al., 1997; Hoshino & Kroll, 2008; Kim & Davis, 2003; Miwa et al., 2014; Nakayama et al., 2012, 2013; Voga & Grainger, 2007). Voga and Grainger (2007) demonstrated in a lexical decision task that cross-script cognates actually produced the greatest facilitation, same-script cognates and cross-script noncognates showed somewhat lower levels of facilitation, and same-script non-cognates showed the smallest amount of facilitation. The advantage for cross-script translation primes is that they do not elicit lateral inhibition between orthographic representations across languages (as same-script translation primes are assumed to do). Electrophysiological evidence supports this claim by demonstrating earlier translation priming effects across different scripts than across languages that share the same script (Hoshino et al., 2010; Midgley et al., 2009).

4. Cross-linguistic interference

4.1. Evidence for interference

The studies described in this section are presented in Table 2 for the reader's convenience. Perhaps the most prominent example of cross-linguistic interference is the cost to lexical access incurred when switching from one language to another, commonly known as the bilingual switch cost. Evidence for this phenomenon comes from language switching paradigms in which the language that participants use to name stimuli varies on a trial-to-trial basis, often depending on an accompanying cue or stimulus feature (e.g., "name blue numbers in English; red numbers in Spanish"). The switch cost refers to slower response latencies when participants change response language (switch trials) compared to when they respond to two consecutive trials in the same language (non-switch trials) (Meuter & Allport, 1999). Switch costs appear to be very robust and have been replicated in both word production (e.g., Broersma et al., 2016; Christoffels et al., 2007; Costa & Santesteban, 2004; Declerck et al., 2017; Kleinman & Gollan, 2018; Li & Gollan, 2018a; Macizo et al., 2012; Mosca & de Bot, 2017) and comprehension paradigms (Declerck & Grainger, 2017; Mosca & de Bot, 2017; Orfanidou & Sumner, 2005; Thomas & Allport, 2000; Von Studnitz & Green, 1997, 2002, but see section 5.3).

Switch costs have also been demonstrated in blocked language-switching paradigms in which the response language changes between blocks of stimuli (Branzi et al., 2014; Casado et al., 2022; Degani et al., 2020; Kleinman & Gollan, 2018; Misra et al., 2012; Wodniecka et al., 2020). It is worth noting that such effects are not confined to translation equivalents: naming *any* pictures in one language can interfere with lexical access in another, although in some cases naming translation equivalents incurs a greater cost (e.g., Kleinman & Gollan, 2018). Other studies with conceptually similar designs have also yielded similar effects. Levy et al. (2007) reported L1 interference following naming of L2 translation equivalents in a mixed-language block, while Kreiner and Degani (2015) report significantly more TOTs for L1 picture naming after viewing a ten-minute video in the L2, relative to L1 naming before the video.

Interference effects have been observed even at the earliest stages of second language learning. One study demonstrated that two newly learned languages can interfere with one another (Isurin & McDonald, 2001). Here, participants learned a list of words in an unfamiliar language and then learned a second list – composed of either translation equivalents of words from the first list or unrelated words – in a second unfamiliar language. At the end of the experiment, participants were less likely to recall words from the first list if they had learned translation equivalents in the second list. More recent studies have demonstrated that retrieving words in the dominant language can interfere with memory for newly learned words in a novel language. Participants were less accurate (Mickan et al., 2020) and slower (Bailey & Newman, 2018; Mickan et al., 2020, 2021) retrieving or responding to words that had been named in the other language, compared to words that had not. Taken together, these studies indicate that newly learned vocabulary from a novel language is susceptible to cross-linguistic interference, both from a

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Table 2. Summary of studies showing behavioral evidence of cross-linguistic interference discussed in Section 4.1. Studies are organized alphabetically by Task / Test of lexical access. This table does not include reviews, meta-analyses, or studies reporting exclusively on neuroimaging results.

Task / Test of lexical access	Description of effect	Citations
Free or cued recall	Impaired recall for words previously spoken in a different language	Bailey & Newman, 2018; Isurin & McDonald, 2001; Levy et al., 2007; Mickan et al., 2020, 2021
Lexical decision	Slower responses to interlingual homonyms	de Groot et al., 2000; Dijkstra et al., 1998, 2000; Lemhöfer & Dijkstra, 2004; Vanlangendonck et al., 2020
	Slower responses to cognates (mixed-language context)	Vanlangendonck et al., 2020
Picture naming	Slower responses to cognates	Broersma et al., 2016; Christoffels et al., 2007; Li & Gollan, 2018a;
	Slower responses on trials following a cognate	Acheson et al., 2012; Broersma et al., 2016
	Language switching cost (mixed-language contexts)	Broersma et al., 2016; Christoffels et al., 2007; Costa & Santesteban, 2004; Declerck et al., 2017; Kleinman & Gollan, 2018; Li & Gollan, 2018a; Macizo et al., 2012; Mosca & de Bot, 2017
	Language switching cost (one language per block)	Branzi et al., 2014; Casado et al., 2022; Degani et al., 2020; Kleinman & Gollan, 2018; Kreiner & Degani, 2015; Misra et al., 2012; Wodniecka et al., 2020
	Slower responses in L1 following a period of L2 immersion	Baus et al., 2013;
Semantic decision	Slower responses to interlingual homographs	Degani et al., 2018; Durlik et al., 2016; Macizo et al., 2010; Martín et al., 2010; Poort & Rodd, 2019
	Slower responses on trials following an interlingual homonym	Macizo et al., 2010; Martín et al., 2010
Text reading	More errors and/or intrusions on cognate trials	Gollan et al., 2014; Li & Gollan, 2018b; Martin & Nozari, 2021
Translation	More errors on cognate trials	Muscalu & Smiley, 2019
	Slower responses to interlingual homonyms	Christoffels et al., 2013, 2016
Translation decision	Slower responses to interlingual homonyms	Elias & Degani, 2022
Word production	Slower responses to cognates	Kroll et al., 2002
Verbal fluency	Fewer or less diverse L1 words produced by bilinguals immersed in L2 versus classroom L2 learners or monolingual controls	Botezatu et al., 2022; Linck et al., 2009; Yilmaz & Schmid, 2012
	Lower verbal fluency in L1 versus L2 after a period of L2 immersion	Beatty-Martínez et al., 2020

different novel language learned in parallel and from previously known languages.

Interference effects have also been observed in more advanced second language learners. The evidence here has mostly come from language immersion studies. When bilinguals are immersed in an L2-speaking environment, even for a relatively short period of time, they often experience perturbed access to their L1 (Baus et al., 2013; Botezatu et al., 2022; Linck et al., 2009). For example, Baus et al. (2013) report that native German speakers who spent a semester in Spain were slower at naming non-cognate pictures in German at the end of the immersion period compared to the beginning. Similarly, Linck et al. (2009) compared a group of native English speakers who had spent a semester in Spain to a separate group taking a non-immersive Spanish class. The immersion group showed reduced word production on a verbal fluency task in their L1, though it is worth noting that their L1 recovered to pre-immersion levels after 6 months.

Looking at the effects of long-term immersion can also be helpful in understanding the role of cross-linguistic interference effects. Research on language attrition has focused on changes to the L1 for individuals living in a predominantly L2 environment for a number of years (Schmid, 2010, 2011). Like short-term immersion studies, long-term L2 immersion studies show that accessing L1 words becomes more challenging (Kasparian & Steinhauer, 2016; Olshtain & Barzilay, 1991; Opitz, 2013). This is particularly true for low-frequency words (Hulsen, 2000; Yilmaz & Schmid, 2012). In discourse production tasks like free speech or story retelling, lexical attrition effects can be observed in terms of reduced lexical diversity, in particular manifesting as a reduction in the number of low-frequency words (Olshtain & Barzilay, 1991; Yilmaz & Schmid, 2012). More constrained, single-word lexical retrieval tasks like confrontation naming (Beatty-Martínez et al., 2020; Yilmaz & Schmid, 2012) and verbal fluency (Baus et al., 2013; Botezatu et al., 2022) do not always reveal the subtle effects of lexical attrition, suggesting that it may not be lexical access itself that is impacted in attrition contexts, but rather integration of retrieved lexical items during production. More generally, losses in L1 seem to scale with the amount of L2 input received in immersion settings (e.g., Datta, 2012; Miller & Rothman, 2020; Stoehr et al., 2017). This mirrors experimental settings, where more exposure to or engagement with one language tends to result in greater interference effects in another (Isurin & McDonald, 2001; Kleinman & Gollan, 2018; Levy et al., 2007).

In contrast to cognate facilitation effects described in the previous section, cognates may also cause interference, relative to non-cognates, in certain contexts. For example, greater switch costs have been found for cognates compared to non-cognates (Christoffels et al., 2007; Li & Gollan, 2018a). Cognates are also more likely than non-cognates to elicit errors and cross-language intrusions (Gollan et al., 2014; Li & Gollan, 2018b; Martin & Nozari, 2021; Muscalu & Smiley, 2019). In a typed translation task, participants showed more orthographic errors and longer typing times for cognates than non-cognates (Muscalu & Smiley, 2019). When reading aloud a mixed-language text, cross-language intrusions were five times more likely to involve cognate words than non-cognate words (Gollan et al., 2014). Cognates may show interference only in L2 (Broersma et al., 2016) or only in L1 (Kroll et al., 2002), depending on the task and perhaps proficiency level. Aside from these immediate access difficulties, there is evidence that cognate retrieval may cause latent interference effects on subsequent trials (Acheson et al., 2012; Broersma et al., 2016). Taken together, these studies indicate that cognates have the potential to cause interference, either during immediate retrieval of the cognate or on subsequent trials, though the precise nature of cognate interference remains unclear.

Interlingual homographs (i.e., false cognates) provide an interesting case of interference. Due to their conflicting semantic representations, co-activation of interlingual homographs leads to slower responses and/or more errors on semantic decision tasks (Degani et al., 2018; Durlik et al., 2016; Macizo et al., 2010; Martín et al., 2010; Poort & Rodd, 2019) and translation tasks (Christoffels et al., 2013, 2016). In addition, Macizo et al. (2010) and Martín et al. (2010) report latent interference effects induced by homographs: participants made semantic judgements about pairs of words in a single language (English) and were slower to respond if the pair contained the non-target language (Spanish) translation for a previously presented homograph (e.g., responses were slower for the pair *Foot-Hand* than for *Finger-Hand* if the prior trial contained *Pie* in English). These interference effects can occur even when the task is restricted to only one language and the two languages have different scripts, meaning that the co-activation of interlingual homonyms does not arise simply through bottom-up activation from shared orthography (Degani et al., 2018; Elias & Degani, 2022). Indeed, learning novel meanings for familiar words within the same language (which is analogous to interlingual homonyms) may elicit opposing forces of facilitation and interference – initially benefiting from form facilitation (i.e., phonological and/or orthographic overlap) but later exhibiting semantic interference (Fang et al., 2017).

4.2. Interpretation of interference effects

It is clear that, much like facilitation, interference has been observed in many contexts. The reader will note that many contexts/paradigms that lead to facilitation (e.g., picture naming) can also give rise to interference, and therefore our interpretations provided below may at first glance seem at odds with those described in the preceding section. To be clear, automatic co-activation and competition are not mutually exclusive processes. Indeed, competition should be understood as a RESULT of co-activation, while inhibition in turn is a means of resolving competition to aid lexical access. This view is uncontroversial and is consistent with popular accounts of bilingual lexical access (Green, 1998; Meuter & Allport, 1999). Moreover, it is our position that whether facilitation or interference effects are observed at the behavioural level is ultimately determined by the relative weight of contributions from each mechanism, which in turn is determined by complex interactions between a number of factors discussed in the subsequent section. We may assume that, in each case of interference discussed below, the deleterious effects of competition/inhibition were sufficient to outweigh benefits conferred by co-activation.

Bilingual switch costs are typically interpreted as a latent effect of inhibition (Meuter & Allport, 1999), whereby the inhibited language is less accessible on subsequent trials or blocks. We may take a similar inhibition-based view of interference effects in the context of language learning and L2 immersion. If inhibition is necessary to resolve cross-language competition, subsequent interference in one language following lexical retrieval in another may be attributed to persistent effects of inhibition that took place during the initial instance of lexical access. As such, many of the interference effects discussed in the preceding section – for

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example, impaired language learning following picture naming in the dominant language (Bailey & Newman, 2018; Mickan et al., 2020, 2021), or diminished dominant language access following immersion or picture naming in a non-dominant language (Baus et al., 2013; Kreiner & Degani, 2015; Levy et al., 2007; Linck et al., 2009) – may be explained by this simple principle of lasting inhibition.

A remaining question is the locus of inhibition in these studies. As discussed earlier, the locus of inhibition may be broadly defined as either global, driven by top-down control processes and/or the speaker's expectations about upcoming demands on the language system, or local, driven by cross-linguistic competition of specific lexical representations during lexical access. Studies have reported both global and local effects (Branzi et al., 2014; Degani et al., 2020; Emmorey et al., 2020; Kleinman & Gollan, 2018; Van Assche et al., 2013), supporting the view that inhibition may operate at different levels of the lexicon in parallel. Interference effects in the context of language learning, whereby newly learned vocabulary interferes with a previously known language, or vice-versa, have primarily been interpreted in terms of local inhibition. This is because most work in this area has identified interference effects by comparing performance for words that were spoken in another language to those which were not (Bailey & Newman, 2018; Isurin & McDonald, 2001; Levy et al., 2007; Mickan et al., 2020, 2021); such comparisons naturally lend themselves to detecting local inhibition. However, the possibility of global inhibition cannot be ruled out. We reason that global inhibition may have taken place in these studies but was simply undetectable. In simple terms, it may be that ALL words were affected by global inhibition, but that item-level differences due to naming in another language arose because local inhibition had an additive effect, resulting in overall greater interference effects on the translations of newly learned words.

Cognate and interlingual homonym interference effects warrant slightly different interpretations from those discussed above. We consider many such cases of interference to reflect response selection problems. It has been suggested that although cognates will initially benefit from co-activation at multiple levels of representation, this co-activation can in some cases lead to excessive amounts of competition, which in turn outweighs the initial facilitation (Broersma et al., 2016; Li & Gollan, 2018a, 2018b). For example, Li and Gollan (2018a) suggested that co-activation at the phonological level may flow to the lexical level in the non-target language, and that this feedback (from phonological to lexical) may induce incrementally greater levels of competition at the lexical level on each subsequent presentation or production of the cognate word. The increased competition at the lexical level will therefore make lexical selection more difficult. This explanation may account for higher rates of errors and cross-language intrusions (Gollan et al., 2014; Li & Gollan, 2018b; Martin & Nozari, 2021; Muscalu & Smiley, 2019) as well as slower picture naming (Broersma et al., 2016; Kroll et al., 2002) for cognates compared to non-cognates.

As with cognates, interlingual homonyms will cause co-activation of overlapping phonological or orthographic representations, which flows to the lexical level. However, due to their conflicting semantic representations, co-activation of lexical representations leads to ambiguous lexical-semantic mapping, and hence worse performance on semantic decision (Durlik et al., 2016; Macizo et al., 2010; Martín et al., 2010; Poort & Rodd, 2019) and translation tasks (Christoffels et al., 2013, 2016). We need not invoke inhibition in order to explain these cases of interference (see also section 6.2). Having said this, the finding that cognates can lead to downstream interference effects (Acheson et al., 2012; Broersma et al., 2016), while interlingual homonyms can cause latent semantic interference (Macizo et al., 2010; Martín et al., 2010), indicates that such cases of lexical competition must still be resolved through inhibition, leading to access difficulties beyond the initial lexical selection process.

5. Modulating factors

We have shown that facilitation and interference effects can each emerge in a variety of experimental contexts. In fact, somewhat paradoxically, some contexts that consistently yield facilitation effects can also give rise to interference. These apparent discrepancies may be at least partially explained by three factors that affect CLI: language context (single- versus mixed-language contexts), direction (effects from the dominant to non-dominant language, or vice-versa), and modality (production versus comprehension).

5.1. Language context

It is important to recognise that lexical selection never occurs as a single, isolated process: it is always subject to constraints imposed by available cues (e.g., stimuli) and broader contextual requirements (e.g., speaking in one language versus switching languages), as well as constraints imposed by response goals (e.g., lexical decision versus picture naming). Such factors appear critical in determining the extent to which facilitation and/or interference arise in a given study.

Taking a broad view of the literature discussed so far in this review, there is much evidence to suggest that cross-linguistic facilitation is likely to emerge (or, alternatively, interference is unlikely) when bilinguals complete tasks and/or respond exclusively in a single language. This is primarily evidenced by reports of facilitation in experiments that used masked priming and simultaneous picture-word presentation. In contrast to single-language contexts, contexts that require participants to rapidly switch back-and-forth between languages often elicit interference, as seen in language switch costs. We should of course be cautious when comparing findings from different paradigms; however, our distinction between single-language (facilitating) and mixed-language (interfering) contexts is further supported by studies directly comparing lexical access across such contexts. A number of studies have indicated that lexical access is more difficult in mixed-language contexts (whereby the response language changes on a trial-to-trial basis) compared to single-language contexts (the response language is consistent throughout a block of trials). These mixing costs[6] have been evidenced by slower and/or more error-prone responses on non-switch trials in mixed-language contexts compared to trials in single-language blocks (Christoffels et al., 2007; Gollan & Ferreira, 2009; Guo et al., 2011; Hernandez & Kohnert, 1999; Jevtović et al., 2020; Ma et al., 2016).

One interpretation of these findings is that responding in only one language enables more efficient planning and maintenance of lexical access. In this vein, there is evidence that both mixing costs and switch costs are diminished in mixed-language contexts with longer delays between language cue and word presentation, which provide participants with more time to prepare to respond in the target language (Costa & Santesteban, 2004; Fink & Goldrick,

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2015; Ma et al., 2016; Verhoef et al., 2010). Switch costs are also diminished in contexts where switch trials are highly predictable (Liu et al., 2018; Macnamara et al., 1968). Similarly, allowing participants to switch languages at will (as opposed to mandatory switching in response to an external cue) may disrupt or even eliminate switch costs altogether (Gollan & Ferreira, 2009; Jevtović et al., 2020; Zhu et al., 2022). For example, Carpenter et al. (2020) found that bilinguals with aphasia produced fewer correct responses than healthy bilinguals on a verbal fluency task when they were limited to only one language or had to switch languages every other response (forced switching), but the two groups performed similarly on the task when switching was optional and voluntary. Green and Abutalebi (2013) suggest that in voluntary switching conditions, the languages are in a cooperative relationship, and cognitive control demands are low; whereas single-language contexts (and presumably cued language switching) place the languages in a competitive relationship, which requires more cognitive control. Thus, in mixed-language contexts where speakers are able to plan ahead – either because switches are predictable, voluntary, or there is more preparation time – costs associated with language switching tend to be reduced or eliminated. These diminished costs may be afforded at least in part by more opportunity for proactive control. By extension, opportunity for proactive control afforded to single-language contexts may explain the absence or reduction of interference effects. For example, when a task requires responses in a single language, bilinguals may proactively boost activation of the target language, making potential target words more readily accessible (Li & Gollan, 2021). Another possibility, which is not mutually exclusive with the boosting account, is that speakers may globally inhibit the non-target language, reducing potential competition (Christoffels et al., 2007). Broadly speaking, this proactive planning account of single versus mixed contexts echoes elements of the Inhibitory Control (Green, 1986, 1998) and BIA + (Dijkstra & van Heuven, 2002) models, both of which emphasise the role of speaker goals ("task schema") in top-down control of lexical activation.

Another point worthy of discussion here is stimulus composition; in particular, cognate status has been shown to interact with contextual effects described above. Cognate facilitation effects are often present in mixed-language contexts (Christoffels et al., 2007; Li & Gollan, 2021). Moreover, cognates facilitate language switches on cued-switch picture naming tasks when in a block of cognate trials (Li & Gollan, 2018a, Experiment 1). When mixed with noncognates, however, cognates may actually elicit greater switch costs than non-cognates (Christoffels et al., 2007; Filippi et al., 2014; Li & Gollan, 2018a). Interestingly, Li and Gollan (2018a, Experiments 2 & 3) report that cognates facilitate switches at the first presentation of a picture but not on subsequent presentations. These authors also report that cognates became increasingly slower with repeated presentation of the same pictures, particularly on switch trials, indicative of increasing cognate interference (Li & Gollan, 2018a, Experiment 3). Non-cognates, by contrast, did not show evidence of increasing competition. This pattern of results suggests that cognates are facilitative at the phonological level but interfering at the lexical level. Thus, whether facilitation or interference is observed depends on task demands and which processing level is targeted (Li & Gollan, 2021).

Work on interlingual homographs has also yielded interesting findings pertaining to language context. Experiments employing lexical decision tasks have reported that homographs either elicited no interference (Dijkstra et al., 2000) or a reaction time advantage (Dijkstra et al., 1998; Lemhöfer & Dijkstra, 2004) relative to control words when they occurred in a single-language block; however, responses to homographs were either slowed (de Groot et al., 2000; Dijkstra et al., 1998, 2000) or did not show the previously observed advantage (Lemhöfer & Dijkstra, 2004) in mixed-language blocks. These findings were replicated and extended by Vanlangendonck et al. (2020), who reported that interference increased for both interlingual homographs and identical cognates in a unilingual lexical decision task when the target word stimuli were mixed in with words from the bilinguals' other language. In fact, the cognate facilitation effect found in the single-language version of the task not only disappeared but turned into an interference cost in the mixed-language version. Since the task required a "yes" response for words in the target language and a "no" response for words in the non-target language, identical cognates (which can be read in both languages) elicited conflict at the response level. It is worth noting that the response language did not differ between conditions – only the stimulus composition. As Vanlangendonck et al. (2020, p. 842) put so well, "What hinders cognate performance in the mixed list is precisely what benefits them in the pure list: their cross-linguistic overlap."

To summarize, mixed-language contexts tend to generate more interference compared to single-language contexts, possibly because they enable less opportunity for proactive control of the target language through boosting and the non-target language through inhibition. Context effects may interact with stimulus composition effects: mixed-language contexts may reverse both cognate facilitation and interlingual homograph interference effects typically seen in single-language contexts. These effects speak to general cognitive control mechanisms that are essential for bilingual lexical access in any context. This fact is particularly evident in studies of neurodivergent individuals (e.g., those with aphasia or Alzheimer's disease) where cognitive control mechanisms break down. Pathological language mixing (i.e., language switching that is inappropriate for the context) can result from a disruption of the neural systems involved in controlling the choice of language output, which may reflect deficits in cognitive control (Fyndanis & Lehtonen, 2021). Furthermore, for bilinguals with aphasia, therapy in one language may lead to increased cross-language intrusion errors in the untreated language due to an inability to inhibit the over-activated language of treatment (Keane & Kiran, 2015; Kurland & Falcon, 2011).

5.2. Language direction

Much research in bilingualism is characterised by asymmetries – that is, effects that may be present or absent, or that differ in magnitude, depending on the direction of CLI being tested. For example, cognate facilitation effects tend to be greater when the task is completed in the non-dominant compared to the dominant language (Christoffels et al., 2007; Costa et al., 2000, 2012; Gollan et al., 1997; Ivanova & Costa, 2008; Lalor & Kirsner, 2001a; Roberts & Deslauriers, 1999; Stadie et al., 1995; Starreveld et al., 2014). In fact, cognate effects are inversely related to language dominance (Anthony & Blumenfeld, 2019). Within spreading activation models, these asymmetries can be explained in terms of the degree to which co-activated translation equivalents are activated. When completing a task in a weaker language, co-activated words in a stronger language may be strongly co-activated because of their privileged connections to shared semantics or because they have lower activation thresholds. By contrast, when completing a task in a stronger language, the co-activation of words in a weaker language may be less strong and thus may exert a weaker cross-language effect on task performance (Li & Gollan, 2021). Support for this comes from a study of lexical decision speed with trilinguals (van Hell & Dijkstra, 2002). A processing speed advantage was found for cognates between the participants' L1 and L2, but not for cognates between the L1 and L3 (their least proficient language). Nevertheless, a cognate benefit in the L1 was observed for participants with higher L3 proficiency. In other words, the degree to which cognate facilitation occurs seems to be dependent on proficiency in the weaker language.

Another experimental paradigm that often yields asymmetries is translation priming. Forward priming (in which a prime in a stronger language is followed by a target in a weaker language) is often reported to be stronger and/or more robust than backward priming (Dimitropoulou et al., 2011b, 2011a; Dubey et al., 2018; Jiang, 1999; Nakayama et al., 2013; Smith et al., 2019), although significant priming effects have been reported in both directions (Basnight-Brown & Altarriba, 2007; B. Chen et al., 2014; Dimitropoulou et al., 2011b; Duñabeitia et al., 2009, 2010; Jiang, 1999; Kiran & Lebel, 2007; Schoonbaert et al., 2009; see also Wen & van Heuven, 2017). One interpretation of this asymmetry, offered by Schoonbaert et al. (2009), is that while the dominant and non-dominant lexicons share overlapping semantic representations (and, therefore, automatic co-activation can occur in either direction), lexical representations in the non-dominant language are associated with fewer semantic nodes than lexical representations in the dominant language. As such, a prime in the dominant language will activate a larger proportion of semantic nodes associated with the non-dominant translation equivalent compared to non-dominant language primes (see also Finkbeiner et al., 2004; Wang & Forster, 2010). This asymmetry in translation priming also appears to be modulated by relative proficiency in each language. Unlike unbalanced bilinguals, balanced bilinguals[7] often exhibit symmetric priming in both directions (e.g., Basnight-Brown & Altarriba, 2007; Duñabeitia et al., 2009). Further, highly proficient bilinguals show stronger backward priming effects compared to less proficient bilinguals (Nakayama et al., 2012, 2013, 2016), though significant backward translation priming can occur even for low-proficiency bilinguals when the interval between prime and target is longer (Lee et al., 2018). This asymmetry can be explained by the Sense Model (Finkbeiner et al., 2004), which assumes that lexical representations in the L2 develop more connections with semantic nodes as proficiency increases. The BIA+ model also predicts that because conceptual links for the non-dominant language are weak, and words in that language have low activation levels in general, the masked prime does not provide sufficient stimulation to trigger a priming effect (Nakayama et al., 2016).

Translation tasks provide another source of evidence for directional asymmetry in bilingual lexical processing. In these tasks, forward translation is typically slower than backward translation (Kroll et al., 2002, 2010; Kroll & Stewart, 1994; Sholl et al., 1995), but note that some studies have revealed translation asymmetries in the opposite direction (Christoffels et al., 2006; de Groot et al., 1994, Experiment 2). The Revised Hierarchical Model (RHM) explains this asymmetry in terms of asymmetric connections between translation equivalents via direct lexical links (Kroll & Stewart, 1994), which are stronger in the L2-L1 direction than vice-versa. Moreover, because of stronger links between the L1 lexical representation and its associated semantic representation, forward translation would necessarily entail semantic mediation, whereas backward translation might be achieved via the more direct lexical route. Hence, according to the RHM, backward translation is faster due to the stronger direct lexical connection from the L2 to the L1, while this asymmetry is often reduced in balanced bilinguals (Kroll et al., 2002). Dylman and Barry (2018) report a similar asymmetric pattern in a simultaneous picture-word paradigm; these authors report greater facilitation when participants saw an L2 distractor and named in L1 compared to vice-versa.

The examples above illustrate greater and lesser degrees of facilitation by co-activation, with asymmetries likely driven by differences in activation levels of words or strength of lexical connections between words. Next we discuss examples of asymmetric interference effects, wherein asymmetries are driven by relative levels of lexical competition.

While bilinguals typically retrieve words faster in their dominant language (e.g., Chen & Leung, 1989), some studies report a switched dominance effect in mixed-language naming contexts whereby naming in the non-dominant language is faster than in the dominant language (Christoffels et al., 2007; Gollan & Ferreira, 2009; Guo et al., 2011; Ma et al., 2016). Intrusion errors are also more common in mixed-language contexts when attempting to name in the dominant language (Gollan et al., 2014; but see Poulisse, 1999 who report more intrusions for non-dominant targets). Asymmetric switch costs are also commonly reported whereby switching into the dominant language is more costly (in terms of increased response time) compared to switching into the non-dominant language (Costa & Santesteban, 2004; Costa et al., 2006; Kleinman & Gollan, 2018; Meuter & Allport, 1999). These observations are widely regarded as evidence that in mixed-language or language-switching conditions, participants inhibit their dominant language more strongly, sometimes resulting in easier access to the non-dominant language (Christoffels et al., 2007; Costa & Santesteban, 2004; Declerck et al., 2013, 2015; Declerck, 2020; Declerck & Philipp, 2015b b; Gollan et al., 2014; Gollan & Ferreira, 2009; Guo et al., 2011; Heikoop et al., 2016; Jylkkä et al., 2018; Kleinman & Gollan, 2018; Li & Gollan, 2018a, 2018b; C. Liu et al., 2019; Philipp et al., 2007; Philipp & Koch, 2009; Verhoef et al., 2010). The reversed language dominance pattern is thought to be the result of proactive global inhibition of the dominant language in anticipation of interference, while the switch-cost asymmetry might reflect a form of reactive control that is more transient (Declerck, 2020; Declerck & Philipp, 2015a). Interestingly, there is also some evidence for asymmetric switch costs between language modalities. Emmorey et al. (2020) reported that switching from producing ASL–English code-blends to producing words in a single language was easier when the single-language naming was participants' dominant language (English) but harder when switching to ASL only. Their explanation was that switching from a code-blend back to a single-language production requires inhibiting the language that will no longer be produced, which will incur a greater cost if the language to be inhibited is the dominant language.

Similarly to priming asymmetries, asymmetric switch costs are modulated by L2 proficiency. Asymmetric switch costs are typically observed amongst unbalanced bilinguals (Costa & Santesteban, 2004; Costa et al., 2006; Kleinman & Gollan, 2018; Meuter & Allport, 1999), while this asymmetry is reportedly smaller (or non-existent) amongst balanced or high- compared to low-proficiency bilinguals (Costa & Santesteban, 2004; Costa et al., 2006; Filippi et al., 2014; Meuter & Allport, 1999; Mosca & de Bot, 2017; Schwieter & Sunderman, 2008); though we note that symmetric switch costs have been observed even amongst low-proficiency bilinguals (see Declerck & Philipp, 2015a for review). These findings reinforce the point that the degree of inhibition that must be applied to resolve competition is likely dependent on relative imbalances between L1 and L2, which in turn is influenced by proficiency in each.

In blocked picture naming tasks, asymmetries have been observed with respect to language order. Naming first in the dominant language facilitates later naming in a non-dominant language (Branzi et al., 2014; Casado et al., 2022; Misra et al., 2012; Wodniecka et al., 2020); by contrast, no such facilitation occurs for the dominant language following a prior block of naming in a non-dominant language. Both new and repeated words in the L1 show interference when preceded by naming in the L2. This suggests a more global lexical control process (rather than a local one) in the L1, but word-specific facilitation in the L2, likely due to automatic co-activation. In a related vein, there is also evidence for similar order effects in a verbal fluency task: Van Assche et al. (2013) report that, when asked to generate exemplars from the same semantic category in two languages, participants produce fewer exemplars in L1 following naming in L2, whereas L2 was not negatively impacted by a prior L1 naming block.

What are we to conclude from this collection of asymmetric effects? At the outset, they may appear rather disjointed – indeed, the fact that these effects are often studied in isolation from one another, using different paradigms, does not help. However, we argue that the evidence presented here speaks to a fundamental principle of cross-linguistic influence: co-activation (and consequently, facilitation) is a ubiquitous phenomenon, present in almost all instances of CLI, but which may be masked when experimental conditions give rise to lexical competition. Critically, the degree to which facilitation is masked is linked to the degree of competition present which, in turn, is at least partially determined by the direction of CLI and relative proficiency levels. The degree of competition present during lexical retrieval depends on relative imbalances in resting activation levels between the target and non-target languages. Certain task demands, like switching back-and-forth between languages, give rise to more competition compared to situations in which participants only need to respond in one language. Moreover, producing words might raise their activation level to a greater degree than merely reading them, causing those words to present more competition on subsequent trials (e.g., on switch trials).

5.3. Modality

A major consideration when describing CLI effects is whether the experimental task requires production (e.g., word naming) or comprehension (e.g., lexical decision). Indeed, some models of bilingual lexical access are exclusively concerned with production (Kroll & Stewart, 1994) or comprehension (Dijkstra & van Heuven, 2002), which speaks to the divergence of these two modalities in the literature. We have already seen in section 5.2 that translation and priming tasks (which entail production and comprehension respectively) reveal asymmetries in opposite directions. Production has been described as a top-down process, whereby activation spreads directly from conceptual-semantic representations to associated lexical forms and their respective phonological representations (Dijkstra et al., 2019). By contrast, comprehension of written forms is bottom-up; activation will initially spread from orthographic or phonological forms (depending on whether the input is written or auditory) to morphologically related forms and associated conceptual-semantic representations (Dijkstra & van Heuven, 2002). These different paths of information flow will likely affect the degrees of facilitation, competition, and subsequent inhibition that occur. For example, comprehension tasks typically lead to coactivation of interlingual homonyms (phonological or orthographic overlap between languages, but no semantic overlap). This type of spreading activation may result in ambiguous mapping to conceptual-semantic representations, leading to semantic interference effects (Durlik et al., 2016; Macizo et al., 2010; Martín et al., 2010; Poort & Rodd, 2019). In the case of production tasks, interlingual homonyms are not expected to induce cross-language competition because activation spreads in the opposite direction.

Switch costs are another area in which production and comprehension diverge. While switch costs are robust in production paradigms (e.g., picture naming), these effects appear to be less robust for comprehension (Declerck & Grainger, 2017; Mosca & de Bot, 2017; Orfanidou & Sumner, 2005; Thomas & Allport, 2000; Von Studnitz & Green, 1997, 2002). For example, Declerck et al. (2019) failed to replicate comprehension-based switch costs across several experiments, using a variety of different comprehension tasks and including bilinguals of varying levels of proficiency. Moreover, proficiency appears to affect switch costs for production (Jackson et al., 2004; Macizo et al., 2012; Mosca & de Bot, 2017) but not comprehension (see Declerck & Philipp, 2015a for review).

These observations suggest that reactive inhibition is differentially deployed in comprehension versus production. Declerck et al. (2019) suggest that in comprehension tasks, in which activation spreads from orthographic/phonological forms to morphological neighbours, parallel activation of lexical representations in the non-target language is less likely (or occurs to a lesser degree). Less parallel activation of potential competitors in the non-target language would require less inhibition, and thus diminished or absent switch costs. In summary, the different paths of information flow in production versus comprehension tasks affect co-activation and competition differently.

6. Discussion and final considerations

6.1. General conclusions

Our review of the existing literature on cross-linguistic facilitation and interference effects in bilinguals has revealed important insights into the nature of these two seemingly contradictory forces. The overwhelming evidence for automatic co-activation suggests that facilitation occurs to some extent in almost all cases of CLI. By contrast, interference – which is not mutually exclusive from facilitation, but which can mask or outweigh facilitative effects – arises only in contexts where cross-linguistic competition from a non-target language might perturb lexical access in the target language. We posit that in the examples of cognate facilitation, translation priming, simultaneous picture-word presentation, and translation, cross-language lexical competition is minimal, revealing robust facilitation effects – particularly in the dominant-to-nondominant language direction. In other situations, such as mixed-language contexts or blocked language switching, cross-language lexical competition is relatively high. This competition necessitates inhibition, which has a latent effect

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on lexical access on subsequent trials, giving rise to interference effects that mask any underlying facilitation by co-activation. Critically, latent inhibition tends to incur a greater cost for the dominant language, likely because dominant language words are activated to a greater extent and/or are more strongly represented, which, incidentally, is precisely what leads them to cause enhanced facilitation in the absence of competition.

Central to both facilitation and interference are the relative levels in resting activation (i.e., accessibility) and, subsequently, degree of co-activation between representations in the target and non-target languages. Generally speaking, words in the dominant language are regarded as having "stronger" lexical representations than those in a non-dominant language (that is, lower activation thresholds and stronger links to semantics). The privileged status of the dominant language both helps and hinders lexical access in the non-dominant language. On the one hand, L2 access is facilitated by the L1 via strong co-activation. In some contexts, however, because of its relatively greater strength, the dominant language can also present more competition during lexical access in the non-dominant language. This heightened competition may necessitate greater degrees of inhibition (both proactive and reactive) in the case of language switching, and subsequently more difficult lexical access when the speaker returns to using the dominant language.

We argue that our account of facilitation versus interference still holds when considering cognate interference effects and interlingual homonyms; findings in this area are complex and often counterintuitive, and so deserve special attention. As a rule, access to words with overlapping semantic, orthographic, and/or phonological representations across languages will initially benefit from co-activation flowing to different levels of representation. This benefit is evidenced by cognate advantages on various production and comprehension tasks and by interlingual homonym advantages on lexical decision tasks in single-language contexts. However, in many situations, competition arising from co-activation can be detrimental to response selection and can also induce latent inhibitory effects. Whether facilitation or interference is observed at the behavioural level depends upon the context and related task demands. For example, cognates can induce competition when participants complete a unilingual lexical decision task because their language membership can be ambiguous (Vanlangendonck et al., 2020). Similarly, when responding to interlingual homographs, participants must inhibit semantically inappropriate competitors when making semantic judgements (Durlik et al., 2016; Macizo et al., 2010, 2010; Poort & Rodd, 2019) or selecting translation equivalents of a presented word (Christoffels et al., 2013, 2016). In these examples, co-activation that resulted in facilitation at the behavioural level in other contexts ultimately led to interference. It is our position that such examples do not preclude initial facilitation from co-activation. Rather, the observed behaviour likely reflects the *sum* of relative degrees of co-activation and competition/inhibition. Thus, in the aforementionned examples, any benefits to lexical access from co-activation were masked by subsequent competition and inhibition. We note that we are not the first to make this case – other researchers have posited similar interpretations to explain the co-occurrence of cognate facilitation and interference effects arising within the same paradigm (e.g., Broersma et al., 2016; Li & Gollan, 2018a b).

CLI is clearly a complex phenomenon that is dependent on many factors. A number of factors, such as language context, direction and modality interact in complex and often counterintuitive ways to affect activation thresholds and degree of co-activation, lexical competition, and inhibition. Additionally, these processes may have both short- and long-term effects and can change on a trial-to-trial basis, giving rise to seemingly contradictory effects. For example, facilitated language switching for cognates on the first presentation of an item, followed by cognate interference on subsequent trials (Li & Gollan, 2018a, Experiments 2 & 3). All of this is to say that one should not view CLI as following a set of rigid determinants, but rather as a highly dynamic process that we are still trying to fully understand.

6.2. Alternatives to inhibition

Throughout this review we have explained latent interference effects mainly in terms of inhibition. We have taken this position because inhibition-based interpretations appear to dominate the literature and moreover provide a convenient and generalisable framework that explains much of the data. However, some have argued that inhibition is not necessary to explain interference. While an evaluation of this position would be beyond the scope of this review, we feel that it is worth outlining a few such accounts here.

Some accounts emphasise the importance of maintaining or modifying activation levels in either language. The persistent activation account (Philipp et al., 2007) was proposed to explain asymmetric switch costs, but may also be applicable to other examples of cross-linguistic interference. This account holds that naming in a non-dominant language requires a large amount of activation in order to overcome higher resting activation level of the dominant language. This increase in L2 activation persists into subsequent trials, presenting a high degree of competition from the non-dominant language, making subsequent retrieval in the dominant language more difficult. In a similar vein, the activation threshold hypothesis (Paradis, 2007) argues that language attrition may be explained by a gradual rise in activation threshold over time if a word is not accessed. While these accounts are not mutually exclusive from inhibition, they do offer another mechanism by which latent interference effects may occur.

Another class of theories posits that cross-language competition is limited by a speaker's intentions or task goals by, for example, raising activation levels for the target language (Grosjean, 2001; La Heij, 2005). Similarly, the response selection account (Finkbeiner et al., 2006) proposes that, following activation of non-target lexical representations (e.g., the translation equivalent of the target word), selection is achieved via top-down control mechanisms that select or reject potential responses based on their compatibility with the speaker's goals. These accounts generally propose that lexical selection is achieved by "biasing" activation levels in one language, while still allowing for lexical competition between languages.

6.3. The time-course of facilitation and interference

The patterns observed for cross-language facilitation and interference imply that their effects might operate over different time scales, an idea proposed by Higby et al. (2020). Specifically, there is some evidence suggesting that facilitative effects afforded by co-activation are long-lasting, while interference effects are more transient in that they often subside after a relatively short period of time after the initial effect was induced. While little work that we are aware of has explored this issue, we note some additional evidence supporting this idea. Casado et al. (2022;

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Experiment 2) reported that after an L2 naming block, L1 lexical access speed recovered over the course of a block of L1 naming. Similarly, latent inhibitory effects induced by interlingual homographs, reported by Martín et al. (2010), dropped off sharply over time: semantic interference was detectable when trials were separated by a 500 ms interval but not a 750 ms interval. In the context of L2 immersion, reduced access to the L1 lexicon shows recovery after returning to the L1 context (Linck et al., 2009). Lastly, interference when learning a novel language diminished to non-significant levels one week later (Mickan et al., 2020).

It is likely that both co-activation and inhibition act upon activation thresholds – with co-activation lowering thresholds of activated words and inhibition raising thresholds – though the time courses of these processes are poorly understood. Paradis (1993, 2007) has argued that activation thresholds can change gradually over time in the absence of stimulation or inhibition. One possibility is that this process occurs at different rates and directions (i.e., raising or lowering), depending on relative amounts of preceding activation and inhibition. In a recent paper, Casado et al. (2022) outline a model of how relative levels of language activation impact the degree of language control required. Future research could attempt to disentangle the time scales of these two effects, particularly using experimental designs that can reveal both facilitation and interference effects within the same participants and design.

6.4. Overlap and divergence from models of the bilingual lexicon

We have attempted in this review to describe broad trends in the literature concerning behavioural outcomes of facilitation and interference and how they may come about through co-activation, competition, and inhibition in various contexts. In our account, we have attempted to incorporate principles from various existing models of bilingual lexical processing. First, we have made the case that co-activation of representations across languages may facilitate retrieval of co-activated words. This position is expressed in many popular accounts of bilingual lexical access (Multilink: Dijkstra et al., 2019; BIA+ Dijkstra & van Heuven, 2002; IC: Green, 1998; RHM: Kroll et al., 2006). Furthermore, modulation of co-activation by relative imbalance of representation strength between languages has become generally accepted in bilingualism research (Dijkstra & van Heuven, 2002; Green, 1998; Kroll & Stewart, 1994).

Some of our assumptions are less universal. Many of the models cited above assume (as do we) that co-activation may lead to lexical competition and that this competition is resolved through varying degrees of reactive and/or proactive inhibition. While inhibitory mechanisms are consistent with the widely-cited Inhibitory Control and BIA+ models, alternative theories have also been proposed (see 6.2). Moreover, our account accommodates a division between the lexico-semantic system and a distinct decision-making system; this is in line with the BIA+ (Dijkstra & van Heuven, 2002) and Multilink (Dijkstra et al., 2019) models. We place a great deal of emphasis on context and task demands, which goes beyond models mainly concerned with specific contexts (e.g., word recognition: Dijkstra & van Heuven, 2002) or tasks (e.g., translation: Kroll & Stewart, 1994). Our account also attempts to encompass both comprehension and production. To our knowledge, only the Multilink model (Dijkstra et al., 2019) encompasses both of these domains. This model operates on many of the same principles as our account (overlapping representations between languages, non-selective co-activation, competition), although we note some disagreement in that the seminal work behind this model assumes no lateral inhibition between competitors (Dijkstra et al., 2019).

Our account does make a few novel claims, though we do not feel that these claims are incompatible with the models discussed above. First, we propose that facilitation is a direct result of co-activation and so is the default form of CLI. By extension, interference effects are context-dependent and may mask (but do not preclude) the initial facilitation. This framework is grounded in simple and straightforward principles that form the basis of many popular models of lexical access (e.g., the IC, BIA +, and Multilink models). Finally, we are not aware of any models that address different time scales for latent facilitation and interference effects (see 6.3). Although the time scale of inhibition has been the subject of some investigation (Higby et al., 2020; Linck et al., 2009; Martín et al., 2010), we are not aware of any such work being implemented in formal models of bilingual processing.

6.5. Future directions

Future research might investigate a number of areas pertaining to CLI. As we have seen, there is substantial evidence that facilitation and interference are not mutually exclusive; both seem to contribute to CLI effects, often within the same contexts. While facilitatory and interfering cross-linguistic effects on lexical processing have typically been studied separately, we argue that, from a theoretical perspective, they must be considered together, with each operating in dynamic ways, in order to understand the nature of lexical processing among bilinguals.

One major theme that emerged from our review is that regulation of the dominant language appears central to many CLI effects. As discussed earlier, the dominant language is typically more strongly represented. This means that regulation of L1 words (via boosting and/or inhibition) may have a more profound effect on relative imbalances in representational strength between the dominant and non-dominant languages compared to regulation of a non-dominant language (Bogulski et al., 2019; Zhang et al., 2021). Future work might therefore investigate differential outcomes of L1 versus L2 regulation upon CLI effects.

One area that needs more clarification is the degree to which activation spreads across languages. The empirical evidence suggests that activation spreads to translation equivalents of a target word, and morphological family members of cognate translation equivalents appear to benefit from spreading activation as well (e.g., Lalor & Kirsner, 2001a). However, the extent to which various lexical representations, beyond cognates and translation equivalents, in the language not in use are co-activated is still underspecified, both empirically and in current models of bilingual lexical processing. Furthermore, how does co-activation affect the time course of processing such that facilitation and interference might arise at different stages? Two studies provide interesting clues. In an eye-tracking study, Miwa et al. (2014) found inhibitory effects of phonological overlap at early stages of word recognition but at later stages phonological similarity facilitated recognition. By contrast, in a written production study, Muscalu and Smiley (2019) reported shorter response onsets for cognates but more errors and longer total production latencies, reflecting initial facilitation followed by interference. Future work should employ methods that reveal more detail about the time-course of processing (such as eye-tracking and

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EEG) in order to capture the dynamic processes of facilitation and interference.

Finally, this review of factors influencing CLI is by no means exhaustive. It may be beneficial for future reviews to address the roles of those factors which we were unable to address comprehensively, such as proficiency and word frequency. Moreover, future reviews might also move beyond CLI in the context of lexical access – the topic of this paper – and examine CLI in other contexts such as syntactic processing.

Notes

1 Language dominance is typically framed in terms of a speaker's native (L1) and second/third/etc. (L2) languages. In some cases, an L2 might become a speaker's dominant language. However, for simplicity, we will use the terms "L1" and "L2" interchangeably with "dominant language" and "non-dominant language" throughout this review.

2 By extension, the "activation level" of a word refers to the extent to which it approaches or exceeds the requisite threshold to be activated.

3 Note that this view does not preclude proactive control mechanisms discussed in the preceding sentences. Despite proactive suppression of words in a non-target language, this may not always be sufficient to prevent at least some target words from competing for lexical selection. This nuanced is captured in de Groot and Cristoffels's discussion of the IC model: "…two loci of control are assumed, one acting proactively, by adapting the levels of activation of the elements in L1 and L2 to the requirements of the task, and a second operating reactively, suppressing non-target language output that inadvertently pops out of the system." (de Groot & Christoffels, 2006, p. 191).

4 Bimodal bilinguals are bilinguals who use both a spoken and a signed language.

5 Aphasia is a language disorder resulting from neurological damage, often due to stroke, which can manifest as impairments in language production, comprehension, or both.

6 Note that "mixing costs" are distinct from switch costs discussed earlier. Switch costs are defined as diminished performance on switch trials relative to non-switch trials in the context of a mixed language block; mixing costs are defined as diminished performance on non-switch trials within a mixed context, relative to trials in a single-language context.

7 Balanced bilinguals' L1 and L2 are considered to have relatively similar activation thresholds and connections to shared semantics

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