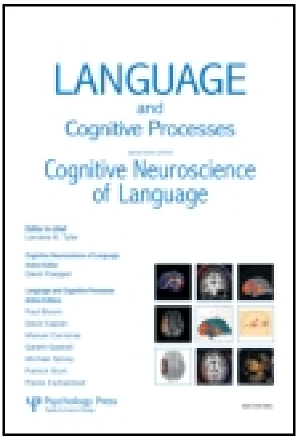

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Where does the delay in L2 picture naming come from? Psycholinguistic and neurocognitive evidence on second language word production

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Where does the delay in L2 picture naming come from? Psycholinguistic and neurocognitive evidence on second language word production

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Bilinguals are slower when naming a picture in their second language than when naming it in their first language. Although the phenomenon has been frequently replicated, it is not known what causes the delay in the second language. In this article we discuss at what processing stages a delay might arise according to current models of bilingual processing and how the available behavioural and neurocognitive evidence relates to these proposals. Suggested plausible mechanisms, such as frequency or interference effects, are compatible with a naming delay arising at different processing stages. Haemodynamic and electrophysiological data seem to point to a postlexical stage but are still too scarce to support a definite conclusion.

Keywords: Bilingual word production; Picture naming.

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Over the past decade, research on bilingual word production—although still much scarcer than bilingual comprehension research—has experienced considerable advances (Costa & Santesteban, 2006). One robust finding in this field is that L2 picture naming latencies tend to be significantly longer[1] and more variable than those of the L1 (Ivanova & Costa, 2008; Kroll, Bobb, & Wodniecka, 2006).

This naming delay holds for the weaker language of bilingual speakers which is generally their second language but word production in the native language, too, may be slower when it is not dominant (switched-dominance bilinguals, e.g., Gollan, Montoya, Fennema-Notestine, & Morris, 2005). In one study, slower naming has been demonstrated even for the first and dominant language of the bilingual speakers when compared with monolingual speakers (Ivanova & Costa, 2008). The bilingual naming delay does not disappear when speakers are proficient in their L2 (e.g., Sholl, Sankaranarayanan, & Kroll, 1995). The delay has been demonstrated across many languages, both similar—e.g., German and Dutch (Christoffels, Firk, & Schiller, 2007), as well as grammatically and orthographically very different languages, such as English and Chinese (Chen, Cheung, & Lau, 1997; Cheung & Chen, 1998). The delay holds for younger (19.3 years) as well as older (74.9 years) bilinguals with similar ages of exposure to their second language (2.7 and 4.6 years of age, respectively) (Gollan, Montoya, Cera, & Sandoval, 2008), and has been shown in both within- and between-subjects comparisons. The effect survives at least three repetitions of the same stimulus (Gollan et al., 2005; Ivanova and Costa, 2008) and is present even if stimulus materials in the two languages are matched on frequency, familiarity, name agreement, and imageability. As shown in Table 1, the size of the effect is highly variable ranging from 33 (Ivanova & Costa, 2008) to 1,221 ms (Ransdell & Fischler, 1987). Finally, although the effect is robust in blocked picture naming tasks, it tends to disappear or reverse in mixed picture naming tasks, where bilinguals have to switch frequently between their two languages.

Although the phenomenon has been frequently replicated, it has not yet been satisfactorily accounted for. A major step towards an answer to this question would be to know at which processing stage[2] the production of L2 words might be slowed down. In the present article, we therefore concentrate

[1] This phenomenon is sometimes referred to as the "bilingual disadvantage" (Gollan et al., 2005; Ivanova & Costa, 2008). However, it is mostly used to refer to the observation that bilinguals tend to be slower in comparison to monolinguals in their *dominant* language. Therefore, we will use a more general term "naming delay" where appropriate.

[2] For an overview of processing stages see Figure 1. Note that Levelt, Roelofs, and Meyer (1999) assume distinct lemma and lexeme (word-form) levels of lexical processing. For a different view see e.g., Caramazza (1997), Caramazza and Miozzo (1998), and Starreveld and La Heij (1996).

TABLE 1

Overview of L1/L2 picture naming studies showing a naming delay in the L2. If not reported otherwise, the task was blocked picture naming, i.e., participants named pictures in each language in separate blocks. ''Size of the difference'' refers to the difference in naming latencies in milliseconds: a positive number means that the delay is present. In some studies, the numbers were not reported, but the difference was statistically significant (reported here as ''sign.''). (A) Studies comparing monolingual and bilingual participants; (B) Studies comparing L1 and L2 of bilingual participants; and (C) Studies showing the effect of repeated naming

Study	*Participants*	*Languages compared*	*Size of the difference (ms)*	*Additional remarks*
(A) Monolingual vs. bilingual participants				
Ransdell and Fischler (1987)	English monolinguals vs. L2 English bilinguals	English mono/English as L2	45 (ns)	Stop-watch measurement of RT
Gollan et al. (2005, Experiment 1)	English monolinguals vs. switched-dominance Spanish/ English bilinguals	English mono/English as dominant L2	Sign.	Repeated picture naming (three blocks)
Gollan et al. (2005, Experiment 2)	English monolinguals vs. switched-dominance Spanish/ English bilinguals	English mono/English as dominant L2	ns	Repeated picture naming (five blocks)
Ivanova and Costa (2008)	Spanish monolinguals vs. Spanish/Catalan bilinguals	Spanish as L1 of monolinguals/Spanish as L1 of bilinguals	33	Monolinguals faster than bilinguals in their L1, even after five repetitions
Gollan et al. (2008)	English monolinguals vs. Spanish/English switched-dominance bilinguals	English as L1/English as dominant L2	Sign.	Monolinguals faster

(Continued)

TABLE 1 (*Continued*)

Study	*Participants*	*Languages compared*	*Size of the difference (ms)*	*Additional remarks*
(*B*) *L1 vs. L2 of bilinguals*				
Ransdell and Fischler (1987)	L2 English bilinguals	Various L1/English as L2	1,221	Stop-watch measurement of RT
Sholl et al. (1995)	Proficient English/Spanish bilinguals	English as L1/Spanish as L2	367	
Chen et al. (1997)	Proficient Chinese/English bilinguals	Chinese as L1/English as L2	164	
Hernandez et al. (2000)	Switched-dominance Spanish/ English bilinguals	Spanish as L1/English as dominant L2	138	Faster in dominant L2
Costa et al. (2000, Experiment 2)	Catalan/Spanish vs. Spanish/ Catalan bilinguals	Spanish as L1/Spanish as L2	35.5	Repeated picture naming (three blocks)
Christoffels et al. (2007) blocked naming condition	Moderately proficient German/ Dutch bilinguals	German as L1/Dutch as L2	63 (cognates) 119 (noncognates)	Effect significant for cognates and noncognates
Ivanova and Costa (2008)	Spanish–Catalan vs. Catalan/ Spanish bilinguals	Spanish as L1/Spanish as L2	46	
Gollan et al. (2008)	Switched-dominance Spanish/ English bilinguals	Spanish as L1/English as dominant L2	Sign.	Faster in dominant L2
Gollan et al. (2008, Experiment 2)	Senior (74.9 years old, AoA 4.6) switched-dominance Spanish/English bilinguals	Spanish as L1/English as dominant L2	Sign.	Faster in dominant L2
Hernandez (2009), pretest	Switched-dominance Spanish/ English bilinguals	Spanish as L1/English as dominant L2	Sign. faster in nondominant L1	Result averaged over blocked and mixed conditions
Gollan and Ferreira (2009, Experiment 1)	Switched-dominance Spanish/ English bilinguals	Spanish as L1/English as dominant L2	~300 faster in dominant L2	Exact numbers not reported
	Balanced Spanish–English bilinguals	Spanish as L1/English as L2	ns	Trend towards faster L2

(*Continued*)

TABLE 1 (*Continued*)

Study	*Participants*	*Languages compared*	*Size of the difference (ms)*	*Additional remarks*
(*C*) *Effects of repetition*				
Gollan et al. (2005, Experiment 1)	English monolinguals vs. switched-dominance Spanish/ English bilinguals	English mono/English as dominant L2	Sign.	Repeated picture naming (three blocks)
Gollan et al. (2005, Experiment 2)	English monolinguals vs. switched-dominance Spanish/ English bilinguals	English mono/English as dominant L2	ns	Repeated picture naming (five blocks)
Ivanova and Costa (2008)	Spanish monolinguals vs. Spanish/Catalan bilinguals	Spanish as L1 of monolinguals/ Spanish as L1 of bilinguals	33	Monolinguals faster than bilinguals in their L1, even after five repetitions
Costa et al. (2000, Experiment 2)	Catalan/Spanish vs. Spanish/ Catalan bilinguals	Spanish as L1/Spanish as L2	35.5	Repeated picture naming (three blocks)

on the problem of locus and mechanisms: when does the L2 delay in picture naming arise and what are the underlying causes?

We divide the views implicitly or explicitly present in the literature into two groups. Firstly, we discuss positions which advocate general factors that apply to both monolingual and bilingual word production but may have a particular impact in the bilingual case. Such factors influencing naming latencies are predominantly word frequency (WF) and the age of acquisition (AoA) of words. Secondly, we review arguments and empirical evidence for positions which attribute the delay to factors that are specific to bilingualism—interaction and/or inhibition between the two languages of the bilingual. Apart from fleshing out these claims we consider what predictions they make regarding the locus of the naming delay, and critically assess the available behavioural and neuroimaging empirical evidence. In the second part of this review, we consider a handful of behavioural and neuroimaging studies looking directly at when in the cascade of processing stages the naming delay arises. These studies provide important, although not yet conclusive, complementary evidence in favour of a postlexical source of the delay in bilingual word production (Figure 1).

GENERAL FACTORS: WORD FREQUENCY (WF) AND AGE OF ACQUISITION OF WORDS

The weaker links hypothesis and the influence of word frequency (WF) on naming latencies

One influential account of the L2 naming delay is the *weaker links hypothesis* (Gollan & Acenas, 2004; Gollan et al., 2005, 2008), which assumes that because a bilingual can often express a given concept with two different words—translation equivalents—each of these words is in effect used less frequently than in the monolingual case. Therefore, the links between semantics and phonology in each of the languages of a bilingual are weaker than those in the one language of a monolingual. By analogy, the same reasoning can be applied to the two languages of an unbalanced bilingual—since words in the nondominant language (L2) are used less often than words in the dominant language (L1), there will be weaker links between the concepts and word-forms of L2, resulting in slower and more error-prone production. Essentially, this view is comparable to a functional frequency account (Poulisse & Bongaerts, 1994), according to which the L2 naming delay is due to L2 items being learned later and used less often than their L1 translation equivalents. Under the assumption that WF in a weaker language can be disproportionately lower than in a stronger language the weaker links hypothesis also predicts an interaction of the bilingual disadvantage with WF.

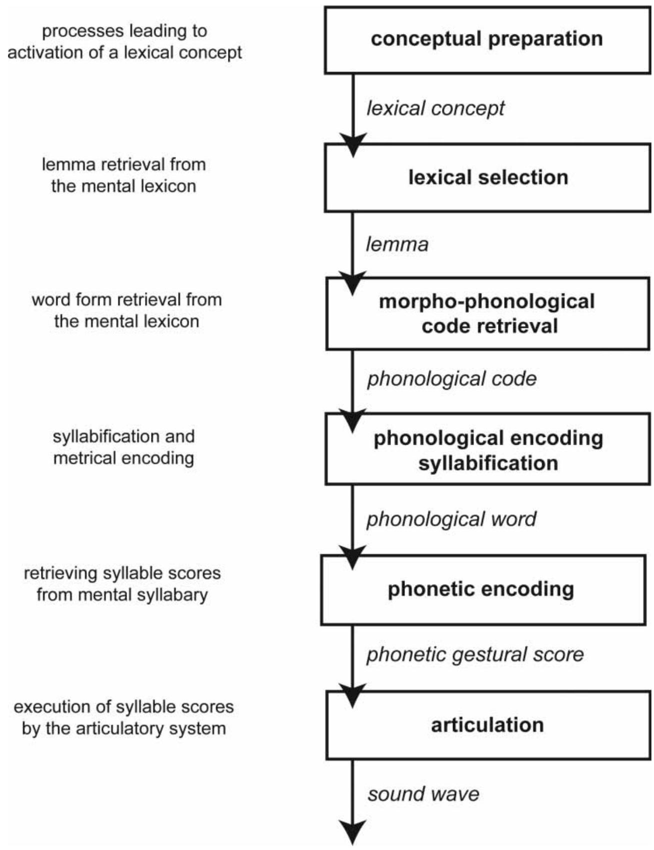

Figure 1. A schematic overview of the different processing stages of the language production architecture, which are referred to throughout the text. The middle column indicates the major processes involved in word production. Below each box (in italics) is a characteristic output resulting from the respective stage. The left column contains a brief description of what happens at each stage of word production. Based on Levelt, Roelofs, and Meyer (1999).

Studies attempting to support the weaker links hypothesis make use of the fact that in the monolingual domain, WF affects the speed (as well as accuracy) of picture naming, whereby naming pictures with low-frequency names tends to be initiated later than naming pictures with high-frequency names (Almeida, Knobel, Finkbeiner, & Caramazza, 2007; Dell, 1990; Jescheniak & Levelt, 1994; Oldfield & Wingfield, 1965).

The weaker links hypothesis has received empirical support from studies in which L2 words are repeated. For example, Gollan et al. (2005) compared picture naming performance in English of an English-speaking monolingual group and a Spanish–English bilingual group (English was their dominant language, but learned slightly later than Spanish, at about the age of 3). They found that through substantial repetition, the bilingual naming disadvantage disappeared: picture naming latencies in the bilinguals' dominant language were still significantly slower than monolingual naming latencies at the third, but no longer at the fifth presentation of the same word. Importantly, there was no effect of group in a task not involving the retrieval of lexical representations—bilinguals scored just as monolinguals on a conceptual classification task. Given that multiple repetitions of the same word in a single experiment might not be the best way to manipulate WF, according to Gollan et al. (2008) a more direct test of the weaker links hypothesis is to study the size of frequency effects in both languages. They showed that the frequency effect was indeed larger for bilinguals than for monolinguals: in other words, there was a bigger difference in naming latencies between low-frequency and high-frequency words for the bilingual than for the monolingual group. The same basic effect was observed when performance in the dominant and the nondominant language of the bilinguals was compared.

A possible objection to the above studies is that the bilingual participants tested in Gollan et al. (2005, 2008) were switched-dominance bilinguals, i.e., their non-native language became dominant, so that their findings may not be generalisable to other bilingual populations, where the native language is dominant (Kroll, Bobb, Misra, & Guo, 2008). However, Ivanova and Costa (2008) replicated the basic result of a bilingual disadvantage for the first language of L1-dominant bilinguals, as well as for the nondominant language (L2) of another group of bilinguals. Again, in the first comparison (L1 of monolinguals vs. L1 of bilinguals), the disadvantage in lexical retrieval was larger for low-frequency words than for high-frequency words. Interestingly, though, this time the disadvantage did not disappear even after five repetitions of the same stimuli. A closer look at Ivanova and Costa's results reveals that the difference in the frequency effects was mostly carried by the low-frequency words: that is, the difference between the monolingual and bilingual naming latencies was stronger for the low- than high-frequency words. This is consistent with the weaker links account if one assumes that words that are rare in the L1 of monolingual speakers are particularly rarely encountered or used in an L2 or the L1 of bilingual speakers and hence their links between semantics and phonology more strongly reduced than those of frequent words.

Although the modulation of the bilingual disadvantage demonstrated in the above-mentioned studies seems to support the "frequency-of-usage" account of the bilingual disadvantage, two aspects of the studies are problematic. The first is the logic of using repetition as a means of "defeating" the bilingual disadvantage. As Gollan et al. (2008) and Ivanova and Costa (2008) note, frequency effects as such have been shown to be quite immune to even substantial repetition by several researchers (Caramazza, Costa, Miozzo, & Bi, 2001; Jescheniak & Levelt, 1994; Navarrete, Basagni, Alario, & Costa, 2006), and thus it is debatable whether they should be used as the crucial test of the frequency account of the bilingual disadvantage. In fact, Gollan et al.'s (2005) and Ivanova and Costa's (2008) results differed in this respect: in the former but not the latter study, repetition was effective in equating monolinguals' and bilinguals' picture naming times.

Secondly, Ivanova and Costa report another result problematic for the hypothesis: while the frequency effect was larger for the L1 of the bilinguals than for the L1 of the monolinguals, the frequency effect did not differ when the same target language was the L1 of one group of bilinguals and the L2 of another group of bilinguals. Note that the overall naming latency was slower when the target language was the L2, so that this finding cannot be explained by assuming that the frequencies of the L2 words in this group just happened to be reduced to a similar extent as those of the L1 words in the other bilingual group.

To conclude, although there is some evidence supporting the predictions of the weaker links hypothesis, the data are not entirely consistent with the hypothesis' predictions. Specifically, testing the predictions via repetition does not have sound support in monolingual experimental studies; and using the frequency effect modulation as evidence has not yielded the pattern of results that the account predicts for L1/L2 comparisons between groups of bilinguals speakers. One reason could be that WF effects are confounded with AoA effects in different ways for different bilinguals. For example, Spanish monolinguals and Spanish–Catalan bilinguals in the Ivanova and Costa study should have similar contributions of AoA effects, because both groups have acquired Spanish as their first language. On the other hand, AoA contribution to the performance in Spanish of Catalan–Spanish bilinguals might be weaker, because they did not acquire Spanish before the age of 4, and thus might have learned some high-frequency and low-frequency Spanish words almost simultaneously. Thus, the frequency effect, which should be typically larger for L2 than for L1, would be masked be a "larger contribution of AoA to naming in L1 than to naming in L2" (Ivanova & Costa, 2008, p. 286). In addition, although it is reasonable to expect that bilinguals' L1 lexical items have lower frequency of usage than L1 lexical items of monolinguals, and L2 lexical representations have an even lower frequency than the two groups, direct empirical evidence for this claim is missing.

The role of age of acquisition (AoA)

Although the weaker links hypothesis takes WF as its explanatory variable, its logic is in fact agnostic as to the origin of the "weaker links". Apart from differences in WF between lexical entries of monolinguals and bilinguals, the bilingual disadvantage might be also readily explainable in terms of different AoA of words in the dominant vs. the weaker language (although this factor has arguably more influence in the case of unbalanced, late bilinguals).

It is not easy—and in monolingual language processing one could even claim that it is not possible—to properly disentangle frequency and AoA accounts. In the following, we briefly summarise monolingual and bilingual research on AoA, and its role in explaining the bilingual disadvantage.

The general finding on the effect of AoA on the speed of lexical retrieval is that names of objects that are acquired earlier in life are named faster than those which names are acquired later in life (Carroll & White, 1973; Cuetos, Ellis, & Alvarez, 1999; Meschyan & Hernandez, 2002), and this effect extends to other tasks, such as word naming (Morrison & Ellis, 1995, 2000), and lexical decision (e.g., Morrison & Ellis, 1995, 2000; Turner, Valentine, & Ellis, 1998). There have been three main explanations of this, each stressing a different locus of the effect: A phonological origin has been suggested by Gilhooly & Watson (1981) who assume that AoA affects the ease of accessing word-forms. Also Levelt, Roelofs, & Meyer (1999) assume that the effect acts at the word-form level, similar to WF. Brown and Watson (1987) proposed that AoA determines the *nature* of phonological representations of words, with early acquired words being stored as unitary representations, while words acquired later in life being more fragmentary in nature—the time-consuming step being the assembly of these fragments online.

Alternatively, a purely semantic origin is advocated by some researchers (Brysbaert, Van Wijnendaele, & De Deyne, 2000; Lyons, Teer, & Rubenstein, 1978). At the heart of their explanation is the observation that, for many words, newly learned meanings rely on previously learned meanings. Therefore, as semantic networks are highly interconnected, semantic representations acquired earlier in life have an organising effect on semantic representations acquired later in life.

According to a third hypothesis, the effect arises in the mapping between different representations of a word, such as semantic, phonological, or orthographic (Ellis & Lambon Ralph, 2000).

However, the evidence for these hypotheses in monolingual word production is yet inconclusive. Moreover, there is still disagreement as to whether AoA and WF have (Dewhurst & Barry, 2006) or don't have (Lewis, Gerhand, & Ellis, 2001) independent effects, and whether they act at the same locus (Meschyan & Hernandez, 2002) or different loci (Belke, Brysbaert, Meyer, & Ghyselinck, 2005) in word production. Thus, it "remains an open question" (Knobel, Finkbeiner, & Caramazza, 2008) to what extent the lexical frequency effect is just an AoA effect, or whether both these factors in fact contribute to performance on word production tasks, especially picture naming (as some studies have found that compared to frequency effects, the effect of AoA is larger in picture naming than in other production tasks (e.g., Barry, Hirsh, Johnston, & Williams, 2001).

Only a few studies investigated systematically the role of AoA in second language word production, and even fewer studies explicitly addressed the time-course question. Izura and Ellis (2002), in a behavioural study with Spanish (L1)–English (L2) bilinguals demonstrated the existence of an AoA effect on naming and lexical decision in both languages. Both L1 and L2 words acquired earlier in life were named faster than words acquired later in life, and this effect was larger in the L2. It is not possible to compare the two effects directly, though, because the L1 and L2 AoAs in the study referred to different "scales': the early L1 AoA meant that the words were acquired before the age of 5 years and 8 months. Earlier-acquired words in L2 were words learned within the first 2 years of studying L2, whereas the bilingual participants started studying English when they were older than 8 years. Interestingly, the authors attempted to disentangle the relative contribution of AoA to each language, as they contrasted lexical decision on subsets of words with early AoA in L1 (such as names of toys or games) and in L2 (such as vocabulary related to money, travel, etc.). The results revealed a correlation between speed of lexical decision and the AoA of words in each language—words learned earlier in L1 (but not L2) speeded up lexical decision in L1 and words learned earlier in L2 (but not L1) speeded up lexical decision in L2.

In the bilingual domain, age of exposure (AoE) is a concept related to AoA. While AoA is a property of words, AoE is a property of speakers: i.e., the age at which a particular speaker is exposed to the L2. The relationship between the two variables is not straightforward: the fact that a speaker had early exposure to a second language does not necessarily mean that all the words in her L2 have an early AoA. However, on the assumption that there is a correlation between AoA and AoE, studies exploring the influence of AoE on the bilingual lexicon are informative.

Perhaps the most prominent question in this line of research is whether there are qualitative differences in brain activation patterns between bilingual speakers with early and late AoE. The typical finding is that these two types of bilinguals do not differ in the *regions* which are activated by language tasks, but in the *degree of activation* in these areas (for overviews see Abutalebi, Cappa, & Perani, 2001; Indefrey, 2006; Perani & Abutalebi, 2005), with late bilinguals having a greater activation in the L2 than early bilinguals, and both groups in comparison to their L1 if the level of proficiency is controlled for. Perani et al. (2003) observed less extensive brain activation for production in the language acquired early in life even though the L2 of their participants was acquired fairly early, at 3 years of age. Bloch et al. (2009) looked at differences in brain activation in a language production task in three groups of multilinguals that differed in terms of

AoE: balanced early L2 speakers, unbalanced early L2 speakers (L2 acquired between the ages of 1–5 years), and unbalanced late L2 speakers (L2 learning started after 9 years of age). All three groups were fluent in a late acquired L3. In an fMRI region-of-interest analysis in Broca's and Wernicke's areas, there was an effect of AoE on activation patterns: compared to early L2 speakers, late L2 speakers showed higher variability of the extent of activation in these areas in all three languages. The authors concluded that early exposure to a second language leads to a language-processing network that treats both early and later learned languages as more or less the same.

As we stated earlier, while studies on AoE effects in bilingualism are informative, it is not clear how they map onto findings about the effects of AoA on naming latencies in the monolingual domain. Whereas arguments about why later AoA slows down monolingual naming focus on what the differences in lexical retrieval are within a single language (for words with earlier and later AoA), bilingual AoE research is typically about whether the entire language system is differentially represented in the brain (i.e., whether there is a difference in the representation of L2 in the brain if it is acquired early or late). This makes direct comparisons and generalisations between these two areas of research difficult, especially because these two factors could well interact. Moreover, as the AoE studies are not predominantly concerned with the time-course of bilingual word production, any argument regarding this issue based on their findings would be too speculative at this point. More informative in this respect are the results of the single study on AoA effects in bilingualism mentioned in this section (Izura & Ellis, 2002), which showed that the effect of AoA on L2 naming and lexical decision latencies are in line with predictions from the monolingual literature; however, more similar studies would be needed to reach confident conclusions about the effect of AoA on L2 naming latencies. Although, to our knowledge, there is no bilingual study that has attempted to disentangle the contribution of AoA and WF to L1/L2 word naming latencies, naming latencies in switched-dominance bilinguals suggest that frequency may overrule AoA effects. Gollan et al. (2008) asked their English-dominant Spanish/English bilingual participants to rate the AoA of picture names in both languages. The names of the pictures were learned earlier in the L1 Spanish although pictures were named faster in the dominant L2 English.

Frequency and age of acquisition (AoA): The question of locus

If the L2 naming delay is essentially a frequency effect or an AoA effect, it should arise at processing stage(s) that are susceptible to frequency/AoA effects. As we already foreshadowed in the preceding sections, there is not yet a consensus as to where the two variables—WF and AoA—manifest themselves during monolingual, let alone bilingual lexical access.

Several accounts of the frequency locus have been put forward and gained some empirical support. Almeida et al. (2007) demonstrated that the locus of the frequency effect lies later than visual recognition and earlier than articulation. Strijkers, Costa, and Thierry (2010) in an event-related potential (ERP) picture naming study showed relatively early frequency effects, 180 ms after picture onset, which would, according to Indefrey and Levelt (2004), correspond to the initial stages of lexical retrieval. Jescheniak and Levelt (1994), on the other hand, locate the frequency effect at the word-form (lexeme) level, but their evidence is also consistent with an effect at the phonological word level, a postlexical processing stage. Finally, Cholin, Levelt, and Schiller (2006) argue for a *syllable* frequency effect, which might arise only once syllable scores are retrieved from the mental syllabary.

Recent studies provided evidence that frequency affects not only the level at which the word's phonology is retrieved, but also the retrieval of the lemma (Kittredge, Dell, Verkuilen, & Schwartz, 2008; Navarrete et al., 2006). Knobel et al. (2008), in an interesting analysis of patient data coupled with computational modelling, showed that there might be an additional locus of frequency effects at the interface of lexical and segmental representational levels. And, in the discussion of their findings, these authors persuasively argue that lexical frequency is possibly represented throughout all the levels and connections between them participating in the lexical access process.

In the section headed "The role of age-of-acquisition (AoA)", we have already discussed the three main hypotheses about the causes of the AoA effect in monolingual production, each placing it at a difference locus within the word production system—at phonological retrieval (e.g., Barry et al., 2001; Brown & Watson, 1987), at lemma retrieval (Brysbaert & Ghyselinck, 2006), or even claiming a purely conceptual locus (Steyvers & Tenenbaum, 2005). In a recent study, Kittredge et al. (2008) analysed picture naming responses of 50 monolingual aphasic patients and found that while log frequency had an effect on both phonological and semantic errors, AoA had a more limited effect only on phonological errors, which would place the locus of the AoA effect in later stages of word processing. To conclude, the available evidence from the monolingual domain and bilingual domain points to a complex interplay of AoA and WF influence on the speed of lexical retrieval. The picture is further complicated by considerable variability in study design and materials. A clear interpretation of the naming delay as caused by one or the other factor, or—in the probable case that both exert some influence on *different* word-planning processes—an account of their interplay, is not yet possible. Even if it would be possible, there is no unequivocal evidence as to the loci that are influenced by these two variables. As we will discuss below, the influence of WF and AoA on slowing down naming in L2 can be also counteracted (the paradoxical language effect). Therefore, it is most likely that they are not the sole factors involved in the bilingual naming delay. We will return to these issues in the second part of the article, when reviewing the available empirical evidence on the timing of the different processes in word production.

FACTORS SPECIFIC FOR THE BILINGUAL SITUATION: INTERACTION AND INHIBITION

Interaction between target and nontarget lexical candidates

Another prominent explanation for the naming delay in bilingual picture naming stresses the role of L1 interference in L2 word production. That is, the delay might arise due to the fact that when an L2 lemma or lexeme is retrieved from the mental lexicon, L1 lexical candidates are also active and—crucially—compete for selection with the activated L2 candidates. The debate about the locus of the delay is thus related to the *locus of selection* issue (Costa, La Heij, & Navarrete, 2006; Kroll et al., 2006). Central to this problem is the question whether the two languages of a bilingual are separated from the very beginning, so that activation spreads exclusively to the lexical representations and word-forms of the target language (La Heij, 2005) or whether the two systems are shared, with a lexicon-external mechanism modulating the relative activation of the lexical candidates, for example by inhibiting nontarget language lexical items (Green, 1998). Proponents of language nonselectivity hold differing opinions about where the conflict is resolved: either at the lemma level, and therefore nontarget language phonology receives no activation (Hermans, Bongaerts, de Bot, & Schreuder, 1998); or at the word-form level, with activation spreading all the way to the level of the nontarget language phonology (Rodriguez-Fornells et al., 2005). There are also views which argue against a fixed locus of selection, but that the exact point where one language is selected for production depends on many factors, among which are language proficiency, task, or degree of activity of the nontarget language (Kroll et al., 2006).

Much of the evidence for nonselectivity in L2 lexical access comes from Stroop-like interference paradigms, where the presence of an L1 distracter affects L2 naming latencies (e.g., Hermans et al., 1998), from phoneme-monitoring tasks (Colomé, 2001; Rodriguez-Fornells et al., 2005), and from language switching studies (Verhoef, Roelofs, & Chwilla, 2009).

For example, the results of phoneme-monitoring studies seem to offer convincing empirical evidence about simultaneous activation of L1 and L2 candidate words up to the level of phonology. In a phoneme-monitoring study by Colomé (2001), highly fluent Spanish–Catalan bilinguals made decisions about the first sound of the name of a presented picture.

Colomé found that "no" responses were initiated at longer latencies when the appropriate response in the other language would have been a "yes".

Rodriguez-Fornells et al. (2005) applied a single-choice go/no-go task with Spanish–German bilinguals and a monolingual German control group. A N200 no-go effect[3] on a phonological decision (consonant vs. vowel at the onset of the word) in the monolingual control group emerged earlier than N200 effects in the bilingual group by about 200 ms, which the authors interpreted as indicating later accessibility of the information necessary to carry out the phonological decision. Moreover, the N200 amplitude was significantly more negative for those stimuli where the two languages differed with respect to the category of the onset phoneme. Since the bilingual noncoincidence effect on the go-stimuli showed up in the same time-range as the monolingual no-go effect, Rodriguez-Fornells et al. interpreted these findings as favouring nonselective lexical access up to the level of phonology. In other words, it seems that where a "go" decision is required for the L2 stimuli, participants also experienced interference from the L1 stimuli, which would result in a "no-go" response.

Although studies such as these are suggestive of a L1/L2 interference at the lexical level, a detailed look at the experimental paradigms on which most of the evidence for nonselectivity is based reveals that the observed effects might be a consequence of the tasks themselves (a similar point was made by e.g., Costa, La Heij, et al., 2006). For example, bilingual picture–word interference paradigms use nontarget language distracters, which introduce competition through the comprehension (word-recognition) system. Similarly, it has been argued that in phoneme-monitoring studies, visual presentation of the nontarget language word's critical phoneme, might also induce extra activation of the corresponding nontarget language phonological candidates (Costa, La Heij, et al., 2006). In switching studies, languages are typically presented in mixed L1/L2 blocks and participants are instructed to alternate between the two languages. Similarly, in Rodriguez-Fornells et al.'s (2005) study the control group completed the task in one purely monolingual session, whereas the bilinguals carried out the same task in alternating blocks of L1 or L2 during a single session, thus keeping both language phonologies active over the course of the experiment.

In sum, these studies do not provide conclusive evidence that there is competition for selection at the lexical level between the two lexicons other

[3] N200 no-go effect refers to a frontally distributed negativity observed on trials where subjects withhold/inhibit a response (no-go trials) in comparison to trials where the response is executed (go trials) (Pfefferbaum, Ford, Weller, & Kopell, 1985; Thorpe, Fize, & Marlot, 1996). The onset and/or peak of the effect can be used to time different cognitive processes even before they show up behaviourally. More on the effect and its use in experiments on bilingual production follows in Section "Studies on the time-course of bilingual lexical access".

than that introduced by the task; and that this competition indeed leads to processing consequences—a delay—at the lexical level. Note that rejecting the competition account does not necessarily mean rejecting the language nonselectivity account: it is conceivable that nontarget language items are activated but do not compete for selection and hence do not slow down the selection of target language items (Costa, 2005; Costa, Miozzo, & Caramazza, 1999).

Task-induced between-language competition can be ruled out for studies where an L1 influence on L2 phonology was demonstrated in purely L2 test situations. For example, Costa, Caramazza, and Sebastian-Galles (2000) performed a picture naming experiment with Catalan–Spanish bilinguals, in which the critical manipulation was whether the name of the picture was a cognate (i.e., had similar phonology and meaning) in the bilingual's two languages. They found a significant facilitation effect for cognates in both of the bilinguals' languages, with larger magnitude for the L2 than for the L1. Costa et al. interpreted their results as evidence that both the target and the nontarget lemmas were active, which resulted in the phonological candidate receiving activation from two sources.

Colomé and Miozzo (2010) used a picture–picture interference paradigm instead of a picture–word interference paradigm, where a distracter picture is superimposed on the target picture. Therefore, no nontarget language activation was introduced by the task itself. The critical manipulation was whether the distracter picture had a cognate name with respect to the two languages of the bilingual participants (L1 Spanish and L2 Catalan). If distracter names activate their phonology in the nontarget lexicon, this activation will interfere with production of the target word. Since cognates will activate many phonological elements twice, this nontarget activation will be stronger and more hindering than with noncognates. This prediction was confirmed by the results: cognate distracters led to slower naming of the target picture than noncognate distracters, but only in the bilingual group.

This effect, however, can be explained by the mechanism underlying the cognate facilitation effect shown by Costa et al. (2000, see above). If cognates are named faster, because their phonology is activated more quickly, then it is likely that also the phonology of the cognate distracters in Colomé and Miozzo (2010) is activated more quickly and hence affects naming of the target more strongly.

The interpretations of both studies rely on the assumption that effects of cognate words can only be explained by their property of having both L1 and L2 word-form representations. However, cognates may also have a special status within the L2 lexicon. According to van Hell and de Groot (1998), the cognate facilitation effect can be explained as a frequency effect at the semantic level, as cognates typically share a host of semantic features. It has been argued that cognates are easier to learn and thus tend to be among the first words learned in a second language, having a higher frequency than other L2 words. Furthermore, given the available evidence for nonselective lexical access in bilingual *comprehension*, it must be assumed that every time a bilingual speaker encounters a cognate word both the L1 and the L2 lexical entries are activated and hence their frequency tally raised. These considerations point to the difficulty that monolingual word frequencies of cognate words most likely underestimate their frequencies in the L2 lexicon. It follows that effects of cognates may not necessarily demonstrate the online activation of both lexicons but long-term frequency effects that are due to cognate status. If cognates have a higher lexical frequency in bilingual compared to monolingual speakers then their lexical phonology—just like the lexical phonology of any other high-frequency word—is retrieved more quickly, resulting in faster naming and more efficient phonological interference.

The paradigm used by Colomé and Miozzo (2010) offers a way to disentangle those different accounts of cognate effects. If their phonological cognate interference effect were observed for cognate distracter pictures that are named equally fast as noncognate control distractor pictures (in a separate distracter picture naming experiment), then L2 frequency could be ruled out as a possible explanation for the interference effect.

Finally, there are also proponents of late effects of the nontarget language on production: Costa, La Heij, et al. (2006), for example, make a point for the interaction being functional between the lexical and sublexical levels—i.e., lexical representations in the nontarget language become activated by feedback from the phonological level. Such an account would be consistent with a fairly late locus of the delay. The authors, however, discuss this mainly as a theoretical possibility, as there are at present no studies which would unambiguously confirm such a position.

The role of inhibition in bilingual word production

In order to prevent candidates from the nontarget language to disrupt production, a number of authors postulate that bilingual word production must involve inhibition of nontarget language candidates (for a review see Kroll et al., 2008). It is not clear, however, how this would map onto the naming delay issue. It seems that successful inhibition would rather *counteract* the delay, i.e., making naming in the nondominant language equally fast as naming in the dominant language. The fact that the naming delay in L2 picture naming *does* exists leads to several possibilities regarding the role of inhibition in bilingual production: (1) there are no inhibition mechanisms, or inhibition mechanisms are imperfect in bilingual word production, and there is still some residual nontarget language activation during L2 naming causing the delay; (2) there are other/additional factors causing the delay, such as those associated with frequency or AoA (and we might observe interaction/modulation of AoA/WF effects by inhibition).

In the next section, we will discuss the results of several studies investigating inhibition during L2 production, and conclude the section by considering which of these two possibilities seems like a more plausible characterisation of the bilingual situation. The most prominent account of inhibition in bilingual production comes from Green (1998). In his view, bilinguals control their production through reactive inhibition, whereby nontarget lemmas are inhibited upon their activation, Green's theory, and the idea of language inhibition as such, was mostly tested in language switching studies (i.e., Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006; Meuter & Allport, 1999). For unbalanced bilinguals, the inhibition hypothesis would predict larger switch costs in picture naming from L2 into L1, because in order to name pictures in the weaker language on L2 trials, the dominant language must have been greatly suppressed on these trials. Overcoming such powerful inhibition leads to asymmetrical switch costs in the direction described. Moreover, the inhibition hypothesis also leads to a prediction that balanced bilinguals would have symmetrical switch costs, as the amount of inhibition needed to suppress both of their languages is basically identical—this has indeed been confirmed in several language switching studies (e.g., Costa & Santesteban, 2004; Costa, Santesteban, et al., 2006). Another interesting result of switching studies is that they yield a so-called paradoxical naming effect: naming latencies in L1 are overall slower—for switch and nonswitch trials—in comparison to naming latencies in L2. This paradoxical language effect is observed mostly when switching costs are symmetrical, but this is not a general rule (e.g., Verhoef et al., 2009, obtained the effect even when switch costs were asymmetrical). The paradoxical language effect is a demonstration that inhibition can interact with whatever causes the naming delay (e.g., the effect of language competition, frequency, or AoA). Crucially, the effect disappears when the same stimuli are named by the same population of participants in blocks of purely L1 or L2 rather than in alternating L1/L2 trials (Christoffels et al., 2007).

There have been alternative hypotheses put forward to account for the observed patterns of switch costs apart from nontarget language inhibition. For example, Verhoef et al. (2009) argued that the asymmetrical switch costs can be explained as repeat-benefit of L1 nonswitch trials. In contrast to the inhibition hypothesis, the repeat-benefit does not assume that the asymmetry in switch costs arises due to slow responding on L1 switch trials (i.e., those L1 trials which immediately follow L2 trials). Rather, it claims that the asymmetry arises due to the fact that the L1 repeat trials (i.e., those L1 trials which follow another L1 trial) are disproportionally fast. This advantage in speed arises from the fact that there is no slowing down relative to L2 repeat, L1 switch, or L2 switch trials, since no alternative task-set (either L1 or L2 task-set) is active.

However, the crucial question in this context is whether the results of switching studies can be extended to more general bilingual situations, such as nonmixed, blocked picture naming. After all, mixing the two languages within a very short time span, on an external cue given by the experimenter, is a somewhat nonstandard situation even for bilinguals.

There are several indications that under different conditions, there is a different pattern of inhibition (if there is inhibition at all) in L2 word production. For example, when bilinguals are able to voluntarily control when to make the switch, there are no asymmetrical switch costs, even though their two languages are not equally dominant (Gollan & Ferreira, 2009). Interestingly, the paradoxical naming effect still remains in this situation, suggesting a sustained inhibition of the dominant language that affects both stay and switch trials. To this date, there is only one study which directly compares how and whether inhibition mechanisms differ under mixed and blocked naming conditions in unbalanced bilinguals. Christoffels et al. (2007), in an ERP study, were able to distinguish between sustained, or global, inhibition, and a more transient, trial-by-trial reactive inhibition. The latter is the type of inhibition which would underlie asymmetrical switch costs, while the former might account for the paradoxical naming effect. In their study, reaction times and ERPs on three types of trials were compared. Switch and nonswitch trials from mixed contexts (mixed-language blocks) and trials from blocked context (naming in purely L1 or L2). With respect to speed of naming there was a cost mainly for the more dominant language of the bilinguals, with L1 slowing down in the mixed condition. Interestingly,

Figure 2 (opposite). The figure shows the difference between ERP effects for language-switched and nonswitched trials (A) and language-mixed and blocked trials (B) in the Christoffels et al. (2007) study. (A) Grand average ERP waveform for electrode site Fz for nonswitch and switch trials for L1 and L2. The time windows 275–375 and 375–475 ms that were used for statistical analyses are framed. Topographic maps of the difference waves are shown for L1 and L2 for two time points from the middle of each time window. (B) Grand average ERP waveform for electrode site Fz for blocked and mixed (nonswitch) trials for L1 and L2. Note that the ERP effects of switching were relatively small: The amplitude for L1 nonswitch trials was more negative than for switch trials in the first analysed time window (275–375 ms poststimulus). This effect persisted into the later time window (375–475 ms). The effects of language context, i.e., whether a trial occurred in the blocked or in the mixed condition were much stronger. In the earlier time interval (275–375 ms), irrespective of language, mixed (nonswitch) trials were more negative than blocked trials for both L1 and L2. In the later time interval (375–475 ms) this pattern changed: L1 blocked trials showed a large negative amplitude, significantly different from L1 mixed trials. The amplitude difference between L2 blocked and L2 mixed trials was not statistically significant. (Reprinted from *Brain Research*, 1147, Christoffels, I. K., Firk, C., & Schiller, N. O., Bilingual language control: An event-related brain potential study, p. 199, Copyright (2007), with permission from Elsevier.)

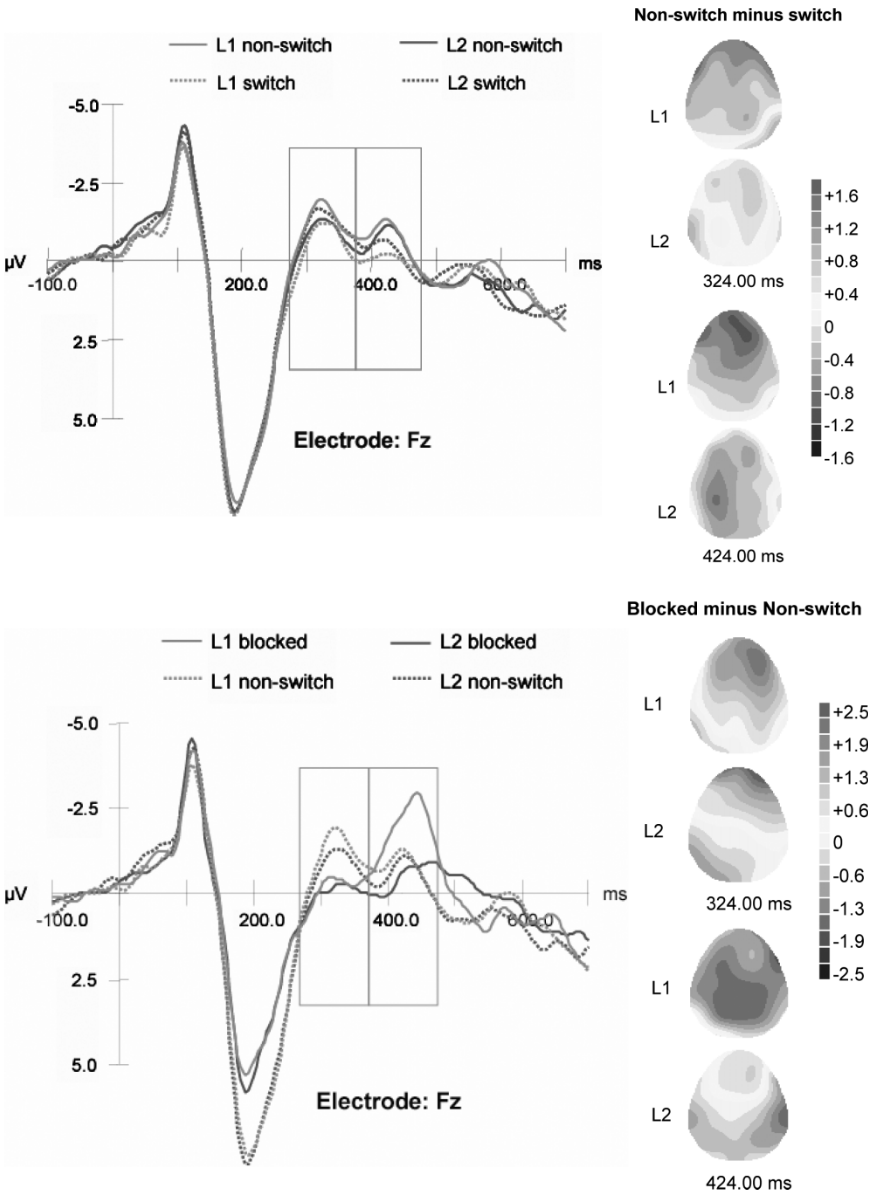

Figure 2 (*Continued*). See facing page for caption.

the L2 naming latencies in both types of contexts remained exactly the same (blocked and nonswitch L2 trials). The ERP effects were dramatically different for the two contexts, and as the authors concluded, language context modulated the ERP waveforms more strongly than language switching did (i.e., the comparison of switch and nonswitch trials within mixed blocks, see Figure 2). The results also caution against the assumption of a straightforward relationship between frontal negativities and enhanced inhibition or cognitive control in bilingual production. Increased negativities have been observed when comparing bilinguals and monolinguals in naming tasks without language switches (Rodriguez-Fornells, de Diego Balaguer, & Münte, 2006) or for predictable switch trials in bilinguals (Jackson, Swainson, Cunnington, & Jackson, 2001; Verhoef et al., 2009; for a review see Moreno, Rodriguez-Fornells, & Laine, 2008). Whereas in the former cases the increased negativities started around 400 ms, they tended to start earlier in the latter cases, making them more similar to typical no-go-negativities. The enhanced negativity for mixed compared to blocked contexts observed by Christoffels et al. (2007) is on the one hand also earlier than the time window of the generally stronger negativity observed for bilinguals (in fact, Christoffels et al. find a positivity in that time window), on the other hand it is functionally clearly different from a switch-related response and better compatible with a sustained inhibition (Note that Verhoef et al., 2009, also favour an interpretation of their enhanced N2 response as reflecting a sustained inhibition because they observe it in L2 repeat trials as well).

Thus, from a study which directly compared the types of inhibition involved in mixed L1/L2 naming and blocked naming within the same participants, it seems that the type of inhibition commonly investigated in the switching tasks is different from processes involved in blocked naming. In highly bilingual environments, inhibition may act by globally down-regulating L1 activity, as supported for example by the paradoxical naming effect and the L1 reaction time differences in the Christoffels et al. study. By contrast in nonmixed environments, there seems to be no need for inhibition, possibly because the nontarget language might be partly deactivated from the start (Grosjean, 1997).

In sum, the results of recent studies on language inhibition make it hard to adjudicate between the two options fleshed out at the beginning of his section. Until further experimentation, the results are basically in line with both of them: imperfect or no inhibition allowing for nontarget language activation and hence competition, or an interplay of this activation and other factors (associated with WF and/or AoA) causing the delay. As noted in the above sections, it is at this point hard to draw clear conclusions as to what causes the naming delay, as even full inhibition of nontarget language activity is in a sense compatible with nontarget language activity resurfacing during later stages of word production, because candidates from the other language might become activated through activation spreading from the phonological-segmental level (Costa, La Heij, et al., 2006). More experiments in relatively monolingual environments are necessary in order to address the issue of inhibition and its processing consequences in a more detail.

HAEMODYNAMIC BRAIN ACTIVATION STUDIES ON L1/L2 PICTURE NAMING

A somewhat unexpected source of evidence about a possible locus for delayed L2 word production are studies investigating haemodynamic brain activation during picture naming in bilingual participants. By their nature, such studies provide spatial, not temporal information. However, we can rely on previous work linking brain regions to processing stages of word production (Indefrey & Levelt, 2004) and thus indirectly conclude that if a brain region shows a different magnitude of haemodynamic activation in L2 compared to L1 picture naming, then there is also some functional difference at the word production stage that region is involved in.

Across five haemodynamic studies comparing L1 and L2 picture naming within participants (De Bleser et al., 2003; Hernandez, Martinez, & Kohnert, 2000; Vingerhoets et al., 2003), no brain region was replicated as being more strongly activated for L1 compared to L2 picture naming. The reversed comparison also showed no difference between languages in those studies whose participants were exposed to the L2 before the age of five (Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Hernandez et al., 2000; Rodriguez-Fornells et al., 2005). In other words, the location and magnitude of haemodynamic brain activation does not differ between the two languages of early bilingual speakers. The anatomical location of brain activation during L2 picture naming in participants with late L2 onset, variable L2 exposure, and relatively high but not balanced L2 proficiency in two other studies (De Bleser et al., 2003; Vingerhoets et al., 2003) also did not differ from L1 picture naming. However, these L2 speakers showed stronger activation of the posterior left inferior frontal gyrus (IFG) for L2 compared to L1 picture naming (see Figure 3A). In a meta-analysis of neuroimaging experiments on monolingual word production, Indefrey and Levelt (2004) identified this region as being involved in a postlexical word production stage because it was reliably activated in all word production tasks including the pronunciation of pseudowords which have no lexical entry. Further evidence for a role of the left posterior IFG activation in postlexical processing comes from MEG studies on picture naming that show activation of this area between 400 and 600 ms after picture onset (Salmelin, Hari, Lounasmaa, & Sams, 1994; Soros, Cornelissen, Laine, & Salmelin, 2003; see

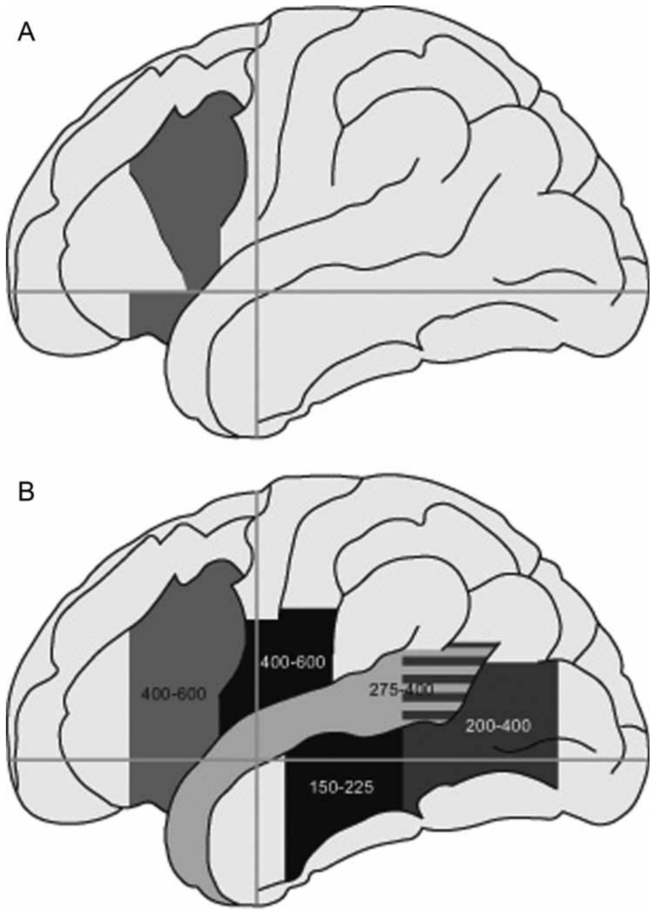

Figure 3. (A) Schematic representation of brain regions showing reliably stronger haemodynamic activation in L2 compared to L1 picture naming of late onset L2 learners (Indefrey, 2006). (B) Schematic representation of left hemisphere brain regions showing reliable haemodynamic activation in L1 picture naming. Numbers in regions indicate time intervals of electromagnetic cortical activation after picture onset (Indefrey & Levelt, 2004).

Figure 3B) which is too late for an involvement in lexical processes (see Section "Studies on the time-course of bilingual lexical access").

Haemodynamic data thus suggest that there is a difference between L1 and L2 word production at a late, postlexical stage at least in one common type of bilinguals (late onset, relatively high proficiency). Although there is no guarantee that this difference is related to the L2 naming delay (after all one cannot exclude that whatever causes the delay does not enhance brain activation and that the observed increase in brain activation has no temporal consequences), such a relationship would follow from the common assumption that stronger L2 activation of a brain region can come about by less efficient processing in that region. Less efficient postlexical processing in the L2 would plausibly also be slower and hence cause a delay in naming.

In sum, haemodynamic data, to date, provide no positive evidence for differences between L1 and L2 naming at conceptual or lexical processing levels, but rather point to a postlexical processing difference.

STUDIES ON THE TIME-COURSE OF BILINGUAL LEXICAL ACCESS

It is generally assumed that most of the conceptual representations of a bilingual are shared between languages, and connected to separate lexical representations in each language (for reviews, see e.g., Francis, 2005; Kroll & de Groot, 1997). Therefore, no timing effects of bilingualism are expected when the semantic/conceptual level is probed in production tasks. This prediction was confirmed in a behavioural study by Gollan et al. (2005), who compared the effect of repetition on naming and semantic classification tasks in a monolingual and bilingual group.[4] While there were longer response latencies in the bilingual group in the naming tasks (Experiments 2 and 3), participants' status did not affect the speed of the classification task (*human made vs. natural*). This is consistent with the view that the first part of the naming process—the selection of concepts—is not slower for bilinguals, as most concepts are actually shared among the two languages (Francis, 2005).

Slowing, however, has been observed at the "opposite end" of the production process. Jacobs, Gerfen, and Kroll (2005), in a study comparing two types of second language learning programme (classroom-learning and immersion), showed that English learners of Spanish in a classroom-type environment (but, interestingly, not in an immersion-learning programme) exhibited slowing even at the very late level of phonetic specification, i.e., longer articulatory duration in L2 for non-cognate words in comparison to cognates.

Recently, there have been a number of ERP studies dedicated to exploring the time-course of bilingual lexical access. One distinctive advantage of the ERP methodology is that it has both excellent temporal resolution, and it can be applied to study cognitive processes which lack, or are prior to, any overt behavioural response such as button press or naming onset. In this section, we will present a small number of studies which—either in a "no-task" context or with a specific experimental manipulation designed to

[4] As noted above, participants in the bilingual group were "switched-dominance bilinguals", and the task was carried out in their dominant language.

influence a particular process implied in picture naming—offer suggestive evidence concerning the locus of delay issue. Of specific interest are those which attempted to disentangle the temporal aspect of the different processes involved in lexical access, while keeping the task-induced nontarget language activation at minimum.

Christoffels et al. (2007) compared picture naming in L1 (German) and L2 (English) of unbalanced bilinguals in a switching study. In addition to a mixed-language block, there was also a blocked-language presentation. Christoffels et al. analysed only the first 600 ms of the EEG signal, i.e., the portion leading up to the point of articulation, to avoid signal contamination with movement artefacts. Apart from the switching mode (blocked or mixed), they also manipulated the cognate status of the picture names. Although the main focus of the study was on disentangling the local and global contribution to language control, comparison of the two blocked conditions allows us to follow the time-course of processes implicated in blocked picture naming. Of special interest are the intervals where the ERPs for L1 and L2 differed. Christoffels et al. analysed two consecutive intervals in their averaged-waveforms: 275–375 and 375–475 ms after the onset of the picture. There was a main effect of language in the latter, but not the former interval, with the ERPs on L1 being more negative than those on L2.

The authors also reported a cognate effect which was, independently of language, already visible in the earlier interval (275–375 ms) and extended into the later interval, after 375 ms. These findings are interesting because they suggest that cognate effects (which are plausibly related to frequency, see also the early frequency effect in the study by Strijkers et al., 2010, mentioned above) can occur in an earlier time window than an L1/L2 language effect. Hence, the language effect does not seem to be caused by frequency or cognate status. If the earliest difference between languages and thus the earliest point in time at which we might expect a naming delay to arise is 375 ms after picture onset, then the available evidence on the time-course of L1 picture naming makes a delay at a lexical processing stage unlikely. Based on reaction time studies, modelling data, and ERP studies, Indefrey and Levelt (2004) estimate a time window between 175 and 330 ms after picture onset for access and retrieval of a word's lexically stored information (Note that the onset of a WF effect at 180 ms reported by Strijkers et al., 2010, is in line with this estimate). From 330 ms onwards, word production proceeds to postlexical processing stages. Hence, one can conclude with some confidence that the time window of the electrophysiological language effect of Christoffels et al. (2007) and also the left inferior frontal activation after 400 ms observed in MEG studies of picture naming (see above) likely reflect postlexical processing. It is less clear, which postlexical processing stage may be involved. Syllabification, the first postlexical process, takes some 25 ms per syllable and completed syllables can be phonetically encoded immediately, so that phonetic and articulatory processes may begin before a word is completely syllabified.

Another ERP paradigm offers possibilities for a more detailed answer regarding the time-course of the individual word-planning processes in question, because it allows for tracking the availability of the output of different processing stages. If we are able to distinguish between the relative timing of the conceptual/semantic stage and the phonological stage in L1 vs. L2, we might be able to reliably state whether the delay arises during conceptual activation, lemma retrieval, or even at a later, postlexical stage of word planning. The paradigm was developed and used to study monolingual picture naming by Schmitt, Munte, and Kutas (2000), Schmitt, Rodriguez-Fornells, Kutas, and Munte (2001), and Schmitt, Schiltz, Zaake, Kutas, and Muente (2001). It makes use of an ERP component called the N200 as an index of response inhibition prior to any overt response. The participants, in the process of naming pictures presented on the screen, carry out two additional tasks—a semantic decision task and a (initial) phoneme-monitoring task—which presumably tap into the conceptual and lexical stages of word planning. Depending on the instruction, each task can either result in a button press, or a button press will be withheld (e.g., as in Rodriguez-Fornells et al., 2005, where a button is pressed if the name of the picture starts with a consonant but is not pressed if it starts with a vowel). The main assumption of the paradigm is that a response can be withheld only at the time point where sufficient information to suppress the response (such as the identity of the first phoneme) is available to the participant, and therefore we will see an index of response inhibition (N200) at or shortly after this point in time, prior to an overt response. By comparing the timing of N200 responses based on conceptual and phonological information, one can gain insights into the timing of the respective processes during word planning in L1 and L2.

Guo and Peng (2007) compared the time-course of conceptual and phonological encoding in the L2 of moderately proficient Chinese learners of English directly to the time-course in monolingual Chinese speakers (Guo, Peng, Lu, & Liu, 2005) using such a two-choice go/no-go task, with a conceptual and a phonological decision. They found that in both the native language and the L2 the "conceptual" N200 effect preceded the "phonological" N200 effect and the length of the semantics-to-phonology interval across the two studies was statistically identical. The interpretability of an L1/L2 comparison between these different studies is certainly limited because they involved different types of participants (monolinguals/bilinguals) and stimuli. Nonetheless, the result implies that there may be no delay in L2 word production up until the stage of word-form retrieval. We also conducted a delayed naming go/no-go ERP paradigm in a study employing a within subject design (Hanulová, Davidson, & Indefrey, 2008). The participants were unbalanced Dutch–English bilinguals, and we employed the same picture materials for both languages. To avoid inducing competition between lexical candidates in the two languages, L1 and L2 were investigated in separate sessions. Prior to naming the pictures in their L1 or L2, the participants were asked to carry out (or refrain from) a button press with either their left or right hand based on one of two decisions. The two decisions were a semantic/conceptual decision (Is the depicted object natural or manmade?) or a phonological decision about the identity of the first phoneme (e.g., Is it a /t/ or not?). For each session, there was also a naming pretest, which showed that voice onset times in picture naming were about 100 ms longer in the L2 English. Whereas reaction times providing information about the availability of semantic or phonemic information were between 850 and 950 ms, the electrophysiological N200 response provided an estimate of the availability of these types of information that was about half a second earlier and hence much closer to the processes as they occur in real time.

The ERP results confirmed the earlier availability of conceptual relative to phonological information observed by Schmitt et al. (2000) for the L1 (Dutch). Crucially, in the L2 we observed the same interval ($\sim$86 ms) between conceptually and phonologically conditioned N200 responses as for the L1, suggesting that at least up to the retrieval of the initial phoneme there is no delay in L2 lexical access during word production.

This finding seems to confirm that L2 lemma selection and accessing the (first phoneme of a) lexical word-form representation are not delayed compared to the corresponding processes for the L1 of bilingual speakers. It is less clear whether an N200 response based on phonemic information taps directly into the retrieval of the lexical word-form (lexeme) information or into a postlexical syllabified representation. Based on experiments demonstrating that reaction times for phoneme monitoring depend on syllable position, Wheeldon and Levelt (1995) argue that this task taps into a syllabified representation. We therefore assume that in order to make the required phoneme decision, participants identified the first phoneme after postlexical phonological encoding, i.e., insertion of the phoneme into a syllable frame. In any case, the results of our study as well as those of Guo and Peng (2007) and Christoffels et al. (2007) do not support an explanation of the L2 naming delay in terms of frequency effects or competition at the lexical level. The evidence from these studies focusing on the time-course of picture naming is more consistent with a rather late, postlexical locus of the naming delay and thus in line with the indirect evidence provided by haemodynamic studies. The available data do not single out a particular postlexical process and one can conceive of plausible mechanisms for an L2 naming delay during syllabification as well as phonetic and articulatory processing. At the phonological encoding stage, time-consuming processes may be due to the carry-over of L1 phonotactic constraints on syllable structure that do not allow for a straightforward assignment of all segments of L2 words to syllable positions and consequently cause the necessity for extra phonological processes. A case in point is the typical vowel epenthesis in the production of certain English consonant clusters by Italian, Spanish, or Japanese L2 speakers of English whose first languages do not allow such clusters. At the phonetic encoding stage where syllables are mapped onto abstract articulatory representations, frequent syllables of the native language may be stored in a mental "syllabary" (Levelt, 1989) allowing for a fast retrieval (Cholin et al., 2006; Cholin & Levelt, 2009). Many L2 syllables will be less frequent or even absent in an L2 speaker's first language, so that their phonetic representations have to be assembled rather than looked up in a syllabary. Finally, as evident in the frequently effortful pronunciation of L2 speech sounds, the production of speech sounds that do not exist in the L1 requires additional motor planning compared to the highly overlearned motor routines that are available for the native language. In order to determine whether the delay in L2 picture naming arises at one or more of these postlexical processing stages, it will be necessary to devise experimental tasks that tap selectively into each of these stages.

CONCLUSIONS

In order to answer our leading question "When does the delay in L2 naming arise?" we discussed several mechanisms suggested by current theories of bilingual word production. These theories suggest that slower L2 naming might be due to lower frequency or later age of acquisition of L2 words in the bilingual lexicon or due to competition from the L1. The available evidence clearly shows that these factors indeed influence L2 naming latencies and yet it does not give an answer to our question because these factors seem to be able to affect different lexical and postlexical processing stages.

Observed WF effects in L2 naming could, therefore, in principle result in a naming delay at a lexical (early) or postlexical (late) stage and this holds similarly for the other effects. More importantly, neurocognitive evidence does not support the simplest assumption namely that frequency (AoA, competition) affects L2 naming from the earliest possible processing stage onwards. Instead, electrophysiological studies (and somewhat indirectly also haemodynamic studies) suggest a rather late (i.e., after lexical word-form access) locus of differences in L1 and L2 word production. Given the, to date, small number of studies this could be a negative evidence problem and earlier L1/L2 differences will be detected in the future. Alternatively, however, one might take these findings seriously and start to investigate why undeniable frequency differences between L1 and L2 might fail to cause a relative delay in L2 lexical activation. Possibly, general inhibition/activation mechanisms may play a role. If global L1 inhibition/L2 activation can overrule frequency differences to the extent that L2 naming is even faster than L1 naming in mixed blocks as demonstrated by paradoxical naming effects, it seems also not implausible that similar mechanisms might compensate for frequency differences at the lexical level in blocked L1 and L2 word production. To put it differently: The bilingual lexicon might not simply have thousands of extra words, but also an additional mechanism that allows their effective retrieval.

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