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Language integration in bilingual sentence production

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Abstract

To what extent are processes used in sentence production integrated between the different languages of a bilingual and to what extent are they kept separate? We consider three models that differ in their assumptions about the degree of integration: De Bot's [De Bot, K. (1992). A bilingual production model: Levelt's Speaking model adapted. *Applied Linguistics, 13*, 1–24] bilingual blueprint of the speaker, Ullman's [Ullman, M. T. (2001). The neural basis of lexicon and grammar in first and second language: The declarative/procedural model. *Bilingualism: Language and Cognition, 4*, 105–122] declarative/procedural model of bilingualism, and Hartsuiker et al.'s [Hartsuiker, R. J., Pickering, M. J., & Veltkamp, E. (2004). Is syntax separate or shared between languages? Cross-linguistic syntactic priming in Spanish/English bilinguals. *Psychological Science, 15*, 409–414] integrated model. A review of the evidence from bilingual sentence production studies shows that Hartsuiker et al.'s predictions are supported, but argues against the other two models. We discuss some repercussions for bilingual language use.

PsycINFO classification: 2340; 2720

Keywords: Bilingualism; Sentence production; Levelt's blueprint of the speaker; Declarative/procedural model; Shared syntax account; Syntactic priming

1. Introduction

To produce a sentence, a speaker needs to engage in two sets of processes. One set is concerned with retrieving words from the mental lexicon. The other set places these words in a sentence structure, so that the sentence conforms to the rules of grammar. Theories differ in their assumptions about how these sets of processes interact (e.g., Chang, Dell, & Bock, 2006; Pickering & Branigan, 1998). The coordination between lexical processes and structure-building processes becomes more complex in bilingualism, because the speaker has to select words and grammatical rules from the correct language. This article reviews the evidence on bilingual sentence production from the perspective of three different models: the bilingual adaptation of Levelt's (1989) blueprint of the speaker (De Bot, 1992); the procedural/declarative model of bilingualism (Ullman, 2001); and the bilingual adaptation of Pickering and Branigan's model of monolingual sentence production (Hartsuiker, Pickering, & Veltkamp, 2004). Our focus is on the extent to which sentence production processes in one language are influenced by the other language.

Most studies of bilingual language production have focused on lexical processing (e.g., Bloem & La Heij, 2003; Colomé, 2001; Costa & Caramazza, 1999; Costa, Roelstraete, & Hartsuiker, 2006; Green, 1998; Hermans, Bongaerts, De Bot, & Schreuder, 1998; Morsella & Miozzo, 2002). These studies strongly suggest that there are cross-linguistic influences; for example, the latency of picture naming in one language can be facilitated by semantically related distracter words from the other language (Costa & Caramazza, 1999). There is considerably less work on syntactic processing in bilingualism, and the models we will discuss differ in their assumptions regarding these processes.

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The three models we consider differ in the level of detail at which they are specified (a global cognitive blueprint in the case of De Bot (1992); a global neuro-anatomical blueprint in the case of Ullman (2001); a more detailed description of cognitive stages and representations in the case of Hartsuiker et al. (2004)). The models all postulate that the production of sentences involves both lexical and syntactic processes, but they make different assumptions about whether sentence production in a first language (L1) and a second language (L2) are integrated or distinct.

According to Ullman (2001), lexical processing is subserved by a domain-general declarative memory system that engages one set of regions in the brain, whereas sentence-level processing uses a domain-general procedural system that engages another set of brain areas (with certain left inferior parietal areas serving as a possible interface). Importantly, this model assumes that the procedural memory system is much more affected by the age of exposure to a second language than the declarative memory system. Late learners cannot rely on the procedural system to acquire grammar and therefore must shift to the declarative system. This means that they learn, represent, and use grammatical rules differently from early learners or native speakers. In particular, late learners either store sentence forms in their entirety or represent grammatical rules in declarative memory.

De Bot's (1992) model is an extension to bilingualism of Levelt's (1989) blueprint of the speaker. This model assumes three main processing levels (a conceptualizer, a formulator, and an articulator) that have access to several knowledge stores (see Fig. 1). The conceptualizer constructs a preverbal message and has access to world knowledge and a record of the previous discourse. The formulator consists of two main processing levels. The level of grammatical encoding constructs a sentence representation; this includes retrieving words from the mental lexicon, assigning grammatical functions to concepts, and building a hierarchical structure in which the words are inserted. The level of phonological encoding spells out the phonological content and structure of the words. The articulator constructs and executes speech motor plans. Importantly, De Bot proposed that the lexicon is shared between a bilingual's languages (with the words connected in networks so that language-specific retrieval is possible), but that there are separate formulators for each language. However, he left open the possibility that the two formulators could interact with each other, and suggested that the degree of interaction could be a function of linguistic distance (with closely related languages sharing the formulator) and of proficiency (with balanced bilinguals having a greater degree of separation). De Bot is unfortunately not explicit about the mechanisms of such an interaction. One possibility is that there are connections between the two (or more) formulators, and that the strength of these connections varies with linguistic distance and proficiency.

Hartsuiker et al.'s (2004) model is specifically concerned with the interface between the mental lexicon and syntactic encoding in bilingualism (see Fig. 2). It assumes that lexical

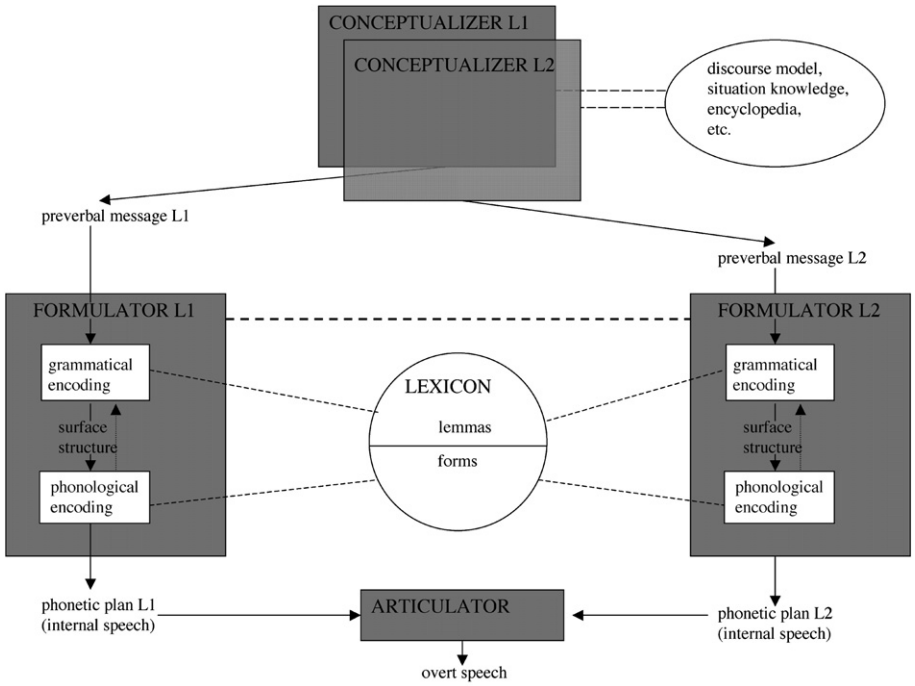

Fig. 1. Blueprint of the bilingual speaker, based on De Bot (1992). In this model, the conceptualizers for the two languages are partly overlapping. There are separate formulators for each language, but these are connected as a function of linguistic distance and proficiency. The other components (i.e., the model of the discourse and semantic memory, the mental lexicon, and the articulator) are shared between languages. For the sake of simplicity, speech comprehension and self-monitoring processes are not depicted.

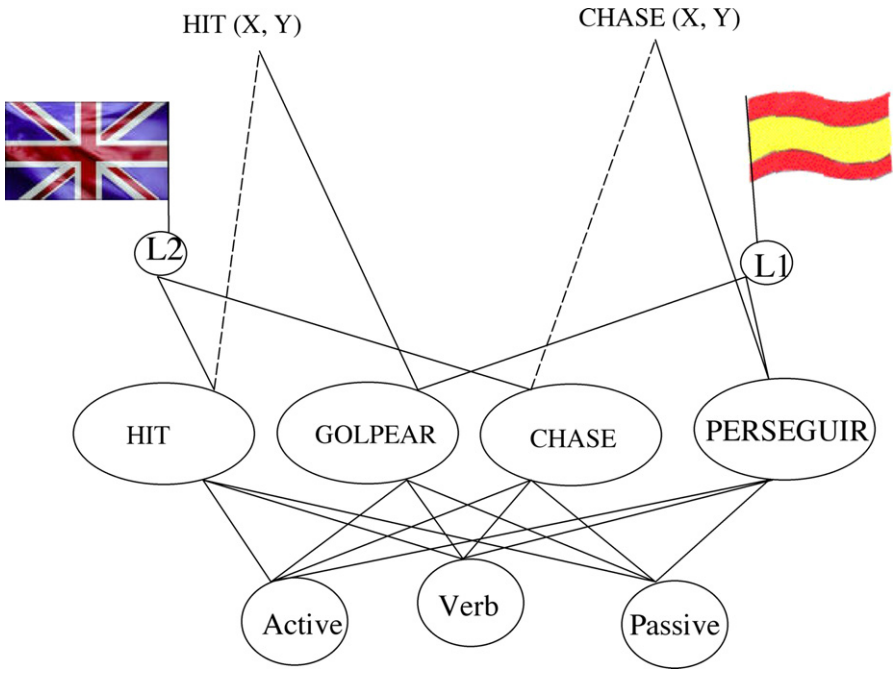

Fig. 2. A partial representation of the lexical entries for the verbs *hit*, *golpear* (hit), *chase*, and *perseguir* (chase) at the lemma stratum of a Spanish–English bilingual in Hartsuiker et al.'s model. In this integrated (shared lexicon, shared syntax) network, each lemma node (*hit*, *golpear*, *chase*, and *perseguir*) is linked to one conceptual node (HIT (X, Y) or CHASE (X, Y)) at the conceptual stratum, to one category node (Verb), to combinatorial nodes (such as active or passive), and to one language node (represented by a British or Spanish flag). Dotted lines indicate relatively weak links between conceptual and L2 lemma nodes.

entries consist of conceptual, lemma, and word-form strata, with syntactic information being represented at the lemma stratum (Levelt, Roelofs, & Meyer, 1999; Pickering & Branigan, 1998). Like De Bot (1992), this model assumes that the lexicon is shared between the different languages of a bilingual. The lemma stratum contains lemma nodes (corresponding to the base forms of words), which are connected to language nodes. These lemma nodes are also connected to nodes capturing syntactic information. For example, the lemma for the verb *hit* is connected to a node indicating that it is a verb and another node indicating that it can combine with a subject and an object noun phrase to form a sentence in the active voice. Importantly, such *combinatorial nodes* are connected to all words with the relevant properties, irrespective of language.

These models diverge on their assumptions about the construction of grammatical structure in bilinguals. Table 1 summarizes these assumptions. De Bot (1992) assumes separate formulators for the different languages. Its strongest version therefore predicts that grammatical processing in one language should not be influenced by the grammatical rules of the other language. However, the model does not rule out interactions between the formulators (i.e., specific influences of one formulator on the other), and therefore a weaker version of this model could explain limited influences of syntactic processing in one language on syntactic processing in the other language. Such influences would be smaller than those occurring within a formulator. In other words, between-language influences should be weaker than within-language influences (within a bilingual or a monolingual). De Bot also suggested that between-language effects should be stronger when the two languages are more rather than less closely related, and stronger when the speaker is less rather than

Table 1
Overview of model predictions about cross-linguistic influences in bilingualism

Prediction	Model			
	De Bot		Ullman	Hartsuiker et al.
	Strong	Weak		
Cross-linguistic influence	No	Yes	Yes	Yes
Within vs. between	–	Within > between	Within > between	Within = between
Linguistic distance	–	x-ling influence decreases	Unclear	No effect
Proficiency	–	x-ling influence decreases	x-ling influence increases	No effect

Note. Only the first two predictions follow from the core assumptions of each model. *Cross-linguistic priming*: Are there cross-linguistic syntactic priming effects? *Within vs. between*: Are within-language syntactic influences larger or smaller than between-language influences? *Linguistic distance*: Are cross-linguistic (x-ling) influences modulated by linguistic distance? *Proficiency*: Are cross-linguistic influences modulated by proficiency?

more proficient in the L2, but note that these suggestions do not follow from the core assumptions of the model.

Ullman (2001) assumes that grammatical processing in L2 partly relies on declarative knowledge, with less proficient L2 speakers using the declarative system to a greater extent than more proficient L2 speakers. In contrast, L1 grammatical processing relies exclusively on procedural knowledge. Thus, this model is compatible with grammatical influences from one language on the other, but these cross-linguistic influences should be weaker than within-language influences. A direct prediction from the model is also that any cross-linguistic influences should be stronger with more rather than less proficient bilinguals (in contrast to De Bot's (1992) suggestion). It is unclear whether Ullman's (2001) model predicts any effect of linguistic distance.

Finally, Hartsuiker et al. (2004) assume that grammatical rules are shared between different languages, whenever these rules are sufficiently similar. Thus, they predict cross-linguistic grammatical influences for these shared rules. Importantly, the model predicts that these grammatical influences from shared rules are as strong between languages as they are within a language, in contrast to both versions of De Bot (1992) and Ullman (2001), with the exception of certain lexically mediated influences (see below for discussion). Hartsuiker et al.'s model predicts no effects of proficiency on cross-linguistic influences (unless, of course, the speaker has not yet learned the relevant L2 construction, or whether particular words can be used with that construction). Additionally, Hartsuiker et al. predict that cross-linguistic influences are unaffected by the linguistic distance between languages (except insofar as more closely related languages have more similar syntactic rules than less closely related languages).

1.1. Cross-linguistic syntactic influences

To evaluate the set of predictions (Table 1), we will turn to recent behavioral evidence from language production experiments, in particular ones using syntactic priming (see below). We focus on behavioral data to limit the length of this article, but we note that there are neurocognitive studies on bilingual production too (e.g., bilingual aphasia, Fabbro, Peru, & Skrap, 1997; fMRI studies of bilingual language production, Golestani et al., 2006) which we will briefly consider in the discussion. Before turning to the priming data, we will first discuss some of the evidence for cross-linguistic effects in three other domains: the production of agreement, syntactic transfer in production, and syntactic transfer in comprehension.

One possible candidate for cross-linguistic influences concerns whether the production of subject–verb number agreement is permeable by semantic information about the numerosity of the subject's phrase referent. Bock and Miller (1991) and Vigliocco, Butterworth, and Garrett (1996) presented native English participants with phrases such as *the baby on the blanket*(*s*) or *the label on the bottle*(*s*), and asked them to complete these phrases to a full sentence. The frequency of number agreement errors (i.e., completions with a plural verb in the examples above) did not depend on whether the head noun was conceptually plural (a label on each bottle, thus many labels) or singular (one baby, sitting on a pile of blankets). However, studies in Spanish, Italian, Dutch, and French did show conceptual number effects (Hartsuiker, Kolk, & Huinck, 1999, Hartsuiker, Kolk & Huiskamp, 1999; Hartsuiker & Barkhuysen, 2006; Vigliocco, Butterworth, & Semenza, 1995; Vigliocco, Butterworth, et al., 1996; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996).

If there are cross-linguistic syntactic influences, one might expect bilinguals who speak languages like Dutch or Spanish to display a conceptual number effect in English (in contrast to English monolinguals). Indeed, Van Hell and Mensies (2004) reported that Dutch/English bilinguals displayed clear conceptual number effects in L2 (English). Additionally, Nicol and Greth (2003) found that English/Spanish bilinguals displayed virtually identical conceptual number effects in their L1 and L2. These data suggest that certain syntactic procedures (i.e., the information called upon to determine a verb's morphology) used in one language transfer to the other language of bilinguals. However, these data are not conclusive, because neither study included a control condition with monolingual English speakers. This is highly problematic, because Eberhard (1999) showed conceptual number effects in this group when the materials were highly imageable, which leaves open the possibility that there is no cross-linguistic difference in the influence of conceptual number after all.

Another way in which the issue of cross-linguistic syntactic influences has been studied is by considering the phenomenon of syntactic *transfer*, which means that bilingual's choice of syntactic construction in one language is influenced by the syntax of the other language (e.g., Hohenstein, Eisenberg, & Naigles, 2006; Marian & Kaushankaya, 2007; Nicoladis, 2006). For example, Hohenstein et al. found that both early and late Spanish/English bilinguals were more likely to use bare verbs and less likely to use manner modifiers (e.g., *the girl exited*) when describing motion events in English than English monolinguals; the bilinguals' pattern is consistent with the way in which motion events are described in their L1 (Spanish), suggesting syntactic transfer from L1 on L2.

Similarly, Nicoladis (2006) found that French/English bilingual children produced more reversals of the order of adjective and noun in both of their languages (as compared to monolingual control children). They were particularly likely to produce the incorrect noun–adjective order in English, when the adjective's French translation was predominantly used in that order. She interpreted these findings in terms of a production model that is highly similar to, but independently motivated from, that of Hartsuiker et al. (2004). The results of these and other studies clearly indicate that there are cross-linguistic syntactic influences, and thus argue against the strong

version of De Bot (1992). However, the phenomenon of transfer does not allow for a comparison of between-language and within-language influences, which is crucial in order to adjudicate between the different models (Table 1).

This article focuses on language integration in sentence production, but it is important to note that a parallel debate is taking place in the domain of sentence comprehension. For example, Clahsen and Felser (2006a, 2006b) argued that the comprehension mechanisms that assign syntactic structure to a string of words and map this structure onto meaning are different for comprehension in L1 and L2, and that there is little evidence for effects of L1 syntax on L2 sentence comprehension. Clahsen and Felser based their argument predominantly on work considering the relative clause attachment ambiguity (e.g., *someone shot the servant of the actress who was on the balcony*), for which comprehenders of some languages show a "high" attachment preference (the servant was on the balcony) and comprehenders of other languages show a "low" attachment preference (the actress was on the balcony); see Cuetos and Mitchell (1988). However, Dussias and Sagarra (2007) found that Spanish speakers with extensive experience of English tended to resolve this ambiguity in Spanish in ways consistent with the preferences of English native speakers for English (i.e., they resolved it "low"); whereas Spanish speakers with little or no knowledge of English did not (i.e., they resolved it "high"). Thus, the evidence for syntactic transfer during comprehension is mixed (see Dussias & Cramer Scaltz (2008/this issue) for further discussion).

In sum, studies on verb agreement in production and on ambiguity resolution in comprehension provide mixed or inconclusive evidence about syntactic influences from one language on the other. Studies on syntactic transfer clearly demonstrate such influences (thus arguing against the strong reading of De Bot's (1992) model), but they do not indicate whether within-language influences are larger than between-language influences (second prediction in Table 1). Rather clearer evidence comes from studies of cross-linguistic syntactic priming, as we shall now see.

2. Evidence from cross-linguistic syntactic priming

Syntactic priming is probably the most frequently used method to investigate sentence production processes (for reviews, see Ferreira & Bock, 2006; Pickering & Branigan, 1999). In a typical experiment, participants are first exposed to a prime sentence with a particular form and then have the choice of two or more forms in their production of a target sentence. For example, Bock (1986) had participants alternate between repeating sentences that they heard and describing pictures of simple scenes, under the guise of a memory task. When the participants had just repeated a passive sentence (e.g., *the building manager was mugged by a gang of teenagers*), they were more likely to describe a subsequent picture with a passive (e.g., *The church is hit by lightning*) than when the prime sentence was an active (*a gang of teenagers mugged the building manager*). Similarly, when the prime sentence was a prepositional-object dative (e.g., *the undercover agent sold some cocaine to the rock star*), participants were more likely to describe a subsequent picture with this structure (e.g., *the waitress is bringing the drinks to the men*) than when the prime was a double-object dative (*the undercover agent sold the rock star some cocaine*).

Importantly, syntactic priming taps into syntactic processes. It occurs in the absence of closed-class lexical repetition (Bock, 1989), and when the thematic roles between prime and target differ (Bock & Loebell, 1990). Although repetition of the head verb in sentences or the head noun in noun phrases can enhance priming, there is still priming in the absence of open-class lexical repetition (Cleland & Pickering, 2003; Pickering & Branigan, 1998). Additionally, priming does not occur when prime and target are superficially very similar but have a different structure. Thus *Susan brought a book to study* (which has a sentence complement) does not prime the production of prepositional-object datives, in contrast to *Susan brought a book to Stella* (Bock & Loebell, 1990). Syntactic priming has been found for many constructions (e.g., Ferreira, 2003; Griffin & Weinstein-Tull, 2003; Hartsuiker, Kolk, & Huinck, 1999, Hartsuiker, Kolk & Huiskamp, 1999; Hartsuiker & Westenberg, 2000; Scheepers, 2003) in languages such as Dutch (e.g., Hartsuiker & Kolk, 1998), English (e.g., Bock, 1986), and German (e.g., Scheepers, 2003). Finally, it occurs from comprehension to production, in other words, when participants merely hear the prime (Bock, Dell, Chang, & Onishi, 2007; Branigan, Pickering, & Cleland, 2000; Potter & Lombardi, 1998).

Pickering and Branigan's (1998) model considers syntactic priming an effect of residual activation of syntactic representations, which are connected to the lexical representations of verbs. They propose that the links between lemmas nodes and combinational nodes are strengthened whenever these representations are simultaneously active. It therefore predicts a "lexical boost" to priming: that is, stronger priming when the head verb (or noun) is repeated between prime and target than when it is not repeated. This prediction is supported by several studies (e.g., Branigan et al., 2000; Cleland & Pickering, 2003; Corley & Scheepers, 2002; Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, in press; Pickering & Branigan, 1998). Note that Hartsuiker et al.'s (2004) model of bilingualism is a direct extension of this lexicalist model.

2.1. Is there syntactic priming across languages?

The strong version of De Bot's model predicts no cross-linguistic syntactic influences. In contrast, the weak version of that model, as well as the Ullman (2001) and Hartsuiker et al. (2004) models, are consistent with such influences

(Table 1). Thus, all models, except the strong version of De Bot (1992), are consistent with cross-linguistic syntactic priming effects.

In support of the latter models, there are now many demonstrations of syntactic priming across languages, for different languages and constructions and using different paradigms, just as there are for within-language priming. Loebell and Bock (2003) found priming between German (L1) and English (L2) in both directions using a picture description task (Bock, 1986). Participants first repeated a prime sentence in one language and then described a picture in the other language. They tended to use the same form of a dative sentence (i.e., prepositional object or double object) when repeating the prime sentence and when describing the picture. However, Loebell and Bock found no comparable priming effects for transitives (i.e., actives and passives).

In contrast, Hartsuiker et al. (2004) did find significant cross-linguistic priming for transitive sentences. They had Spanish–English bilinguals describe cards to each other in a dialogue game (Branigan et al., 2000). Participants first heard a prime description in their L1 (Spanish) and then had to describe the subsequent picture using their L2 (English). They produced English passive sentences more often following a Spanish passive than following a Spanish active or an intransitive sentence (see also Heydel & Murray, 2000, for a brief report of priming from German to English transitives).

Cross-linguistic priming also occurs for dative sentences in Spanish–English bilinguals (Meijer & Fox Tree, 2003), in Dutch–English bilinguals (Schoonbaert, Hartsuiker, & Pickering, 2007), and in Greek–English bilinguals (Salamoura & Williams, in press). Meijer and Fox Tree used a sentence recall task (Potter & Lombardi, 1998), and found that English dative sentences with a double-object structure are more often falsely remembered as datives with a prepositional object after Spanish datives containing a prepositional object than after Spanish primes that contain no prepositional object. Schoonbaert et al. investigated syntactic priming within and between languages using spoken dialogue. They found priming in L1 (Dutch), in L2 (English), and between L1 and L2 (in both directions). Salamoura and Williams used a sentence completion task, in which a prime fragment forced completion as either a prepositional-object dative or double-object dative, whereas a target fragment allowed for both alternatives, similar to Pickering and Branigan (1998). Three experiments revealed priming of these structures from L1 (Greek) to L2 (English).

Additionally, there is cross-linguistic priming for noun phrases in Dutch–German bilinguals (Bernolet, Hartsuiker, & Pickering, 2007). Participants were more likely to produce a structure containing an adjective embedded in a relative clause in German (*der Hai der rot ist*, lit. *the shark that red is*) given a noun phrase with a similar structure in Dutch (*de baby die groen is*, lit. *the baby that green is*), as compared to a noun phrase with adjective–noun order (*de groene baby*, *the green baby*). Similar effects occurred within Dutch and English, both in Bernolet et al. (2007) and in Cleland and Pickering (2003). Interestingly, there was no comparable cross-linguistic effect of these structures between Dutch and English, a finding which we will return to below.

These cross-linguistic effects could in theory be due to lexical priming of translation-equivalent function words between languages (e.g., from *por* to *by* in Hartsuiker et al., 2004). This explanation is unlikely because there is no evidence for within-language priming of function words (e.g., Bock, 1989). Such an explanation also does not seem compatible with Bernolet et al.'s (2007) finding of priming between one set of languages (Dutch and German) but not between another set of languages (Dutch and English), as any lexical priming would most likely occur in both sets. Additionally, Desmet and Declercq (2006) showed priming of relative clause attachment (e.g., *The farmer fed the calves of the cow that..*, where the modifier starting with "that" can either be attached to "calves" or "cow") from Dutch to English (see Scheepers, 2003, for comparable within-language effects). This type of priming cannot be tied to lexical items in the prime sentence, because both prime sentences used the same words (with the gender of the relative pronoun disambiguating between low and high attachment).

However, cross-linguistic priming can be lexically triggered. Salamoura and Williams (2006) found that L1 to L2 priming occurred when participants simply read an isolated verb and then completed a target sentence fragment: participants produced more English prepositional-object datives after reading Dutch verbs that could only take a prepositional-object dative (e.g., *uitreiken*, "present") than after verbs that could only take a double-object dative (e.g., *besparen* "save"); see Melinger and Dobel (2005), for comparable within-language effects.

In short, all these studies provided evidence for cross-linguistic priming (the only exceptions being Loebell & Bock's, 2003, experiment with transitives and Bernolet et al.'s (2007) experiments with noun phrases between Dutch and English). Hence, the findings are consistent with the predictions of the weak version of De Bot (1992), as well as Hartsuiker et al. (2004) and Ullman (2001), but not with the strong version of De Bot. This strong version is also inconsistent with the occurrence of cross-linguistic transfer, as noted in the introduction. We will therefore restrict our further discussion only to the weaker reading of De Bot and the Ullman and Hartsuiker et al. models.

2.2. Is priming within languages stronger than between languages?

The second row of Table 1 lists the models' predictions about the relative strength of within-language influences and between-language influences. The weak reading of De Bot's (1992) model predicts stronger within- than between-language priming because different languages use

different formulators, and therefore any such priming would be mediated by links between these formulators. Ullman (2001) predicts stronger priming within L1 or L2 than between L1 and L2, because syntactic processing in L2 relies more strongly on declarative knowledge than syntactic processing in L1.

The predictions of Hartsuiker et al.'s model are slightly more complicated, because the magnitude of priming is determined by both a syntactic component (i.e., residual activation of the combinatorial nodes, see Fig. 2) and by a lexical component (i.e., temporary increases in the strength of connections between lemmas and combinatorial nodes). This means that when the main verbs in the prime and target sentences are different both within and between languages, there should be no difference in within-language and between-language priming, because the representation that is primed (i.e., a combinatorial node) would be shared by the two languages. But within-language priming using the same verb should be stronger than between-language priming using translation-equivalent verbs. This is because translation-equivalent verbs cannot share the same lemma (because otherwise it would be impossible to ensure that the verb from the correct language was uttered).

Schoonbaert et al. (2007) tested all four directions of priming (L1 to L1, L2 to L1, L2 to L2, and L1 to L2) using a single set of items. In each experiment, there was a condition in which the verbs differed between prime and target (the unrelated condition) and one in which the verbs were identical or were translation equivalents (the related condition). When the verb differed, priming within and between languages was very similar. When the verb was related, there was a much stronger priming effect within than between languages.

Schoonbaert et al.'s (2007) finding of similar within- and between-language priming for different verbs depends on a comparison between different sets of participants. Two unpublished studies have shown very similar within- and between-language priming within an experimental session. Pickering, McLean, Branigan, Cheung, and Peacock (submitted for publication) investigated priming in dialogue, in a design in which participants heard prime sentences (actives or passives) in English (L1) or French (L2) and described target sentences in English. Only a different-verb condition was used. The results confirmed those of Schoonbaert et al.: Priming was practically identical within English and between French and English. Additionally, Kantola and Van Gompel (submitted for publication) tested between- and within-language priming in Swedish–English bilinguals using dative sentences. They used sentence completion (similar to Pickering & Branigan, 1998, and Salamoura & Williams (in press)). This experiment compared priming within L2 (English) with priming from L1 (Swedish) to L2 (English), and found virtually identical priming. In short, the results of three studies support the prediction of Hartsuiker et al. (2004) that within- and between-language priming do not differ (in the absence of verb repetition).

2.3. Is priming between languages modulated by linguistic distance?

The third row of Table 1 lists the model's predictions about effects of linguistic distance on cross-linguistic influences. De Bot (1992) speculated that the degree of cross-linguistic influence is determined by linguistic distance, but we have already noted that this suggestion does not follow directly from the model's core assumptions. It is not clear what Ulmann's (2001) model predicts; Hartsuiker et al. (2004) predict no difference between cross-linguistic priming in closely related languages (e.g., Dutch and English) or very distant languages (e.g., Korean and English), as long as the languages have a similar syntactic rule.

So far, the cross-linguistic priming literature has shown effects within Germanic language pairs (Dutch–English, Dutch–German, German–English, Swedish–English) but also between Germanic and Romance languages (English–Spanish, English–French) and between a Germanic language (English) and Greek (which is an independent branch of Indo-European) with comparable results. Additionally, a recent experiment (Shin & Christianson, 2007) tested for priming between Korean as L1 and English as L2. These languages are typologically very different and genetically unrelated, so presumably they count as linguistically distant. Like Meijer and Fox Tree (2003), these authors used a recall paradigm. The targets were English prepositional-object and double-object datives and the prime sentences were Korean datives (a double-object dative and a prepositional-object dative with canonical word order, as well as a dative with scrambled word order). English double-object datives were significantly more often misrecalled as prepositional-object datives following Korean prepositional-object dative primes than following Korean double-object dative primes, thus demonstrating syntactic priming between Korean and English. Therefore, syntactic priming does occur between distant languages and there appears to be no reason to assume that priming is affected by linguistic distance.

3. Further development of the Hartsuiker et al. model

In this section, we discuss two linguistic influences on cross-language priming that have resulted in further development of Hartsuiker et al.'s (2004) model: an influence of the lexicon and an influence of word order.

3.1. Lexical modulation of priming

As discussed above, Schoonbaert et al. (2007) included conditions in which the verb was identical or translation-equivalent across prime and target. As predicted by Hartsuiker et al. (2004), within-language priming with identical verbs was stronger than between-language priming with translation-equivalent verbs (see Section 2.2). Additionally, priming from L1 to L2 was significantly stronger when verbs were translation-equivalents (thus had the same

meaning) than when they were completely different (see Cleland & Pickering, 2003, for a semantic effect on monolingual syntactic priming). Schoonbaert et al. interpreted their "translation-equivalent boost" as the result of the L2 target lemma (e.g., *give*) reactivating the L1 prime lemma (e.g., *geven*) via their shared conceptual node, so that activation spreads via the recently strengthened link between the L1-lemma and the combinatorial node.

In contrast, priming from L2 to L1 was unaffected by whether the verbs in prime and target were translation equivalents or completely different. To account for this, Schoonbaert et al. (2007) assumed that the connections between concepts and L2-lemmas are relatively weak. Therefore, the L1-target lemma only weakly reactivates the L2-prime lemma, so that very little activation spreads via the link between the L2-lemma and the combinatorial node. This proposal is compatible with the finding that picture naming is slower and more error-prone in L2 than L1 (e.g., Ivanova & Costa, in press; Potter, So, Von Eckhardt, & Feldman, 1984). It is also compatible with the assumption of weak links between concepts and L2-lemmas in Kroll and Stewart's (1994) Revised Hierarchical Model of bilingual lexical access.

We note that Salamoura and Williams (in press, Experiment 1) did not find a translation equivalence boost in L1 to L2 priming, a finding that a first glance seems to contradict those of Schoonbaert et al. (2007). But there was always a filler sentence separating the prime and target sentence, so that lexical activation may have decayed by the time of target completion (as Salamoura and Williams indeed note). Consistent with this interpretation, Hartsuiker et al. (in press) recently found that the within-language lexical boost decayed rapidly.

3.2. Word order and priming

Hartsuiker et al. (2004) claim that combinatorial nodes are shared between languages as long as the structures in the two languages are sufficiently similar. But how similar do they need to be? To investigate this, Bernolet et al. (2007) tested whether cross-linguistic priming is sensitive to word order differences. As noted in Section 2.1, they found priming of noun phrases between Dutch and German, which have the same word order in the relative clause, but they did not find priming between Dutch and English, which have a different word order in the relative clause. These findings strongly suggest that different languages only share syntactic representations for constructions that involve the same word order.

This conclusion is supported by the results of Salamoura and Williams (in press) in a study of dative priming between Greek and English. In addition to double-object and prepositional-object primes in Greek, that study also included a so-called "shifted" dative in which the Prepositional Phrase is placed before the direct object (e.g., *the captain gives to the barmaid a shell*). Consistent with the hypothesis that word order needs to be identical for cross-linguistic priming to occur, the shifted dative did not prime the prepositional dative beyond baseline; note that Pickering, Branigan, and McLean (2002) found similar results within English using this construction.

4. Discussion and conclusions

This article asked whether sentence production in one language is influenced by the grammar of a bilingual's other language, in order to distinguish among De Bot's (1992) separate-formulator account, Ullman's (2001) procedural/declarative account, and Hartsuiker et al.'s (2004) shared-syntax account. Data on syntactic priming between and within languages support Hartsuiker et al.'s account but not the other two accounts. First, there are now eight published studies that show significant between-language priming, from L1 to L2 and vice versa, using several pairs of languages, several types of constructions, and several experimental paradigms (Bernolet et al., 2007; Desmet & Declercq, 2006; Hartsuiker et al., 2004; Loebell & Bock, 2003; Meijer & Fox Tree, 2003; Salamoura & Williams, 2006, in press; Schoonbaert et al., 2007). Between-language priming thus appears to be robust. In conjunction with studies on syntactic transfer, these findings rule out the strong version of De Bot's model, which predicts no cross-linguistic influence at all.

Second, three studies demonstrate comparable within-language priming and between-language priming, as long as the verbs in prime and target are different. These findings argue against Ullman's (2001) model and also against a weaker version of De Bot's (1992) model, but support a prediction of Hartsuiker et al.'s (2004) model. Third, there is cross-linguistic priming between typologically very different languages (English–Korean). This argues against De Bot's suggestion that cross-linguistic interactions are restricted to closely related languages.

Furthermore, Hartsuiker et al.'s (2004) model predicts that priming in same-verb conditions (within languages) is stronger than priming in translation-equivalent verb conditions (between-languages) and this prediction has been confirmed (Schoonbaert et al., 2007). Additionally, only Hartsuiker et al.'s model predicts that in between-language priming, translation-equivalent verb conditions show more priming than different-verb conditions, and this prediction has also been confirmed, at least for priming from L1 to L2. The lack of such a translation equivalence boost in L2-to-L1 priming, however, motivated a modification of the model, so that the connections between concepts and L2 words is weaker than that between concepts and L1 words. This modification is consistent with theories of lexical representation in bilingualism (e.g., Kroll & Stewart, 1994). Further, Hartsuiker et al. assume that syntactic representations are shared when the syntactic structures are sufficiently similar in the two languages. Two studies suggest that structures that have different word orders in the two languages are insufficiently similar to have shared

representations (Bernolet et al., 2007; Salamoura & Williams, in press).

As should be obvious from this review, there is still relatively little psycholinguistic data on bilingual sentence production. Several further predictions of the three models have so far not been tested. For example, both Ullman (2001) and De Bot (1992) predict that proficiency affects the degree of cross-linguistic syntactic interaction (greater seperation in more proficient bilinguals according to De Bot, greater separation in less proficient bilinguals according to Ullman), whereas Hartsuiker et al. (2004) do not predict proficiency effects. In syntactic priming, these accounts thus predict that within-language and between-language priming should be more similar in less proficient bilinguals (De Bot), more similar in more proficient bilinguals (Ullman), or that there should be no difference (Hartsuiker et al.). This prediction has not been tested so far.

The models also differ in their predictions about priming between different second languages in multilinguals. Assume a trilingual knows two late-acquired languages (L2a and L2b) at a comparable level. If one then compared cross-linguistic priming between L2a and L2b, between L1 and either L2a or L2b, and within-language priming, De Bot (1992) would predict equivalently weak between-language priming in all cases and stronger within-language priming. In contrast, Ullman (2001) would predict stronger priming between L2a and L2b than between L1 and either L2a or L2b, because L2a and L2b would have partly declarative representations of grammar, whereas L1 would not. Finally, Hartsuiker et al. (2004) would predict no difference between any of the conditions.

With respect to brain imaging, Ullman's model predicts that L1 and L2 syntactic processing should activate more distinct brain areas in less proficient bilinguals. Current evidence seems to support Ullman's model: Kim, Relkin, Lee, and Hirsch (1997) found that frontal activations are more separate in late rather than early bilinguals, though their study confounded age of acquisition with proficiency. However, within late bilinguals, there is more separation for less rather than more proficient bilinguals (Golestani et al., 2006). The problem with this type of data is, however, that it compares almost the complete process of sentence production in L1 versus that in L2 (i.e., covert word reading with covert sentence production with the word as a cue), so that it is difficult to give a functional interpretation to the separation or overlap of areas activated in the L1 and L2 conditions. Hartsuiker et al. (2004) predict that if a given brain area is sensitive to within-language syntactic priming, than that same area should be equally sensitive to between-language syntactic priming (a region of interest is the left temporal pole, which is differentially active in primed versus unprimed conditions in sentence comprehension, Noppeney & Price, 2004).

Although further work is necessary to understand the architecture of sentence production in a second language, the current evidence suggests that bilingual speakers share syntactic representations and processes as much as they can. An integrated architecture has repercussions for several situations in which bilinguals use language. For example, translators and simultaneous interpreters are confronted with the task of transforming a source text or utterance in one language into a target text or utterance in another language. The Hartsuiker et al. (2004) model predicts that this process will be facilitated when the two languages have parallel syntactic structures; this is because processing the source structure will act as a syntactic prime that leaves the target structure with residual activation. In support of that prediction, Ruiz, Paredes, Macizo, and Bajo (2008/this issue) showed that translators are affected by syntactic congruency between the two languages when reading for translation, but not when reading for comprehension.

In conclusion, current evidence supports Hartsuiker et al.'s (2004) contention that the two languages of bilinguals influence at each other the syntactic level. This model makes several new predictions, not only with respect to syntactic priming studies (that motivated the model) but also with respect to other domains, such as translation, interpretation, and syntactic transfer.

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