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Lexical Access in Speech Production: The Bilingual Case

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In this paper we review models of lexical access in speech production in bilingual speakers. We focus on two major aspects of lexical access: a) how lexical selection is achieved, and b) whether lexical access involves cascaded or discrete stages of processing. We start by considering the major assumptions of how lexical access works in monolingual speakers, and then proceed to discuss those assumptions in the context of bilingual speakers. The main theoretical models and the most recent experimental evidence in their favor are described.

Key words: Speech Production, Lexical Access, Bilingualism.

Speaking involves translating concepts and ideas into patterns of sounds produced by our articulatory organs. During this "translation" process, speakers have to retrieve the appropriate words for conveying the intended message. Furthermore, they must combine these words according to the grammatical properties of the language being spoken. Finally, they have to retrieve information about how to articulate the selected words. How do these processes work? How do speakers master this extraordinary ability that is spoken language? Although speakers go through all these processes very easily (producing fewer than 1 error per 1000 words) and very rapidly (2 words every second; Levelt, 1989), the mechanisms involved in speech production are very complex and poorly understood.

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Most research in psycholinguistics has dealt with the processes involved in speech perception and reading. Nevertheless, in the last two decades an increasing number of researchers have addressed the structure of the processes involved in speaking. These studies have focused both on the functional architecture and on the dynamics of the processes involved in speech production. Among the main questions that have been addressed are: How many levels of representation/stages of processing are there in speech production? Is there an interaction between the different levels of representation? How does the speaker select the proper lexical node from among all the activated words? Does the activation of non-target lexical nodes (words) interfere during lexical access? Are the phonological segments of non-target words activated during the course of speech production? How are the words combined following the grammatical properties of the language being spoken? In spite of the many attempts to answer these and related questions, the nature of the processes and of the representations involved in lexical access are still being debated.

Perhaps because of the complexity of the study of lexical access in speech production, one issue that has not received much attention is how these processes function in the case of bilingualism[1]. In this paper, we focus on the issue of lexical access in bilingual speech production. In the first part, we discuss the main features of the functional architecture and the processing dynamics of the speech production system in monolingual speakers. In the second part, we discuss how these properties of the lexical access system might be implemented in bilingual production. We will assume that the architecture of the bilingual speech system is grossly similar to the one proposed for monolingual speakers. Nevertheless, a clear understanding of the bilingual speech production system requires the postulation of additional assumptions.

2. An overview of lexical access: functional architecture and dynamics

One way to investigate the processes involved in lexical access is by examining the mechanisms engaged in naming a picture. Although picture naming is an oversimplification of the processes involved in language

[1] Notice that, unlike the research on speech production, the mechanisms and representations involved in bilingual word perception have been extensively studied (e.g., Altenberg & Cairns, 1983; Bijeljac-Babic, Biardeau, & Grainger, 1997; Caramazza & Brones, 1980; Dufour & Kroll, 1995; Grainger & Dijkstra, 1992; Van Heuven, Dijkstra & Grainger, 1998).

production[2], it engages many of the processes involved in lexical access. When naming a picture, the first step is to recognize the picture and to select its corresponding semantic representation (e.g. *dog*)[3]. During this process, it is assumed that the semantic representation corresponding to the picture is not the only one that is activated, but that related semantic representations are also activated (e.g. *cat*). The activated conceptual representations spread proportional activation to their corresponding lexical nodes (words) in the mental lexicon, and the speaker has to select the lexical node corresponding to the picture ('dog') from among the activated lexical nodes ('dog', 'cat', 'mouse', etc.). Once a lexical node is selected, its phonological segments (the sounds) are retrieved (/d/, /c/, /g/). Later stages of speech production involve access of the articulatory routines corresponding to the phonological properties of the selected word (e.g., the exact position of the muscles involved in the production of speech). The stage at which lexical selection takes place is sometimes referred to as grammatical encoding since it is at this stage that the grammatical properties of the word are accessed (Bock & Levelt, 1994, Levelt, Roelofs & Meyer, 1999). The stage at which the segmental (sounds) information of the word is retrieved is called phonological encoding (or orthographic encoding in the case of writing- see figure 1). Although theories of language production agree on these general characteristics of the major stages of the process, they differ widely on how they are implemented. (Caramazza, 1997; Dell, 1986; Levelt, et al., 1999; Roelofs, Meyer & Levelt, 1998; Starreveld and La Heij, 1995).

2.1. Implications of the spreading activation principle: Lexical selection

One of the most widely accepted principles of lexical access assumes that in the process of picture recognition several semantic representations are activated. For example, when naming the picture of a *dog* several

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[2] Picture naming is an oversimplification of the language production process because in this task many of the processes regarding grammatical encoding are not typically engaged. Nevertheless, some researchers have tried to study the processes of grammatical encoding by asking participants to name pictures using simple phrases (e.g. Noun Phrase phrases or simple sentences) instead of single nouns (e.g. Costa, Sebastián-Gallés, Miozzo & Caramazza, 1999; La Heij, Mak, Sander, & Willeboordse, 1998; Meyer, 1996; Miozzo & Caramazza, 1999; Schriefers, 1993). Several studies have also been conducted to address the processes involved in syntactic planning using sentence completion tasks (e.g. Bock and Levelt, 1994; Bock, Loebell, & Morey, 1992; Bock & Miller, 1991; Vigliocco & Nicol, 1998; Vigliocco & Zilli, 1999).

[3] Throughout the paper we make use of the following notation: *italics* for stimuli (pictures or words); single quotation marks for lexical representations; and underline for semantic representations.

semantic representations receive activation. The idea of multiple activation at the semantic level has been implemented in at least two different ways. According to the models of non-descompositional semantics (where concepts are represented as indivisible nodes; Levelt, 1989; Roelofs, 1992) the nodes corresponding to a concept are linked to the nodes of semantically related concepts. The activation of the conceptual node corresponding to the picture (e.g., *dog*) “spreads” some activation to other semantic representations that are associated with it (such as *cat*, *fish*, etc). According to other models (Caramazza, 1997; Dell, 1986), which represent concepts (e.g. *dog*) as a bundle of semantic features (animal, four legs, barks, etc.), the activation of a given concept (e.g. *dog*) would activate part of the semantic representation of other related concepts (e.g. *cat)* because some of their semantic features are shared. Regardless of the specific mechanisms, these two proposals share the assumption that in the course of naming a picture, several semantic representations are activated to some degree. This is either because semantic representations are interconnected or because they share several semantic features.

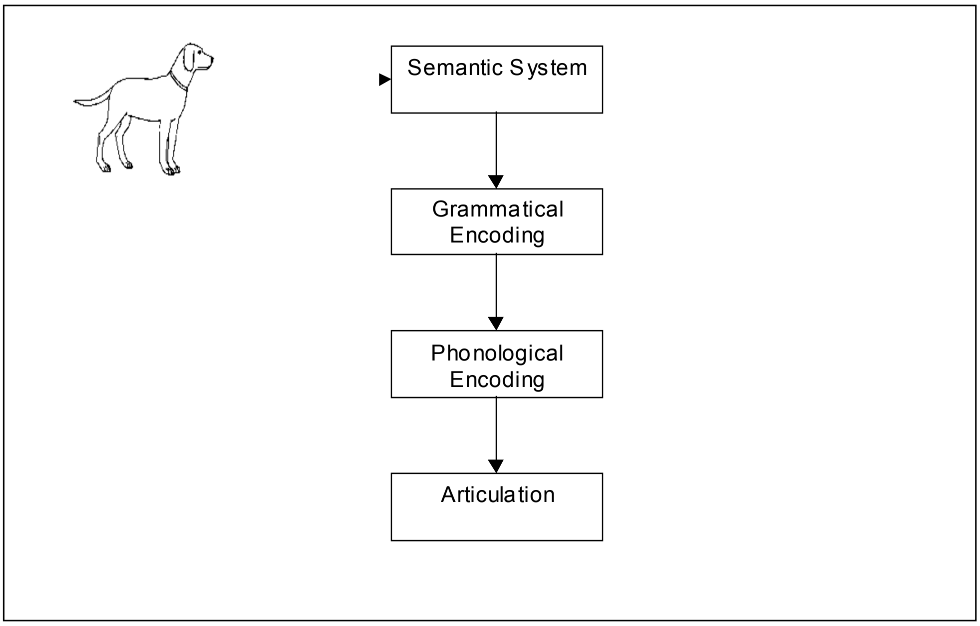

Figure 1. Schematic representation of the different stages involved in speech production.

Furthermore, the activated conceptual representations spread some proportional activation to their corresponding lexical nodes, i.e., activation spreads between levels of representation. In other words, according to the spreading activation principle, the activated semantic representations (*cat*, *dog*, and *fish*) will in turn send activation to the lexical level (see figure 2), activating to some extent their corresponding lexical nodes.

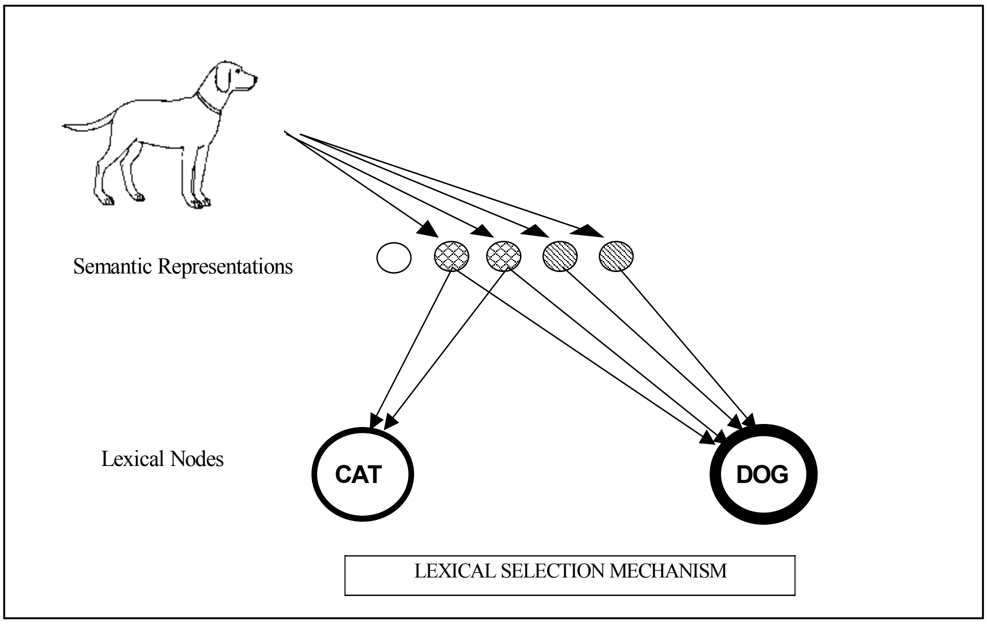

Figure 2. Schematic representation of a picture naming task. The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations. The lexical selection mechanism evaluates the level of activation of the lexical nodes and selects the one with the highest activation level.

The main consequence of this principle is the activation of multiple lexical nodes at the lexical level. Therefore, it is necessary to have a mechanism that will select a lexical node from among the activated nodes. The speaker has to choose from among all the word candidates ('cat', 'dog', 'fish') that are activated. There is a wide variety of evidence that there is *activation of multiple lexical nodes*. One of the best examples is found in spontaneous speech errors. Imagine a situation in which the speaker wants to say the sentence *the dog barks*, but produces *the cat barks* instead. Errors of this type are assumed to reflect a momentary malfunction of the lexical selection mechanism rather than a problem in the selection of the semantic representation (e.g., see Caramazza & Hillis (1990) for the possible sources of semantic errors). That is, the lexical selection mechanism fails to select the proper word corresponding to the selected semantic representation.

Assuming that the spreading activation principle and its most immediate consequences (multiple lexical activation and the necessity of a lexical selection mechanism), are correct, how does the speaker select the lexical node corresponding to the intended conceptual representation from the set of activated lexical nodes? Models of lexical access tend to agree that the selection of a lexical node is based on its level of activation. The selection mechanism selects the lexical node with the highest level of activation, which usually corresponds to the concept that the speaker wants to convey. Some researchers further assume that this process is also affected by the level of activation of the other activated lexical nodes: the higher the activation of non-target lexical nodes (competitors: 'fish', 'cat') the more difficult the selection is (e.g., Roelofs, 1992). In other words, *lexical selection entails lexical competition*: non-target lexical nodes act as lexical competitors during lexical selection. As described above, if at the moment of lexical selection the node with the highest activation level is not the target ('dog') but instead a semantically related word ('cat'), the speaker will produce a semantic error. What are the implications of the spreading activation and the lexical competition principles for bilingual speakers? If activation spreads from the semantic system to both languages of a bilingual regardless of the language selected for production, the lexical nodes of the two lexicons of a bilingual (e.g. Spanish-English bilingual) will become activated. Thus, if activation flows freely from the semantic system to the lexical system without any language restriction, the semantic representation of the picture of *dog* will send activation to its English name ('dog') but its Spanish translation ('perro') will also receive some activation. If that were the case, the question arises whether or not the lexical nodes of the non-response language ('perro') also act as lexical competitors during lexical access (and therefore, can interfere with the selection of the target lexical node). Later in the paper (section 3.3) we present experiments aimed at answering this question.

2.2. Do all the activated lexical nodes spread activation to their phonological segments?

As described in the Introduction, once the target lexical node is selected the next step in speech production is the selection of the word's phonological segments. The dynamics of the activation and selection of the phonological component of words varies widely between models. One of the major differences involves the extent to which the models implement the spreading activation principle between the lexical layer and the phonological layer. Although the spreading activation principle has been widely adopted when characterizing the dynamics of processing between the semantic level and the lexical level (see the above section), it is not as widely employed when characterizing processing at the segmental phonological level. According to discrete stage models of lexical access

(Levelt, 1989; Levelt et al., 1999; Schriefers et al., 1990), the activation of phonological properties is restricted to those of the selected lexical node (see figure 3). Furthermore, the activation of the phonological properties of words begins only after the target lexical node has been selected. In contrast, the cascaded models of lexical access (Caramazza, 1997; Costa, Caramazza & Sebastian, in press; Dell, 1986; Dell et al., 1997; Dell & O'seaghdha, 1991, 1992; Harley, 1993, Starreveld and La Heij, 1996; Stemberger, 1985) assume that all the lexical nodes activated from the semantic level ('cat', 'dog', 'fish') send proportional activation to their phonological segments. Furthermore, the activation of the phonological properties of words occurs before lexical selection takes place (see figure 3).

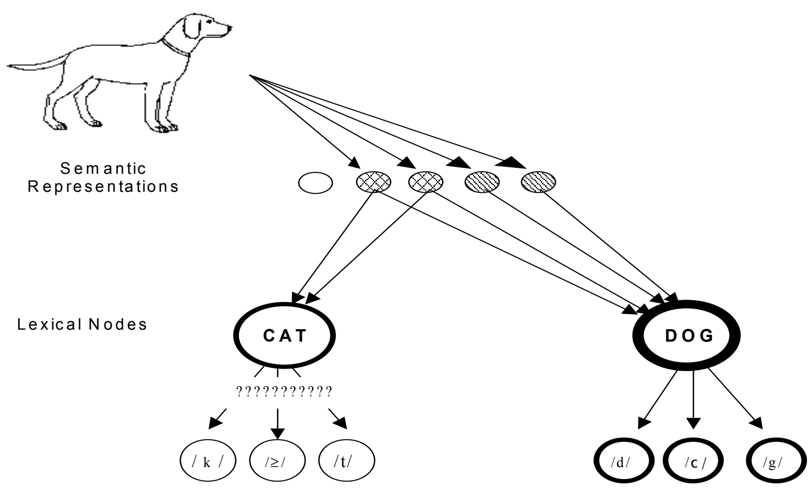

Figure 3. Schematic representation of the cascaded and discrete view of lexical access. The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations. The question marks represents the assumption of whether sublexical information of the non-selected lexical node (cat) is (cascaded view) or is not (discrete view) activated. If the connections between the non-selected lexical node (cat) and the sublexical units is confirmed the cascaded view will be supported.

For example, when intending to name the picture of a *dog*, several lexical nodes are activated due to the spreading activation principle ('cat' and 'dog'). The discrete and cascaded activation theories of lexical access agree up to this point. However, the discrete hypothesis posits that, following the selection of the target lexical node ('dog'), only the phonological segments of the selected lexical node receive activation (/d/,

/c/, /g/). The cascaded activation models of lexical access assume instead that the phonological segments of both the target (/d/, /c/, /g/) and non-target lexical nodes (/k/, /æ/, /t/) are activated. This activation takes place before the target lexical node is selected[4].

In summary, according to the cascaded view of lexical access the spreading activation principle is applied between all the levels of representation involved in lexical access (the semantic, lexical, and phonological levels). By contrast, the discrete stage models restrict this principle to the semantic and lexical levels, preventing phonological activation of non-selected lexical nodes. These two views also have implications for models of bilingual lexical access. Assuming that the semantic system activates the two lexicons of a bilingual in parallel, the question arises whether or not the activation of the lexical nodes of the non-response language spreads to their phonological segments. For example, does the activation of the lexical node 'perro' (dog) in the non-response language spread to its phonological segments (/p/, /e/, /r/, /o/)? According to discrete models, the only segments that are activated are those corresponding to the selected lexical node, and therefore the words in the non-response language would not activate their phonological properties. However, if the cascaded view is correct and its principles apply regardless of the language selected for response, we would expect to observe phonological activation of the words in the non-response language (perro in the example). In Section 3.4 we will present data relevant to this issue.

3. Lexical access in bilingual speakers

3.1. General assumptions

Current models of lexical access in bilingual speakers typically assume that the *semantic system is shared by the two languages of a bilingual* (De Bot, 1992; Costa, Miozzo & Caramazza, 1999; Green, 1986; 1998; Kroll and Stewart, 1994; Potter, So, von Eckhardt, & Feldman, 1984; Poulisse & Bongaerts, 1994). In other words, each semantic/conceptual representation is connected to its corresponding lexical nodes in the two languages. Although, some researchers (e.g., Lucy, 1992; Paivio & Desrochers, 1980; see also Van Hell & De Groot, 1998, for a more recent

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[4] Some of the cascaded activation models further assume the existence of backwards activation from the segmental layer to the lexical layer (e.g., Dell, 1986; Stemberger, 1985). These so-called interactive models assume that the activation of the phonological segments bounces back to all the words that contain them. Following our example, the activation of the target phonological segments (/d/, /c/, /g/) would activate the target lexical node 'dog' but also some phonologically related lexical nodes such as 'doll'. The same applies to the phonological segments that belong to the other activated lexical nodes: 'cat' would activate other lexical nodes such as 'cap'.

proposal) have claimed that conceptual representations are language dependent, recent proposals widely favor the idea that, at least for common words, bilingual subjects have a unique conceptual store shared by both languages.

If the semantic system is shared by the two languages of a bilingual, the question arises whether or not the spreading activation principle between the semantic system and the lexical system also applies regardless of the language programmed for response. We have noted that activated semantic representations spread proportional activation to their corresponding lexical nodes. Does the activation of the semantic system spread to the two languages of a bilingual? If not, and the semantic system only spreads activation to the lexical nodes corresponding to the bilingual's response language (the language in which the speaker wants to communicate), lexical access in bilinguals may proceed as in the case of monolingual speakers. Along these lines, some earlier proposals (McNamara & Kushnir, 1972; McNamara, Krauthammer, Bolgar, 1968; Penfield and Roberts, 1959) argued for the existence of a switching device that turns the flow of activation from the semantic system on and off, preventing the activation of lexical nodes that do not belong to the language-in-use. In other words, the bilingual speaker would have only one lexicon activated at a time.

However, more recent theories assume that the activation of the semantic system spreads to the two languages of a bilingual regardless of the language programmed for response (De Bot, 1992; Green, 1986; Poulisse & Bongaerts, 1994; Poulisse, 1997). According to these theories, there is *parallel activation of the two languages of a bilingual* regardless of the language chosen for production. In other words, current models follow the general spreading activation principle and assume that there is parallel activation of the two lexicons of a bilingual. As we will see below there are experimental findings that support this notion of parallel activation.

In the next sections we will interpret the data of several studies in the framework of a model of bilingual lexical access that assumes that: a) the semantic system is shared by the two languages of a bilingual and, b) the semantic system activates the two lexicons of a bilingual regardless of the language programmed for response.

3.2. Is lexical selection language- specific or language- non-specific?

An important implication of the spreading activation principle is that multiple lexical nodes are activated and, therefore, a lexical selection mechanism is required in order to select the target lexical node. The lexical selection mechanism is assumed to consider the activation levels of all the lexical nodes and to pick the one with the highest level of activation. It is further assumed that the ease with which the selection takes place depends on the level of activation of both the target lexical node and the non-target lexical nodes, which act as lexical competitors and may hinder the selection of the target word. How does this mechanism work in the case of bilingual speakers? Bilingual speakers not only must select the lexical node corresponding to the intended concept, but also must do so in the appropriate language. If lexical selection depends on the level of activation of the target lexical node and of the other activated lexical nodes, do the lexical nodes of the non-response language compete for selection? How do speakers keep the two languages apart and prevent lexical intrusions from the language-not-in-use?

Consider the situation in which an English-Spanish bilingual is asked to name the picture of a *dog* in English. According to the parallel activation principle, once the semantic representation of *dog* is activated it sends activation to its corresponding lexical nodes in the two lexicons of a bilingual ('dog' and 'perro'), and also to other semantically related words in the two languages ('cat' and 'gato') (see figure 4). At this point lexical selection has to take place by selecting the lexical node with the highest level of activation. However, since the target lexical node 'dog' and its Spanish translation 'perro' share the same semantic representation, they are both highly activated. How does the speaker select the right word instead of its twin in the other language? It is clear that bilingual speakers demonstrate excellent control in keeping the two languages separated; they rarely mis-select the translation word when speaking in one of their languages. This is an important property of the bilingual's lexical access system since language intrusions would hamper communication dramatically, especially when the interlocutor does not know the language in which the intrusion is produced. Therefore, a mechanism must exist that assures the selection of the lexical nodes in the appropriate language. Two solutions have been proposed to account for these observations.

The first solution assumes the existence of an inhibitory mechanism that *suppresses the activation of the lexical nodes of the language not-in-use* (e.g., de Bot, 1992, Green, 1986, 1998; Poulisse & Bongaerts, 1994). As a result of this inhibitory mechanism, the activation of the lexical node 'dog' will be larger than the activation level of its translation in Spanish, 'perro', thereby preventing the selection of the latter lexical node. According to this proposal, *lexical selection is language non-specific* since it considers the activation of all the lexical nodes in the bilingual's two languages. It is important to note that this proposal includes a new principle that clearly diverges from those assumed in the monolingual models: lexical access entails inhibitory mechanisms that are crucial for the proper selection of lexical nodes.

The second proposal assumes that the lexical selection mechanism *considers only the activation of the lexical nodes of the language-in-use* (e.g. Costa, et al, 1999; Costa & Caramazza, 1999; Roelofs, 1998).

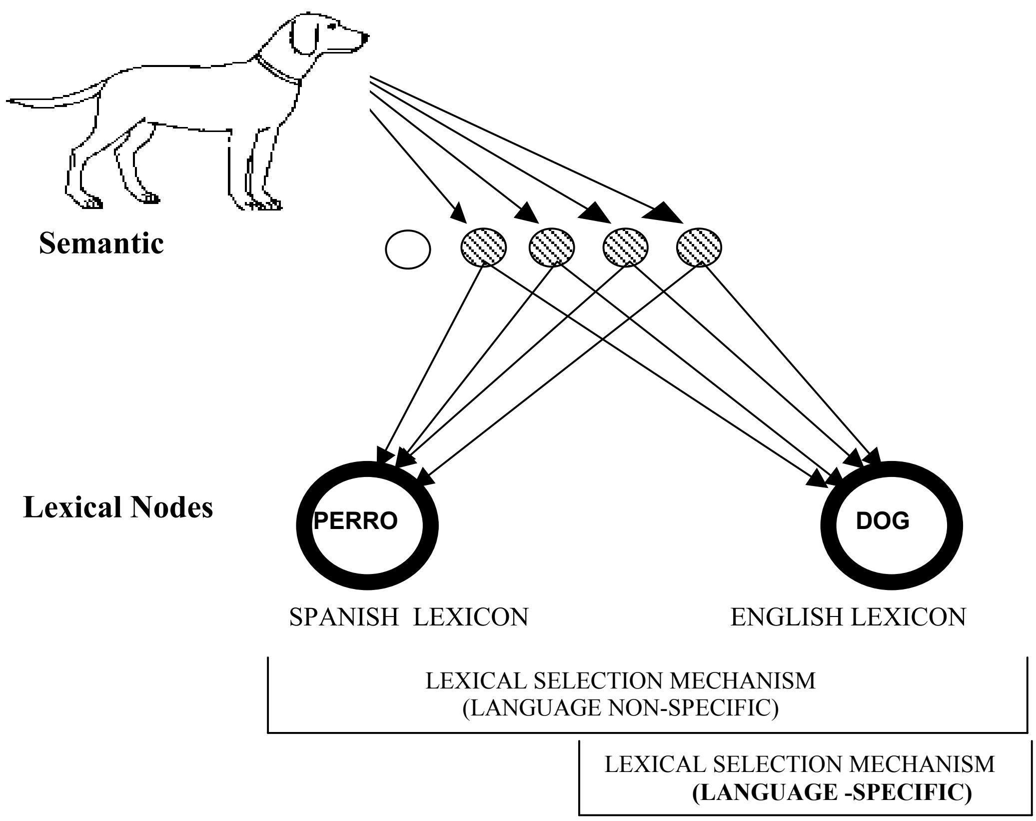

Figure 4. Schematic representation of the language specific and non-specific selection hypotheses. The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations.

According to these models, the activation of the lexical nodes that do not belong to the language-in-use are not considered during the lexical selection process. Therefore, lexical selection may proceed in the same way as with monolingual speakers, since only one language is considered at any moment in time. This proposal assumes that *lexical selection is language-*

specific since the activation of the lexical nodes of the language-not-in-use are ignored.

Although, these two proposals look very similar, at first, they have different implications regarding one of the main principles of lexical access proposed by monolingual models. As described earlier, the non-target lexical nodes that are activated during speech production act as competitors during lexical selection. If there are other lexical nodes that are highly activated, the selection of the target lexical node may be delayed. According to the language non-specific hypothesis, the activated lexical nodes belonging to the language-not in-use are also considered in the course of lexical selection, and, therefore, also act as lexical competitors, hindering the selection of the target lexical node. In contrast, according to the language-specific selection hypothesis, since the activation levels of the lexical nodes of the language-not-in-use are ignored, they cannot compete during lexical selection.

Therefore, a central question regarding lexical access in bilingual speakers is the extent to which lexical selection entails competition between the lexical nodes belonging to different languages. In the following section we describe studies that have addressed this question. To anticipate some of the conclusions we will reach on this issue, the results of these studies suggest that the lexical nodes of the non-response language do not compete during lexical selection. In other words, the bilingual's lexical selection mechanism seems to be language-specific.

3.3. Experimental evidence: The picture-word interference paradigm

As already noted, an important source of constraints for models of lexical access in speech production is provided by the analysis of spontaneous and experimentally elicited speech errors (e.g Dell, Juliano, & Govindjee, 1993; Fay & Cutler, 1977; Fromkin, 1971, 1973, 1980; García-Albea, del Viso, Igoa, 1989; Garrett, 1976, 1980; Martin, Weisberg, & Saffran, 1989; Martin, Gagnon, Schwartz, Dell & Saffran, 1996; Stemberger, 1990). However, it has been argued that the speech error analyses have important limitations when the objective is to characterize the dynamics of the processes involved in language production (e.g., Meyer, 1992). Therefore, much of the recent research on speech production has focused on reaction time experiments that allow us to test more specific predictions derived from the theoretical models.

One of the most popular paradigms for studying the processes involved in lexical access is the picture-word interference paradigm, an extension of a paradigm developed by Stroop more than half a century ago

(Stroop, 1935; see McLeod, 1991; for a review). In this paradigm a picture is presented along with a distractor word; participants are instructed to name the picture and to ignore the distractor word. The two major effects observed with this paradigm are the semantic interference effect and the orthographic/phonological facilitation effect. The semantic interference effect (e.g. Caramazza & Costa, in press; Glaser & Glaser, 1989; Glaser, & Düngelhoff, 1984; Lupker, 1979; Roelofs, 1992; Starreveld & La Heij, 1996) refers to the longer naming latencies observed when the distractor word and the picture belong to the same semantic category (picture: *dog*, distractor: *cat*) than when they do not (picture: *dog*, distractor: *car*). The orthographic/phonological facilitation effect (e.g., Costa & Sebastian-Gallés, 1998; Lupker, 1982; Rayner & Springer, 1986; Underwood & Briggs, 1984) refers to the faster naming latencies observed when the distractor word and the picture's name are phonologically or orthographically related (picture: *dog*, distractor: *doll*) than when they are not (picture: *dog*, distractor: *car*)

3.3.1. The semantic interference effect

It has been argued that the semantic interference effect reflects competition between lexical items during lexical selection (Roelofs, 1992; Schriefers, et al., 1990; Starreveld and La Heij, 1995; but see Miozzo and Caramazza, submitted). In the semantically related condition, the distractor word creates more interference than the unrelated distractor word because it receives extra activation from the semantic representation of the picture. The larger activation of the semantically related lexical node *cat* in comparison to that of the unrelated lexical node *car* is assumed to be responsible for the semantic interference effect.

Given that the semantic interference effect reflects the competition of different lexical nodes at the lexical level, it is a good tool for determining whether there is competition between lexical nodes that belong to different languages. Several studies have addressed this question by presenting the distractor word in the language not-in-use (Ehri & Ryan, 1980; Mägiste, 1984, 1985; Smith & Kirsner, 1982; Goodman, Haith, Guttentag, & Rao, 1985; for the Stroop variant of the task see e.g., Albert & Obler, 1978; Altarriba & Mathis, 1997; Smith & Kirsner, 1982; Chen & Ho, 1986; Dyer, 1971; Mägiste, 1984, 1985; Preston & Lambert, 1969; Tzelgov, Henik & Leiser, 1990; La Heij, de Bruyn, Elens, Hartsuiker, Helaha, & van Schelven, 1990; for a review see McLeod, 1991; Smith, 1997). For example, a Spanish-English bilingual may be asked to name the picture of a *dog* in English with a simultaneously presented semantically related Spanish word (*gato*) or an unrelated Spanish word (*coche*). The standard result is that there is semantic interference in the cross-language situation. That is, naming latencies are slower when the distractor word is semantically related to the picture's name regardless of whether or not it is printed in the response language. This outcome may reflect the possibility that the two languages of a bilingual do indeed compete during lexical selection, supporting the language non-specific hypothesis.

However, as we have argued elsewhere (Costa et al., 1999, Costa and Caramazza, 1999), the semantic interference effect observed across languages cannot be taken as evidence of cross-language competition and therefore cannot adjudicate between the language-specific and language non-specific hypotheses. This is because the competition created by the semantically related word printed in the non-response language may have two sources. First, according to the language non-specific hypothesis, the English lexical node corresponding to the picture 'dog' and the Spanish lexical node corresponding to the distractor word 'gato' compete, thereby delaying the lexical selection of the English target word. Second, according to the language-specific selection hypothesis, the semantic interference created by the Spanish word may be reflecting the competition of its English translation. Let us explain how this within-language competition may arise in the case in which the distractor word is printed in the non-response language. The Spanish distractor word *gato* activates its semantic representation (*cat)*, which because of the parallel activation principle activates it s lexical nodes in the two output lexicons of the bilingual (gato and cat). In this scenario, the English lexical node 'cat' can interfere with the selection of the English target word 'dog' (see figure 5).

Therefore, the semantic interference between-languages may be due either to competition between lexical nodes that belong to the same language ('dog' and 'cat') or to competition between lexical nodes in different languages ('dog' and 'gato'). To resolve this issue, we analyzed the effects of identical distractors in the picture-word interference paradigm.

3.3.2. The identity effect within and between languages

The identity condition across languages represents the situation in which the distractor word corresponds to the translation of the picture's name. For example, the picture of a *dog*, to be named in English, appears with the Spanish distractor word *perro* (dog in Spanish). By comparing the naming latencies in this condition to the appropriate control condition (see figure 6), it may be possible to decide between the language-specific and the language non-specific selection hypotheses, since they predict different outcomes.

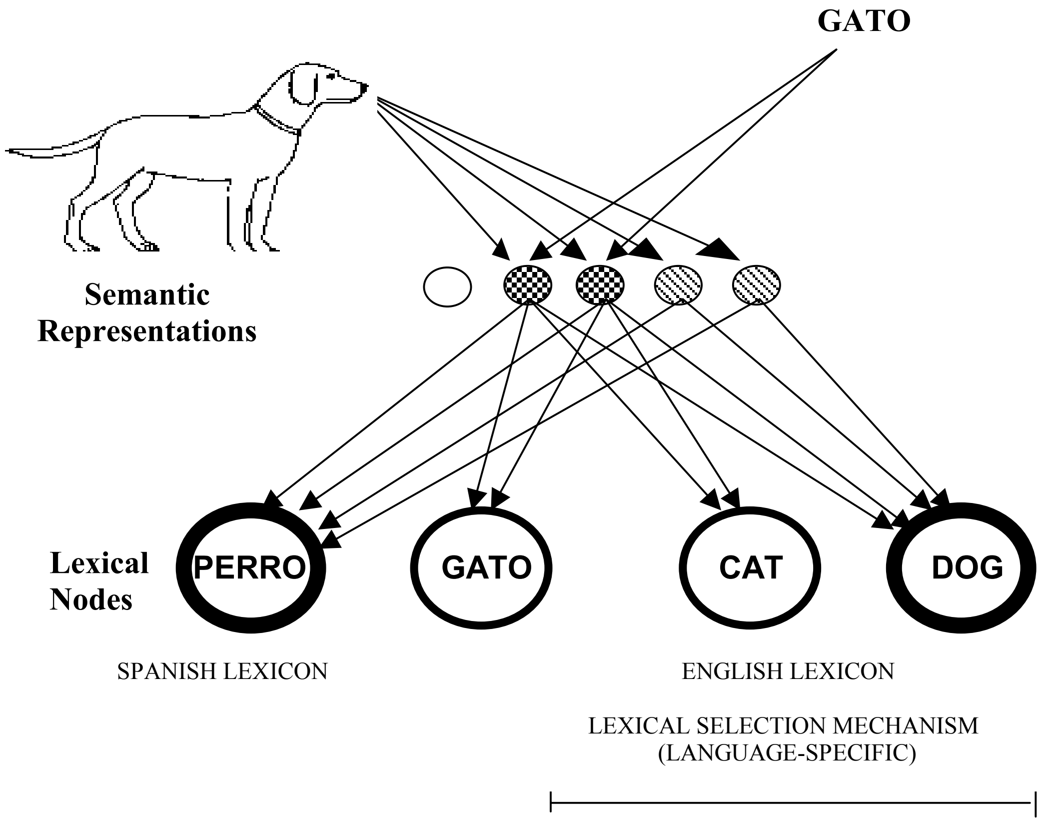

Figure 5. Schematic representation of the semantic interference effect produced by a semantically related distractor printed in a language different from the response language according to the language specific selection hypothesis. Subjects are asked to name the picture in English (dog) while ignoring a semantically related distractor printed in Spanish (gato). The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations.

The language non-specific hypothesis predicts longer naming latencies in the identity condition than in the unrelated condition. If lexical selection is not language specific the highly activated Spanish lexical node will interfere with the selection of the target lexical node in the English lexicon. The Spanish lexical node is highly activated because it receives activation from the picture and the written stimulus (see figure 7).

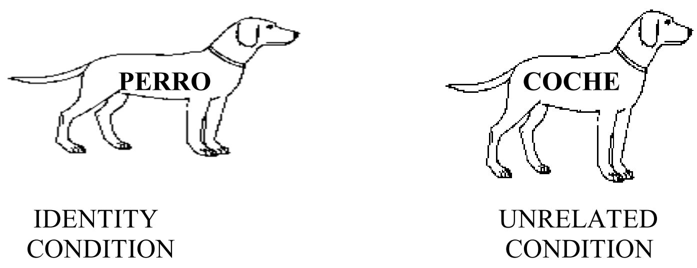

Figure 6. Examples of the cross-language identity and unrelated conditions in the picture-word interference paradigm. Subjects are asked to name the picture in English (dog) while ignoring the Spanish distractor word that may be either the target's translation (perro) or an unrelated word (coche).

Therefore, in the identity condition the lexical selection mechanism will encounter two lexical nodes that are highly activated (the English target lexical node 'dog', and its translation in Spanish 'perro'). In the unrelated condition the activation of the Spanish lexical node corresponding to the Spanish distractor word (*coche*) is not as high as in the identity condition, since it does not receive the extra activation from the picture's semantic representation. Therefore, on the assumption that the ease with which lexical selection is achieved depends on the activation of not only the target lexical node but also that of other lexical nodes, the selection of the English target lexical node would be easier in the unrelated than in the identity condition. Note that on this account, one might even expect to find that in cross-language tasks identical distractors interfere more than semantically related distractors. In fact, if an identical picture activates the distractor's meaning more than a semantically related picture, and if this difference translates into a difference in the activation of the distractor's lexical form, larger interference might be observed with identical than semantically related distractors.

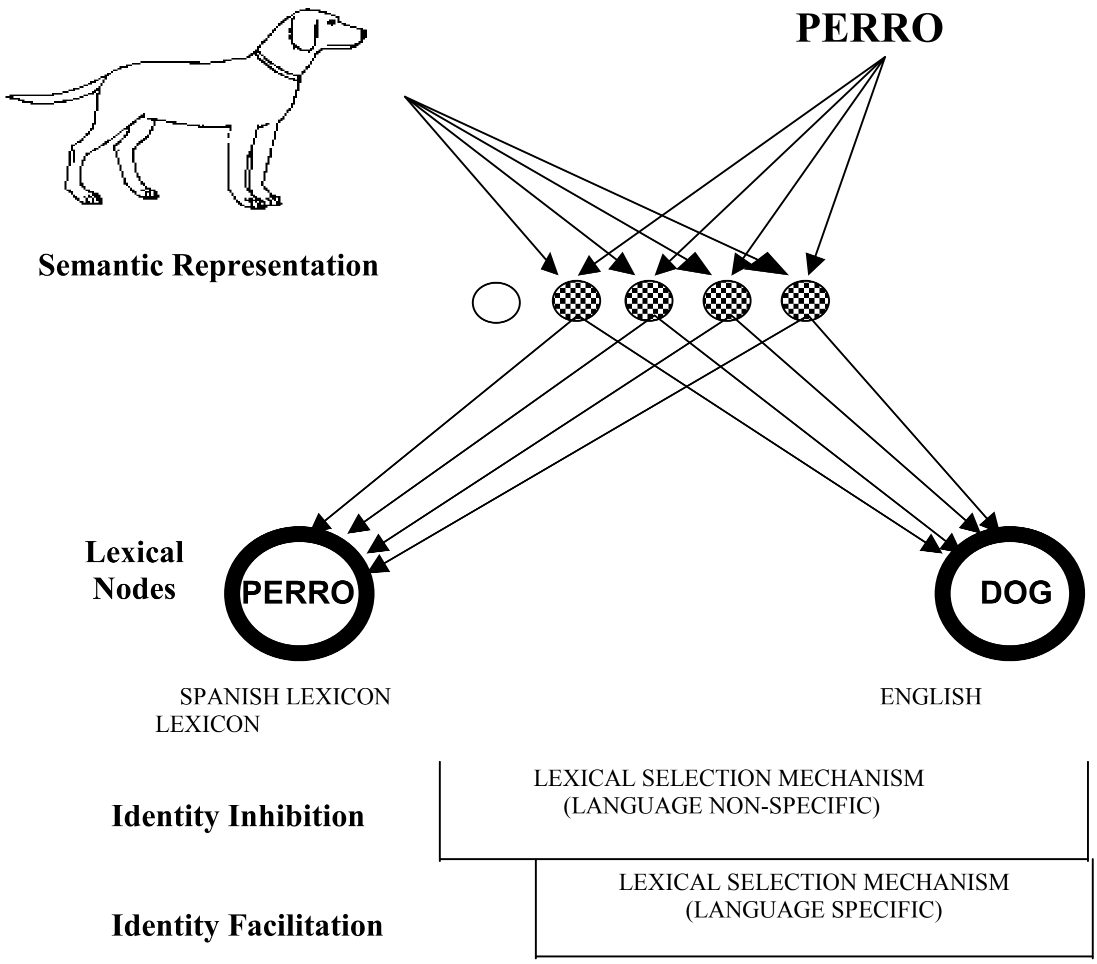

Figure 7. Schematic representation of the identity condition between-languages according to the language specific and non-specific selection hypotheses. Subjects are asked to name the picture in English (dog) while ignoring its translation word in Spanish (perro). The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations.

In contrast, the language-specific hypothesis predicts faster naming latencies in the identity condition than in the unrelated condition. This expectation is based on the reasoning that the Spanish distractor (through its semantic representation) activates the lexical form of its English translation and therefore further activates the target response. Under the assumption that only the lexical nodes in the English lexicon are considered for selection, the extra activation that the lexical node 'dog' receives from the presentation of the Spanish distractor word 'perro' facilitates its production (see figure 7).

In several experiments, in which the distractor word and the picture were presented simultaneously, we have shown that naming latencies are faster when the distractor word corresponds to the translation of the target word than when the two stimuli are unrelated (see figure 8). As described above, this outcome is precisely as predicted by the language-specific hypothesis. This effect demonstrates that the lexical selection mechanism considers only the activation of the lexical nodes that belong to the language-in-use.

The phenomenon is robust since we have found it with bilinguals of very different (English-Spanish) and very similar (Spanish-Catalan) languages, with participants asked to name the pictures both in the dominant and the non-dominant language. This shows that the language-specific selection mechanism may be functional in different bilingual situations. Therefore it seems that the results of our research support the notion that lexical access in bilingual speakers is language-specific.

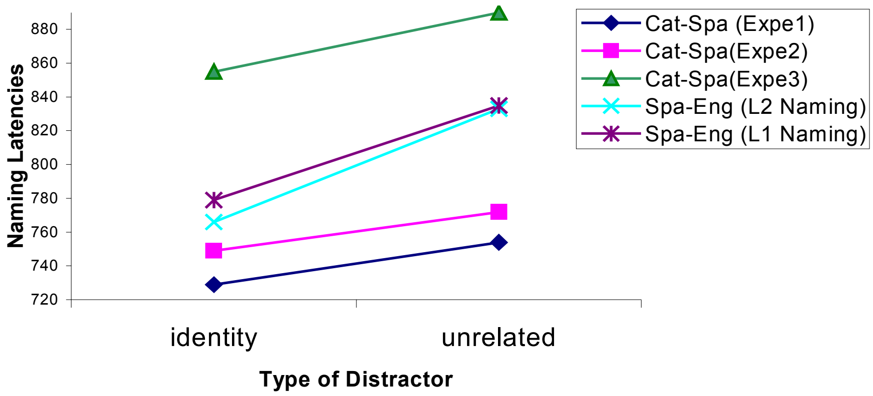

Figure 8. Identity Facilitation between-languages

There is, however, one particular version of the language non-specific hypothesis that is compatible with the observed results. If one assumes that the inhibitory mechanism is powerful enough to completely suppress the activation of the lexical nodes of the language-not-in-use, the activation of the lexical nodes of the non-response language cannot interfere during lexical access (even if they are considered in the course of lexical access).

On this strong version of the suppression hypothesis, the language-specific and non-specific hypotheses become equivalent regarding the extent to which there exists across language competition. Therefore, the identity effect observed in our experiments cannot adjudicate between the two accounts. Indeed, as in the case of the language-specific selection hypothesis, this strong version of the language non-specific selection hypothesis predicts that both the semantic interference effect and the identity facilitation effect must arise as a consequence of within-language competition. Nevertheless, the two views make different predictions regarding whether or not there may be activation of the phonological segments of the lexical nodes belonging to the non-response language. According to the complete suppression view, the lexical nodes of the non-response language would not activate their phonological properties since they are completely suppressed. In contrast, the language-specific selection hypothesis would predict that, given cascaded processing, the phonological information of the lexical nodes of the non-response language should receive some activation. In the next section we will describe results regarding this issue that allow us to test these two predictions.

Although the results of our investigation suggest that the lexical nodes of the non-response language do not compete during lexical selection, in a recent paper, Hermans, Bongaerts, de Bot & Schreuder (1998) argued that bilingual speakers cannot prevent interference from their dominant language when speaking in their second, non-dominant language. They tested Dutch-English bilinguals in a picture-word interference study in which the distractor word was phonologically related to the target's translation (the phonologically mediated identity condition). For instance, when naming the picture of a *mountain* in English, the distractor was the Dutch word (*berm* – verge in English), which is phonologically related to the Dutch word for mountain (berg). Hermans et al. argue that, if the lexical selection mechanism takes into account the activation of the two languages of a bilingual, lexical selection should be slower in the phonologically mediated identity condition (*berm-mountain*) than in the unrelated condition (*kaars-mountain*). This expectation is based on the phonological overlap between the distractor word *berm* and the translation word (*berg*) of the target's lexical node ('mountain'). They argue that the distractor word *berm* will activate to some extent the lexical node 'berg', in addition to the activation it receives from the presentation of the picture (*mountain*). On this reasoning, the activation of the Dutch lexical node 'berg' will be larger in the phonological mediated identity condition than in the unrelated condition, where it receives activation only from the picture's semantic representation. The results confirm this prediction: naming latencies were slower for the phonological mediated identity condition (*mountain-berm*) than for the unrelated condition (*mountain-kaars* –candle in English). According to the authors, this inhibitory effect supports the idea that bilingual speakers cannot prevent interference from the language not-in-use. In other words, it supports the language non-specific selection hypothesis.

Nevertheless, the interpretation in terms of lexical competition across languages is not the only one for this result. It could be argued that the interference effect created by the Dutch lexical node 'berg' through the presentation of the distractor word *berm* can be located at the retrieval of the phonological information corresponding to the target word *mountain*. That is, it may be that the distractor word *berm* activates its phonological segments /b/, /e/, /r/, /m/. Some of these segments are further activated by the lexical node 'berg' /b/, /e/, /r/, which has been previously activated through the presentation of the target picture (*mountain*). In such a scenario, the retrieval of the phonological segments corresponding to mountain (/m/ /o/, /u/, /n/, /t/, /a/, /i/, /n/) may be delayed because other segmental information is highly activated (/b/, /e/, /r/). This explanation of the effect reported by Hermans' et al. is based on two assumptions: first, there is phonological activation of non-selected lexical nodes (cascaded processing), and second, the activation of phonemes that are not part of the target word may affect the retrieval of the target word phonemes. In the next section we will present data supporting these two assumptions.

3.4. Is the segmental information of the words of the language-not-in-use activated?

In this section we address the extent to which the activation of the lexical nodes that belong to the non-response language spreads to their corresponding phonological segments. In Section 2.2 we presented two different views of the time course of lexical access in speech production: the discrete and the cascaded view. According to discrete models, the activation of phonological segments is restricted to those of the selected word, and the activation of a non-selected lexical node does not spread to its corresponding segmental information. In contrast, in the so-called cascaded models, activation flows freely through the whole system, such that all the activated lexical nodes send further proportional activation to their corresponding segments.

There are several studies that have addressed whether phonological activation of non-selected lexical nodes is found during lexical access in monolingual speakers (Cutting & Ferreira, 1999; Jescheniak & Schriefers, 1998; Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991;

Peterson & Savoy, 1998). One of the more compelling results comes from the study conducted by Peterson and Savoy (1998). In their study, participants were asked to name pictures as the primary task and to read words as the secondary task. In the majority of the trials, participants had to name the picture that was presented on the screen. However, in some trials, after the presentation of the picture, a word appeared on the screen and participants were required to read the word instead of naming the picture. In the critical condition the word was phonologically related to a synonym of the picture's name. For example, when the picture to be named was *couch*, the word was phonologically related to the couch's synonym sofa (e.g. *soda)*. The authors argue that if the non-selected word 'sofa' sends activation to its phonological segments, reading latencies for the word *soda* should be faster when preceded by the picture of a *couch* than when preceded by an unrelated picture (e.g. *lemon*). The data support this prediction. Furthermore, this effect was only observed when the word was phonologically related to a synonym of the picture's name (*soda* for *sofa*) but not when it was phonologically related to a word from the picture's semantic category (*bet* for *bed*) (for the latter result see also Levelt, et al. 1991). According to the authors, this dichotomy is due to the fact that although all the activated lexical nodes send proportional activation to their phonemes, this activation is only detectable when the lexical node is highly activated as in the case of synonyms (e.g., *couch* -*sofa*).

Do the non-selected lexical nodes that belong to the language-not-in-use in bilinguals also send activation to their corresponding phonological features? In the next section we describe experimental evidence that suggests that the activation of lexical nodes of the non-response language further spreads to their phonological segments.

3.4.1. Picture naming and the cognate effect

As shown by Peterson and Savoy (1998), the probability of detecting phonological activation of non-selected lexical nodes increases when the non-selected node is highly activated, as in the case of synonyms. Translations provide a natural way to test the cascaded vs. discrete view of lexical access since they are guaranteed to be highly activated given that they share a common semantic representation. Assuming that the parallel activation principle is correct, when a Catalan-Spanish bilingual is asked to name the picture of a *dog* in Spanish, the activation of the Catalan translation word (e.g. 'gos' –dog in Catalan) corresponding to the target lexical item (e.g., 'perro' –dog in Spanish) is also activated. Furthermore, the activation of the target's translation word must be quite large since the two words share a semantic representation and therefore the semantic overlap of translation words is larger than the overlap between synonyms. In this situation, according to cascaded models of lexical access, one predicts detection of the phonological activation of the non-selected word (the target's translation word).

In a recent study, we tested this hypothesis by analyzing the naming performance of Catalan-Spanish bilinguals (Costa et al., in press). We explored the effect of the cognate variable in picture naming. Cognate words are translations that are orthographically and phonologically very similar in the two languages (e.g. 'gato' [Spanish, cat], 'gat' [Catalan, cat]), while non-cognate words correspond to those translations that are dissimilar (e.g. 'perro' [Spanish, dog], 'gos' [Catalan, dog]. We argued that if the phonological properties of non-selected lexical nodes that belong to the non-response language are activated, naming latencies should be faster for cognate than for non-cognate words. This prediction is based on the following reasoning. Consider the situation where a Spanish-Catalan bilingual is asked to name a picture with a cognate name in Spanish ('gato'). The activation of the semantic representation of *cat* will spread some activation to both the Catalan lexical node 'gat' and the Spanish target lexical node 'gato'. The activation of the Catalan word will spread to its phonological properties (/g/, /a/, /t/) which also happen to be part of the phonological representation (/g/, /a/, /t/, /o/) of the Spanish target lexical node ('gato'; see figure 9).

In contrast, when naming a picture with a non-cognate name ('perro') the activation of the phonological form of the target's Catalan translation ('gos' – dog in Catalan) will activate different phonemes (/g/, /o/, /s/) than those belonging to the Spanish target lexical node ('perro' – dog in Spanish), and therefore this activation might interfere rather than help with the retrieval of the target's phonological segments (gos -Catalan; see figure 10). Therefore, and on the assumption that the ease with which phonological segments are retrieved depends on their level of activation, cognate words should be named faster than non-cognate words.

The results of our study were clear: pictures with cognate names were named faster than pictures with non-cognate names (see figure 11). This effect was observed both when naming in the dominant language and when naming in the non-dominant language. Furthermore, the fact that no differences between the two sets of pictures were observed when Spanish monolingual speakers were tested suggests that the two sets of pictures are comparable on other variables that might affect naming latencies.

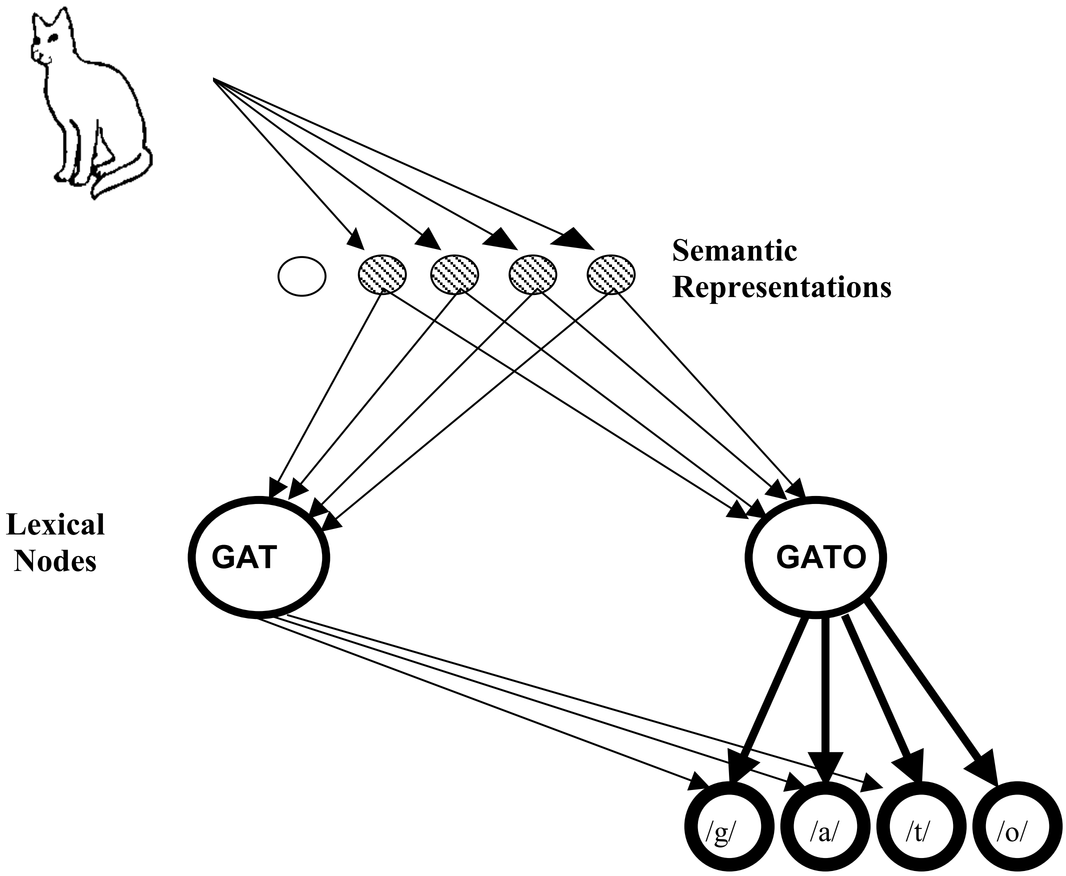

Figure 9. Schematic representation of picture naming for cognate words (gato-gat; cat). The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations. Some phonological segments corresponding to the Spanish target word (gato) receive some additional activation from its Catalan translation word (gat).

In a recent unpublished study, the cognate facilitation effect has been replicated by Janssen (1999) with two different groups of bilinguals (Dutch-English and Dutch-French bilinguals). This study tests the robustness of the cognate effect, and it extends the generality of the phenomenon to languages that are more distantly related than Spanish and Catalan. In summary, the results of these investigations suggest that there is phonological activation of non-selected lexical nodes that belong to the non-response language; the cascaded notion of lexical access is favored. Further evidence for cascaded processing is presented in the next section.

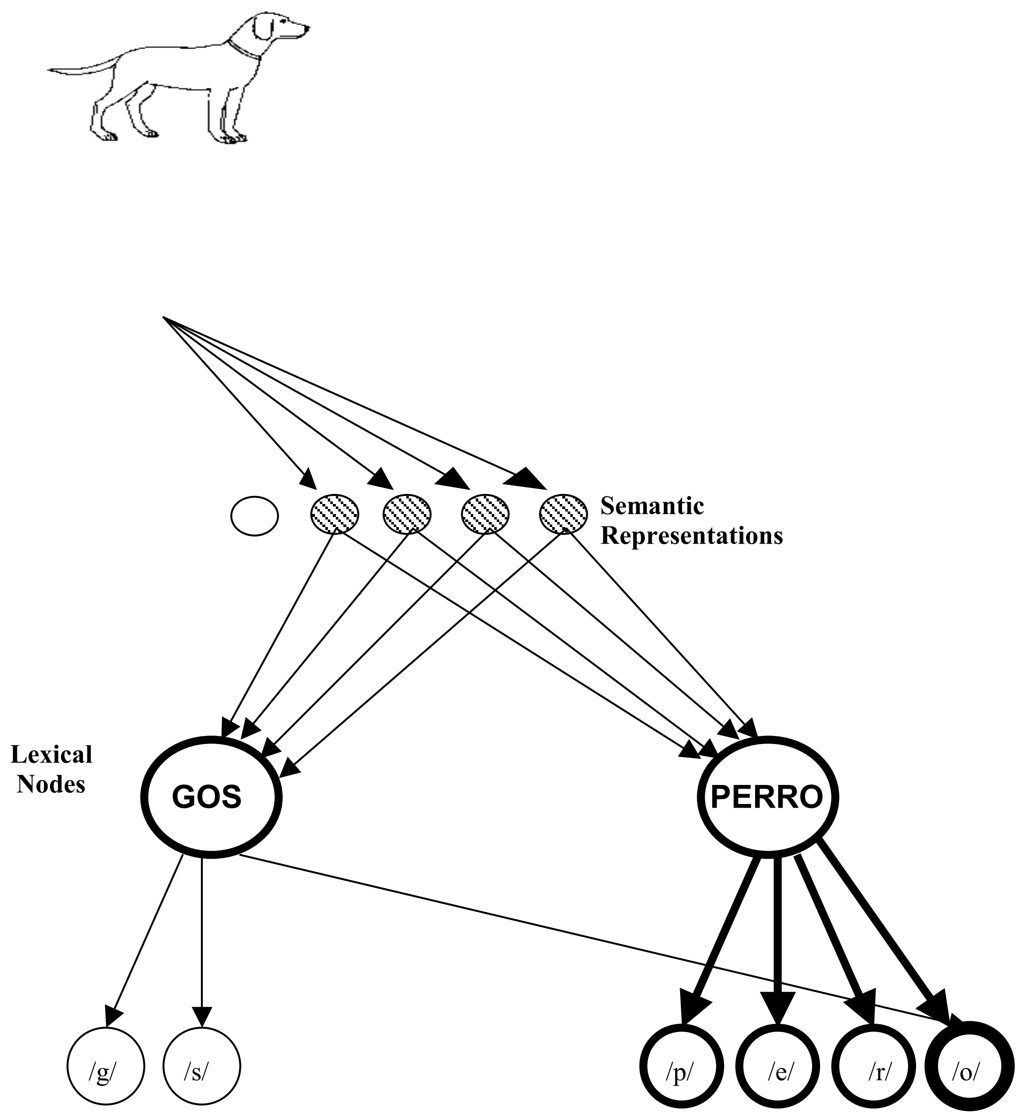

Figure 10. Schematic representation of picture naming for non-cognate words (perro; gos). The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations.

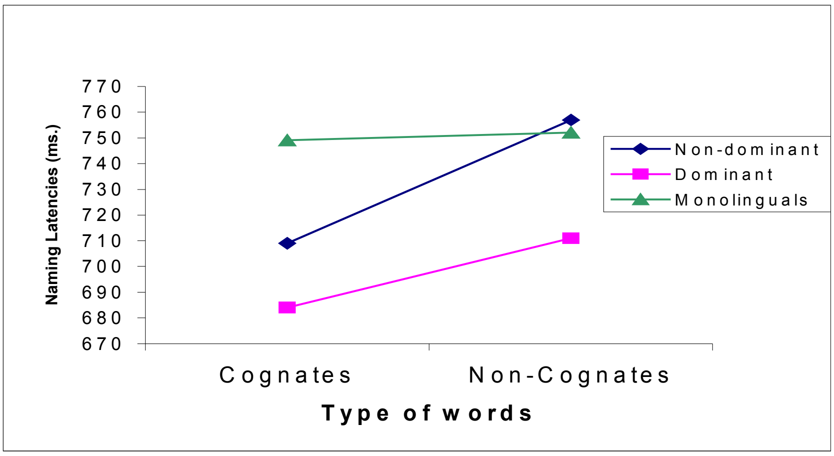

Figure 11. Cognate facilitation effect

3.4.2. Between-language phonological interference in a phoneme monitoring task

The phoneme monitoring task has usually been used for studying the phonological representations involved in speech perception (e.g., Mehler, Dommergues, Frauenfelder & Segui, 1981). In this task, participants have to decide whether a target phoneme (or a letter corresponding to that phoneme) is present in an auditorily presented stimulus. This task has recently been adapted to the study of phonological encoding in language production (Wheeldon and Levelt, 1995; Morgan & Wheeldon, 1999; Costa, Pallier, Sebastián-Gallés & Colomé, in press). Colomé (submitted) asked subjects to decide whether a phoneme was included in a picture's name to investigate the extent to which there is phonological activation of non-selected lexical nodes of the language not-in-use. Catalan-Spanish bilinguals were asked to decide whether a target phoneme was or was not present in the Catalan names of the pictures. Colomé argued that when monitoring the Catalan words, reaction times may also be affected by the activation of the phonological segments belonging to the Spanish name of the pictures. She argued that if the non-target Spanish lexical node corresponding to the picture's name is also activated along with its phonological segments, to reject a phoneme as not being part of the target Catalan word it would be harder if that phoneme is part of its Spanish name. For example, consider the situation in which the picture of a dog is presented to be monitored in Catalan (*gos*). Assuming that there is cascaded processing, the Catalan lexical node 'gos' and its Spanish translation 'perro' would activate their respective phonological segments (/g/,/o/,/s/ and /p/,/e/,/r/,o/). Colomé argued that in such a scenario, rejection of the target phoneme /p/ as not being present in the Catalan target word (*gos*) would be harder than rejection of the unrelated target phoneme /b/. This is because the level of activation of the phoneme /p/ is larger than that of the phoneme /b/. The results of her research were clear-cut: segments that were part of the translation word (but were not present in the target word) were harder to reject than segments that were not part of the translation word. Colomé interpreted this effect as demonstrating that words in the language not-in-use are activated not only at the lexical level but also at the segmental (phonological) level. These results fit nicely with the cognate facilitation effect in bilingual naming, and together suggest that: a) the semantic system not only activates the lexical nodes of the language in use but also those of the language not-in-use, and b) the lexical nodes of the language not-in-use spread some proportional activation to their phonological segments.

3.4.3. Further implications of the phonological activation of non-response lexical nodes

The phonological activation of the lexical nodes belonging to the non-response language has two main implications.

First, these results may be taken as direct evidence that semantic representations activate both lexicons of a bilingual in parallel. This interpretation is based on the assumption that the source of the phonological activation is the previous activation of their corresponding lexical nodes (see the parallel activation principle assumed in section 3.1.).

The second and more important implication has to do with the two hypotheses regarding the lexical selection mechanism discussed in Section 3.2. The results observed in the identity condition across languages with the picture-word interference paradigm suggest that the lexical nodes of the non-response language do not compete during lexical selection. We have argued that these results support the notion that the lexical nodes of the language not-in-use are not monitored during lexical selection (i.e., the language-specific selection hypothesis) However, those results are compatible with a version of the language non-specific hypothesis in which the lexical nodes of the language not-in-use are *completely inhibited*. The language-specific selection and the language non-specific selection hypotheses become equivalent in their predictions of the identity effect in the picture-word interference paradigm. This is because the lexical items of the non-response language cannot create competition either because they are ignored (language-specific selection), or because their activation levels are zero (strong version of the language non-specific selection). However, the "complete suppression" version of the language non-specific hypothesis cannot explain the results of phonological activation of the lexical nodes belonging to the non-response language. This is because, in order to have this phonological activation, the lexical nodes of the non-target language should be at least partially activated. If the activation of the lexical nodes of the language-not-in-use is completely suppressed (complete suppression hypothesis), they could not activate their phonological elements. Therefore, the cognate facilitation effect and the results obtained with the phoneme monitoring cannot be explained by the "complete suppression" version of the language non-specific hypothesis.

Related to this issue, in section 3.3.2. we described the investigation conducted by Hermans et al. (1998), which seems to pose dificulties for the language-specific selection hypothesis. In those experiments naming latencies were slower when the distractor word (*berm*) was phonologically related to the target's translation (berg). The authors interpreted this interference effect as reflecting the competition created by the target's translation ('berg') during the selection of the target's lexical node ('mountain') (see section 3.3.2. for a more detailed explanation of the results). However, an alternative explanation for these results is that the interference effect may arise at the retrieval of the phonological elements of the target word. This explanation does not rely on competition across the two languages of a bilingual during lexical selection. The activation of the target's translation word ('berg') would spread some activation to its phonemes (/b/,/e/, /r/, /g/). However, the level of activation of these phonemes would be larger for the related than for the unrelated condition. This is because in the related condition these phonemes (/b/, /e/, /r/, /g/) would receive some activation from the distractor presentation (*berm*) while they would not receive any extra-activation in the unrelated condition (*kaars*). Therefore, the selection of the target's phonological information might be delayed by the competition of other activated phonological information. This argument is based on two assumptions. First, there is cascaded processing, and therefore lexical nodes that are not selected nonetheless activate their phonological properties, and second, the activation of phonological elements that do not belong to the target may interfere with its retrieval. The results observed in the cognate study and the ones obtained with the phoneme monitoring paradigm seem to support these two assumptions. Therefore, the results reported by Hermans et al. (1998) are not necessarily problematic for the language-specific selection hypothesis, since alternative explanations are possible for the phonological mediated identity effect. The results reviewed in this paper find a natural explanation in the functional architecture of the bilingual lexical system presented in figure 12.

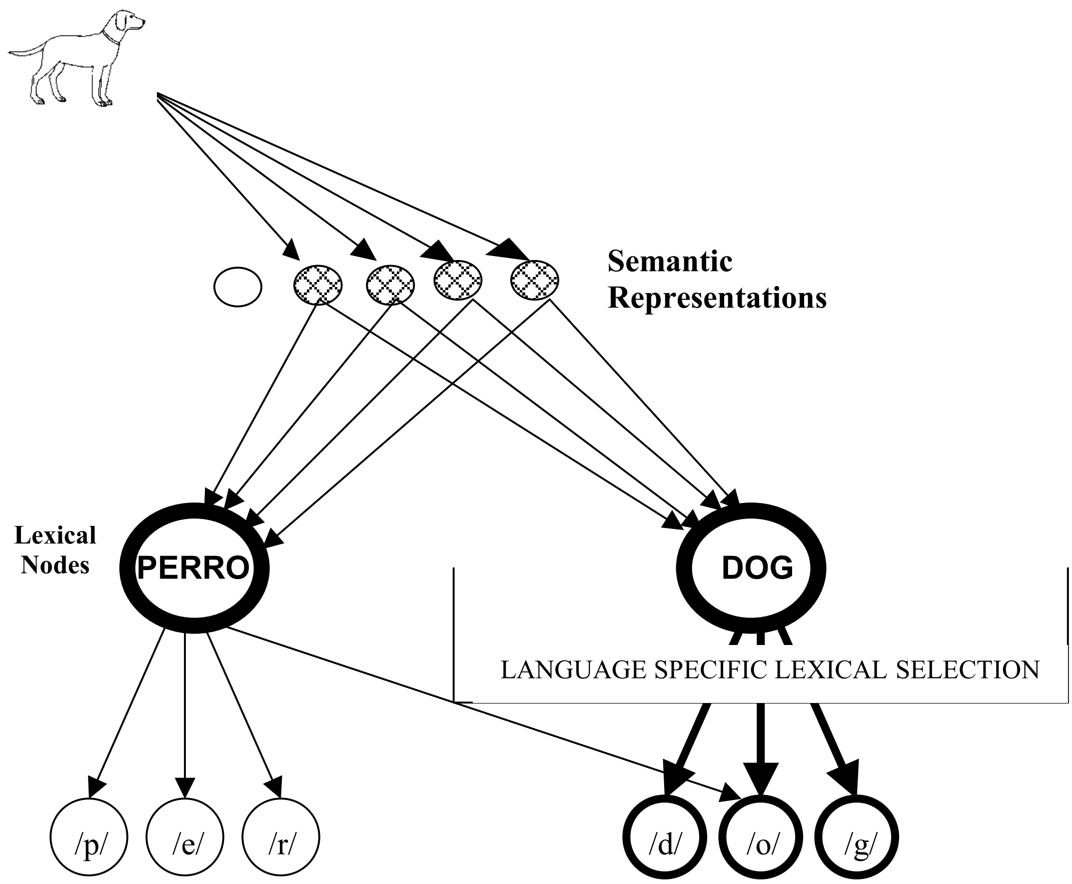

Figure 12. Schematic representation of a model of bilingual lexical access in which: a) the semantic system is shared, b) there is parallel activation of the two languages, c) lexical selection is language specific and, d) there is cascaded processing. The arrows represent the flow of activation and the thickness of the circles the level of activation of the representations.

This model implements the following principles. First, the semantic system is language-independent, and it is shared by the two languages of a bilingual. Second, activation flows freely through the two lexical systems. That is, the semantic system activates the two languages of a bilingual regardless of the language being spoken, and all the activated lexical nodes spread proportional activation to their phonological components/elements. Third, lexical selection in the target language is achieved by a selection mechanism that considers only the activation of the lexical nodes that belong to the target language, without requiring inhibitory processes. The assumptions implemented in this functional architecture raise a number of questions that need to be addressed in future research. For example, how flexible is the bilingual lexical selection mechanism? If we assume that the lexical selection mechanism is language- specific, what are the implications of this assumption for situations in which speakers switch from one language to the other (the code-switching situation). Is this mechanism able to cope with code-switching situations? How fast is the switching device? Could it be that in circumstances of frequent code-switching, the lexical selection mechanism inspects the two languages simultaneously, thereby creating lexical competition between the two languages?

Along the same lines, we can ask when the language-specific selection mechanism becomes functional during second language acquisition. Does this specific mechanism function very early during language acquisition, in order to prevent lexical intrusions from the language-not-in-use? Does the availability of this mechanism depend on the age of second language acquisition (in childhood or adulthood)?

There are also unresolved issues regarding the implications of sublexical activation of the language-not-in-use. The most immediate issue involves the extent to which this activation creates interference during phonological encoding. We have demonstrated that cognates are named faster than non-cognates. This phenomenon may be understood as either a) an interference created by the non-target sublexical units activated by the non-cognate translations, or b) a facilitation created by the sublexical overlap between cognate words. At the moment, we cannot tease apart these two explanations; that both of them play a role is also possible. Moreover, a further analysis of this effect and of its causes may shed some light on the processes involved in the retrieval of phonological units, both in monolinguals and in bilinguals.

As we have briefly presented, there are many questions that have not been yet addressed in the study of bilingualism and speech production. Furthermore, many of the topics are still scarcely understood, despite the vast research devoted to their study. We hope that future studies will address some of these questions.

RESUMEN

Acceso léxico en producción del lenguaje: el caso bilingüe. En este artículo se revisan modelos de acceso léxico en producción de lenguaje en hablantes bilingües. Nos centramos en dos aspectos fundamentales del acceso léxico: a) cómo se alcanza la selección léxica , y b) si el acceso léxico implica estadios de procesamiento discretos o en cascada. Comenzamos considerando supuestos importantes sobre el funcionamiento del acceso léxico en monolingües, para después discutirlos en el contexto de los hablantes bilingües. Se describen los modelos teóricos y la evidencia empírica reciente acorde a estos supuestos.

Palabras clave: Producción de lenguaje, Acceso Léxico, Bilingüismo.

REFERENCES

Albert, M. L., & Obler, L. K. (1978). *The bilingual brain*. New York: Academic Press.

Altarriba, J., & Mathis, K. (1997). Conceptual and lexical development in second language acquisition. *Journal of Memory and Language*, 36, 550-568.

Altenberg E. P. & Cairns, H.S. (1983). The effects of phonotactic constraints on lexical processing in bilingual and monolingual subjects. *Journal of Verbal Learning and Verbal Behavior*. 22, 174-188.

Bijeljac-Babic, R., Biardeau, A., & Grainger, J. (1997). Masked orthographic priming in bilingual word recognition. *Memory and Cognition*, 25, 447-457.

Bock, J. K., & Miller, C. A. (1991). Broken agreement. *Cognitive Psychology*, 23, 45-93.

Bock, J. K., Loebell, H., & Morey, R. (1992). From conceptual roles to structural relations: Bridging the syntactic cleft. *Psychological Review*, 99, 150-171.

Bock, J. K. & Levelt, W. J. M. (1994). Language production: Grammatical Encoding. In M. A. Gernsbacher, (Ed.), *Handbook of Psycholinguistics*. San Diego: Academic Press.

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology*, 14, 177-208.

Caramazza, A., & Brones, I. (1980). Semantic classification by bilinguals. *Canadian Journal of Psychology*, 34, 77-81.

Caramazza, A. & Hillis, A. E. (1990). Where do semantic errors come from? Cortex, 26, 95-122.

Caramazza, A. & Miozzo, M. (1998). More is not always better: A response to Roelofs, Meyer and Levelt. *Cognition*, 69, 231-241

Caramazza, A., & Costa, A. (in press). The semantic interference effect in the picture-word interference paradigm: Does the response set matter? *Cognition*.

Chen, H. -C., & Ho, C. (1986). Development of Stroop interference in Chinese-English bilinguals. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 12, 397-401.

Colomé, A. (submitted). Lexical activation in bilingual's speech production: language-specific or language-independent?

Costa, A., & Sebastián-Gallés, N. (1998). Abstract phonological structure in language production: Evidence from Spanish. *Journal of Experimental Psychology:Learning, Memory and Cognition*, 24, 886-903.

Costa, A., & Caramazza, A. (1999). Is lexical selection language specific? Further evidence from Spanish-English bilinguals. *Bilingualism: Language and Cognition*. 2, 231-244.

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language*,41(3), 365-397

Costa, A., Sebastián-Gallés, N., Miozzo, M., & Caramazza, A. (1999). The Gender congruity effect: Evidence from Spanish and Catalan. *Language and Cognitive Processes*, 14(4), 381-391.

Costa, A., Pallier, Ch., Sebastián-Gallés, N. & Colomé, A. (in press). El desarrollo temporal de la codificación fonológica: ¿ Un procesamiento estrictamente serial ? (The time course of segment-to-frame association in phonological encoding: a strictly serial processing?). *Cognitiva*.

Costa, A., Caramazza, A., & Sebastian, N. (in press). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory and Cognition.*

Cutting, J. C., & Ferreira, V. S. (1999). Semantic and phonological information flow in the production lexicon. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 25(2), 318-344.

De Bot, K. (1992). A bilingual production model: Levelt's speaking model adapted. *Applied Linguistics*, 13, 1-24.

Dell, G. S. (1986). A spreading activation theory of retrieval in sentence production. *Psychological Review*, 93, 283-321.

Dell, G. S., & O'Seaghdha, P. G. (1991). Mediated and convergent lexical priming in language production: A comment on Levelt et al. (1991). *Psychological Review*, 98, 604-614.

Dell, G. S., & O'Seaghdha, P. G. (1992). Stages of lexical access in language production. *Cognition*, 42, 287-314.

Dell, G. S., Juliano, C. & Govindjee, A. (1993). Structure and content in language production. A theory of frame constraints in phonological speech errors. *Cognitive Science*, 17, 149-195.

Dell, G. S., Schwartz, M. F., Martin, N. M., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*, 104, 801-838.

Dijkstra, A. & Van Heuven, W. J. B. (1998). The BIA model and bilingual word recognition. In J. Grainger & A. Jacobs (eds.), *Localist connectionist approaches to human cognition*, pp. 189-225. Hillsdale, NJ: Lawrence Erlbaum.

Dufour, R., & Kroll, J. F (1995). Matching words to concepts in two languages: A test of the concept mediation model of bilingual representation. *Memory and Cognition*, 23(2), 166-180.

Dyer, F. N. (1971). Colour-naming interference in monolinguals and bilinguals. *Journal of Verbal Learning and Verbal Behaviour*, 10, 297-302.

Ehri, L. C., & Ryan, E. B. (1980). Performance of bilinguals in a picture-word interference task. *Journal of Psycholinguistic Research*, 9 (3), 285-302.

Fay, D. & Cutler, A. (1977). Malapropisms and the structure of the mental lexicon. *Linguistic Inquiry*, 8, 505-520.

Fromkin, V. A. (1971). The non-anomalous nature of anomalous utterances. *Language*, 47, 27-52.

Fromkin, V. A. (1973). *Speech errors as linguistic evidence*. The Hague: Mouton.

Fromkin V. A. (1980). *Errors in linguistic performance. Slips of the tongue, ear, pen, and hand*. New-York: Academic Press.

García-Albea, J. E., del Viso, S., & Igoa, J. M. (1989). Movement errors and levels of processing in sentence production. *Journal of Psycholinguistic Research*, 18, 145-161.

Garrett, M. F. (1976). Syntactic processes in sentence production. In R. Wales & E. Walker (Eds.), *New approaches to language mechanisms*. Amsterdam: North Holland Press.

Garrett, M. F. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language Production. Vol. 1: Speech and Talk*. London: Academic Press.

Glaser, W. R. & Düngelhoff, F. J. (1984). The time course of picture-word interference. *Journal of Experimental Psychology: Human Perception and Performance*, 10, 640-654.

Glaser, W. R., & Glaser, M. O. (1989). Context effect in Stroop-like word and picture processing. *Journal of Experimental Psychology: General*, 118, 13-42.

Goodman, G. S., Haith, M. M., Guttentag, R. E., & Rao, S. (1985). Automatic processing of word meaning: Intralingual and interlingual interference. *Child Development*, 56, 103-118.

Grainger, J., & Dijkstra, T. (1992). On the representation and use of language information in bilinguals. In R. J. Harris (Ed.), *Cognitive processing in bilinguals* (pp. 207-220). Amsterdam: Elsevier.

Green, D. W. (1986). Control, activation and resource: A framework and a model for the control of speech in bilinguals. *Brain and Language*, 27, 210-223.

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, 1, 67-81.

Harley, T. A. (1993). Phonological activation of semantic competitors during lexical access in speech production. *Language and Cognitive Processes*, 8, 291-309.

Hermans, D., Bongaerts, T., de Bot, K., Schreuder, R. (1998). Producing words in a foreign language: can speakers prevent interference from their first language? *Bilingualism: Language and Cognition*, 1(3), 213-230.

Janssen, N. (1999). Bilingual word production: The time course of lexical activation in a mixed language context. *Unpublished Master Thesis*, University of Nijmegen, Nijmegen, The Netherlands.

Jescheniak, J., & Schriefers, H. (1998). Discrete serial versus cascaded processing in lexical access in speech production: Further evidence from the coactivation of Near-Synonyms. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 24, 1256-1274.

Kroll, J. F. & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33, 149-174.

La Heij, W., De Bruyn, E., Elens, E., Hartsuiker, R., Helaha, D., Van Schelven, L. (1990). Orthographic facilitation and categorical interference in a word-translation variant of the Stroop task. *Canadian Journal of Psychology*, 44, 76-83.

La Heij, W., Mak, P., Sander, J., Willeboordse, E. (1998). The gender-congruency effect in picture-word tasks. *Psychological Research*, vol.61(3), 209-219.

Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. Cambridge, MA: MIT Press.

Levelt, J. M. W., Schriefers, H., Vorberg, D., Meyer, A. S., Pechmann, T., & Havinga, J. (1991). The time course of lexical access in speech production: A study of picture naming. *Psychological Review*, 98, 122-142.

Levelt, J. M. W., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioural and Brain Sciences*, 22, 1-75.

Lucy, J. A. (1992). *Grammatical categories and cognition: A case study of the linguistic relativity hypothesis*. Cambridge, England: Cambridge University Press.

Lupker, S. J. (1979). The semantic nature of response competition in the picture-word interference task. *Memory and Cognition*, 7, 485-495.

Lupker, S. J. (1982). The role of phonetic and orthographic similarity in picture-word interference. *Canadian Journal of Psychology*, 36, 349-367.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, 109, 163-203.

Mägiste, E. (1984). Stroop tasks and dichotic translation: The development of interference patterns in bilinguals. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 10, 304-315.

Mägiste, E. (1985). Development of intra- and inter-lingual interference in bilinguals. *Journal of Psycholinguistic Research*, 14, 137-154.

Martin, N., Weisberg, R.W. & Saffran, E.M. (1989). Variables influencing the occurrence of naming errors; Implications for models of lexical retrieval. *Journal of Memory and Language*, 28(4), 462-485.

Martin, N., Gagnon, D. A., Schwartz, M. F., Dell, G. S., & Saffran, E. M. (1996). Phonological facilitation of semantic errors in normal and aphasic speakers. *Language and Cognitive Processes*, 11, 257-282.

McNamara, J., Krauthammer, M., Bolgar, M. (1968). Language switching in bilinguals as a function of stimulus and response uncertainty. *Journal of Experimental Psychology*, 78 (2, Pt 1), 208-215.

McNamara, J. & Kushnir, S.L. (1972). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behaviour*, 10, 480-487.

Mehler, J., Dommergues,J., Frauenfelder, U., y Segui, J. (1981). The syllable's role in speech segmentation. *Journal of Verbal learning and Verbal Behaviour*, 295, 333-352.

Meyer, A. S. (1992). Investigation of phonological encoding through speech error analyses: Achievements, limitations, and alternatives. *Cognition*, 42, 181-211.

Meyer, A, S. (1996). Lexical access in phrase and sentence production: Results from picture-word interference experiments. *Journal of Memory and Language*, 35, 477-496.

Miozzo, M. & Caramazza, A. (1999). The selection of determiners in noun phrase production. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 25(4), 907-922.

Miozzo, M., & Caramazza, A.,(submitted). The frequency effect in the picture-word interference paradigm: A paradoxical result.

Morgan, J.L. & Wheeldon, L.R. (1999). Phoneme monitoring in internal and external speech. Paper presented at the Architecture and Mechanisms for Language Processing (AMLaP). Edimburgh, UK.

Paivio, A. & Desrochers, A., (1980). A dual coding approach to bilingual memory. *Canadian Journal of Psychology*. Vol.34(4), 388-399.

Pallier, C., Dupoux, E & Jeannin. (1997). Expe5: An expandable programming language for on-line psychological experiments. *Behavior Research, Methods, Instruments and Computers*.

Penfield, W. & Roberts, R. (1959). *Speech and Brain Mechanisms*. Princeton: Princeton University Press.

Peterson, R. R., & Savoy, P. (1998). Lexical selection and phonological encoding during language production: Evidence for cascaded processing. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 24, 539-557.

Potter, M. C., So, K. -F., von Eckhardt, B., & Feldman, L. B. (1984). Lexical and conceptual representation in beginning and more proficient bilinguals. *Journal of Verbal Learning and Verbal Behavior*, 23, 23-38.

Poulisse, N. (1997). Language production in bilinguals. In A. M. B. de Groot & J. F. Kroll (eds.), *Tutorials in bilingualism: Psycholinguistic perspectives*, pp. 201-224. Mahwah, NJ: Lawrence Erlbaum Associates.

Poulisse, N., & Bongaerts, T. (1994). First language use in second language production. *Applied Linguistics,* 15, 36-57.

Preston, M. S., & Lambert, W. E. (1969). Interlingual interference in a bilingual version of the Stroop color-word task. *Journal of Verbal Learning and Verbal Behavior*, 8, 295-301.

Rayner, K., Springer, C. J. (1986). Graphemic and semantic similarity effects in the picture-word interference task. *British Journal of Experimental Psychology*, 77, 207-222.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, 42, 107-142.

Roelofs, A. (1998). Lemma selection without inhibition of languages in bilingual speakers. *Bilingualism: Language and Cognition*, 1, 94-95.

Roelofs, A., Meyer A., & Levelt, W. J. M. (1996). Interaction between semantic and orthographic factors in conceptually driven naming: Comment on Starreveld and La Heij (1995). *Journal of Experimental Psychology: Learning, Memory and Cognition*, 22, 246-251.

Roelofs, A., Meyer A., & Levelt, W. J. M. (1998). A case for lemma/lexeme distinction in models of speaking: Comment on Caramazza and Miozzo (1997). *Cognition*, 69, 219-230.

Ruml, W. & Caramazza, A. (in press). An evaluation of a computational model of lexical access: comments on Dell et al. (1997). *Psychological Review*.

Schriefers, H. (1993). Syntactic processes in the production of noun phrases. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 841-850.

Schriefers, H., Meyer, A. S., & Levelt, W. J. M. (1990). Exploring the time course of lexical access in production: Picture-word interference studies. *Journal of Memory and Language*, 29, 86-102.

Smith, M. C. (1997). How do bilinguals access lexical information? In A. M. B. De Groot, & J. F. Kroll (eds.), *Tutorials in bilingualism: Psycholinguistic perspectives*, pp. 145-168. New Jersey: Lawrence Erlbaum Associates.

Smith, M. C. & Kirsner, K. (1982). Language and orthography as irrelevant features in color-word and picture-word Stroop interference. *Quarterly Journal of Experimental Psychology*, 34A, 153-170.

Starreveld, P. A., & La Heij, W. (1995). Semantic interference, orthographic facilitation and their interaction in naming tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 686-698.

Starreveld, P. A., & La Heij, W. (1996). Time-course analysis of semantic and orthographic context effects in picture naming. *Journal of Experimental Psychology: Learning Memory and Cognition*, 22, 896-918.

Stemberger, J. P. (1985). An interactive activation model of language production. In W. Ellis (Ed.), *Progress in the psychology of language*, Vol.1 (143-186). Hillsdale, NJ: Erlbaum.

Stemberger, J. P. (1990) Wordshape errors in language production, *Cognition*, 35(2), 123-157.

Stemberger, J. P. ; Elman, J. L., & Haden, P. (1985). Interference between phonemes during monitoring: Evidence for an interactive activation model of speech perception. *Journal of Experimental Psychology: Human Perception and Performance*, 11(4), 475-489.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18, 643-662.

Tzelgov, J., Henik, A., & Leiser, D. (1990). Controlling Stroop interference: Evidence from a bilingual task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 760-771.

Underwood, G., & Briggs, P. (1984). The development of word recognition processes. *British Journal of Psychology*, 75, 243-255.

Van Hell, J. G., & de Groot, A. M. B. (1998). Conceptual representation in bilinguals memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition*,1 (3), 193-211.
Van Heuven, W. J. B., Dijkstra, A., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language*, 39, 458-483.
Vigliocco, G. & Nicol, J. (1998). Separating hierarchical relations and word order in language production: Is proximity concord syntactic or linear? *Cognition*, 68(1), B13-B29.
Vigliocco, G. & Zilli, T. (1999). Syntactic accuracy in sentence production: The case of gender disagreement in Italian language-impaired and unimpaired speakers. *Journal of Psycholinguistic Research*, 28(6), 623-648
Wheeldon, L. R., & Levelt, W. J. M. (1995). Monitoring the time course of phonological encoding. *Journal of Memory and Language*, 34, 311-334.