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The Production of Noun Phrases in English and Spanish: Implications for the Scope of Phonological Encoding in Speech Production

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The role of the phonological word as a planning unit in the production of noun phrases (NPs) was investigated in three picture–word interference experiments. We addressed this issue cross-linguistically by asking Spanish and English speakers to produce simple (determiner + noun [in English]) and complex (determiner + adjective + noun [in English] or determiner + noun + adjective [in Spanish]) NPs while ignoring phonologically related or unrelated distractors. The results showed that naming latencies are faster when the distractor is phonologically related to the noun or to the adjective irrespective of the type of NP tested. The results suggest that NP naming latencies are affected by the level of activation of the phonological content of the lexical nodes of the NP, regardless of whether they belong to the first or second phonological word. The results are interpreted in the framework of theories of phonological encoding. © 2001 Elsevier Science

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Speech production involves several processing stages that work concurrently over different types of representations in an incremental fashion (e.g., Dell, 1986; Garrett, 1975; Levelt, 1989). The two main levels of processing are the grammatical and the phonological encoding stages. At the grammatical encoding stage, the speaker selects the appropriate words for the intended message and assigns them to a syntactic frame that specifies the grammatical relations among them. The construction of the syntactic frame is itself driven in part by the selection of the head lexical nodes of each phrase. During phonological encoding the speaker retrieves the phonological content of the previously selected words. The processes engaged at each level of representation overlap in time, occurring in an incremental fashion. That is, while parts of the utterance are being grammatically encoded, other parts, which have already been grammatically encoded, are being phonologically encoded. The size or scope of the planning units at each of these levels of representation appears to differ. Here, we present evidence concerning the scope of the phonological encoding stage. Specifically, we study the role of the phonological word as the unit that governs phonological encoding by exploring whether there is concurrent phonological activation of lexical nodes that belong to different phonological words during speech production. We address this issue by analyzing the naming performance of English and Spanish speakers in the production of noun phrases (NPs) in the picture–word interference paradigm.

Until recently, the main source of information used to inform claims about the sizes of the planning units at the grammatical and phonological encoding stages was the analysis of lexical and phonological errors in spontaneous speech (e.g., Garrett, 1988). Lexical errors are assumed to arise at the level of grammatical encoding where the selection of lexical nodes occurs. For example, in the lexical error "*give the*

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baby to the banana" (from Meyer, 1996), the words "*baby*" and "*banana*" have been transposed. Their misordering suggests that the two lexical items are concurrently active at the point in time when the first of the two words is inserted into the syntactic frame. And, since the two words belong to different phrases in the same clause, it is reasonable to conclude that the scope of grammatical encoding is, at least, the clause and not smaller units such as the phrase. In contrast, phonological errors such as "*heft lemisphere*" (from Fromkin, 1973), where the sounds /l/ and /h/ have been transposed, arise at the level of phonological encoding. The elements that interact in this type of error tend to involve sounds relatively close to one another in the same phrase. Therefore, it appears that the scope of processing of grammatical encoding is larger than that of phonological encoding. While grammatical encoding seems to encompass the phrases included in a clause, phonological encoding seems restricted to a smaller unit, perhaps no more than two phonological words within a phrase.

Linguists have proposed several types of prosodic units in order to account for the prosodic regularities observed in speech production. In line with the hierarchical organization of syntactic structures, it has been assumed that these are also organized hierarchically. Among the several phonological units that have been proposed in order to account for the production of prosody (phonological phrases, intonational phrases, etc.), the phonological word (or prosodic word) has been considered as one of the minimal prosodic constituents. Although there are several definitions of the phonological word (e.g., Ferreira, 1993; Nespor & Vogel, 1986; Selkirk, 1984, 1986; Wheeldon & Lahiri, 1997) all of them agree in considering the phonological word as a stressed word plus all the unstressed words that cliticize to it. Because of this property, some scholars, including Hayes (1989) and Nespor and Vogel (1986), have also used the term "clitic group." Since clitization most often involves function words, one could also define the phonological word in terms of grammatical classes, as any content word plus other function words next to it. However, in some contexts a function word may correspond to a whole phonological word by itself, as when the function word is topicalized, and therefore a definition in terms of stress values seem to be more appropriate. According to this definition, the prosodic structure of the complex English NP "the red car" (determiner + adjective + noun) consists of two clitic groups or phonological words ("The red" /də ɹɛd/ and "car"/kaɹ/). This is because the lexical word "the" does not bear any stress and therefore clitizises to the lexical word "red," resulting in the phonological word /də ɹɛd/.

From the processing point of view, phonological words are the domain over which syllabification rules are applied (e.g., Levelt, 1989, 1992; Levelt & Wheeldon, 1994). In fluent speech, the phonological properties of the words are adapted to the contexts in which they appear. Consider the indefinite determiner "a" in English. The phonological realization of this determiner depends on whether the next word starts with a vowel (e.g., an elephant) or a consonant (e.g., a tiger). The syllabification rules take into account the metrical and segmental properties of the words that form the phonological word and combine them to produce a series of phonological syllables that are then delivered to the articulator. It has also been argued that the phonological word is the minimal phonological unit that needs to be fully computed before the next stage of processing can be engaged (e.g., Levelt, 1989). Thus, in principle, it is possible that articulation of the elements of the first phonological word could proceed before the phonological properties of the second phonological word have been retrieved (Wheeldon & Lahiri, 1997; see also Schriefers, de Ruiter, & Steigerwald, 1999).

However, the fact that segments that belong to two different phonological words interact in speech errors suggests that, at the level at which these errors occur, there is concurrent phonological activation of lexical nodes from different phonological words. For example, the lexical items involved in the error "*flow snurries*" (for "snow flurries"; from Dell, 1986) belong to two different phonological words, which suggests that the phonological properties of both phonological words were concurrently active.

Although the study of the regularities observed in spontaneous speech errors has proven to be a valuable tool for understanding the processes and representations involved in speech production, it is not beyond criticism. Some researchers have argued that speech errors reveal how the normal speech production system can occasionally get derailed and that inferences to the structure of normal processes from error patterns is not always transparent (e.g., Bock & Levelt, 1994; Levelt, Roelofs, & Meyer, 1999; Meyer, 1992). For example, the observation that sound errors involve segmental information of words belonging to different phonological words may reflect the outcome of the unusual situation in which more than one phonological word is encoded at the same time. That is, it could be argued that under normal circumstances the scope of phonological encoding is one phonological word and that errors arise in those nonnormal situations in which the production system is derailed and two phonological words are encoded at the same time. On this view, the data from speech errors would not illuminate the normal speech production process. It is important, therefore, to complement the study of slips of the tongue with methodologies that focus on error-free speech production in order to obtain converging evidence for specific theoretical claims.

In recent years, the picture–word interference paradigm has been used to investigate issues related to the functional architecture and processing dynamics of lexical access in speech production (e.g., Jescheniak & Schriefers, 1998; Schriefers, Meyer, & Levelt, 1990; Starreveld & La Heij, 1995, 1996). In this paradigm, participants are asked to name a picture while ignoring a distractor word (see MacLeod, 1991, for a review of Stroop-like tasks). By manipulating the relationship between the picture's name and the distractor word, different effects are observed. The two best-studied effects are the *semantic interference* effect and the *phonological facilitation* effect. The semantic interference effect stands for the observation that picture naming latencies are longer when the distractor word and the picture are semantically (categorically) related than when they are not (e.g., Glaser & Glaser, 1989; Glaser & Düngelhoff, 1984; Lupker, 1979). By contrast, phonologically related distractors speed up naming latencies relative to phonologically unrelated distractors (e.g., Costa & Sebastian-Galles, 1998; Lupker, 1982; Meyer & Schriefers, 1991; Rayner & Springer, 1986). Researchers have argued that these two contrasting phenomena reflect the mechanisms and representations at two different stages of processing. The dominant view is that the semantic interference effect is the product of a delay in the selection of the target lexical item during grammatical encoding and that the phonological facilitation effect is due to facilitation in selecting representations at the phonological encoding stage (e.g., Levelt, Schriefers, Vorberg, Meyer, Pechman, & Havinga, 1991; Schriefers et al., 1990; see also Starreveld, 2000, for a discussion of the nature of the phonological facilitation effect in this paradigm).

Schriefers (1992, 1993) was the first to extend the picture–word interference paradigm to investigate lexical access in the context of NP production (see also Alario & Caramazza, in press; Caramazza et al., in press; Costa, Sebastian-Galles, Miozzo, & Caramazza, 1999; La Heij, Mark, Sander, & Willeboordse, 1998; Miozzo & Caramazza, 1999; Schriefers & Teruel, 2000; van Berkum, 1997). Meyer (1996) extended the paradigm to address the size of the grammatical and phonological planning units in speech production. She asked Dutch speakers to produce either a conjunction noun phrase ("the arrow and the bag")[1] or a simple sentence ("the arrow is next to the bag"), while ignoring a distractor word. The distractor word could be related either to the first or to the second noun. Meyer observed that naming latencies were slowed when the distractor word was semantically related to the first (*bomb* for *arrow*) or to the second (*sack* for *bag*) noun of the utterance, irrespective of the type of utterance (NPs or sentences) produced by the participants. This result was interpreted as an indication that the second noun of

[1] Throughout the paper we use the following notation: double quotation marks for responses, *italics* for stimuli (pictures or words), and single quotation marks for lexical representations.

the utterance (*bag*) was concurrently active with the first noun (*arrow*) at the level where the semantic interference effect is thought to occur—the lexical node selection stage. Interestingly, the results observed with phonological distractors contrasted sharply: naming latencies were affected by distractors that were phonologically related to the first noun of the utterance (*art* for *arrow*) (see Miozzo & Caramazza, 1999, Experiment 4, for similar results in Italian) but not when the distractors were related to the second noun (*ball* for *bag*). This result was interpreted to indicate that the level of activation of the phonological properties of the second noun of the utterance (*bag*) does not affect the onset of speaker's articulation. The contrasting results obtained with semantically and phonologically related distractors were taken as evidence that the scope of the grammatical encoding process is larger than that of the phonological encoding process.

The results of Meyer (1996) are consistent with the notion that the phonological word is the basic unit of phonological encoding. This is because phonological facilitation arises whenever the primed word is included in the first phonological word (e.g., *arrow* is included in the first phonological word "the arrow"), but not when the primed word is located outside the first phonological word. This observation suggests that the level of activation of the phonological properties of the words that are not part of the first phonological word does not affect naming latencies (e.g., *bag* in the NP "the arrow and the bag"). These results fit well with the hypothesis that the retrieval of the phonological segments of the lexical nodes that comprise the first phonological word must be completed before articulation of the phrase is initiated. They are also consistent with the proposal that the phonological properties of the lexical nodes that are not part of the first phonological word do not need to be selected before articulation starts (e.g., Levelt & Maassen, 1981; Meyer, 1996).

However, recent results have questioned both the notion that the phonological word has to be fully processed before articulation starts and the assumption that the phonological properties of lexical items that do not belong to the first phonological word do not affect naming latencies. Regarding the first issue, Schriefers and Teruel (1999) asked German speakers to produce no-determiner noun phrases ("rosa Tisch" [pink table]) while ignoring distractors that were phonologically related either to the first syllable of the adjective (*ro* for *rosa*) or to the first syllable of the noun (*tis* for *Tisch*). Naming latencies were speeded only when the distractor word was related to the first word of the utterance. This result by itself seems to support the notion that only the first phonological word needs to be computed for articulation to start. This is because in the NPs used in this study the first word of the utterance corresponds to the first phonological word (e.g., "rosa", [pink]), while the second word, the noun (e.g., "Tisch"), falls outside of the first phonological word and corresponds to the second phonological word. However, Schriefers and Teruel also reported a result that suggests that the first phonological word does not need to be fully processed before articulation starts. In their study, phonological facilitation was not observed when the distractor was phonologically related to the second syllable of the adjective (e.g., *sa* for *rosa* [pink]). This result led the authors to conclude that the phonological word may not be the lower limit of phonological encoding and that it is possible that speakers start articulation without having completed the phonological encoding of the first phonological word. These authors conclude then that the size of phonological encoding may be, in certain circumstances (not specified by the authors), smaller than the first phonological word.

More importantly for our purposes are those results that suggest that the level of activation of the phonological elements of lexical nodes located in the second phonological word of the NP may affect naming latencies. Miozzo and Caramazza (1999, Experiment 5) asked Italian participants to produce determiner + adjective + noun NPs in a simple picture naming task. The definite determiner in Italian depends on both the gender of the noun and, for masculine nouns, on the phonological properties of the word that follows it. Masculine nouns take the determiner "lo" when the following word's onset consists of a vowel, a consonant cluster of the form "s+ consonant" or "gn," or an affricate; in all other contexts masculine nouns take the determiner "il." Thus, for example, for the masculine word "scoiattolo" [squirrel] the determiner is "lo" ("lo scoiattolo" [the squirrel]) but it is "il" if the adjective "grande" [big] is interposed between the determiner and the noun ("il grande scoiattolo" [the big squirrel]). Therefore, in order to select the proper determiner for masculine nouns, the phonology of the next word must be available to the selection mechanism. Miozzo and Caramazza took advantage of this property to investigate what phonological information is available at the point at which the form of a determiner is selected. They reasoned that if the only phonological information active at the moment at which the determiner is selected were that of the word immediately following it (the adjective), then the phonological properties of the noun should not affect naming times since this information could not serve as a basis for interference in determiner selection. However, if the phonology of the noun were active at the point at which determiner forms are selected, there should be a cost in naming times when the phonology of the noun provides information conflicting with that provided by the adjective. Thus, in the latter case, the production of phrases such as "il grande scoiattolo" [the big squirrel] should be slower relative to phrases such as "il grande tavolo" [the big table]. This is because the initial segments of "grande" and "scoiattolo" require the determiners "il" and "lo," respectively, whereas the initial segments of "grande" and "tavolo" both require the determiner "il." The results were clear: slower naming latencies were observed when the phonology of the adjective and the phonology of the noun in the NP required different determiner forms ("il grande scoiatolo") in comparison to the condition where the two words require the same determiner ("il grande tavolo"). These results suggest that the phonological form of the noun is active at the point at which determiner form selection takes place. Similar results have been observed in French with possessive adjectives and demonstrative pronouns whose gender-marked forms also depend on the phonology of the following word (Alario & Caramazza, in press). Also, Roelofs (1998), using the implicit priming paradigm (see Meyer, 1990, 1991), observed phonological activation of words located in the second phonological word. Finally, recent results by Ferreira and Swets (in press) suggest that processing difficulty of material beyond the first phonological word affect initiation times. On the basis of these results, the authors claim that the system requires planning beyond the initial phonological word.

Taken together, the results from Miozzo and Caramazza (1999), Alario and Caramazza (in press), Roelofs (1998), and Ferreira and Swets (in press) suggest that there is concurrent activation of phonological information of lexical nodes that belong to different phonological words. Interestingly, this conclusion is consistent with the data from spontaneous speech errors, where quite often the elements involved in sound exchange errors belong to different phonological words.

As reviewed here, the chronometric evidence on the role of the phonological word in speech production is somewhat contradictory. There are three main sets of results. One set shows no phonological activation of elements that fall outside the first phonological word (Meyer, 1996). Another set of results demonstrates that there is concurrent phonological activation encompassing at least two phonological words (Alario & Caramazza, in press; Miozzo & Caramazza, 1999; Roelofs, 1998). Finally, there is a data set that suggests that encoding of the entire phonological word is not necessary to begin articulation (Schriefers & Teruel, 1999). Further discussion of this third possibility is deferred to the General Discussion. In the following, we focus on the extent to which the activation of the phonological form of lexical nodes that fall outside of the first phonological word affect naming latencies.

We address this question by asking Spanish and English speakers to produce NPs in the context of a picture–word interference task. An important difference in the structure of NPs in these two languages affords the opportunity to address the role of grammatical structure in determining whether lexical nodes that fall outside the first phonological word are concurrently active with it. In the experiments we report, we also included semantically related distractors. This distractor condition was included primarily to assess the sensitivity of our task to lexical interference. Semantic interference is a highly reliable effect in the picture–word interference paradigm and its presence indicates that the task has the sensitivity to reveal effects of the magnitude of the semantic interference effect.

EXPERIMENT 1: SEMANTIC AND PHONOLOGICAL EFFECTS FOR THE NOUN IN ENGLISH NP PRODUCTION

In this experiment, three groups of native English speakers were asked to name a series of colored pictures using one of three different types of utterances: (a) bare nouns (e.g., "car"), (b) determiner + noun NPs (e.g., "the car"), and (c) determiner + adjective + noun NPs (e.g., "the red car"). The pictures were presented with semantically related, phonologically related, and unrelated control distractors. Our main goal was to test whether naming latencies are affected by distractor words that are phonologically related to the noun when the position of the noun varies between being in the first, second, or third position in the NP. Crucially, and given the standard definition of the phonological word given above, whether the noun belongs to the first or to the second phonological word varies across these different types of utterances. In the bare noun (e.g., "car") and determiner + noun conditions (e.g., "the car"), the noun belongs to the first phonological word ("car"/kaɹ/ and "the car" /də kaɹ/ respectively), while in the determiner + adjective + noun condition it belongs to the second phonological word (e.g., first phonological word: "The red" /də ɹɛd/; second phonological word: "car" /kaɹ/). The question is whether phonological distractors related to the noun of the NP (e.g., *cap*) will affect naming latencies differently than unrelated distractors (e.g., *pen*) in all three NP conditions.

We expect to find phonological facilitation when the noun is placed in the first phonological word even if it is not the first word in the utterance, replicating previous results (Meyer, 1996; Miozzo & Caramazza, 1999; but see Schriefers & Teruel, 1999). Therefore, we should observe phonological facilitation in the first two types of NPs (e.g., bare noun, "car", and determiner + noun, "the car").

The prediction regarding the effects of phonologically related distractors for the determiner + adjective + noun NPs is more complicated. If naming latencies are independent of the level of activation of the words included in the second phonological word, the phonological facilitation effect should not arise in complex NP production. In contrast, if phonological encoding comprises more elements than those included in the first phonological word, as suggested by the results of several studies (Alario & Caramazza, in press; Miozzo & Caramazza, 1999; Roelofs, 1998), it is possible for phonologically related distractors to produce phonological facilitation even when the noun is located outside the first phonological word (e.g., determiner + adjective + noun; "the red car" /də ɹɛd/ /kaɹ/). And, on the assumption that the phonological effects observed in this paradigm indicate phonological activation of the word that is related to the distractor, a phonological facilitation effect for the noun would suggest that its phonological properties are concurrently active with the phonological encoding of the other parts of the utterance.[2] We also included a semantically related condition, as was done by Meyer (1996) and Miozzo and Caramazza (1999), in order to provide more information about the effects of semantically related distractors in the production of NPs.

Method

Participants. Fifty-one native speakers of English took part in the experiment. Participants were students at Harvard University and were paid for their participation. Participants were randomly assigned to the three experimental groups.

[2] Starreveld (2000) has recently argued that the phonological facilitation effect may reveal the ease with which the word-form representation of the target is retrieved rather than the ease with which the segmental information of that word is retrieved (Meyer & Schriefers, 1991). Our predictions do not depend on which of these two explanations is correct, and therefore we will not pursue this issue.

Material. We selected 28 pictures with monomorphemic names (see Appendix A). The pictures were presented in three different colors (red, green, or blue), but each picture always appeared in the same color. The pictures were paired with five different distractors: (a) a semantically related distractor, (b) a phonologically related distractor, (c) an unrelated control distractor matched on various variables with the semantically related distractors, (d) an unrelated distractor matched with the phonologically related distractors, or (e) a string of XXXs. The pictures and the distractors were paired such that each distractor appeared once in the related condition and once in the unrelated condition. For example, the picture of a *horse* appeared with the semantically related distractor *donkey* and with the unrelated distractor *spoon*. The same distractors appeared with the picture *fork*. However, for this picture the word *donkey* served as the unrelated distractor and the word *spoon* as the semantically related distractor. The same matching procedure was used for the phonologically related distractors and their unrelated controls. This design allows us to control for possible effects of individual distractors that might affect the results in any systematic way, other than their semantic or phonological relatedness with the pictures' names. The distractors paired with a given picture had similar frequencies (Francis & Kučera, 1982). Care was taken to avoid any phonological or semantic relatedness between the distractor words and the color name of each picture. The phonologically related distractors shared at least their first two segments with the pictures' names. Twenty-six pictures were selected as fillers and were also presented five times each with unrelated distractors. The fillers were also used as warmup stimuli in the first three trials of each block.

The distractor words were shown in uppercase letters (Helvetica font, bold, 27 point) and were superimposed on the pictures. Pictures appeared in the center of the screen. To prevent participants from anticipating a distractor's position, word position varied randomly in the region around fixation with a maximum variation of 1.5 cm. For a given picture, however, the distractors always appeared in the same location. Stimuli were presented in 5 blocks of 54 trials (28 experimental plus 26 fillers). Each picture appeared once per block. In each block, stimuli of the various conditions appeared an equal number of times (5 or 6). Block trials were randomized with the restriction that distractors of the same experimental condition appeared in no more than two consecutive trials. Five different block orders were constructed, and similar number of participants randomly assigned to each.

Procedure. Participants were tested individually in a sound-attenuated room. They were instructed to name the picture and its color as quickly and as accurately as possible using either a bare noun, a determiner + noun NP or a determiner + adjective + noun NP, depending on the group of participants. They were informed that they would see picture–word pairs and were asked to ignore the words. Before the experiment proper, participants were presented with the entire set of pictures along with their designated names. Next, the experimenter showed all the pictures without their names and participants named the stimuli. Each trial had the following structure. First, a fixation point (an asterisk) was shown in the center of the screen for 1 s, followed by a blank interval of 500 ms. Then, the picture–word pairing was presented for 600 ms. If a response was not provided within 3 s, the next trial started automatically. The intertrial interval was 1.5 s. Response latencies were measured from the onset of the stimulus to the beginning of the naming response. Stimulus presentation was controlled by the program Psyscope (Cohen, MacWhinney, Flatt & Provost, 1993). Response latencies were measured by means of a voice key. The session lasted approximately 45 min.

Analyses. Three types of responses were scored as errors: (a) production of names that differed from those designated by the experimenter, (b) verbal dysfluencies (stuttering, utterance repairs, and production of nonverbal sounds that triggered the voice key), and (c) recording failures. Erroneous responses and outliers (i.e., responses exceeding 3 standard deviations) were excluded from the analyses of response latencies. Separate analyses were carried out with subjects and items as dependent variables, yielding $F1$ and $F2$ statistics, respectively. Three variables were analyzed: Type of Utterance (Bare Noun, determiner + noun NP, determiner + adjective + noun NP), Semantic Relationship (Semantically Related vs Semantic Unrelated), and Phonological Relationship (Phonologically Related vs Phonologically Unrelated). The first variable was a between-subjects variable and the others within-subject variables. The results of the error analyses are reported only if significant. Table 1 shows the mean response latencies and error rates as a function of type of distractor and type of utterance.

Results

Erroneous responses were observed on 7.5% of the trials. The naming latencies derived from one picture were excluded from the analyses because it elicited a high percentage of errors (more than 14%).

Semantically related distractors. The main effect of semantic relationship was significant [$F1(1,48) = 26.3$, $MSE = 579.2$, $p < .001$; $F2(1,26) = 8.7$, $MSE = 3288.0$, $p < .007$]: naming latencies were slower with semantically related than with unrelated distractors. The main effect of type of utterance was also significant [$F1(2,48) = 5.1$, $MSE = 23094.8$, $p < .009$; $F2(2,52)$ 80.0, $MSE = 2405.5$, $p < .001$]. Importantly, the interaction between the two factors did not even approach significance (both Fs < 1), suggesting that the semantic interference effect created by the semantically related distractors was independent of the type of utterance produced by the participants. When we consider determiner + adjective + noun utterances alone, we find that semantically related distractors produce more interference that semantically unrelated distractors [$F1(1,16) = 6.7$, $MSE = 519.5$, $p < .019$; $F2(1,26) = 3.5$, $MSE = 1532.6$, $p < .07$]. Both semantically related and unrelated distractors led to slower naming latencies than the XXX condition (all ps $< .014$). Semantically related distractors also produced more errors than unrelated distractors [$F1(1,48) = 5.9$, $MSE = 2.6$, $p < .018$; $F2(1,26) = 3.05$, $MSE = 3.2$, $p < .09$]. This effect was also independent of the type of utterance (Fs < 1). Finally, the XXX condition led to fewer errors than the semantically related and unrelated conditions (all ps $< .012$).

Phonologically related distractors. The main effect of phonological relationship was significant [$F1(1,48) = 32.5$, $MSE = 707.5$, $p < .001$; $F2(1,26) = 11.2$, $MSE = 3310.6$, $p < .002$], indicating that naming latencies were faster with phonologically related than unrelated distractors. The main effect of type of utterance was also significant [$F1(2,48) = 3.9$, $MSE = 24180.2$, $p < .02$; $F2(2,52) = 44.0$, $MSE = 3263.1$, $p < .001$]. More importantly, the interaction between the two factors did not even approach significance (both Fs < 1), suggesting

TABLE 1

Naming latencies (in Milliseconds) by type of Distractor and Type of Utterance in Experiment 1

	Type of utterance										
	Bare noun			Det + noun			Det + adj + noun			Total	
Type of distractors	Mean	*SD*	E%	Mean	*SD*	E%	Mean	*SD*	E%	Mean	E%
Semantically related	788	100	10.2	669	101	10.9	715	138	9.5	724	10.2
Semantically unrelated	761	95	6.7	644	83	6.3	694	126	8.9	699	7.3
Phonologically related	729	104	5.0	629	102	6.8	680	119	7.4	679	6.4
Phonologically unrelated	768	111	6.3	657	102	9.2	704	128	10.2	709	8.6
XXXXs	704	105	4.3	604	81	4.4	668	111	5.6	658	4.8
Semantic effects (unrelated-related)	−27			−25			−21			−25	
Phonological effects (unrelated-related)	39			28			24			30	

Note. Noun phrase production in English; distractors related to the Noun.

that the effects of phonologically related distractors are similar in the three types of utterances. When we consider determiner + adjective + noun utterances alone, we find some evidence that phonologically related distractors led to faster naming latencies than unrelated distractors. The 24-ms difference between conditions was only significant in the subjects analyses [$F1(1,16) = 6.0$, $MSE = 802.1$, $p < .026$; $F2(1,26) = 2317.6$, $MSE = 2.7$, $p < .11$]. Naming latencies in the XXX condition were faster than in the phonologically related and unrelated conditions (all *p*s $< .011$). Participants made more errors in the unrelated condition than in the phonologically related condition [$F1(1,48) = 4.9$, $MSE = 1.8$, $p < .032$; $F2(1,26) = 2.9$, $MSE = 1.52$, $p < .091$]. This effect was independent of the type of utterance (*F*s < 1). Error rates in the XXX condition were lower than in the unrelated condition (all *p*s $< .010$).

Discussion

The results of this experiment showed two main findings. First, distractors that are semantically related to the noun slow naming latencies more than unrelated distractors. Second, distractors that are phonologically related to the noun lead to faster naming latencies than unrelated distractors. Furthermore, these two effects are independent of the type of NP that speakers had to produce.

The semantic interference effect and the phonological facilitation effect were expected when participants named the pictures with bare nouns (e.g., Lupker, 1979, 1982). Similarly, the semantic interference effect observed in the determiner + noun and determiner + adjective + noun conditions was expected since the scope of grammatical encoding has been shown to be the clause (Meyer, 1996).

The phonological facilitation effect for determiner + noun NPs replicates previous findings in Dutch (Meyer, 1996) and Italian (Miozzo & Caramazza, 1999; Experiment 4). Furthermore, it extends the observation of phonological facilitation effects for the second word of the utterance to a language in which the first element of the NP (the determiner) is independent of the grammatical and phonological properties of the noun, as opposed to Dutch and Italian.

The most critical result for us is the phonological facilitation effect observed in the determiner + adjective + noun NP condition, in which the noun was located outside the first phonological word. Assuming that the effects of phonologically related distractors reflect processes at the stage of phonological encoding, the results imply that the phonology of the noun in an NP is activated even when it is located in the second phonological word. The results reported here and those of Miozzo and Caramazza (1999, Experiment 5; see also Alario & Caramazza, in press) invite the inference that the scope of phonological encoding extends more than the first phonological word.

However, before going into more specific claims about the implications of the observed results it is important to test the reliability of the phonological facilitation effect for lexical nodes that are located outside the first phonological word. In the following experiment we replicate the conditions where we obtained phonological facilitation in Experiment 1, using different materials and a slightly different design. This is especially relevant given that the phonological facilitation effect for the determiner + adjective + noun utterances was only significant in the analysis by subjects.

EXPERIMENT 2: PHONOLOGICAL EFFECTS FOR THE NOUN IN ENGLISH NP PRODUCTION

In this experiment participants were asked to produce complex NPs of the form determiner + adjective + noun in English. As in the previous experiment, we analyzed the effects of phonologically related distractors to the noun on the onset of naming latencies.

Method

Participants. Twenty participants from the same population as in Experiment 1 took part. None of them had participated in Experiment 1.

Material. We selected 40 pictures with monomorphemic names (see Appendix B). The pictures were presented in four different colors: green, red, blue, and purple. The pictures were paired with three different distractors: (a) a phonologically related distractor, (b) an unrelated control distractor matched on various variables with the phonologically related distractors, or (c) an unrelated filler distractor. As in Experiment 1, the pictures and the distractors were paired such that each distractor appeared once in the related condition and once in the unrelated condition. The distractors paired with a given picture had similar frequencies. Care was taken to avoid phonological or semantic relatedness between the distractor words and the color name of each picture. The phonologically related distractors shared at least their first two segments with the pictures' names. Four pictures were selected as fillers and were presented as warmup stimuli in the first four trials of each block along with unrelated distractors. All the pictures were presented before the experiment proper along with unrelated distractors. Thus, each picture appeared four times (once in the training phase and three times in the experiment proper). Each picture appeared in each of the four colors included in the experiment. The colors were distributed within the different conditions a similar number of times.

Stimuli were presented in 4 blocks of 44 trials (40 experimental plus 4 fillers). Each picture appeared once per block. In each block, stimuli of the three different conditions appeared a similar number of times (13 or 14). Trials within blocks were randomized with the restriction that distractors of the same experimental condition appeared in no more than two consecutive trials. Ten different block orders were constructed and two participants were randomly assigned to each order. The other details of the experiment's design and procedure were similar to those of Experiment 1.

Results and Discussion

Following the same criteria as in Experiment 1, 12.6% of the trials were excluded from the analyses. The reaction times derived from one participant and from one picture were discarded from the analyses due to their large number of errors (more than 16%).

Naming latencies were significantly faster when the distractors were phonologically related (865 ms) than when they were unrelated [887 ms; $F1(1,18) = 5.8$, $MSE = 820.8$, $p < .027$; $F2(1,38) = 4.2$, $MSE = 1979.7$, $p < .046$]. The error rates in the two conditions were statistically identical (13.2 and 12.1 for related and unrelated distractors respectively, both Fs < 1).

The results of this experiment replicate those observed in Experiment 1 for the complex NP production group. In both studies, a reliable and robust phonological facilitation effect for the noun of the NP was observed in the production of complex NPs (determiner + adjective + noun). As discussed above, these results suggest that the scope of phonological encoding extends beyond the first phonological word.

However, such a conclusion may be premature. The type of NPs used in these experiments allows two interpretations of the observed phonological effects with respect to the scope of phonological encoding. One possibility, as already noted, is that the scope of phonological processing encompasses at least part of the second phonological word of the NP. The other possibility is that phonological encoding always includes the head of the phrase plus any other words located before it. These two possibilities are indistinguishable on the basis of the available data. This is because the head of the phrase in the English NPs used in the previous experiments always belonged to the second phonological word and therefore word position and grammatical class are conflated. That is, since in English the adjective is always located prenominally, the third element of a three-word NP is necessarily a noun. Therefore the results of Experiments 1 and 2 are consistent with both of the alternatives proposed above.

Note that the latter hypothesis is not implausible. It may be argued that, because selection of the noun is necessary for the construction of an NP frame, the lexical node of the noun is the first element selected during the grammatical encoding of a phrase. If we further assume that after the selection of a lexical node its phonology is activated automatically, then the phonological properties of the noun are activated before the selection of other elements of the NP (determiner and adjective, in our experiments). According to this idea, even though the phonological content of the noun will be produced after that of the determiner and the adjective, it actually becomes activated earlier than that of the other two items. If this explanation is correct, then our results would be completely compatible with those obtained by Meyer (1996) in which no phonological facilitation was observed when the distractor word was related to the second noun in a complex NP (e.g., “the arrow and the car”). In this case, the first noun of the NP may be acting as the head of the NP while the second noun could be acting as the head of a second NP. Therefore, it is possible that phonological facilitation is only observed for the head of the first but not for the head of the second NP, and this is why Meyer (1996) did not find any phonological facilitation for the words placed outside the first phonological word.

In Experiment 3 we try to adjudicate between the two explanations described above by asking Spanish participants to produce determiner + noun + adjective NPs. Unlike English, color adjectives are usually placed postnominally in Spanish (e.g., “La casa azul” [literally, the house blue]). Therefore, a comparison of the effects of phonological distractors related to the third word of Spanish and English NPs allows us to distinguish between word position and grammatical class—the third word is a noun in English NPs but is an adjective in Spanish NPs—while keeping constant their position in terms of phonological words (e.g., always the second phonological word). This is because the prosodic structure of these Spanish NPs contains two phonological words (“la casa”: /la kasa/ and “azul”: /aɵ̲ul/). If the scope of phonological encoding encompasses the first two phonological words of the NP regardless of their grammatical class, we should observe a phonological facilitation effect when the distractor word is related to the lexical node corresponding to the second phonological word (in the Spanish case, the adjective, “azul”). However, if the phonological facilitation effect observed in English reflects the special status of the head of the NP (the noun) during phonological processing, phonological facilitation effects should not be observed for lexical items that are not the head of the NP and that are located outside the first phonological word.

EXPERIMENT 3: SEMANTIC AND PHONOLOGICAL EFFECTS IN THE PRODUCTION OF SPANISH NPS

In this experiment we asked participants to produce determiner + noun + adjective NPs in Spanish. As described above, and although in some cases (mostly in poetic contexts) Spanish color adjectives may occupy a prenominal position, they typically occur in postnominal position and therefore the third element of the NP is an adjective and not a noun. Therefore the lexical item that now falls outside the first phonological word is the adjective, whereas before (in Experiments 1 and 2) it was the noun. If we do not observe a phonological facilitation effect for the adjective in Spanish, we can conclude that the results obtained in Experiments 1 and 2 reflect the special status of the noun in the construction of the NP. By contrast, phonological facilitation effects for the adjective would suggest that the scope of phonological encoding includes the element located in the second phonological word regardless of its grammatical properties.

Method

Participants. Thirty native speakers of Spanish from the University of Barcelona took part in the experiment in exchange for course credit.

Materials. The design was similar to that of Experiment 1. Two sets of materials were included (see Appendix C). In the first set, 26 pictures with monomorphemic names were selected. Each of these pictures was presented with three different distractors: (a) a distractor semantically related to the adjective—a color name (e.g., *gris* [gray] for *azul* [blue]), (b) a distractor semantically unrelated to the adjective—an unrelated adjective (e.g., *ideal* [ideal] for *azul* [blue]), or (c) a string of XXXs. Each distractor in this set was presented four times (except for the distractors *rosa* [pink] and *eficaz* [efficient], which were presented six times). All the distractors in these two conditions were adjectives. The 26 pictures in the second set of items were presented with three different distractors each: (a) a distractor phonologically related to the adjective (e.g., *azucar* [sugar] for *azul* [blue]), (b) a distractor phonologically unrelated to the adjective (e.g., *drama* [drama] for *azul* [blue]), or (c) a string of XXXs. These distractors were always nouns and were presented only once.

The distractors included in each set had similar frequencies [Set 1: semantically related = 161, semantically unrelated = 158 ($F < 1$); Set 2: phonologically related = 152, phonologically unrelated = 155 ($F < 1$)] (Sebastian, Marti, Cuetos, & Carreiras, 1996). They also had comparable numbers of letters [Set 1: semantically related = 5.8, semantically unrelated = 6.5 ($F < 1$); Set 2: phonologically related = 5.5, phonologically unrelated = 5.2; ($F < 1$)]. Thirteen pictures were selected as filler pictures and were presented three times each. The fillers were also used as warmup stimuli in the first three trials of each block. Stimuli were presented in 3 blocks of 52 experimental trials each (26 pictures from Set 1 and 26 pictures from Set 2). Each picture appeared once per block. In each block, stimuli of the various conditions appeared a similar number of times (eight or nine). Block trials were randomized with the restriction that distractors of the same experimental condition appeared in no more than two consecutive trials. Three different block orders were constructed, and similar numbers of participants were assigned to each of them.

The pictures were presented in one of three different colors: blue (azul), brown (marron), and green (verde). However, each picture was always presented in the same color. Care was taken to avoid phonological or semantic relatedness between the distractor words and the picture's name. Approximately half of the picture's names were masculine; the remainder were feminine. The other details of the design and procedure are similar to those in Experiment 1.

RESULTS AND DISCUSSION

The scoring criteria used in Experiment 1 were also used in this experiment, leading to the exclusion of 9.6% of the data points. In the analysis we considered the effect of semantic and phonological relatedness of the distractors to the adjective in the NP. Table 2 shows the mean response latencies and error rates as a function of type of distractor.

Semantically related distractors. The main effect of semantic relationship was significant [$F1(1,29) = 10.7$, $MSE = 994.6$, $p < .003$; $F2(1,25) = 7.1$, $MSE = 1292.2$, $p < .013$]: naming latencies were slower with semantically related than with unrelated distractors. Both semantically related and unrelated distractors produced longer naming latencies than XXX distractors (all ps $< .001$). The only significant difference in the error analyses was between the XXX condition and the semantically related condition (all ps $< .01$)

Phonologically related distractors. The main effect of phonological relationship was significant [$F1(1,29) = 4.5$, $MSE = 871.5$, $p < .041$; $F2(1,25) = 6.1$, $MSE = 728.9$, $p < .020$], indicating that naming latencies were faster with phonologically related than with unrelated distractors. Naming latencies were faster in the XXX condition than in the other two conditions (all ps $< .001$). No significant effects were observed in the error analysis.

Two main results were obtained in this experiment. First, semantically related distractors delayed the production of the NP in comparison to unrelated distractors, replicating the results of Experiment 1. Second, phonologically related distractors sped up naming latencies in compar-

TABLE 2

Naming Latencies (in Milliseconds) by Type of Distractor and Set of Pictures in Experiment 3

Type of distractors	Mean	*SD*	E%
SET 1			
Semantically related	755	124	12.7
Semantically unrelated	728	112	10.0
XXXXs	703	106	7.6
SET 2			
Phonologically related	735	109	10.1
Phonologically unrelated	752	123	9.4
XXXXs	694	109	8.2
Semantic effects (unrelated-related)	−27		
Phonological effects (unrelated-related)	17		

Note. Noun phrase production in Spanish, with distractors related to the Adjective.

ison to unrelated distractors. These results suggest that naming latencies are affected by the activation level of the phonological properties of the adjective in the production of complex NPs with the structure "determiner + noun + adjective" (la casa azul [literally, the house blue]). This result indicates that by altering the level of activation of the phonological properties of the lexical node that belongs to the second phonological word (see footnote 2), even when that lexical node is not the head of the phrase (but the adjective), naming latencies are also affected.

GENERAL DISCUSSION

The main goal of this study was to explore the role of the phonological word as a basic unit of phonological encoding in speech production, and the extent to which there is concurrent phonological activation of lexical nodes that fall outside the phonological word being encoded. We carried out three experiments in which English and Spanish speakers were asked to produce adjectival NPs (English: determiner + adjective + noun; Spanish: determiner + noun + adjective) while ignoring the distractor words. On the assumption that phonologically related distractors affect the level of activation of the phonological properties of the words (or the word forms) with which they are related, we used phonological facilitation effects to reveal the extent to which the phonological representations of the different phonological words of the NP are activated.

In Experiment 1 and 2 we tested the effects of phonologically related distractors to the nouns of English NPs. The results of both experiments showed that naming latencies were faster when the pictures were presented along with phonologically related distractors than when presented with unrelated distractors. Importantly, the phonological facilitation effect was observed regardless of the position of the noun in the NP (first, second, or third position), and therefore the effect is independent of whether the noun belongs to the first or second phonological word. The results of Experiment 3 demonstrate that when the distractor word is phonologically related to an adjective placed in the second phonological word of a Spanish NP a reliable phonological facilitation effect is obtained. Taken together, as shown in Fig. 1, the results suggest that the level of activation of the phonological information of the lexical nodes that belong to the second phonological word in an NP affects naming latencies. Furthermore, the effect of the phonologically related distractors on the words located in the second phonological word of the NP seems to be independent of the grammatical status of the word placed in that position, since they were observed for both nouns (in English) and adjectives (in Spanish).

Our results fit well with other evidence suggesting that the phonology of the elements belonging to the second phonological word of an NP is concurrently active with earlier elements of the phrase (e.g., Ferreira, 1991; Dell & O'Seaghdha, 1992). Importantly, we now have convergent evidence for this proposal with different experimental paradigms relying on chronometric analyses of behavior. For example, Miozzo and Caramazza (1999) found that the phonology of the noun in Italian determiner + adjective + noun NPs affects the selection of the phonological form of determiners (the first word in the NP) in a simple naming task. Similar results have been obtained in a French variant of this experiment using possessive + adjective + noun NPs (Alario & Caramazza, in press). Along the same lines, Roelofs (1998) obtained larger facilitation effects, with an implicit priming paradigm, when the target words share not only parts of the first phonological word but also parts of the second phonological word. The fact that the activation of phonological elements that are not in the first phonological word of the NP is observed with different chronometric paradigms (simple picture naming, the picture–word interference paradigm, and implicit priming) as well as in the analyses of spontaneous and experimentally induced speech errors increases our confidence in the reliability of the phenomenon and its potential theoretical importance.

It is important to note that our results and those of Alario and Caramazza (in press), Miozzo and Caramazza (1999), and Roelofs (1998) are not, strictly speaking, inconsistent with those reported by Meyer (1996). Meyer's

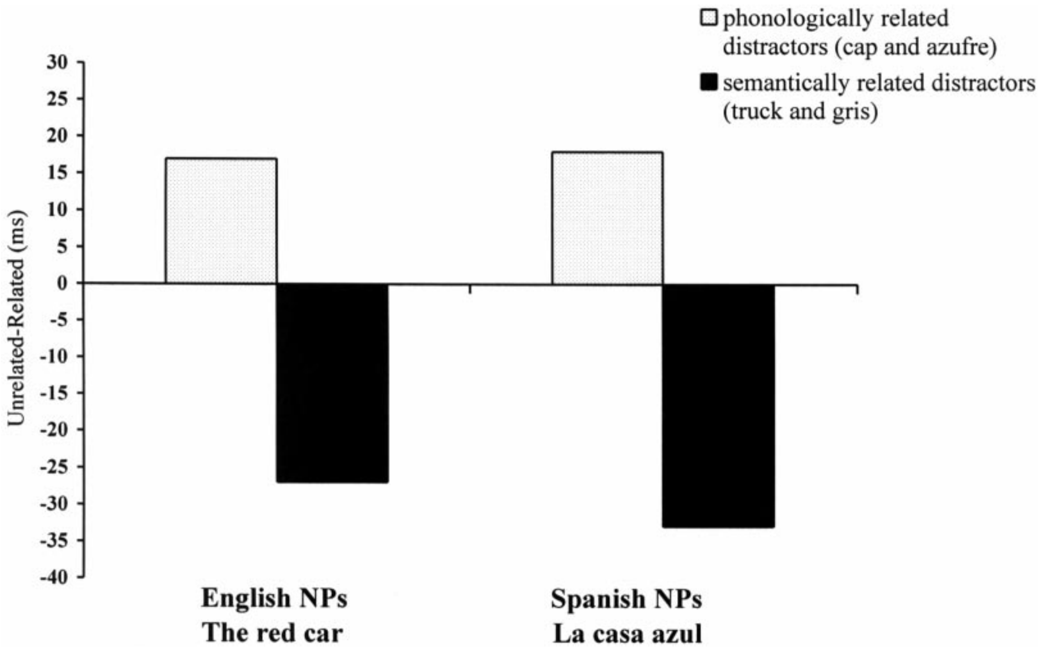

FIG. 1. Differential effects of semantically related distractors and phonologically related distractors in NP production (English and Spanish). In both cases, the distractors were related to the lexical node located in the second phonological word—the noun in English and the adjective in Spanish.

study differs from the others cited here not only in the types of structures subjects were required to produce (e.g., conjoined NPs and sentences) but also in the number of phonological words involved in these structures. In the structures tested in our experiments, the primed word was always located in the second phonological word. In contrast, in Meyer's experiment using sentences such as "the bag is next to the arrow," the position of the primed word "arrow" is not the second phonological word but rather the third or fourth phonological word. Along the same lines, it is unclear whether in the structure "the bag and the arrow" arrow is located in the second or third phonological word. In sum, whereas in our experiments we tested whether the second phonological word was concurrently active with the first phonological word, in Meyer's study it is arguable whether the primed word was located in the second or third (or later) phonological word. Thus, taking both Meyer's results (no concurrent activation of first and third phonological word) and ours (concurrent activation of first and second phonological word) into account, we can tentatively conclude that the upper bound of phonological encoding is two phonological words.

Although our results are clear regarding the existence of concurrent activation of elements that belong to different phonological words, they are silent regarding the extent to which processing of the second phonological word needs to be completed before articulation starts. Do our results necessarily mean that the second phonological word must be fully retrieved before the articulatory routines of the first phonological word can be executed? Since naming latencies are affected by manipulating the speed with which the second phonological word is retrieved, one may be tempted to conclude that the encoding of the second phonological word must be completed before the first phonological word can be delivered to the next stage of processing. However, this is not necessarily the case, and our results can also be explained in the framework of an incremental processing architecture in which the phonological word is the basic unit of phonological encoding (see also Roelofs, 1998).

In the introduction we mentioned that speech fluency is explained (in part) by assuming that the processes engaged at different levels of representation are functioning concurrently on different parts of the utterance. Some researchers have assumed that the phonological word is the minimal information required for computing the next level of representation (e.g., Levelt, 1989). In such a framework, speakers could be computing a phonological word and passing this information onto the next level of analysis as they begin to work on the next phonological word. Thus, speakers could be retrieving the phonetic plan of the first phonological word as they are engaged in computing the second phonological word. In this scenario two processes are engaged simultaneously at the phonological level, broadly defined: the formation of the second phonological word (e.g., “car”/kaɹ/) and the retrieval of the articulatory gestures of the first phonological word (e.g., “The red”/də ɹɛd/). If we were to assume that the processing resources implicated at these two levels of processing—phonological word formation and articulatory routine retrieval—are not independent, then the ease with which a representation at one level of processing is computed may affect the retrieval of representations at the other level. Therefore, by facilitating the retrieval of the phonological properties of the second phonological word of the utterance (/kaɹ/) more processing resources may be allocated in computing the phonetic elements of the first phonological word (/də ɹɛd/). As a consequence, naming latencies may be accelerated. The phonological facilitation effect observed in our experiments could reflect the differential use of processing resources in the phonologically related and unrelated conditions. This type of explanation is consistent with models that claim that the phonological word is the minimal phonological information required in order to start the production of an utterance (e.g., Levelt, 1989; Wheeldon & Lahiri, 1997).

Before concluding, it is important that we address an apparently discordant result in the literature. In the introduction, we noted that Schriefers and Teruel (1999) obtained a reliable facilitation effect when the distractors were phonologically related to the first syllable of the NP (*ro* for “rosa Tisch”), but not when they were related either to the second syllable of the first phonological word (*sa* for “rosa Tisch”) or to the second phonological word (*ti* for “rosa Tisch”). This result is at variance with those reported here as well as with Meyer’s (1996), both of which demonstrated clear phonological facilitation for the second lexical item within a phonological word. What is the source of the discrepancy? There are several differences in the procedures of those studies that may be responsible for the conflicting results. In our experiments and in those of Meyer (1996) and Miozzo and Caramazza (1999), the distractors were words, while in Schriefers and Teruel they were word fragments (two or three phonemes corresponding either to the beginning or the end of the word; see Starreveld, 2000, for contrasting effects when word fragments vs words are used as distractors). Furthermore, the NPs used by Schriefers and Teruel were different from those used in the other two studies. While Schriefers and Teruel used adjective + noun NPs, in the other studies the NPs always started with a determiner (the red car; la casa azul [literally, the house blue]; de kerk en het boek [literally, the church and the book]). Note also that in our experiments the distractors were presented visually instead of auditorially as in Schriefers and Teruel’s study. However, this factor cannot be the main reason for the contrasting results since Meyer (1996) also used auditory distractors, and she observed reliable phonological facilitation for the second syllable of the first phonological word (the noun).

Schriefers and Teruel (1999) acknowledge implicitly that their results are inconsistent with other results in the literature on the scope of phonological encoding and entertain the hypothesis that the scope of phonological encoding may be variable.[3] They propose that the

[3] Ferreira and Swets (in press) have also suggested that incrementality may be under strategic control, but that the size of the planning unit cannot be smaller than one phonological word.

amount of phonological information that needs to be computed before speakers start articulation may not be fixed, but instead may depend on the speaking demands of a particular experimental (or natural) context. However, they do not identify the variables in their experiments that could have led to such a drastic reduction of the scope of phonological encoding—a single syllable. A tentative answer to this question may be found when we analyze two properties of the study conducted by Schriefers and Teruel (1999): the number of pictures and the number of repetitions. In the experiments in which Schriefers and Teruel did not find phonological facilitation for the second syllable of the first word of the NP, participants were asked to name a small set of pictures (6 pictures) many times (14 times) in four different SOA conditions. Thus, participants were repeating each of the 6 target words a total of 56 times (14 times in each of the 4 SOAs). It is possible that the use of very small phonological planning units (e.g., the first syllable of the utterance) depends, among other things, on how easy it is to retrieve the targets' lexical nodes. If, furthermore, the ease with which name retrieval occurs depends, in part, on the number of possible responses in the experiment plus the number of times they are repeated, then Schriefers and Teruel's design could have favored the use of such a small phonological planning unit. Note that in the other studies in which the phonological planning unit appears to be larger, the number of items was larger and the number of repetitions was smaller than in Schriefers and Teruel's study, presumably preventing the use of very small phonological planning unit. Future research will have to determine which of these properties (or possibly some other variable such as word frequency, length, etc.) might be responsible for the seemingly contrasting results.

The results of the present experiments also replicate and extend the observation of semantic interference effects when producing NPs in English. Critically, English differs in one important dimension from the languages (Dutch and Italian) in which the semantic interference effects have already been observed in NP production. In those languages the determiner of the NP agrees with the grammatical gender of the noun (het boek [the book]; de kerk [the church]), and therefore its selection can only take place *after* the selection of the noun. If the selection of the noun is delayed, for example, by presenting a semantically related distractor, then the selection of the determiner (the first word in the utterance) is also delayed, leading to a delay in naming latencies. Therefore, it is not surprising that a semantic interference effect arises in languages such as Dutch and Italian. The situation in English is different, however. The selection of the determiner in English could be achieved independently from the selection of the noun (at least in the type of NPs used in our experiments). Therefore, in principle, a delay in the selection of the noun need not necessarily result in a delay in naming latencies. Nevertheless, the results of our experiments show a clear semantic interference effect even in this situation. These results, along with those from the phonologically related distractors, support the hypothesis that the scope of the grammatical stage is, at least, as large as the scope of the phonological encoding unit.

CONCLUSION

The results of the three experiments reported here demonstrate that the level of activation of the phonological properties of the lexical nodes that fall outside the first phonological word affect naming latencies. This observation suggests that the phonological elements of the second phonological word of the NP are activated before articulation begins. This is an important finding that fits quite well with the information gathered with other chronometric paradigms such as picture naming (Alario & Caramazza, in press; Miozzo & Caramazza, 1999) and implicit priming (Roelofs, 1998). Importantly, our results are also in agreement with analyses of spontaneous speech errors, in which, as reviewed above, the phonological information of lexical nodes that belong to different phonological words do interact. Although the full implications of this observation still need to be worked out, we can at least conclude that the window of phonologically active representations is larger than a single phonological word.

APPENDIX A

Materials Employed in Experiment 1

Picture	Semantically related	Unrelated	Phonologically related	Unrelated
Hat (R)	Scarf	Mosquito	Hag	Wand
Pigeon (R)	Sparrow	Flute	Pimple	Orchid
Lamp (R)	Torch	Fox	Latch	Dock
Horse (R)	Donkey	Spoon	Horde	Fore
Hammer (R)	Shovel	Skirt	Hammock	Vent
Rabbit (G)	Mouse	Onion	Racquet	Carriage
Corn (G)	Wheat	Cannon	Cord	Tack
Leg (G)	Elbow	Shark	Lemon	Doll
Lettuce (G)	Tomato	Elephant	Lens	Camper
Bench (G)	Stool	Cow	Bell	Pill
Peach (B)	Apple	Rose	Peak	Tumor
Bottle (B)	Pitcher	Lion	Boss	Tile
Mug (B)	Bowl	Piano	Mud	Guilt
Arm (B)	Chest	Truck	Arc	Card
Wasp (R)	Mosquito	Scarf	Wand	Hag
Organ (R)	Flute	Sparrow	Orchid	Pimple
Dog (R)	Fox	Torch	Dock	Latch
Fork (R)	Spoon	Donkey	Fore	Horde
Vest (R)	Skirt	Shovel	Vent	Hammoc
Carrot (G)	Onion	Mouse	Carriage	Racquet
Tank (G)	Cannon	Wheat	Tack	Cord
Dolphin (G)	Shark	Elbow	Doll	Lemon
Camel (G)	Elephant	Tomato	Camper	Lens
Pig (G)	Cow	Stool	Pill	Bell
Tulip (B)	Rose	Apple	Tumor	Peak
Tiger (B)	Lion	Pitcher	Tile	Boss
Guitar (B)	Piano	Bowl	Guilt	Mud
Car (B)	Truck	Chest	Card	Arc

Note. The color of the pictures is shown in parentheses (R = Red; B = Blue; G = Green).

APPENDIX B

Materials Employed in Experiment 2

Picture	Phonologically related	Unrelated
Basket	Batch	Hammock
Carpet	Card	Lack
Carrot	Carriage	Safe
Castle	Cast	Harvest
Cherry	Check	Vessel
Cradle	Crane	Hedge
Crown	Crowd	Drug
Drum	Drug	Crowd
Eagle	Eager	Carriage
Flag	Flash	Eager
Fork	Form	Stand
Globe	Glow	Peak
Hammer	Hammock	Batch
Harp	Harvest	Flash
Helmet	Hedge	Cast
Lamp	Lack	Form

APPENDIX B—*Continued*

Picture	Phonologically related	Unrelated
Peach	Peak	Glow
Sail	Safe	Crane
Stamp	Stand	Check
Vest	Vessel	Card
Bed	Bell	Gut
Bottle	Bottom	Winter
Bridge	Brick	Doll
Coat	Coal	Mouse
Dog	Doll	Brick
Dress	Dread	Wheat
Gun	Gut	Bell
Hat	Hatchet	Shin
Moon	Moose	Trumpet
Mountain	Mouse	Race
Nose	Node	Treat
Plane	Play	Coal
Rain	Race	Play
Ship	Shin	Hatchet
Sun	Sum	Trail
Train	Trail	Sum
Tree	Treat	Node
Truck	Trumpet	Moose
Wheel	Wheat	Dread
Window	Winter	Bottom

APPENDIX C

Materials Employed in Experiment 3

Picture	Phonologically related	Unrelated
	SET 1	
Manzana (BL) (apple)	Gris (gray)	Ideal (ideal)
Cuchillo (BL) (knife)	Gris (gray)	Ideal (ideal)
Cama (BL) (bed)	Violeta (violet)	Egoista (egoist)
Falda (BL) (skirt)	Naranja (orange)	Vertical (vertical)
Cebolla (BL) (onion)	Lila (purple)	Ruin (contemptible)
Coche (BR) (car)	Violeta (violet)	Egoista (egoist)
Silla (BR) (chair)	Granate (garnet)	Crujiente (cruchy)
Jarra (BR) (pitcher)	Granate (garnet)	Crujiente (crunchy)
Ventana (BR) (window)	Rosa (pink)	Eficaz (effective)
Collar (GR) (necklace)	Naranja (orange)	Vertical (vertical)
Fresa (GR) (strawberry)	Lila (purple)	Ruin (comtemptible)
Aranya (GR) (spider)	Rosa (pink)	Eficaz (effective)
Barco (GR) (boat)	Rosa (pink)	Eficaz (effective)
Trompeta (BL) (trumpet)	Gris (grey)	Ideal (ideal)
Zanahoria (BL) (carrot)	Gris (grey)	Ideal (ideal)
Tanque (BL) (tank)	Violeta (violet)	Egoista (egoist)
Tiburon (BL) (shark)	Naranja (orange)	Vertical (vertical)
Castillo (BL) (castle)	Lila (purple)	Ruin (contemptible)
Brazo (BR) (arm)	Violeta (violet)	Egoista (egoist)
Bicicleta (BR) (bike)	Granate (garnet)	Crujiente
Nariz (BR) (nose)	Granate (garnet)	Crujiente
Conejo (BR) (rabbit)	Rosa (Pink)	Eficaz (effective)

APPENDIX C—*Continued*

Picture	Phonologically related	Unrelated
Leon (GR) (lion)	Naranja (orange)	Vertical (vertical)
Guitarra (GR) (guitar)	Lila (purple)	Ruin (contemptible)
Pistola (GR) (gun)	Rosa (pink)	Eficaz (effective)
Luna (GR) (moon)	Rosa (pink)	Eficaz (effective)
	SET 2	
Barba (BL) (beard)	Azote (stroke)	Fianza (surety)
Casa (BL) (house)	Azufre (sulfur)	Jasmin (jasmine)
Gato (BL) (cat)	Azurcar (sugar)	Drama (drama)
Botella (BL) (bottle)	Azotea (roof)	Trenza (plait)
Arbol (BR) (tree)	Marfil (ivory)	Pincel (brush)
Bomba (BR) (bomb)	Margen (margin)	Rabia (rage)
Avion (BR) (plane)	Marca (mark)	Techo (ceiling)
Cangrejo (BR) (crab)	Marco (frame)	Leche (milk)
Calcetin (BR) (sock)	Marcha (march)	Golpe (blow)
Hombre (GR) (man)	Verbo (verb)	Farol (lantern)
Casco (GR) (helmet)	Verja (fence)	Bruja (witch)
Gorra (GR) (cap)	Vera (edge)	Tubo (tube)
Camello (GR) (camel)	Verso (verse)	Tropa (troop)
Mono (BL) (monkey)	Azote (stroke)	Fianza (surety)
Piano (BL) (piano)	Azufre (sulfur)	Jazmin (jasmine)
Raqueta (BL) (racquet)	Azucar (sugar)	Drama (drama)
Payaso (BL) (clown)	Azotea (root)	Trenza (braid)
Vaso (BR) (glass)	Marfil (ivory)	Pincel (brush)
Paloma (BR) (pigeon)	Margen (margin)	Rabia (rage)
Pelota (BR) (ball)	Marca (mark)	Techo (ceiling)
Perro (BR) (dog)	Marco (frame)	Leche (milk)
Pera (BR) (pear)	Marcha (march)	Golpe (blow)
Mano (GR) (hand)	Verbo (verb)	Farol (lantern)
Pierna (GR) (leg)	Verja (fence)	Bruja (witch)
Reloj (GR) (watch)	Vera (edge)	Tubo (tube)
Martillo (GR) (hammer)	Verso (verse)	Tropa (troop)

Note. SET 1 = Semantically Related/Unrelated Distractors to the Adjective; SET 2 = Phonologically Related/Unrelated Distractors to the Adjective. The color of the pictures is shown in parentheses (GR = Green; BL = Blue; BR = Brown).

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