Frequency Effects in the Production of Noun Phrases

F.-Xavier ALARIO and Albert COSTA*
Harvard University

1. Introduction

In this study we explore some of the properties involved in the production of multi-word English utterances. In order to produce such utterances, the speech production system must retrieve several lexical units and organize them in a well-formed utterance, which follows the rules of the language being spoken. According to current models, the linguistic mechanisms involved in this process can be divided into two main stages: grammatical encoding and phonological encoding (see, e.g., Bock and Levelt 1994; Levelt, 1989). The first stage involves the selection of the various words that belong to the NP along with their grammatical properties (the so-called grammatical encoding). During the second stage, the phonological information of the lexical nodes that have been selected is retrieved, and the phonological adjustments needed to produce those words in the proper phonological context are computed (the so-called phonological encoding). After these stages the processes of articulation programming and execution start (see, e.g. Caramazza 1997; Dell 1986; Levelt, Roelofs, and Meyer, 1999). In the present study we will focus on the characteristics of phonological encoding. More specifically, we will concentrate on evaluating the amount of phonological information that is concurrently activated in the system during speech production.

The study of speech error corpora has been a major source of information for our understanding of the speech production system (including the properties we have briefly described. See, e.g., Garrett 1975, 1992). The kinds of errors that are observed and their distributional properties constrain possible models of speech production. Consider for example the error that arises when a speaker misplaces two words in an utterance, by exchanging their intended positions (e.g., "she donated a *library* to the *book*", instead of " she donated a *book* to the *library*", from Garrett 1975). Very often, these errors involve members of the same grammatical class (e.g. two nouns or two verbs) and they are interpreted as arising at a level in which lexical selection takes place. Moreover, the lexical items that interact in such errors occupy relatively

* F.-Xavier Alario was supported by a postdoctoral fellowship from the Fyssen foundation. Albert Costa was supported by a postdoctoral fellowship from the Spanish government (Fulbright program). We thank Delia Kong and Adelaide Papazoglou for their help in running the experiment. We thank Brad Mahon and Adam Szczegielniak for comments on a previous version of the manuscript.

distant positions inside the clause, revealing that, at that level of processing, several words are activated and processed simultaneously.

Other errors can involve the phonological segments that compose the words to be produced. For example, a speaker produces “ni*fe* li*te*” where he intended “night life” (from Garrett 1975). This type of error can reflect a malfunction during the selection and/or encoding of the phonological segments of the intended words, i.e. during the stage of phonological encoding. For one thing, sound errors indicate that the phonological properties of words are not selected as a whole, rather, the specific components of the words (e.g. its segments) are retrieved separately. That is, a process of phonological encoding which is susceptible to failure constructs on-line a complete phonological representation of the word. The existence of sound exchanges also indicates that the phonological properties of several words can be activated at the same time during phonological encoding. However, contrary to what was said earlier about lexical errors, when two sounds are misplaced, the corresponding words do not necessarily respect the grammatical constraint presented earlier (the exchanged segments can belong to words of different classes). More important for our purpose here is the fact that the exchanged segments tend to belong to words that are relatively close in the utterances (usually two adjacent words) indicating that the number of lexical items that are being phonologically processed at the same time is relatively small.

Thus, a temporary conclusion that could be drawn from these observations is that the number of lexical items that are simultaneously involved in grammatical encoding is larger than the number of items involved in phonological encoding. Still, the existence of phonological exchanges and other types of phonological errors suggests that the phonological properties of various words can be concurrently active during the encoding of an utterance.

Evidence for the concurrent phonological activation of multiple lexical items also comes from fluent error-free speech. For example, in English, the indefinite article *a* is produced as *an* when used in front of a vowel ("*a* pear", "*an* apple"). In this case the system requires the phonology of the following word in order to produce the correct determiner form. As a matter of fact, it has been proposed that the prosodic unit "phonological word" (i.e., a content word plus any surrounding unstressed function word that can be cliticized to it. Slekirk 1984) could be the unit of phonological encoding (for discussion see Levelt 1989, or Schriefers and Teruel 1999). Under this type of hypothesis, when producing for example an NP, the production system can start to program and execute articulation when it has phonologically encoded the first phonological word of the utterance, irrespective of whether that first phonological word is the whole NP or not.

In this study, we investigate the extent to which there is concurrent activation of the phonological information of lexical nodes that belong to different phonological words. This issue is addressed in the particular case of the production of noun phrases (NPs, e.g. "the kite" or "the blue kite"). NPs are simple utterances that can be easily elicited in classic picture-naming experiments; yet the production of an NP requires the kind of multi-word encoding we are interested in.

2. Phonological Encoding During NP Production

Empirical evidence for the proposal that the phonological word governs the process of phonological encoding has come, among others, from experiments conducted by Meyer (1996). Meyer asked Dutch speakers to produce simple utterances: either conjunctions of noun phrase (e.g. the Dutch equivalent of “the arrow and the bag”) or simple sentences (e.g. “the arrow is next to the bag”) while ignoring a distractor word. The distractor word was phonologically related either to the first or to the second noun of the utterance. Results showed that naming latencies are affected by distractors phonologically related to the first noun of the utterance (e.g. *art* for “arrow”), but not by distractors phonologically related to the second noun (e.g. *ball* for “bag”. See also Dell and O’Seaghdha 1992, for similar results using a different paradigm). In this type of experiment, the presence or absence of an effect elicited by a phonologically related distractor word is usually taken to reflect ongoing phonological encoding. Accordingly, the observation of an effect for the first noun (which is in the first phonological word) but not for the second (which is not in the first phonological word) is consistent with the idea that the phonological word is the unit of encoding. It also suggests that the level of activation of the phonological properties of the items outside the first phonological word do not affect the onset of articulation. The result was interpreted as indicating that phonological encoding involves no more than one or two words at a time. According to that interpretation, the phonological planning unit involved in NP production may be the phonological word.[1]

Notice however that the results of some recent experiments suggest that the phonological properties of items that are outside the first phonological word can influence naming latencies. In an experiment conducted in French, Alario and Caramazza (submitted) manipulated the property that the form of some French determiners depends on the phonology of the word, which follows them in the utterance. For example, in front of a consonant the form of the first person singular possessive ("my") is *mon* if the controlling noun is masculine, and the form is *ma* if the controlling noun is feminine; however, if the word following the possessive in the utterance begins with a vowel, then the possessive is *mon* regardless of the gender of the noun. For example, the correct forms are "ma table" ("my table") and "mon ampoule" ("my light bulb") where both nouns are feminine. Interestingly, when the noun is not in the first phonological word, if for example a pre-nominal adjective is used, then it is the phonology of the adjective (and not that of the noun) that constrains determiner form: therefore the correct forms are now "mon ancienne table" ("my old table") and "mon ancienne ampoule" ("my old light bulb"). By manipulating these properties these authors observed that naming times for complex det + adj + noun NPs were

[1] Evidence *consistent* with this interpretation comes from the results obtained by Miozzo and Caramazza (1999; Experiment 4), in which Italian speakers produced simple NPs (“il tavolo” [the table]), where the noun is inside the first phonological word. In this experiment, faster naming latencies were observed when the distractor word was phonologically (e.g., “tana” [burrow]) related to the noun than when it was unrelated. Note however that this result does not speak to the issue of the activation of phonological information *beyond* the first phonological word.

longer if the phonology of the adjective and the phonology of the noun required different determiner forms than if they required the same determiner form. For instance, subjects were slower in producing "mon ancienne table" ("my old table") — where the adjective requires *mon* because it is vowel initial and the noun would require *ma* because it is feminine and consonant initial — than in producing "mon ancienne ampoule" ("my old light bulb") — where the adjective requires *mon* and the noun would also require *mon*. Miozzo and Caramazza (1999) have reported similar results in Italian. Importantly, this effect is observed *in spite of the fact* that in these cases the phonology of the noun is *a priori* not required to fix the form of the determiner. As was indicated earlier, this result suggests that the phonological properties of an item *outside* the first phonological word can influence naming latencies and therefore that the unit of phonological encoding might be larger than the first phonological word.

In summary then, the evidence briefly reviewed here is mixed regarding the extent to which there is phonological activation of lexical nodes that do not belong to the first phonological word. The results reported by Meyer (1996) indicate that the phonological items that are outside the first phonological word are not encoded before articulation starts. However, other results (Alario and Caramazza submitted) suggest that the phonological properties of items that are outside the first phonological word can influence naming latencies (see also Costa & Caramazza submitted).

In this study we present an experiment that addresses the issue of the unit of phonological encoding by exploring the speaker's performance in a simple picture-naming task. In the experiment, we explored the properties of the process of phonological encoding by manipulating one basic property of the pictures' names: their frequencies.

3. The Frequency Effect in Speech Production

In a seminal study, Oldfield and Wingfield (1965) found that pictures with low frequency names were named slower than those with high frequency names. This so-called frequency effect has been shown to be a replicable and a robust effect (Jescheniak and Levelt 1994; Levelt, Praamstra, Meyer, and Salmelin 1998). The fact that when non-verbal responses are required the effect of frequency is non-existent or very much reduced and the fact that the frequency effect is relatively independent of conceptual and visual factors jointly suggest that this effect is linguistic in nature rather than conceptual. It is therefore safe to assume that at least part of the frequency effect has its source during the retrieval of the representations corresponding to the picture's name. Furthermore, it has been assumed that the frequency effect arises during the stage of phonological encoding of the utterances (Jescheniak and Levelt 1994; but see Dell 1990). Although the evidence for such a claim has been questioned on empirical grounds (Caramazza, Costa, Miozzo, and Bi submitted), there is not direct evidence against the proposal. In the present study, we will make use of the assumption made by Levelt's model that the frequency effect takes place at the phonological level. This allows the derivation of experimental predictions about phonological encoding based on the potential existence of a frequency effect in NP production.

4. The Present Study

If the scope of phonological encoding during the production of NPs corresponds to the phonological word and frequency effects occur at the stage of phonological encoding, then frequency effects will be observed only for those items located in the first phonological word. This is because naming latencies are supposed to be independent of the level of activation of the phonological representations that fall outside the first phonological word. On the contrary, if the phonological planning unit includes elements that fall outside of the first phonological word, then naming latencies would depend, among other things, on the speed with which the phonological properties of those items are retrieved.[2]
In the experiment we present, we tested whether we could observe an effect of the frequency of the noun during the production of NPs. We manipulated the position of the noun in the utterance. In one condition, participants had to produce NPs where the noun was in the first phonological word (e.g. utterances like "[the kite]"[3]). In the second condition, the noun was outside the first phonological word (e.g. utterances like "[the blue][kite]"). If the unit of phonological encoding is the phonological word, the frequency effect should only be observed for simple determiner + noun NPs. If the unit of encoding is larger than the phonological word the frequency effect should be observed for both simple and complex (determiner + adjective + noun) NPs.

5. Experiment: Frequency Effects in Simple (Det+Noun) and Complex (Det+Adj+Noun) NPs.

In this experiment 18 native speakers of English named pictures by using English noun phrases. In the first part of the experiment, participants were instructed to use complex NPs (determiner + adjective + noun; e.g., "[the blue][kite]"), while in the second, they were asked to use simple NPs (determiner + noun; e.g., "[the kite]"). We also manipulated the frequency of the names of the pictures: half of the pictures had high frequency names and the other half had low frequency names.

Method

We selected 32 pictures of common objects, 16 with high frequency names (average: 174 occurrences per million in Francis and Kucera's (1982) database; range: 58-662) and 16 with low frequency names (average: 13 occurrences per million; range: 1-36)[4]. Each picture was presented in 8 different colors (blue,

[2] This argument is similar to the one that was developed when interpreting the results of the phonological facilitation effect in the picture-word interference paradigm (e.g. Meyer 1996; Miozzo & Caramazza 1999). In those studies, the observation that naming latencies were shorter when the distractor was phonologically related to a target word was interpreted as evidence that the target word was phonologically processed.

[3] The brackets enclose phonological words.

[4] Pilot testing showed that the manipulation of frequency between the two groups of pictures indeed produced a frequency effect of 18 ms in a classic bare naming task (e.g., participants had to produce "kite").

black, green, orange, pink, purple, red, and yellow). The objects represented in the pictures could always be plausible when colored with the different colors used in the study.[5]

The experiment had two parts. In the first part participants were asked to name the pictures as fast and as accurately as possible using complex NPs (determiner + adjective + Noun), in which the noun was located in the third position of the NP. Since, we do not know whether the frequency effect may arise whenever the noun is not in initial positions of the NP, we also included a second condition in the second part of the experiment. In this condition participants were asked to name the pictures using simple NPs (determiner + noun) in which the noun was located in the second position of the NP. This control condition allows us to determine whether the frequency effect may arise when the noun is not the very first element of the utterance but still is not outside the first phonological word. In each condition, each item (picture) was presented four times during the block.

Each trial had the following events: first a fixation point (+) for 500 ms, then a blank screen for 300 ms and then the picture to be named. The picture remained on the screen until the voice key detected the response or when a deadline of 2500 ms was reached without overt response. The next trial started 1500 ms after the participant's response. The experimenter monitored the participant's responses.

Results and discussion

A summary of the data is presented on Figure 1. After the exclusion of the trials where participants gave incorrect responses, naming latencies were submitted to analysis of variance by participants (*F1*) and by items (*F2*). We only report here the relevant comparisons. We observed an effect of the frequency of the noun, with faster responses to NPs using high frequency nouns than with NPs using low frequency nouns [HF = 589 ms, LF = 605 ms; $F1(1\text{-}17) = 13.4$, $MSE = 1460$, $p < 0.01$; $F2(1\text{-}30) = 4.64$, $MSE = 2937$, $p = 0.04$]. The variables frequency and format did not interact [$F1(1\text{-}17) = 2.00$, $MSE = 515.4$, $p = 0.17$; $F2(1\text{-}30) < 1$], indicating that the effect of frequency is independent of response format.

The results of Experiment 1 show the existence of a frequency effect when participants are naming pictures using NPs. The effect was stable across the two different types of NPs, complex and simple, that were used. This result is a novel observation that extends the frequency effect (Oldfield and Wingfield 1965) to those cases in which the noun is not the first element in the utterance. Furthermore, under the assumption that frequency effects occur at the level of phonological processing, we can take the results of this experiment to indicate that the phonological processing of the noun influences naming latencies, irrespective of whether the noun was in the first phonological word or not. In other words, the scope of phonological encoding extends beyond the first phonological word of the utterance.

[5] For example, "car" was used, but not "banana".

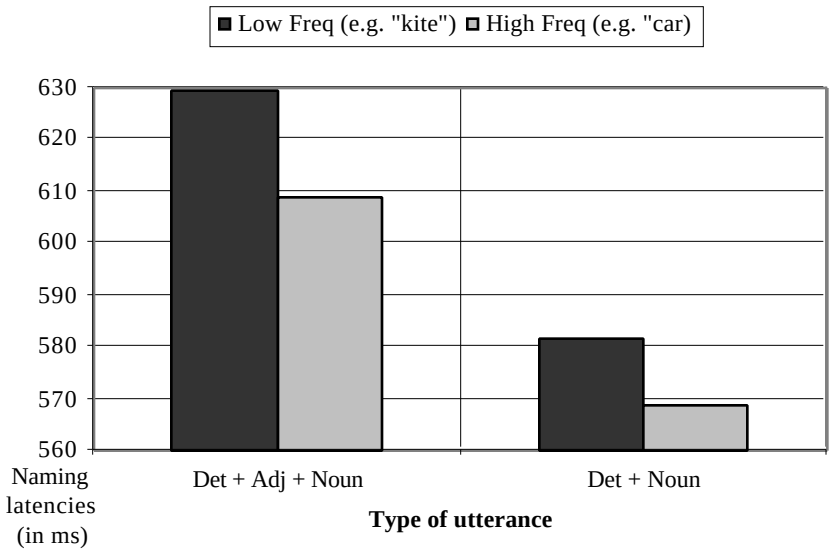

Figure 1 — Naming latencies per condition for complex (Det + Adj + Noun) and simple (Det + Noun) NPs. The data are collapsed over repetitions.

6. General Discussion

Evidence from the analysis of speech error corpora indicates that the phonological properties of several words can be active at the same time during the preparation of an utterance. In the research reported in this study, we have investigated some of the characteristics of phonological encoding during the production of a specific type of utterance: noun phrases. We were particularly interested in determining whether during normal (non-erroneous) speech there is activation of the phonological properties of the items that are outside the first phonological word before articulation starts. Note that this question is important as it might that the evidence that speech errors provide for the concurrent phonological activation of several words (see Introduction) is in fact biased. It could well be that phonological speech errors arise *precisely* because of an *unusually high activation* of the phonological properties of items occurring later in the utterance. As such, those speech errors would not strictly reflect the characteristics of normal speech.

We addressed this question in a picture naming experiment where the frequency of the targets to be produced was manipulated. In the experiment, we observed an effect of the frequency of the noun when participants were producing NPs. Crucial for our purposes here are the results observed in the conditions in which participants had to name the pictures using a complex NP (determiner + adjective + noun), where the noun is outside the first phonological word. Under the assumption that the frequency effect occurs during the

processes of phonological encoding, the observation of a frequency effect in that condition indicates that the onset of articulation is affected by the activation of the phonological properties of the lexical nodes that are not part of the first phonological word. This interpretation indicates that the scope of phonological encoding involves more than one phonological word. This is in line with the results of Alario and Caramazza (submitted) and Miozzo and Caramazza (1999), who found an influence of the phonological properties of items outside the first phonological word on naming latencies (see also Costa and Caramazza submitted).

Note that this interpretation does not compel us to state that the second phonological word is necessarily encoded before articulation starts, nor that the amount of phonological encoding that precedes articulation is invariably fixed. That is to say, the unit of phonological encoding might in fact be variable. As suggested by various authors (Ferreira 1993; Nespor and Vogel 1986; Schriefers and Teruel 1999), it is possible that the amount of advance planning and encoding that is realized during speech production adapts flexibly to factors such as speech rate, prosodic structure, or the interaction of prosodic with syntactic structure. What the results reported here as well as the convergent evidence cited earlier jointly suggest is that the amount of phonological encoding that precedes articulation needs not be restricted to a single phonological word.

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F.-Xavier Alario
Cognitive Neuropsychology Laboratory
Department of Psychology
Harvard University
33, Kirkland Street
Cambridge, MA 02138, USA

alario@wjh.harvard.edu
http://www.wjh.harvard.edu/~alario

Albert Costa
Cognitive Neuropsychology Laboratory
Department of Psychology
Harvard University
33, Kirkland Street
Cambridge, MA 02138, USA

acosta@wjh.harvard.edu
http://www.wjh.harvard.edu/~acosta