Is the scope of phonological planning constrained by the syntactical role of the utterance constituents?

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Abstract

Five experiments looked the effect of repeated phonemes in the production of color adjective+noun phrases in English ("green gun"), or noun+color adjective phrases in Spanish and French. Whereas phoneme repetition sped up naming latencies in the case of prenominal color adjectives, it induced inhibition in the postnominal case. We argue that these dissociation is not compatible with a genuine crosslinguistic difference in the scope of phonological encoding. Rather we explain it in terms of the interplay between an activation gradient, coding word order, and an activation bias, coding the syntactical role of the utterance constituents.

Keywords: psycholinguistics; phonological planning; speech production; reaction times; crosslinguistic effects;

Introduction

Speaking requires some degree of (advance) planning, i.e., the pre-activation and selection of upcoming portions of the utterance. How far speakers plan ahead is likely to be longer at higher processing levels (pragmatic, conceptual, syntactical) than at lower ones (phonological). As far as planning at the phonological level, the focus of this paper, is concerned, several types of accounts have been proposed, ranging from *minimalist* views (e.g., Dell, Juliano, & Govindjee, 1993), according to which planning is limited, to *non-minimalist* ones, according to which articulation cannot proceed before at least one phonological word has been encoded (e.g., Levelt, Roelofs, & Meyer, 1999).

One methodology used to examine this issue is to manipulate the form properties and/or the degree of phonological activation of a non-initial portion: if speech onset latencies are affected, then the utterance must have been planned up to that portion before articulation was initiated. The results obtained with this technique favor the idea of large window of advance planning at the phonological level. For instance, looking at single word two-syllable utterances Levelt and Wheeldon (1994) showed that the second syllable frequency affects then naming response latencies, indicating that the entire word, not just its initial syllable, is encoded prior to articulation. Costa and Caramazza (2002) applied this logic to the picture-word interference paradigm. They found that latencies in the production of multi-word phrases of the type determiner+adjectif+noun ("the green plane") were shorter with visual distractor words form-related to the noun than with unrelated ones (see also Damian & Dumay, 2007, for similar findings under time pressure). Schnur, Costa and Caramazza (2006) subsequently reproduced this effect with sentences such as "The orange girl walks" and visual distractors ("walnut") form-related to the verb.

However, contrary to these findings, others, using either multiple-object naming (Meyer, 1996; Meyer, Sleiderink & Levelt, 1998) or production of complex numerals (Ferreira & Swets, 2002; Korvorst, Roelofs & Levelt, 2006), suggest that the scope of planning is typically very limited, and to some extent under strategic control. For instance, in the picture-word interference paradigm, Meyer (1996) observed that noun phrases such as The "the bag and the spoon" or sentences such as " The bag is next to the spoon" were initiated much faster when auditory distractors were form-related to the first noun, but showed a small inhibitory trend when the distractors were form-related to the second noun.

Using pairs of complex numerals to be produced as house numbers or clock times, Korvorst et al. (2006) found that speakers' gaze durations were sensitive to formal properties of the numerals, such as length and frequency, thereby suggesting incrementality, and thus a limited planning scope. In sum, whereas picture-word interference studies support the idea that phonological planning is way ahead of articulation, others studies using new measures and/or complex displays or numerals favor the idea of a limited planning scope.

An new technique speaking in favor of non-minimalist views of phonological planning, and based on phoneme repetition, was recently introduced by Damian and Dumay (2007, and in press). In these experiments participants had to name coloured objects (line drawings) with adjective-noun phrases as quickly as possible. Color and objects were paired such that the adjective and the noun either overlapped in terms of their segmental content ("green goat") or did not ("red goat"). Response latencies were shorter in the former (related) than in the latter (unrelated) condition. As here the

identity of a segment of the second word influences the time utterance onset latencies, one can conclude that speakers must have co-activated the phonological forms of both words prior to initiating their response.

In the experiments reported below, we capitalized on this effect of phoneme repetition to assess the extent to which the scope of phonological co-activation is modulated by the syntactical properties of the utterance. One possibility is that the amount of phonological co-activation is determined by the quantity of resources available at a given time, with no constraints imposed by syntactical processes. However an alternative possibility is that the order of activation at the form level is edicted by the syntactical structure.

Two sets of data reported by Schriefers and Teruel (1999) are particularly relevant here. These authors had German speakers name coloured pictures ("der grüne Tisch" [the green table]) while spoken distractors were presented at various stimulus-onset asynchronies (SOAs). A semantic (negative) influence of distractors related to the noun ("Stuhl" [chair]) on the naming latencies was found at SOA = -150 ms, whereas a similar effect from the distractors related to the adjective ("rot" [red]) was obtained at a later time point (SOA = +150 ms). Critically, French speakers tested on an equivalent task, and thus using phrases with postnominal adjectives ("la table verte") showed a different pattern of naming latencies: semantic distractors related to the noun had an effect early SOAs, but in this language distractors related to the adjective did not produce any effect whatever the SOA. On the basis of the results, Schriefers and Teruel suggested that at the higher, lemma level, the phrase as a whole does not need to be fully encoded before articulation can ensue: what matters is the position of the head, in this case, the noun; whether or not the adjective is included in grammatical planning depends directly on its position.

Assuming this hypothesis holds, it should be therefore possible to observe a similar crosslinguistic dissociation at the phonological level. In languages with postnominal adjectives, such as French and Spanish, phonological manipulations targeting the adjectives should not affect response onset latencies (because planning up to the noun is enough for articulation to proceed). Conversely, in languages with prenominal adjectives, such as German and English, phonological manipulations targeting the noun should systematically affect onset latencies. According to this view, the above phoneme repetition effect within noun phrases which we reported for English (Damian & Dumay, 2007, and in press) should not replicate in languages with postnominal adjectives.

Whether this is the case is an empirical question. However, one can already note that the pattern of effects obtained in the picture-word interference paradigm by Costa and Caramazza (2002) does not fit with Schriefers and Teruel 's (1999) suggestion. In their experiment, Costa and Caramazza had Spanish speakers name coloured pictures with phrases of the type "det+noun+adjective" ("la casa azul" [the blue house]) while visual distractors semantically or phonologically related to the adjective were superimposed onto the to-be-named picture. Despite the postnominal position of the adjective, both classical effects (i.e. semantic interference but phonological facilitation) were found, which led the authors to argue that phonological encoding of a phrase is independent of the grammatical status of its constituents.

In the present set of experiments, we investigated systematically whether or not the effect of repeated phonemes which we found in English (Damian & Dumay, 2007, and in press) generalizes to languages with postnominal adjectives. Experiment 1 reproduced the baseline effect in English, whereas Experiment 2 and 3 assessed its counterparts respectively in French and Spanish. Finally, Experiments 4 and 5 evaluated an alternative explanation for the crosslinguistic dissociation obtained.

Experiment 1

Methods

Participants Sixteen undergraduates from the University of Bristol were tested. They were all English native speakers, with normal (or corrected-to-normal) vision and no history of language disorder.

Materials and design. The key materials were 20 colored pictures (line drawings) of common objects with monosyllabic names (Celex frequency: 17.7 per million; length: 3.5 phonemes). In the phonologically related condition, objects and colours (blue, green, pink, red) were combined such that the initial phoneme of the adjective and the noun (and in two cases, also the following vowel) coincided ("blue bed"; the average phonemic overlap represented 34.8% of target length); in the phonologically unrelated condition, they were recombined such that their initial segments differed ("green bed") and overlap in other positions was minimised. In both conditions, care was taken to avoid obvious associations, such as "green grass". Each object was presented once in each condition, plus another four times paired with the two remaining colors, which resulted in 40 test and 80 filler trials. Order of item presentation was pseudorandomized for each participant such that neither the same colour adjective nor the same target appeared on subsequent trials.

Procedure. The experiment was controlled using DMDX (Forster & Forster, 2003). All pictures had a standardized size of 7 x 7 cm and were presented centrally for 1,800 ms following a 500-ms fixation cue. Naming responses were captured using a high quality headset microphone, and utterance onset latencies determined to the nearest millisecond. Participants were first familiarized with the entire set of pictures and corresponding names. They were then shown the four possible colours in which the line drawings would from now on be presented, and instructed to name what they saw as quickly as possible using a phrase of

the type "adjective+noun". After 20 unrelated practice trials, four experimental blocks of 30 trials were carried out.

Results and discussion

Table 1: Mean response latencies (in ms) and errors rates (in parentheses) for Experiments 1-5.

	Unrelated	Related	Difference
Exp. 1 (English)	766 (5.3)	806 (4.0)	+40 (+1.3)
Exp. 2 (Spanish)	767 (4.4)	764 (3.4)	+3 (+1.0)
Exp. 3 (French)	749 (9.5)	745 (8.8)	+4 (+0.7)
Exp. 4 (English)	663 (7.3)	633 (4.3)	+30 (+3.0)
Exp. 5 (Spanish)	783 (5.6)	816 (6.9)	-33 (-1.3)

Trials on which there was a hesitation, a stutter, an unexpected response, or no response at all were classified as errors (4.7%) and excluded from the latency analysis. Latencies smaller than 250 or larger than 1,500 ms (1.3%) were also removed from the chronometrical analysis. All results are reported in Table 1. In all four experiments the data points were analyzed using a linear mixed effects methodology (e.g., Baayen, 2007). As expected in the English case, the naming latencies were significantly faster (40 ms) in the related than in the unrelated condition ($F(1,562) = 7.56$, $p < .01$). Convergingly, error rates were slightly lower (1.3%) in the related than in the unrelated case; however, this difference was not significant ($F < 1$).

The results of this first experiment nicely replicate those previously reported by Damian and Dumay (2007, and in press), with a substantial phonological facilitation between adjective and noun. Having now confirmed our baseline effect in English, we can now move on to a target language, namely Spanish, in which colour adjectives systematically occur in postnominal position.

Experiment 2

Methods

Participants Sixteen undergraduates from the University of Murcia (Spain), all were tested. They were all Spanish native speakers and were selected using the same criteria as for Experiment 1.

Material, design and procedure The materials was devised along the same lines as in Experiment 1. It combined 20 common objects depicted as line drawings with four colours (blue, red, green, or brown). Object names were either mono- or bisyllabic, and had an average length of 4.1 phonemes and a spoken frequency of 20.0 per million (Real Academia Española). In the related condition ("ajo azul" [blue garlic]), the average overlap represented 41.5% of target length. Expect the instructions, i.e., to name the pictures using a phrase of the type "adjective+noun", and

the smaller number of filler trials (64), all other procedural aspects were identical to Experiment 1.

Results and discussion

Using the criteria of Experiment 1, 3.9% of the trials were classified as errors, and a further 0.6% of the latencies were excluded from the chronometrical analysis as outliers. As can be seen Table 1, the naming latencies in the related and unrelated condition were virtually identical, with no significant effect of overlap (3 ms; $F < 1$). Likewise, error rates showed no effect of overlap either (1%; $F < 1$).

The results from the Spanish speakers are in stark contrast to those obtained from the English speakers: a similar degree of onset phonological overlap between colour adjective and object name had absolutely no impact on the naming performance in the postnominal-adjective, Spanish case, but a strong positive influence in the prenominal-adjective, English case. However, before we attempt to make sense of this finding, and because our failure to obtain any facilitation in Spanish may be seen as a null finding, Experiment 3 tried to give another to the effect by testing in language with postnominal colour adjective, i.e. French. In this experiment, we were able to use exclusively monosyllabic nouns and adjectives (as in the English experiment); we also had a larger picture set and tested more participants.

Experiment 3

Methods

Participants Thirty undergraduates from the University of Brussels (Belgium) were tested. All were native speakers of French and were selected using the same criteria as for the previous experiments.

Material, design and procedure The materials was devised along the same lines as in Experiments 1 and 2. This time it combined 32 (instead of 20) common objects depicted as line drawings with four colours (blue, grey, green, and mauve). Object names were all monosyllabic as in Experiment 1, with an average length of 3.2 phonemes, and an average spoken frequency of 6.5 per million (Content, Mousty, & Radeau, 1990). In the related condition ("vache verte" [green cow]), the average overlap represented 34.9% of target length. All procedural aspects were identical to Experiment 2.

Results and discussion

Using the criteria of Experiment 1, 4.3% of the trials were classified as errors, and a further 1.2% of the latencies were excluded from the chronometrical analysis as outliers. As can be seen Table 1, the naming latencies in the related and unrelated condition were again virtually very similar, with no significant effect of overlap (4 ms; $F < 1$). Likewise, there was no effect overlap on the error rates either (0.7%; $F < 1$).

As observed with Spanish speakers in Experiment 2, French speakers did not any effect of phonological overlap between colour adjective and object name. Taken together, these two experiments strongly suggest that phonological encoding of an utterance-initial noun is carried out independently of the encoding of the subsequent colour name. These results fit well with Schriefers and Teruel's (1999) hypothesis that the scope of syntactical encoding is determined by the position of the head noun; if in Spanish and French the postnominal adjective does not need to be encoded before articulation can proceed, there is no reason to expect any phonological effect from the adjective onto onset latencies. However, before concluding that the discrepancy between English, and Spanish and French, reflects a genuine cross-linguistic dissociation, an alternative account of these findings, in terms of the relative temporal availability of the color and the object dimension has to be assessed.

Let's assume that in our experiments colour identification is slower than object identification. A phonological effect should be easier to obtain in English, where the object name, therefore retrieved first, yet comes second in the utterance, than in Spanish and French, where the object name, retrieved first, by contrast also comes first in utterance. Whether this scenario applies to our experiments is not immediately clear. On the one hand, the fact that we used at least 20 objects, but only four colours, could make colour names easier to retrieve than object names; on the other, colour identification in line drawings is particularly difficult compared to plain patches (see Kuipers and La Heij, in press).

In the subsequent experiments, we tackled the "relative time course" account by inverting the color display, such that objects were shown in white lines on coloured background. Display inversion, if successful in rendering colour information more salient, should speed up English speakers: in their language colour adjectives come first in the utterance, and no gender agreement with the noun is required. More crucially, if despite increased colour saliency still no phonological effect emerges in Spanish or French, languages in which colour adjectives are named postnominally, we would be in a strong position to argue that the dissociation observed indeed reflects a true cross-linguistic difference in the planning of speech. English was assessed in Experiment 4, whereas the postnominal case was assessed in Spanish only, in Experiment 5.

Experiment 4

Methods

Participants Another 16 undergraduates from the University of Bristol were tested. All were native speakers of English and were selected using the same criteria as for the previous experiments.

Material, design and procedure These were identical to Experiment 1, except that the colour display was inverted, so that colour was now conveyed by the drawing background.

Results and discussion

Using the criteria of Experiment 1, 5.8% of the trials were classified as errors, and a further 0.3% of the latencies were excluded from the chronometrical analysis as outliers. As can be seen Table 1, the naming latencies were significantly faster (30 ms) in the related than in the unrelated condition ($F(1,563) = 11.14$, $p < .001$), whereas there was no significant effect of overlap on the error rates ($F < 1$).

A combined analysis of Experiments 1 and 4 demonstrated that display inversion significantly sped up naming latencies (by 138 ms) compared to the standard mode ($F(1,1125) = 10.69$, $p < .001$), and that the strength of the phonological facilitation was unaffected by display inversion ($F < 1$). Error rates indicated a facilitatory trend in the related condition (2.2%; $F(1,1196) = 2.94$, $p = .09$).

The significant reduction of the naming latencies in the inverted compared to the standard colour display mode demonstrates that the manipulation introduced in Experiment 4 effectively made the colour dimension more salient, and *ipso facto* retrieval of the corresponding adjective quicker. The fact the phonological facilitation is unaffected by the increase in colour saliency indicates that English speakers are still unable to initiate their response based just on the colour information. Having established that colour display inversion speeds up retrieval of the adjective, Experiment 5 applied this manipulation to the Spanish language.

Experiment 5

Methods

Participants Another 16 undergraduates from the University of Murcia were tested. All were Spanish native speakers and were selected using the same criteria as for the previous experiments.

Material, design and procedure These were identical to Experiment 2, except that the colour display was inverted, so that colour was now conveyed by the drawing background.

Results and discussion

Using the criteria of Experiment 1, 6.3% of the trials were classified as errors, and a further 0.3% of the latencies were excluded from the chronometrical analysis as outliers. As attested by the effect overlap ($F(1,596) = 6.78$, $p < .01$), and to our surprise, the naming latencies were here (33 ms) slower in the related than in the unrelated condition (see Table 1), whereas corresponding error rates did not differ statistically (-1.3%; $F < 1$). As indicated by a combined analysis of Experiments 2 and 5, the inhibition obtained on the latencies with the display inversion procedure was statistically distinct from the null effect found in Experiment

2 (F(1,1205) = 4.00, p < .05). The phonological inhibitory effect found here is clearly at odds with Schriefers and Teruel's (1999) hypothesis that the planning scope is strictly determined by the position of the head noun: with the right experimental settings, speakers do co-activate noun and postnominal adjective prior to articulation.

General discussion

The present set of experiments exploited the (facilitatory) effect of phoneme repetition to explore whether the syntactical role of the utterance constituents modulate the scope of phonological (advance) planning. Experiment 1 replicated the baseline effect in English, using color adjective+noun phrases, but Experiments 2 and 3 fail to find its counterpart in Spanish and French, languages where the color adjective by contrast was in postnominal position. The final experiments increased colour saliency, by inverting the display such that the colour information was conveyed by the background rather than by the lines of the drawing. Experiment 4, by speeding up the naming latencies of English speakers (compared to Experiment 1) demonstrated that color display inversion had the desired effect. Crucially, Experiment 5, carried out in Spanish, showed that with increased colour saliency, phonological overlap between noun and postnominal adjective can result in the inhibition of naming responses.

Our finding of phonological inhibition with increased accessibility of a non-initial constituent converges with the inhibitory influence reported by Meyer (1996; cf. Introduction). It also converges with the inhibition observed again in the picture-word interference paradigm by Jescheniak, Schriefers and Hantsch (2003). Asking participants to produce bare nouns ("Kamm" [comb]), "det+noun" phrases ("der Kamm" [the comb]), or "det+adjective+noun" phrases ("der rote Kamm" [the red comb]), these authors found that phonological distractors related to the noun induced a substantial facilitation in bare nouns, a reduced facilitation in "det+noun" phrases, which turned into inhibition in the longer, "det+adjective+noun" phrases. Based on these and our Experiment 5, one can certainly conclude that if an utterance non-initial constituent is primed, inhibition should ensue, not facilitation (by contrast to utterance-initial constituents). In any case, our Spanish inhibition effect is incompatible with Schriefers and Teruel's (1999) suggestion, according to which syntactic — and by implication, phonological— planning encompasses all constituents up to and including the phrase head, and thus would include prenominal, but not postnominal adjectives.

Arguably, our inverted stimuli, with the colour filling the background as well as the drawing itself, are closer to real objects than are the coloured lines of our standard stimuli. Consequently, the main results to account for here are the phonological facilitation obtained with prenominal adjectives, and its inhibitory equivalent found with postnominal adjectives.

The theoretical account of phonological encoding in multi-word utterances proposed by Jescheniak et al. (2003) could be valuable in that respect. Originally devised to explain picture-word interference in the production of phrases the model works as follows. At the lemma level, all the phrase semantic/syntactic constituents are activated in parallel and are each assigned to a syntactic slot. At a lower level, the order of the successive phonological word forms is represented as an activation gradient, such that the first word of the utterance receives the strongest activation, the second one less, the third one still less, etc. Presentation of a phonological distractor boosts the activation of the target word, and therefore helps its retrieval. However, priming a non-initial element has indirect cost: it temporally disturbs the activation gradient coding for the sequential order of the utterance constituents. In extreme cases, this may in fact result in an overt speech error ("the big house, euh, the big red house"). Nonetheless, in all other cases producing the correct sequence will consume time and resources. Hence, the net outcome for any experimental situation is a balance between priming (due to activation boost and consequent easier retrieval) and interference (due to the time and resources needed to maintain the correct word order). Distractors form-related to the utterance initial element should benefit naming, because in this case the activation boost facilitates retrieval, but also reinforces the appropriate activation gradient. By contrast, whether a distractor form-related to a non-initial element should prime or inhibit performance will depend the task specific settings, and with the possibility that both effects cancel each other out.

How the "phonological activation gradient" theory accommodate the present data is not straightforward though. According to the model word order is coded by the activation gradient, implying that by default in the English utterance "green goat", "green" is more activated than "goat". The mechanism underlying the phoneme repetition effect is presumably an exchange of activation between the two related word forms (cf. Damian & Dumay, in press). This should render retrieval of both elements. However, as part of this exchange, the non-initial element "goat" receives additional activation, and so the gradient will be disturbed, counteracting the priming of the initial element. Nonetheless, it is probably safe to assume that the disturbance is weak, relative to priming, otherwise speaker would produce the words in the wrong order. Under the right parameters, the model could therefore explain the facilitatory effect of phoneme repetition obtained in English.

However, because the model is blind to higher-level variables, such as word class, and only considers the sequential position of the elements, it makes the same prediction for postnominal adjective constructions as in French/Spanish. One possible modification that would enable the model to explain our full pattern of effects would assume that all else being equal, nouns always have more activation than adjectives. This could occur via cascadedness from the syntactic to the word form level: the noun being crucial element of the phrase, it might have a

head start in terms of activation; another possibility would be that object identity always receives more activation due to attentional factors.

Under this assumption of an asymmetric "baseline" activation, the exchange between adjective and noun should particularly benefit the "adjective+noun" word order. In "green goat", "green" should receive a substantial activation from the (important) object name "goat"; by contrast, the object name should benefit relatively less from the priming flow sent by the (less important) colour adjective. By contrast, for phrases of the type "noun+adjective", the activation sent by the highly activated "vache" should heavily prime the postnominal adjective "verte", thereby affecting the activation gradient more in the related than in the unrelated condition. As a result, the speaker should find it more difficult to suppress the colour adjective, when preceded by a phonologically related object name. Therefore, by means of the assumption that nouns have a relatively higher activation level than adjectives, the model could explain both facilitation in prenominal constructions and inhibition in postnominal ones.

Overall, our results and interpretations are compatible with a view of phonological advance planning which denies the need for cross-linguistic differences, as advocated by Schriefers and Teruel (1999). The same underlying mechanism of coding for sequential order and exchange of activation due to phonological relatedness is in principle able to account for the divergent pattern of results obtained from languages with different word order.

Acknowledgments

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