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Is the Scope of Phonological Planning Constrained by the Syntactic Role of the Utterance Constituents?

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Abstract

Five experiments looked at the effect of repeated phonemes in the production of colour adjective+noun phrases in English (“green gun”), or noun+colour adjective phrases in Spanish and French. Whereas phoneme repetition sped up naming latencies in the case of prenominal colour adjectives, it induced either no effect or inhibition in the postnominal case. We argue that this dissociation does not reflect a genuine cross-linguistic difference in the scope of phonological planning. Rather, we explain it in terms of the interplay between an activation gradient, coding word order, and an activation bias, coding the syntactic role of the utterance constituents.

Keywords: psycholinguistics; phonological encoding; speech production; reaction times; cross-linguistic effects

Introduction

Cognitive psychologists and neuroscientists concerned with the preparation of voluntary action sequences have devoted a lot of attention to issue of advance planning. In their research area, a central issue is whether a given response sequence is planned in its entirety before it is initiated, or whether planning and execution are carried out concurrently (e.g., Inhoff, Rosenbaum, Gordon & Campbell, 1984). A special instance of a voluntary action sequence is language production. Speakers, prior and during the articulation of any utterance, must achieve the balance between the cognitive load associated with the planning process and the risk of dysfluencies due to not having planned enough. Speakers likely plan ahead to a greater extent at higher (conceptual and syntactic) processing levels than at lower (phonological and articulatory) levels. As far as planning at the phonological level - the focus of this paper - is concerned, several types of accounts have been proposed, ranging from theories hypothesizing only a very small amount of planning (e.g., MacKay, 1987), to others according to which articulation cannot proceed before at least one phonological word has been encoded (e.g., Levelt, Roelofs & Meyer, 1999).

In both research on motor programming and language production, one methodology used to assess the scope of advance planning is to manipulate the properties of a non-

initial element of the sequence and examine whether response initiation is affected. For instance, in speech production research this approach typically involves manipulating either the sound or meaning properties of a non-initial portion, or the level of phonological or semantic activation of that portion. If latencies at initiating the response are affected, then the sequence must have been planned, or at least its elements up to the manipulated portion must have been activated, before articulation was initiated.

As far as speech production is concerned, the results obtained with this approach generally favor the idea of a relatively large window of planning at the phonological level. For instance, Meyer (1996) exploited the picture-word interference paradigm, in which a form relation between a picture name and a to-be-ignored distractor typically entails facilitation, and extended it to multi-word utterances. She observed that noun phrases such as “The bag and the spoon” or sentences such as “The bag is next to the spoon” were initiated much faster when distractors were form-related to the first noun (“bell”), but also found a small inhibitory trend when distractors were form-related to the second noun (“spouse”). Costa and Caramazza (2002) observed that when speakers named coloured pictures and produced multi-word phrases of the type determiner+adjective+noun (“the green plane”), latencies were shorter with distractors 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.

A new technique to investigate phonological planning, and based on phoneme repetition, was introduced by Damian and Dumay (2007, 2009; see also Spalek & Damian, 2008, for a cross-linguistic investigation). In these experiments, participants named coloured objects (line drawings) as quickly as possible using adjective+noun phrases. Nouns and objects were paired such that the adjective and the noun overlapped in segmental content (“green goat”) or did not (“red goat”). Naming latencies were shorter in the former (related) than in the latter (unrelated) condition. Given

that here the identity of a segment of the second word appears to affect the time it takes speakers to initiate the utterance, one can conclude that speakers must have, at least, co-activated the two phonological forms prior to response initiation.

In the experiments reported below, we capitalized on this effect to assess the extent to which the scope of phonological co-activation is modulated by the syntactic properties of the utterance. One theoretical possibility is that the amount of phonological co-activation within the utterance is strictly determined by the quantity of resources available at a given time, irrespective of higher-level constraints, such as the syntactic roles of the various elements. For instance, the model of phonological advance planning outlined by scheniak, Schriefers and Hantsch (2003) stipulates that the sequential order of successive phonological word forms is encoded as an activation gradient, such that the first word of the utterance receives the most activation, the second one less, the third one still less, etc. Under this account, advance planning is thus exclusively driven by the number of coming lexical elements. However, an alternative scenario is that the degree of co-activation at the form level is constrained by the syntactic structure of the utterance, a possibility which we assessed in the five experiments reported in this paper.

Evidence supporting the latter scenario comes from a set of studies which suggest that semantic/syntactic planning (and therefore also the access to the lower, phonological level) is constrained by the syntactic organisation of the utterance. Schriefers and Teruel (1999) asked German speakers to 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 the distractors related to the noun ("Stuhl" [chair]) was found on naming latencies at SOA - 150 ms, whereas a similar effect from the distractors related to the adjective ("rot" [red]) was found at a later time point (SOA +150 ms). Critically, French speakers tested on an equivalent task, thus using phrases with postnominal adjectives ("la table verte") showed a different pattern: the semantic distractors related to the noun had an effect at early SOAs, but the distractors related to the adjective produced no effect whatever the SOA. Schriefers and Teruel therefore 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, and whether or not the adjective is part of the grammatical planning window strictly depends on its position relative to the noun.

Assuming this is actually how things work, the position of the noun should also constrain the degree of phonological planning and, with adjectival phrases, a similar cross-linguistic dissociation at the phonological level should be observed. In languages with postnominal colour adjectives, such as French and Spanish, phonological manipulations targeting the non-initial adjective should not affect naming latencies, as planning up to the noun should be enough for

articulation to proceed. By contrast, in languages with prenominal adjectives, such as German and English, phonological manipulations targeting the non-initial noun should affect onset latencies. This view therefore predicts that the effect of phoneme repetition which we reported for English adjective+noun phrases (Damian & Dumay, 2007, 2009) should not replicate in languages with postnominal adjectives.

Whether this is the case is still an open question. However, it is already worth noting that picture-word interference data obtained by Costa and Caramazza (2002) are not patible with the Schriefers and Teruel (1999) suggestion. In this experiment, Spanish speakers had to name coloured pictures using phrases of the type "det+noun+adjective" ("la casa azul" [the blue house]), while visual distractors semantically or phonologically related to the adjective were presented. Despite the postnominal position of the adjective ("azul"), both classical effects of semantic interference and phonological facilitation were found, leading the authors to conclude that at the phonological level phrases are encoded independently of the grammatical status of their constituents.

In the present series of experiments, we investigated whether the effect of phoneme repetition between the adjective and the noun which we found in English (Damian & Dumay, 2007, 2009) generalizes to languages with postnominal adjectives. Whereas Experiment 1 reproduced the baseline effect in English, Experiments 2 and 3 assessed its counterparts in Spanish and French. In the latter experiments, we found no effect of phoneme repetition, suggesting that phonological planning is indeed constrained by syntactic structure (cf. Schriefers & Teruel, 1999). However, an alternative account, relying on the relative temporal availability of the colour and the object dimension, is also possible. Let us assume that in line drawings colour identification is slower than object identification. In English, the object name, which should therefore be retrieved first, yet occupies a non-initial position, and so a phonological effect from the name onto the adjective should be observed. By contrast, in Spanish and French, the object name has to be produced first, and so the fact that one of its phonemes is repeated in the following adjective should not affect performance. Experiments 4 and 5 tested the "relative temporal availability" account in English and Spanish, by manipulating the saliency of the colour dimension. Through a simple display inversion procedure, the objects in the latter experiments were presented as white lines on coloured background.

Experiment 1 - English

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 coloured pictures (line drawings) of common objects with monosyllabic names (average length: 3.5 phonemes; average spoken frequency: 17.7 counts per million; Baayen, Piepenbrock & Gulikers, 1995). In the phonologically related condition, objects and colours (blue, green, pink and red) were combined such that the initial phonemes of the adjective and the noun (and in two cases, also the following vowels) coincided (“blue bed”; the average phonemic overlap represented 34.8% of target length); in the phonologically unrelated condition, objects and colours 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 colours, 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 Pictures of size 7 x 7 cm were presented centrally on a computer screen for 1,800 ms, following a 500-ms fixation cue. Naming responses were captured using a high-quality headset microphone and utterance onset latencies were 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 were to be presented, and instructed to name as quickly as possible what they saw, 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

Reaction times accompanied by an incorrect response, i.e., stutters, hesitations, or other than the expected one (4.7%) were excluded from the chronometrical analysis. Latencies smaller than 250 or larger than 1,500 ms (1.3%) were also excluded. All results are reported in Table 1. In this and the following experiments, the data points were analyzed using a linear mixed effects methodology (Baayen, 2007). Naming latencies were significantly faster in the related than in the unrelated condition ($F(1,562) = 7.56$, $MSE = 163,090$, $p < .01$). Error rates were slightly lower 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 reported by Damian and Dumay (2007, 2009), with a substantial facilitatory “activation exchange” between the phonology of the adjective and that of the noun. Having confirmed our baseline effect in English, we could then look at languages in which colour adjectives systematically occur in postnominal position. Experiment 2 used the Spanish language.

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

	Unrelated	Related	Difference
Exp. 1 (English)	806 (5.3)	766 (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)

Experiment 2 - Spanish

Methods

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

Material, design and procedure The materials were devised along the same lines as in Experiment 1. Twenty common objects with bisyllabic names (average length: 4.1 phonemes; spoken frequency: 20.0 counts per million; Real Academia Española) were depicted as line drawings in four colours (blue, red, green and brown). In the related condition (“ajo azul” [blue garlic]), the average overlap represented 41.5% of target length. Apart from the instructions, to name the pictures using a phrase of the type “noun+adjective”, and a smaller number of fillers (64), all other procedural aspects were identical to Experiment 1.

Results and Discussion

Overall, 3.9% of the trials were classified as errors, and a further 0.6% of the latencies were excluded from the response time analysis as outliers. As Table 1 shows, naming latencies in the related and unrelated conditions were virtually identical, with no significant effect of overlap ($F < 1$), and error rates showed no effect of overlap either ($F < 1$).

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 a strong positive influence on the naming performance in the prenominal-adjective, English case, but no influence whatsoever in the postnominal-adjective, Spanish case. However, before we attempt to make sense of these findings, and because our failure to obtain facilitation in Spanish may be seen as a null result, Experiment 3 tried to give the effect a second chance, by testing another language with postnominal colour adjective, i.e., namely French. In this as in the English experiment, we were able to restrict ourselves to monosyllabic nouns and adjectives, meaning that the temporal distance between the initial phoneme and its repetition was shorter than in the Spanish experiment; we also had a larger picture set and tested more participants.

Experiment 3 - French

Methods

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

Material, design and procedure Thirty-two common objects with monosyllabic names (average length: 3.2 phonemes; average spoken frequency: 6.5 counts per million; Content, Mousty, & Radeau, 1990) were depicted as line drawings in four colours (blue, grey, green and mauve). 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

Overall, 4.3% of the trials were classified as errors, and a further 1.2% of the latencies were treated as outliers. As can be seen Table 1, naming latencies in the related and unrelated conditions were again very similar, with no significant effect of overlap ($F < 1$). Likewise, there was no effect of overlap on the error rates ($F < 1$).

As observed with Spanish speakers (Experiment 2), French speakers did not show any effect of phonological overlap between the colour adjective and the noun. Together these two experiments thus suggest that phonological coding 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 syntactic encoding is determined by the position of the head noun; if in Spanish and French the postnominal adjective is not encoded before articulation proceeds, there is no reason to expect any logical influence from the adjective onto speech onset latencies.

However, before concluding that the discrepancy between English, and Spanish and French, reflects a genuine cross-linguistic dissociation, an alternative account in terms of the relative temporal availability of the colour and the object dimension has to be assessed. Assuming that in line drawings colour identification is slower than object identification, a phonological effect should be easier to obtain in English, where the object name which should be retrieved first yet comes second in the utterance, than in Spanish and French, where the object name, whether or not retrieved first, has to come first in the utterance. However, whether this scenario applies is not straightforward: if colour identification in line drawings may be particularly difficult compared to plain patches (Kuipers & La Heij, 2009), the fact that we used at least 20 objects and only four colours conversely could make colour names easier to retrieve than object names.

In the subsequent experiments, we tackled the “relative time course” account by inverting the colour display, such that objects were now shown as white lines on four possible

coloured background. Display inversion, if successful in rendering colour information more salient, should speed up English speakers: in their language colour adjectives have to come first in the utterance and no gender agreement with the noun is required. Crucially, if, despite increased colour saliency, still no phoneme repetition effect emerges in a guage in which colour is named postnominally, we will be in a strong position to argue that the dissociation observed indeed reflects a genuine cross-linguistic difference in the scope of planning. English was assessed in Experiment 4, whereas the postnominal case was assessed in Spanish in Experiment 5.

Experiment 4 - English (with inverted display)

Methods

Participants Sixteen undergraduates from the University of Bristol, all native speakers of English, 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 background, rather than the lines of the drawing.

Results and Discussion

Overall, 5.8% of the trials were classified as errors, and a further 0.3% of the latencies were treated as outliers. As Table 1 shows, naming latencies were significantly faster in the related than in the unrelated condition ($F(1,563) = 11.14$, $MSE = 124,516$, $p < .001$), whereas there was no significant effect of overlap on 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 ($F(1,1125) = 10.69$, $MSE = 218,545$, $p < .001$), and that the strength of phonological facilitation was unaffected by display inversion ($F < 1$). In addition, error rates indicated a facilitatory trend in the related condition ($F(1,1196) = 2.94$, $p = .09$).

The significant reduction of the naming latencies with inverted (compared to the standard) colour display states that the manipulation introduced in Experiment 4 made colour more salient and so retrieval of the corresponding adjective much quicker. Yet, the fact the phonological facilitation is unaffected by increased colour saliency states that English speakers are still unable to initiate their response based just on colour information. Having shown that colour display inversion speeds up retrieval of the adjective, Experiment 5 applied the manipulation to the Spanish language.

Experiment 5 - Spanish (with inverted display)

Methods

Participants Sixteen undergraduates from the University of Murcia, all Spanish native speakers, 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 background.

Results and Discussion

Overall, 6.3% of the trials were classified as errors, and a further 0.3% of the latencies were treated as outliers. As can be seen Table 1 and to our surprise, naming latencies were now substantially *slower* in the related than in the unrelated condition ($F(1,1205) = 6.78$, $MSE = 124,257$, $p < .01$), whereas corresponding error rates did not differ statistically ($F < 1$).

As indicated by a combined analysis of Experiments 2 and 5, the inhibition obtained on the latencies under display inversion was statistically distinct from the null effect found in Experiment 2 ($F(1,1205) = 4.00$, $MSE = 74,532$, $p < .05$). This inhibition is clearly at odds with Schriefers and Teruel's (1999) hypothesis that the planning scope is 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 effect of phoneme repetition to explore whether the syntactic role of an utterance constituents modulates the scope of phonological planning. Experiment 1 replicated the baseline effect in English, using colour adjective+noun phrases, but Experiments 2 and 3 fail to find its counterpart in Spanish and French, languages where colour adjectives by contrast occur in postnominal position. The last two experiments increased colour saliency by inverting the display, such that colour information was conveyed by the background rather than by the lines of the drawing. Experiment 4 sped up English speakers' naming latencies and thereby confirmed that display inversion had the desired effect. Crucially, Experiment 5, carried out in Spanish, showed that, provided increased colour saliency, phonological overlap between nouns and postnominal adjectives can result in the inhibition of the naming responses.

Our finding of phonological inhibition with increased accessibility of a non-initial constituent converges with the inhibitory trend reported by Meyer (1996; cf. Introduction). It also converges with the inhibition observed again in the picture-word interference paradigm by Jescheniak et al. (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 substantial a facilitation in bare nouns, which decreased in the "det+noun" phrases and turned into inhibition in the longer, "det+adjective+noun" phrases. By contrast to the facilitation observed with ance-initial constituents, priming a non-initial constituent thus appears more likely to induce interference. In any case, our phonological inhibition effect in Spanish is incompatible with Schriefers and Teruel's (1999) suggestion, in which syntactic 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 internal parts of the object, 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 ones.

The theoretical account of phonological encoding in multiword 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 an indirect cost, as it temporally turbs the activation gradient that codes for the sequential order of the constituents. Thus, in extreme cases, this may in fact result in an overt speech error ("the big house r, 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 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 on the task settings, with the possibility that both effects cancel each other out.

How Jescheniak et al.'s (2003) "phonological activation gradient" theory accommodates the present data is not straightforward though. According to the model, word order is coded by the activation gradient, meaning that by default in the English utterance "green goat", "green" is more activated than "goat". If an exchange of activation between the two related word forms underlies our phoneme repetition effect (cf. Damian & Dumay, 2007, 2009) both elements should be easier to retrieve. However, as part of this

change, and given the activation gradient, the non-initial element “goat” should receive more activation than it can give, with the net result that the gradient should be disturbed, thereby counteracting the retrieval of the initial element (“green”). Nonetheless, it is probably safe to assume that, relative to priming, gradient disturbance is weak, otherwise speakers would produce words in the wrong order. Under the right parameters, the model could thus explain the facilitatory effect of phoneme repetition obtained in English.

However, the model is blind to higher-level variables, such as word class, and only considers the sequential position of the elements. It therefore makes the same prediction for Spanish/French postnominal-adjective constructions. One possible modification that would enable the model to explain our full pattern of effects would therefore be to sum 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 (and thus the corresponding noun) 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 it is 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, contrary to fers and Teruel (1999). The interplay between an activation gradient, coding word order, and an activation bias, coding the syntactic role of the constituents, is sufficient to account for the divergent pattern of results obtained from languages with different word order.

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