A WORD-ORDER CONSTRAINT ON PHONOLOGICAL ACTIVATION

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Abstract

Word-order rules impose major constraints on linguistic behavior. For example, adjectives appear before nouns in English, and after nouns in French. This means that constraints on word-order must be language-specific properties upheld on-line by the language system. Despite their importance, little is known about how these rules operate. We report an influence of word-order on the activation of phonological representations. Participants were presented with colored objects. They named either the color or the object while the phonological similarity between words was manipulated. French speakers showed a phonological congruency effect in color but not in object naming. English participants yielded the opposite pattern: A phonological effect in object, but not in color naming. Differences in the typical order of nouns and adjectives in French and English offer a plausible account for the cross-linguistic contrast. More generally, these results provide direct evidence for the operation of word-order constraints during language production.

Many languages impose constraints on the order in which words from various grammatical classes appear in a sentence. Compare, for example, the following English and French noun phrase (NP) fragments:

1. blue_{ADJ} car_{N}
2. $\text{voiture}_{\text{N}}$ $\text{bleue}_{\text{ADJ}}$

Whereas in English, adjectives appear *before* nouns, in French, adjectives typically appear *after* nouns. This example suggests that constraints on word-order are language-specific properties upheld on-line by the language system. Within the field of language production, relatively little research has been dedicated to understanding word-order constraints (some exceptions are: Bates, Wulfeck, & Juarez, 1988; Bock, 1987; Cleland & Pickering, 2003; Dell & Reich, 1981; Garrett, 1976; Hartsuiker, & Westenberg, 2000; Janssen, 2005). In the current article, we investigated how word-order influences the activation of phonological representations.

The prevalent view in language production models is that phonological representations are activated by means of a cascading flow of activation from the lexical level. As soon as a lexical representation is activated, its corresponding phonological representations are activated (see Goldrick, 2006 for a review; but see Levelt, Roelofs, & Meyer, 1999). The phonological congruency effect of Morsella and Miozzo (2002) was interpreted in support of this hypothesis. These authors observed that naming a target picture (e.g., dog) is faster in the context of a distracting picture that is phonologically congruent (e.g., doll) compared to incongruent (e.g., bell). The account of this finding assumes that the activation of the context picture name cascades to its phonological representations. When the context and target phonological representations are congruent, their activation and selection is achieved faster (Goldrick, 2006, and references therein; see also Meyer & Damian, 2007; Morgan & Meyer, 2005; but see Bloem & La Heij, 2003).

This unregulated cascading hypothesis states that any active word representation will activate its phonological representations. This simple view is problematic for utterance production, where many words that will ultimately be produced are concurrently active. Under such circumstances, it is not obvious how target phonological representations are distinguished on-line from non-targets. One solution is to assume incremental activation of phonological representations constrained by the linear relationships among lexical items. For example, if word-order constrains phonological activation, then at any point in time phonological representations of earlier words receive stronger activation than those of later words (e.g., Dell, 1986). Evidence for this hypothesis is scarce. Some results consistent with it were reported in studies investigating the scope of phonological encoding during multi-word production with the picture word interference paradigm. Jescheniak, Schriefers, and Hantsch (2003) observed that phonological priming effects were modulated by word position. This was taken as evidence for graded phonological activation of the words composing the target utterance (see also Costa & Caramazza, 2002; Damian, & Dumay, 2007; Dell, Burger, & Svec, 1997; Meyer, 1996). Consider in this context the two NP examples given above. If word-order constrains phonological activation, then the canonical word-order will initially lead to greater activation of adjective over noun phonology in English, and the opposite should happen in French.

Navarrete and Costa (2006) extended the evidence in support of a cascading flow of activation to the situation where an adjective and a noun are concurrently active. Spanish participants named the color of colored objects faster when the phonological onset between color and object name was congruent (e.g., *v*ela *v*erde [green candle]) compared to incongruent (e.g., *v*ela *a*zul [blue candle]). In Spanish, nouns typically appear before adjectives. The hypothesis that word-order modulates phonological activation explains the phonological congruency effect in adjective naming by assuming early noun activation. This hypothesis further predicts that object noun naming should not be influenced by color adjective phonology. This is because, in Spanish, the activation of noun phonology should precede the activation of adjective phonology.

We tested this prediction in Experiment 1, where French speakers named either the color or object of colored objects. In French, object nouns typically appear before color adjectives. The word-order modulation hypothesis predicts a phonological facilitation effect for the adjectives, but not for the nouns. Alternatively, finding similar phonological effects for nouns and adjectives would argue against the hypothesis.

Experiment 1 – Color and object naming in French

Methods

Participants

Thirty-two native speakers of French participated in the Experiment. Half of them performed the color naming task, and half the object naming task. They were students at the Université de Provence, France. They received course-credit for participation.

Materials and design

Four colors (red, green, blue and orange) were used. To create the congruent condition, a set of seven pictures (Alario & Ferrand, 1999) was selected for each color such that each picture in the set shared at least the onset consonant with the color name. The incongruent condition was created by re-pairing each picture set once with a color such that picture names and color names did not overlap in phonology (see Appendix). An additional set of 28 pictures was selected and paired twice with color names that did not overlap in phonology. The ratio of congruent to incongruent trial was 1:3. Finally, eight practice items were selected among filler items. Colored pictures were created by coloring the normally black line-drawing into one of the four designated colors.

Items were pseudo-randomized into four blocks of trials. Each block consisted of an equal number of trials from each condition, each picture appearing once, and each color appearing an equal number of times. There were never the same colors or pictures with a semantic or phonological relationship on consecutive trials. There were no more than three items from the same condition in a sequence. The order of the blocks was counterbalanced following a Latin-square design.

Procedure

Participants performed either the object or the color naming task. They sat in front of a PC with an attached microphone. The experimental software was DMDX (Forster & Forster, 2003). In both object and color naming, there were three parts in the experiment. First, participants were familiarized with the objects and their names. On each trial, they saw a fixation cross (700 ms), followed by a blank screen (200 ms), followed by the picture (1000 ms), finally followed by the picture with its name (1000 ms). Participants named the picture aloud. Participants in the color naming task were told the four color names. Part two (task training) and part three (experiment proper) had identical trial structures: a fixation cross (700 ms), followed by a blank screen (200 ms), followed by the picture of the colored object (1500 ms). Depending on the instruction, participants named the object or the color (with the unmarked adjective) upon picture presentation. The experiment lasted 25 minutes.

Results

We report the results for color and object naming separately. Errors, non-vocal responses, and no-responses were discarded from the analysis. For each participant, reaction times (RTs) larger than 3 standard deviations above or below the participant's mean were also discarded. There was one main factor in each analysis: Phonological Congruency (Congruent vs. Incongruent). Participants (t1) and items (t2) were random factors. An overview of the data is presented in Table 1.

Color naming. 3.3% of the trials were discarded. The RT analysis revealed a main effect of Congruency ($t1(15) = 3.43$, $p < .004$, Prep = .971, $d = 1.77$; $t2(27) = 2.86$, $p < .004$, Prep = .963, $d = 1.10$). RTs in the congruent condition were shorter than in the incongruent condition. There was no effect of congruency in the error analysis (both ts<1).

Object naming. 4.1% of the trials were discarded. Neither the analysis of RTs nor errors revealed an effect of Congruency (all ts<1).

TABLE 1 HERE

Discussion

The results revealed a phonological congruency effect in color naming (see Navarrete & Costa, 2006) but not in object naming. These results are consistent with the assumption that word-order constraints modulate the activation of phonological representations. This assumption predicts a phonological congruency effect in color, but not in object naming. However, an alternative, non-linguistic interpretation is possible. The results could be due to differences in the speed of processing objects and colors which, in turn, can lead to differences in how fast the phonology of the object and color name are activated. For example, if the phonology of the object name were activated faster than the phonology of the color name, then the activation of object name phonology would affect color naming. However, object naming would not be affected by the slower activation of color name phonology, the latter being activated too late. Note that object naming latencies are overall slower than color naming latencies (Table 1). This, however, does not necessarily exclude faster phonological activation for nouns over adjectives.

In Experiment 2 we put this alternative hypothesis to a test with native English speakers. In English, nouns and color adjectives appear in the opposite order of French. If the results of Experiment 1 arose due to language independent processing speeds of colors and object names, then the same pattern of phonological congruency effects is expected. Alternatively, if the results of Experiment 1 arose due to the influence of language-specific word-order constraints, then the opposite pattern is expected: A phonological congruency effect in object but not in color naming.

Experiment 2 – Color and object naming in English

Method

Participants

Thirty native speakers of English participated in the experiment. Half of them performed the color naming task, and half the object naming task. They were students at Harvard University, USA. They received course-credit for participation.

Materials, design, and procedure

The design, procedure and analysis were identical to Experiment 1. The four colors were: red, green, blue and pink. Each color was paired with ten pictures (see Appendix).

Results

An overview of the data is presented in Table 1.

Color naming. 3.8% trials were discarded. The RT analysis revealed no effect of Congruency (both $ts<1$), nor did the error analysis ($t1(14)=1.1$, $p = .31$, Prep = .739, $d = 0.59$; $t2 < 1$).

Object naming. 3.5% trials were discarded. The RT analysis revealed an effect of Congruency ($t1(14) = 3.20$, $p < .007$, Prep = .960, $d = 1.71$; $t2(39) = 3.18$, $p < .003$, Prep = .980, $d = 1.02$). RTs in the congruent condition were shorter than in the incongruent condition. There was no effect of congruency in the error analysis (both $ts<1$).

Discussion

In contrast to Experiment 1, the results of Experiment 2 showed a phonological congruency effect for object but not for color naming. This observation rules out the possibility that the results of these experiments are due to non-linguistic differences in the retrieval speed of object and color name phonology. If such were the case, one would have expected the same pattern of phonological congruency effects in Experiments 1 and 2. The alternative word-order hypothesis provides an accurate account of the contrastive results in French and English, based on a clear contrastive property that differentiates these two languages.

Could other language-specific properties be responsible for the results? Lexical properties are unlikely candidates. The ratios of adjective and noun lexical frequency across trials were similar in both experiments (average in French: 20; in English: 15; $t(134) <1$). The same was true for word length (average in French: .9; in English: .9; $t(134)<1$).

Another important difference between French and English NPs is that the former often require grammatical gender agreement, while the latter never do (Corbett, 1991). Consider then the following scenario. In general, color names are retrieved faster than object names, hence explaining the English data. In languages with grammatical gender, however, these differences in the speed of color and object name retrieval would be reduced because of the dependencies imposed by agreement processes on adjective and noun retrieval. In French, the phonological form of adjectives depends on the grammatical gender of the corresponding noun. The faster processing of the adjective phonology would be delayed until the gender of the corresponding noun is available.

Although suggestive, this explanation does not accurately account for the pattern of results observed in Experiment 1. If the dependency of gender agreement brings the speed of color name processing on a par with object name processing, one expects a phonological congruency effect in both color and object naming. Given that this was not observed, this explanation (as well as any explanation that equates the two activation speeds to honor agreement constraints) is unlikely[1].

General Discussion

In two experiments, participants were presented with colored objects while the phonological congruency between the color and object name was manipulated. In Experiment 1, with French participants, a phonological congruency effect was found for color (see Navarrete & Costa, 2006) but not for object naming. In Experiment 2, with English participants, the opposite pattern of results was obtained: phonological congruency effect for object but not for color naming.

Language independent processing speeds of colors or objects, or differences in the requirement of gender agreement in the NP cannot account for these results. Rather, we assume that, when presented with colored objects, the activation of the phonology of the color and object names is modulated by language-specific word-order constraints. Specifically, given that French nouns typically precede adjectives, the activation of noun phonology is initially favored over the activation of adjective phonology. Consequently, the activation of

[1] To further tease apart the individual contributions of word-order and gender to our pattern of results, one could investigate the appearance of the phonological congruency effect in color and object naming in a language that shares relevant word-order constraints with English and gender-agreement with French (e.g., Dutch).

object name phonology primes color naming. The later activation of color name phonology does not prime object naming. The opposite pattern of results is expected, and observed, in English.

A surprising aspect of the findings is that participants were producing single words – adjectives or nouns – not complete NPs. This means that the word-order constraint postulated here would be operational even for single word utterances. This constraint could stem from the partial activation of a canonically ordered NP frame (e.g., Garrett, 1976), from word-order information present in the lexical representation of the items (e.g., Levelt, 1989), or in statistically learned biased mappings linking object and colors to nouns and adjectives (e.g., Dell, Reed, Adams, & Meyer, 2000). For now, the results we report do not adjudicate between these possibilities. They indicate that when multiple words are activated, the activation of their phonological representations through cascading is modulated by language-specific word-order properties. This phenomenon provides some insight in how word-order is used for producing language.

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Appendix – Picture names

Experiment 1: râteau (rake), règle (ruler), renard (fox), requin (shark), robe (dress), robinet (sink), roue (wheel), ballon (balloon), banc (bench), barbecue (barbecue), bougie (candle), bouteille (bottle), bouton (button), bureau (desk), vache (cow), valise (suitcase), vase (vase), verre (glass), violon (violin), vis (screw), voiture (car), œil (eye), oignon (onion), oiseau (bird), orange (orange), oreille (ear), orteil (toe), ours (bear)

Experiment 2 : rabbit, rake, racket, rocket, ruler, rat, rope, record, ring, road, broom, bow, barn, barrel, bike, bottle, bear, bed, ball, book, glove, giraffe, guitar, grave, globe, ghost, glasses, goat, gun, glass, paddle, pitcher, parrot, peanut, plug, pear, pen, pants, pig, pipe

Table

Table 1. Mean RTs, error rates, and 95% Confidence Intervals (CI) in Experiments 1 and 2.

		Congruent	Incongruent	*Diff*	*CI*
EXP1 - French	Color	595 (2.9)	622 (3.8)	27	11
	Object	660 (4.0)	664 (4.2)	4	9
EXP2 - English	Color	616 (3.2)	619 (4.3)	3	6
	Object	689 (3.7)	705 (3.3)	16	6