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Heavy constituent extraposition: experimental evidence for parallel processing¹

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Dominant models of speech production have employed linguistic components with a high degree of functional specialization, positing that phonological processing occurs only after semantic and syntactic processing has been completed (e.g., Levelt 1989). It has also been claimed, however, that processing at the phonological level can affect syntactic structure (e.g., Wasow 1997, Zubizarreta 1998). The experimental results to be presented here show effects on Dutch syntactic structure that appear to be related to separate factors of definiteness and prosodic weight. These results are thus generally consistent with modular models of language ability. However, because they suggest that purely prosodic factors can influence syntactic structure, they provide evidence for feedback from phonology to syntax. While in conflict with models that posit serial processing (e.g., Levelt 1989), these results are compatible with models that hypothesize parallel encoding and competitive constraints (e.g., Jackendoff 1997).

Two interactive-game task experiments investigated influences on Dutch speakers' extraposition of a prepositional adjunct from a DP. The first experiment demonstrated an influence of definiteness on the use of extraposition constructions. The second experiment demonstrated an influence of prosodic weight in the likelihood of PP extraposition from definite DPs. Speakers in this experiment were significantly more likely to extrapose PP adjuncts of two prosodic words than they were to extrapose PP adjuncts of only one prosodic word. The influence of prosodic word-length suggests that the process of speech production cannot be strictly serial, supporting the idea that constraints coming from separate components compete in the interface. Section 1 provides some background on the syntactic construction used in our experiments. Section 2 and 3 describe our experiments and the results. Section 4 discusses the implications of our results for models of language.

¹. This paper comes out of research conducted as part of the Language in Use project at Utrecht University. Acknowledgement is owed to Theo Veenker and Rianneke Crielaard for their assistance in setting up and running the experiments, and to the participants of the Prosody in Processing Workshop in Utrecht, July 2001, for their comments on a previous presentation of our experimental results.

1. PP extraposition in Dutch

A grammatical alternation between the constructions in (1) exists for many speakers of Dutch. This alternation is similar to one in English (cf. (2)), in that the length of the verbal complement influences grammaticality. Speakers of English judge sentences in which only a very "light" constituent occurs after a verbal particle as ungrammatical (cf. (2)). The alternations are otherwise quite different, however. In English, the entire DP appears to the right of the verb particle *up*. In the Dutch alternation, the adjunct PP is extraposed out of the DP that it modifies.

- (1) (a) Nu pakt ze de reisgids van Tuko Tipo op.
 (b) Nu pakt ze de reisgids op van Tuko Tipo.
Now she's now picking the travel guide for Tuko Tipo up.
- (2) (a) Now she's picking the travel guide for Tuko Tipo up.
 (b) Now she's picking up the travel guide for Tuko Tipo.
 (c) Now she's picking it up / *Now she's picking up it.

The influence of "heaviness" seen here is also evident in other alternations frequently discussed in the linguistics literature (dative alternation, e.g., Greene 1989, Arnold et al., 2000, Snyder 2001; heavy-NP shift, e.g., Zec & Inkelas 1990, Birner & Ward 1998, Zubizarreta 1998). These alternations have long posed problems for syntactic analysis, and present a further question regarding the nature of this heaviness: does it reflect syntactic complexity, discourse factors of information structure, prosodic factors, or some combination thereof? Given the fact that heavy constituents tend to have greater syntactic complexity, higher information status and greater prosodic complexity, it is difficult to distinguish these factors in ordinary circumstances (Ladd 1996). We therefore designed our experiments to separate prosodic complexity from the other factors.

Before arguing for a clear role for prosodic weight in sentence production on the basis of the experimental results to be reported here, we must briefly address the controversy surrounding the syntactic status of PP extraposition. PP extraposition has long posed problems for syntactic analysis, and various competing proposals have emerged, none of which has been broadly accepted (see den Besten & Rutten 1989, den Dikken 1995, Ackema & Neeleman to appear). This leaves open the possibility that PP extraposition is a post-syntactic stylistic or PF (phonetic form; Chomsky 1986, 1995) phenomenon rather than a syntactic one. Views that consider PP extraposition to be essentially a post-syntactic 'stylistic' or PF process, however, fall short of explaining its sensitivity to certain syntactic factors that become evident when the full range of PP extraposition data is considered. These syntactic factors include grammatical role, syntactic movement, unaccusative and resultative lexical effects, and related effects for aspect (see Cohan, Kager & Quené in review for an in depth treatment of this issue). PP extraposition must thus be carried out at a level where such syntactic information is available.

Our experimental findings suggest that prosodic information is also available at this level. Two experiments were conducted that investigated the influence prosodic factors on PP extraposition from DP.

2. Experiment I

2.1. Methods

A cooperative, interactive game task was designed to encourage the spontaneous production of sentences in which extraposition of a PP out of a DP could be observed. The task was set up so that the participants played an interactive game in which there were two roles: reporter and prompter. The two players could not see each other's screens, and thus did not know what images the other player was viewing. The object of the game was for the prompter to determine the events of cartoon story based on her partner's descriptions of each panel of the cartoon. The prompter chose from a set of three images presented on her computer screen the one that best matched the reporter's description of the story panel that he was viewing. The prompter's speech was completely constrained by the rules of the game. She was only permitted to ask the specific questions that were provided to her on the computer screen, and could only signal that reporter's description was inadequate by repeating a question. Her speech was thus not part of the data analyzed. The reporter described the events of the stories presented in response to the questions posed by the prompter, but his speech was otherwise entirely unconstrained; these utterances comprised the data to be considered. These utterances were recorded, transcribed and coded for analysis.

The experiment included a practice round to ensure that the participants understood the instructions and to familiarize them with the task. Utterances produced during the practice round were not included in the analysis.

2.2. Materials

The materials consisted of a series of four cartoon stories that could be viewed on a computer screen. Each story consisted of a sequence of 10 panels to be viewed by the reporter and a matched sequence to be viewed by the prompter. One story was used in the practice round. The remaining three stories were used in the experimental portion of the experimental session.

Nonce place names appeared as text within each cartoon as part of an object depicted, for example, in the title of a book or brochure. When speakers would refer to such objects during the experimental task, they would be likely to produce a full DP containing the noun and its PP restrictor: e.g., *a brochure from X*. Nonce names controlled for any effect that familiarity of the place name might have on the performance of individual speakers: all names would be equally unfamiliar to all speakers. Nonce names also allowed controlling for syntactic and prosodic complexity. All the nonce forms had the same syntactic-semantic status: they were all referential DPs referring to some unfamiliar locale. We used nonce place names of three types: (1) two-syllable, single prosodic words (e.g., *Poto, Nomo, Kimo, Nipo, Timo, Mako, Patu*); (2) four-syllable, single prosodic words (e.g., *Pakitoto, Mukipoko, Topatuko, Pomanipo, Mopamito, Natokitu*) and (3) two prosodic words of two syllables each (e.g., *Topa Katu, Kopi Natu, Kamu Pako, Naki Pono, Puna Mupa, Tuko Tipo, Matu Piko*). The two-word status of the final category was taken to be purely prosodic, since the speakers' lexicons

could not contain lexical entries for the individual words in the two-word nonce name. Nonce place names also allowed for controlled comparison of possible effects of syllable length, since one-word two- and four-syllable items could also be compared.

The reporter sequence contained two introductory screens, followed by the eight panels of the cartoon story. The two introductory screens consisted of a list of place names that would appear in the cartoon story, and an overview of the complete cartoon story. These screens were intended to familiarize the reporter with the elements of the story he would have to relate to his partner. The remaining screens each consisted of one panel of the cartoon story. Above each of these panels appeared a "hint" verb, intended not only to cue the reporter to what was depicted, but also to encourage use of particular verb constructions in describing the panels, without otherwise constraining the reporter's speech.

Reporter screens were paired with prompter screens that contained three images, only one of which matched the image of the corresponding reporter screen (see Figure 1). Each prompter screen also contained a sentence or question to be read aloud. These were intended to prompt specific responses from the reporter that would enable the prompter to make a correct choice, and to encourage the reporter to produce the kind of utterances that were useful for analysis under the goals of the experiment.

Prompter asks:
Wat doet de vrouw in plaatje 3?
 "What is the woman doing in picture 3?"

Desired Reporter response:
Ze laat een boek over Tuko Tipo zien.
 "She's holding a book about Tuko Tipo up."

Figure 1: Sample Materials

The materials were thus designed to elicit spontaneously produced sentences which would nevertheless be controlled for syntactic structure, focus structure, reference and content, specifically sentences that could be analyzed for the occurrence of PP extraposition from DP.

2.3. Experimental Predictions

We predicted an effect of prosodic weight: specifically, that the heavier a PP adjunct, the more likely speakers would be to extrapose it from a DP. We also expected an effect for

discourse status/definiteness: speakers were expected to use PP extraposition more often from a discourse-new, indefinite DP than from a discourse-old, definite DP.

2.4. Participants

Sixteen native Dutch speakers (6 male, 10 female) were recruited to participate in the first experiment. All were students and employees of Utrecht University, ranging in age from 18-36 (mean age 24.4). Volunteers were not paid for their participation. Participants were naïve to the purposes of the experiment.

2.5. Data & Analysis

Because of the spontaneous nature of the data collected, many of the utterances containing nonce names in PP adjuncts were not analyzable for the purposes of the experiment and the issues it was designed to investigate. These utterances were excluded from the data before statistical analysis was performed.

Analyzable utterances were those in which PP extraposition from a direct object could potentially occur (i.e., represented a syntactically well-formed alternative to an utterance without extraposition), and could be observed if it did occur. Examples of such utterances appear in (3) and (4) below. Utterances (3a) and (4a) demonstrate the unmarked alternative, without extraposition, and (3b) and (4b), the alternative with extraposition.

- (3) Analyzable utterances with particle verbs:
- (a) ze neemt een folder van Nipo mee naar huis
she takes a folder from Nipo along to home
She takes a folder from Nipo home with her
 - (b) ze pakt een brief op uit Kamu Pako
she picks a letter up from Kamu Pako
She picks up a letter from Kamu Pako
- (4) Analyzable utterances with inflected verb and infinitive:
- (a) de man laat de vrouw een reisboek over Nomo zien
the man lets the woman a travel book about Nomo see
The man shows the woman a travel book about Nomo
 - (b) een vrouw laat een boek zien over Tuko Tipu
a woman lets a book see about Tuko Tipu
A woman shows a book about Tuko Tipu

Utterances that were not analyzable, and therefore excluded from the analysis, were those in which PP extraposition either could not occur (see examples in (5)), could not be observed if it were to occur (see (6)), or were otherwise not comparable to the kinds of utterances we wished to analyze (see (7)).

- (5) (a) hij wijst Topatuko af
he rejects Topatuko

46

J. Cohan, H. Quené, R. Kager, S. Nooteboom

- (b) ze maakt de envelop open waar Kimo opstaat
she opens the envelop on which Kimo appears
- (6) (a) ze kopen het boek vakantie in Kopi Natu
they're buying the book Vacation in Kopi Natu
(b) de man denkt na over een folder over Naki Pono
the man is considering a brochure about Naki Pono
- (7) (a) ze rekenen het boek af over vakantie in Pomanipo
they're paying for the book about vacation in Pomanipo
(b) een boek over Pana Mupa voorstellen
suggesting a book about Pana Mupa

The selection process yielded a set of 95 analyzable utterances.

2.6. Results

Speakers participating in Experiment I extraposed PPs containing nonce forms out of DPs in 27.4% of the analyzed utterances. The data were divided into two categories that would control for a possible effect of discourse status on the likelihood of PP extraposition. The first category included only the utterances involving indefinite DPs, which were always new, and the second, only those involving definite DPs, which in our data, were always discourse old. These data were analyzed separately to test our prediction that prosodic weight would have an influence on the likelihood of extraposition. The distribution of these data for the two categories appears in Table 1.

Table 1: Extraposition by nonce categories (Experiment I)

		Nonce Categories			
		1-2	1-4	2-4	
<i>Indefinite</i>	<i>n</i> extraposed	4	6	10	20
	%	40.0%	46.2%	45.5%	44.4%
	All	10	13	22	45
<i>Definite</i>	<i>n</i> extraposed	1	0	5	6
	%	5.3%	--	29.4%	12.0%
	All	19	14	17	50

Indefinite data: $\chi^2 = 0.058$, $df = 2$, $p = 0.97$. Definite data: incalculable.

Statistical analysis for frequency of extraposition by nonce category could only be performed for the indefinite data, as the frequency of extraposition from definite DPs in the data was too low for the calculation of statistics (predicted values less than 5). Contrary to our prediction, the data, which were otherwise controlled for discourse status/definiteness and syntactic structure, showed no effect for prosodic weight. Speakers were equally likely to extrapose PPs containing nonce forms across all three prosodic categories appearing in the materials. An analysis of the frequency of extraposition was not significant, and the null hypothesis could not be rejected.

Although the frequency of extraposition from definite DPs was too low for statistical calculation, the data nevertheless suggested a pattern that hinted at a possible role of prosodic weight in influencing the likelihood of PP extraposition from a DP. The likelihood of extraposition of one prosodic word items appeared to be lower (5.3% for PPs with two-syllable nonce forms and 0% for PPs with four-syllable nonce forms) than for the two prosodic word items (29.4%). We were thus motivated to investigate this issue further in a second experiment, the results of which are presented in section 3.

As the data in Table 1 suggest, experiment I did demonstrate a significant effect for the likelihood of extraposition from DPs for discourse status or definiteness. Speakers were significantly more likely to extrapose from discourse new, indefinite DPs than from discourse old, definite DPs (44.4% vs. 12.0%; $p < 0.01$; $\chi^2 = 9.07$, $df = 1$, $p = 0.003$), indicating an effect of definiteness of the DP on the likelihood of extraposition of a PP adjunct (see Table 2 and Figure 2).

Table 2: Extraposition from DP Type (Experiment I)

	Extraposition		All data
<i>Indefinite DPs</i>	20	44.4%	45
<i>Definite DPs</i>	6	12.0%	50
	26	27.4%	95

$\chi^2 = 9.07$, $df = 1$, $p = 0.003$

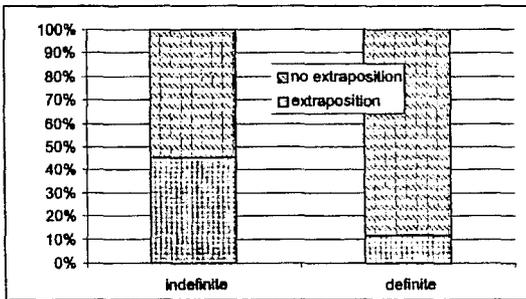


Figure 2: Extraposition from DP Type (Experiment I)

3. Experiment II

3.1. Methods & Materials

The methods and task used in experiment II did not differ from those used in experiment I. The materials used were adapted from those in Experiment I. Six additional cartoon stories were prepared, providing a total of 10 stories (one of which appeared in a practice round). Each cartoon story also contained an additional panel not appearing in the materials used in experiment I. This was added near the beginning of the story to

introduce all the objects that the reporter would refer to in her description, to encourage more frequent production of definite DPs in the second experiment.

3.2. Experimental Prediction

We again predicted an effect of prosodic weight: the heavier a PP adjunct, the more likely speakers would be to extrapose it from a definite DP.

3.3. Participants

Fourteen native Dutch speakers (5 male, 9 female) took part in the second experiment. Participants were naïve to the purposes of the experiment. All were students and employees of Utrecht University ranging in age from 18-36 (mean age 23.6). As an incentive for participation, the names of the participants were entered into a lottery for NLG. 150. This sum was awarded to a randomly selected participant.

3.4. Data & Analysis

As with the first experiment, utterances that were not analyzable for the purposes of the experiment were excluded from the data before statistical analysis was performed. All utterances containing indefinite DPs with nonce forms were excluded from the outset. Otherwise, the analyzed and excluded utterances were of the same kinds as those included in analysis of the first experiment (see section 2.5). The exclusion process provided 196 utterances for statistical analysis.

3.5. Results

Speakers participating in the task extraposed PPs containing nonce forms out of definite DPs in 22.4% of the analyzed utterances. A frequency distribution across all three prosodic categories indicated a non-significant trend in the predicted direction. Speakers were most likely to extrapose PPs with nonce forms of four syllables/two prosodic words (33.8%), less likely to extrapose PPs with nonce forms of four syllables/two prosodic words (18.0%) and least likely to extrapose PPs with nonce forms of two syllables/one prosodic word (15.7%). A χ^2 analysis of the likelihood of extraposition over prosodic word categories, however, was significant (see Table 3 and Figure 3). Adjunct PPs containing nonce items of two prosodic words were significantly more likely to be extraposed than adjunct PPs containing nonce items of a single prosodic word (33.8% vs. 16.8%, $p < 0.02$; $\chi^2 = 5.64$, $df = 1$, $p = 0.018$).

Table 3: Extraposition by prosodic word count categories (Experiment II)

	<i>Prosodic Word Categories</i>		
	1 PW	2 PW	
<i>n</i> extraposed	22	22	44
%	16.8%	33.8%	22.4%
All clauses	131	65	196

$\chi^2 = 5.64$, $df = 1$, $p = 0.018$

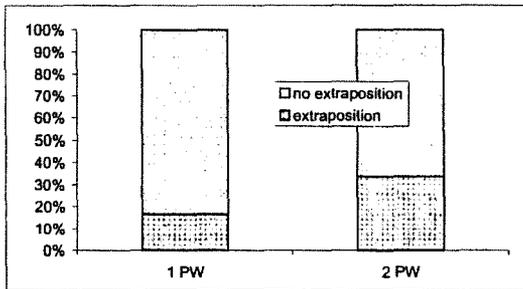


Figure 3: Extraposition by prosodic word count categories (Experiment II)

Notably, the relevant phonological category appears to be prosodic word rather than syllable, since the extraposition of adjuncts containing one-word two-syllable nonce forms (15.7%) did not differ from the extraposition of adjuncts containing one-word four-syllable nonce items (18%)

4. Discussion

Our experimental data indicate that PP extraposition from DP in Dutch is a relatively robust linguistic phenomenon in spontaneous speech. It is also apparently a complicated one, as its occurrence appears to be influenced by at least two factors: syntactic factors (see section 1), prosodic factors (see section 3.5), as well as possibly discourse factors (see section 2.6). The definiteness effect found in Experiment I could be related to the discourse status of the DP with which extraposition occurs, or to the syntactic nature of (in)definite DPs. This cannot be determined on the basis of our experiments, since indefinite DPs were always new, while definite DPs were always old in our data. The goals of our current research concern primarily the interaction of the first two factors and the syntax-phonology interface.

The findings of the Experiment II indicate that the likelihood of extraposition of a PP adjunct from a definite DP is related to the prosodic character of the adjunct. We interpret this effect of a prosodic factor on syntactic output as evidence of feedback from phonology to syntax, at a level of language at which information about the number of prosodic words is available.

Our results indicate an interaction between syntax and phonology (in the form of prosody) that is problematic for a strictly serial architecture for language. If prosodic phonology is something that is simply imposed on a given syntactic output, how could prosodic weight influence word order, as the results of Experiment II suggest? To complicate matters further, the influence of prosodic weight seems to be selective: the mechanism responsible for controlling extraposition of prosodically heavy PPs is apparently "aware" of DP definiteness, since it allows extraposition from indefinites quite freely, even with prosodically light adjuncts. If extraposition of heavy PPs was strictly a post-syntactic process, we would not expect it also to be influenced by syntactic factors

like grammatical role of the DP, lexical syntactic features of the main verb, movement operations, and definiteness.

It could be argued that the effect of definiteness on the likelihood of PP extraposition from DP is itself located in a post-syntactic discourse level of operation ordered *after* prosody. At the post-syntactic prosodic level, heavy PPs would be allowed to undergo extraposition (regardless of definiteness), and then at the post-syntactic discourse level, PPs with discourse new/indefinite DPs would be allowed to undergo extraposition (regardless of heaviness). This kind of ordering could result in something compatible with the definiteness effect we found, although it presents other problems. Crucially, the problem of the sensitivity of PP extraposition from DP to deep syntactic factors remains. Even if the extraposition of heavy PPs were to operate blindly with respect to a definite/indefinite distinction, the prosodic component would still need to be "aware" of the other syntactic factors that influence acceptability of PP extraposition.

This cannot be accounted for by a strictly serial model in which each component operates on the single output of the previous component. Adapting a serial model to incorporate feedback between components would greatly increase its complexity, as it would entail multiple feedback loops between the components. Our results are, however, compatible with models that employ parallelism in the form of competing constraints. In a parallel linguistic architecture like that proposed in Jackendoff 1997, the different demands of syntactic and prosodic phonology would be addressed by the conflict-resolving operation. Syntax would generate outputs compatible with its requirements, while phonology would generate outputs compatible with its requirements. The conflict-resolving operation would then choose from the outputs the one that best satisfies the demands of all components, and this would presumably serve as the input for articulation. This output could reflect the prioritization of prosodic phonology over syntax, something the output of a strictly serial model cannot do. In regard to the particular construction investigated here, syntax would produce outputs with or without PP extraposition from DP as its constraints allow, taking into consideration the syntactic factors known to influence the construction (i.e., grammatical role, lexical syntactic properties, indefiniteness, etc.). Phonology would produce prosodic outputs compatible with PP extraposition or not compatible with PP extraposition, as its constraints allow (i.e., prosodic weight, and presumably others like rhythmic constraints), leaving the conflict resolving mechanism to decide what should be passed along for articulation.

In another kind of parallel architecture (compatible with recent optimality theory models, Prince & Smolensky 1994, Grimshaw 1997, Bresnan 2000, Blutner 2000, Hendriks & de Hoop 2001), syntax could theoretically be ordered before phonology (as in a serial model), but it would generate in parallel multiple (ranked) outputs. Phonology would then operate in parallel on the multiple syntactic inputs, yielding itself multiple (ranked) outputs to be delivered as input to the subsequent component. Phonology would not need to be "aware" of particular syntactic constraints, it would need only take into account the relative rankings of the inputs. In this type of architecture, conflict resolution can occur within the individual modules. Specifically, syntax would produce outputs with and without PP extraposition. Outputs violating the fewest syntactic constraints would be ranked highest, and their rankings passed along as part of the output to phonology.

Phonology would operate on the multiple inputs, yielding ranked outputs that incorporate the relative rankings of the input, as well as prosodic constraints.

Parallel models allow prosodic factors to take precedence over syntactic constraints in some circumstances, and thus can account for the phenomena apparent in our experimental results.

5. Summary

Serial models of language cannot deal with the kinds of conflicts that natural language displays, at least not without adaptation that would result in a much greater complexity for its architecture. A parallel architecture, however, has built-in mechanisms that allow for the resolution of conflicts between components, and thus have an advantage over serial models in accounting for the complexity of interaction evident in our experimental results. Parallel models can allow for feedback between components, while preserving the modularity that has typically been assumed for the language faculty and which is supported by much linguistic and empirical data, including that discussed here. PP extraposition from indefinite DPs, for example, occurs freely, regardless of the prosodic character of the adjunct PP. Whether this effect is due to syntactic or discourse requirements is not clear from our data, but it is clear that it is independent of prosodic phonological requirements, consistent with the modular view of language. Our results also indicate, however, that this modularity is coupled with an interaction between components, since prosodic phonological factors can influence syntactic output. A model that incorporates parallelism in its architecture can deal with this type of interaction without sacrificing the notion of modularity. Theoretical models of language have already begun to reflect the spirit of parallelism to account for this kind of interaction, and the research presented here suggests that the implications of this type of architecture for language production deserve further exploration.

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