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It's not Just the “Heavy NP”: Relative Phrase Length Modulates the Production of Heavy-NP Shift

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Abstract

Heavy-NP shift is the tendency for speakers to place long direct object phrases at the end of a clause rather than next to the verb. Though some analyses have focused on length of the direct object phrase alone, results from two experiments demonstrate that the length of the direct object relative to that of other phrases, and not the length of the direct object alone, predicts production of the shifted structure. These data support an accessibility-based interpretation of length effects in word order emerging from incremental production processes, in which longer phrases tend to be less easily planned and therefore are delayed during utterance planning.

Keywords

Sentence production; Language production; Grammatical encoding; Heavy-NP shift; Constituent ordering

Introduction

Direct object noun phrases (NPs) typically are uttered just after their verbs in English, as in *Emma explained the regulations to Jim*, where the direct object *the regulations* appears immediately following *explained*. Other word orders (e.g., *Emma explained to Jim the regulations*) seem ungrammatical or awkward to English speakers. When the direct object becomes very long or “heavy,” however, it may optionally be uttered in clause-final position, as in *Emma explained to Jim all of the regulations regarding import and export taxes for pottery*. This additional phrase order option, often called “Heavy-NP Shift,” has received extensive attention in linguistics (e.g., Givón 1988; Hawkins 1994; Ross 1967; Wasow 1997; Zec and Inkelas 1990). In keeping with this literature, we will identify the late appearance of a direct object NP as “shifting,” though our use of this term does not imply that a “shifted” NP is literally moved during stages of production planning.

In contrast to its extensive treatment in linguistics, there has been relatively little attention to heavy-NP shift in the psycholinguistics literature. As a result, comparatively little is known about the comprehension of shifted structures (Staub et al. 2006), the utterance environments that permit the option of Heavy-NP shift (Stallings et al. 1998; Yamashita and Chang 2001) or the relationship of Heavy-NP shift to other length-based choices during production (Arnold et al. 2000; McDonald et al. 1993; Wasow and Arnold 2003). Two

important results have emerged, however. First, phrase length in number of words appears to affect Heavy-NP Shift and other length-based syntactic structure choices, while word-internal length, such as the number of syllables, does not (McDonald et al. 1993; Stallings et al. 1998). The reason for this contrast appears to reside in the sequence of operations executed during utterance planning, in which grammatical structure is assigned at a planning stage that is largely completed before phonological encoding processes commence, so that word length information is not available when syntactic decisions are made (Bock and Levelt 1994; McDonald et al. 1993). The unavailability of word length information during such stages is different from later planning stages, where word length does affect word order. Thus, ordered lists or conjunctions within phrases, where shorter words tend to precede longer ones, as in *to love and to cherish*, and *planes, trains, and automobiles*, utilize a *linearization* process within phrases that appears to be at a later planning stage where word length information can influence planning (McDonald et al. 1993).

A second finding is that, despite its name, the production of heavy-NP shift does not stem from properties of the NP alone. Both experimental studies (Stallings et al. 1998) and corpus analyses (Wasow 1997) have shown that the rate of shifting varies with the type of verb uttered, and verb properties also affect the ease of comprehending these structures (Staub et al. 2006). These results suggest that during the production process, several factors may conspire to yield greater or lesser rates of shifting in different circumstances, even with object NP length controlled. If so, the study of heavy-NP shift could shed light on the processes of grammatical encoding, the stage of language production in which producers translate a message into a syntactic structure (Bock and Levelt 1994). As Stallings et al. (1998) noted, shifted versus unshifted structures provide an interesting contrast from several other syntactic alternations that have been investigated in the production literature, because in heavy-NP shift, NPs retain the same grammatical roles independent of their phrase order—the direct object retains the same grammatical role no matter its location in the sentence. By contrast, the passive/active alternation affects both word order and grammatical role; for example, the NP *the regulations* has the role of direct object in the active sentence *Emma explained the regulations* and the role of subject in the passive sentence *The regulations were explained by Emma*. Contrasts between role-preserving and role-changing structures have been important in the development of theories of grammatical encoding (McDonald et al. 1993), and additional study of heavy-NP shift may similarly be informative.

Hawkins (1994) reported findings from a small corpus analysis that suggested that the rate of heavy-NP shifting was better predicted by “relative weight,” the length (in words) of the direct object NP relative to that of the other material in the verb phrase (e.g., a prepositional phrase such as *to Jim*), than by the length of the object NP alone. Several researchers have suggested that if speakers could weigh the relative length of the object NP versus other material during utterance planning, it would reduce processing load for the speaker. There is extensive evidence that production planning is incremental, such that speakers plan and begin to utter initial parts of an utterance while planning later portions of the utterance (Bock and Levelt 1994; Bock and Warren 1985; De Smedt 1994). Production fluency is maximized by placing more easily-planned or *accessible* sentence elements earlier in the sentence, so that these can be uttered while planning of more difficult material is underway. If shorter phrases tend to be more accessible, by virtue of having fewer words to plan, then they should tend to be placed earlier in the utterance plan, yielding more time to continue planning the longer, less accessible phrases (Bock and Levelt 1994; Chang 2009; De Smedt 1994; Wasow 1997). On this view, in which length is one factor modulating accessibility, and accessibility in turn shapes phrase ordering, it makes sense that the relative length of phrases, rather than the absolute length of only one element, would modulate the relative accessibility and thus phrase ordering in English. The available evidence on relative length stems from corpus analyses (Hawkins 1994; Wasow 1997) and judgments of acceptability

(Wasow and Arnold 2003), and is generally consistent with this relative length-accessibility view.

What is lacking, however, is an experimental test of the role of relative phrase length in production. Production experiments provide an important complement to other assessments of production processes such as acceptability judgment studies, which may reflect comprehension mechanisms more than production processes. Laboratory production studies also complement corpus analyses: studies of spoken or written corpora provide a naturalistic sample of utterances, but they also necessarily afford less control over the production environment than in a laboratory experiment, in that the element of interest (here, syntactic choices) may be confounded with other factors such as the topic being discussed, the linguistic genre(s) sampled in the corpus, and other factors. The interrelationships between factors such as these are ultimately critical to a full account of language use, but psycholinguistic theories of production mechanisms greatly benefit from experimental manipulations of a small number of factors and holding others constant. We therefore conducted two well-controlled production experiments investigating the relative length of the direct object NP and a verb-modifying prepositional phrase (PP) in order to investigate whether relative length of these constituents affects speakers' structure choices during language production.

Experiment 1: Manipulating PP Length

In this study, experimental participants constructed sentences from phrases appearing on a computer screen, with the dependent variable being the rate of sentences with heavy-NP shift structures (Verb PP object-NP) versus the more common Verb NP PP order. A modified recall-based production method was used (McDonald et al. 1993; Race and MacDonald 2003; Stallings et al. 1998; Yamashita and Chang 2001). Recall-based production tasks have become an important method in studies of sentence production, following Lombardi and Potter's (1998) findings that sentence recall is driven by speakers' regeneration of the sentence from the remembered conceptual message, so that structures produced in recall show similar patterns to those generated in other production environments. In particular, Stallings et al. (1998) showed that the recall methodology used here yielded patterns of heavy-NP shift that closely corresponded to people's judgments of the acceptability of shifted and unshifted structures.

To investigate the effect of relative length, we examined how shifting rates changed for NPs of a fixed length, as a function of PP length. All experimental items contained direct object NPs of 10 words in length, and PP length was manipulated at three levels (2, 5, and 7 words). If NP length alone affects shifting, then shifting rates should be constant across all PP length conditions. However, if relative length guides behavior, then shifting should be more common with shorter PP phrases than with longer ones.

Method

Participants—Thirty-six undergraduates were either paid or received extra credit in psychology courses for their participation. All were native speakers of English.

Materials—Thirty experimental items were constructed, each consisting of three components: a subject-verb phrase, a 10-word noun phrase (NP), and short (2-word), mid (5-word), and long (7-word) prepositional phrases (PP) (see Table 1 for examples). The subject-verb phrases were 3–4 words in length (e.g., *The dancer realized*, *The radio listeners accepted*) and did not include any alternating dative verbs such as *give*, because these verbs can participate in phrase orders other than those that were under investigation here. The nouns in the 10-word NPs were modified by only adjectives and prepositional phrases and

excluded other structures such as relative clauses. At all three lengths, the PPs expressed Time, Location or Manner roles modifying the verb, so that the PPs could not be interpreted as modifying the direct object NP. Ten practice and thirty filler items were similarly constructed with subject-verb and object NP phrases (of varying lengths) and PPs or other non-object phrases.

Design and Procedure—The experiment used a constrained production paradigm that Stallings et al. (1998) had previously used to elicit heavy-NP shift structures, in which participants planned sentences using phrases presented on a computer screen and recalled them after a brief delay. The PP length variable was manipulated within subjects with 10 trials each at the short, mid, and long PP conditions.

In each trial, the subject-verb phrase appeared in the center of the screen and the direct object NP and PP appeared above and below this phrase. Six lists were prepared to counterbalance the top versus bottom screen position of the NP and PP phrases and to counterbalance PP length across items.

Participants were instructed to read the phrases, arrange them in a sensible order, and prepare to produce the resulting sentence from memory when cued to speak. They were informed that sentences should always start with the words in the middle of the screen.

All 10 practice and 20 of the 30 filler items were constructed so that only one ordering of the top and bottom phrases yielded a grammatical sentence, to discourage participants from perseverating on a single phrase order pattern. The other 10 filler items consisted of a two-word PP and a two-word NP to provide variety of NP lengths. To counteract a tendency, observed in pilot work, to favor the phrase order MIDDLE (of screen)-BOTTOM-TOP, thirteen (65%) of the 20 fixed-order filler items were grammatical only in the phrase order middle-top-bottom.

At the start of each trial, three left-justified phrases appeared at their assigned screen locations. Participants pressed a key to indicate when they were ready to begin speaking. This keypress was followed by a 1 s blank screen interval, which was in turn followed by the reappearance of the subject-verb phrase on screen, serving as a prompt to begin uttering the entire sentence as accurately as possible. As soon as participants began speaking, the prompt disappeared, and the screen remained blank through the rest of the trial.

Following the 10 practice items, the experimental and filler trials were presented in random order. The sessions were tape-recorded for later transcription and lasted between 30 and 45 min.

Results and Discussion

Participants' utterances were transcribed and scored for both the structure uttered and the number of words produced in the NP and PP components. Trials were excluded when participants' "ready to speak" response times were less than 500 ms (1.9%), and when participants failed to utter both an NP and PP phrase (6.7% of the trials).

Participants' responses were not scored for accuracy of recall of the exact words presented onscreen but were scored for the number of words uttered and the syntactic structure of the sentence. Participants often made slight changes to the words in their utterances, similar to the patterns in Stallings et al. (1998) and consistent with previous research showing that sentence recall is not just verbatim repetition from phonological memory but stems from actual production planning from the remembered meaning (Lombardi and Potter 1998). Since the length of participants' utterances is critical for analyses of relative length effects, it

is important to establish the length of the phrases actually uttered when considering the role of relative length on structure choice. Coding of participants' productions showed that even though participants were not completely accurate, their utterances mirrored the relative length of the three conditions quite well. Participants produced an average of 8.18 words ($SD = 1.45$) for the 10-word NPs. For the three PP conditions, they produced on average 2.08 words ($SD = 0.23$) for the short (2-word) PPs, 4.33 words ($SD = 0.76$) for the mid (5-word) PPs, and 5.14 words ($SD = 1.34$) in the long (7-word) PP condition. Thus, on average, trials in the Short PP condition had an NP-PP length difference of 6.10 words, trials in the Mid PP condition had an average NP-PP difference of 3.85 words, and Long PP trials had an average of 3.04 words. These mean length differences did not change as a function of whether speakers produced the shifted or basic word order, $F_s < 1$. These results suggest that though speakers were not perfect in their recall of the phrases, their utterances can be used to investigate the effects of relative length on shifting.

An analysis of shifting and screen position revealed a somewhat greater tendency for participants to produce shifted utterances when the PP appeared at the top of the screen (36.99%) than at the bottom (29.68%); $F\ 1(1, 35) = 4.756, p < .05$; $F\ 2(1, 29) = 6.479, p < .05$. However, screen position did not interact with PP length, $F_s < 1$, and will not be discussed further.

Phrase Order Choice—As shown in Fig. 1, there were effects of PP length on the rate of shifted sentences uttered, such that as the PP grew longer (and relative length between the PP and NP decreased), the rate of shifted utterances declined, $F\ 1(2, 70) = 3.11, p = .05$; $F\ 2(2, 58) = 3.31, p < .05$. Participants shifted reliably more in the short (2-word) PP condition (38.7% shifted utterances) than in the long (7-word) PP condition (29.7% shifting) $F\ 1(1, 35) = 4.22, p < .05$; $F\ 2(1, 29) = 4.56, p < .05$. The mid PP condition (5-word, 37% shifting) was numerically in between these two conditions in shifting rate and did not differ reliably from either the short or the long PP condition.

These results show that the same 10-word NPs were produced in shifted structures as a function of the length of the PP. This result means that production of the heavy-NP shift syntactic structure does not stem from properties of the heavy NP alone but appears to vary with the relative length difference between the NP and the PP. Hawkins (1994) suggested that this relative length factor might be the only length-based factor that affects shifting rates, such that the length of the NP alone has no effect on shifting once relative length is considered. Given the strict control on the 10-word NPs in this study, the results of Experiment 1 cannot address this claim. Moreover, the Experiment 1 results might not generalize to NPs of different lengths; relative length effects might be different for longer or shorter NPs. Experiment 2 begins to investigate both of these issues by manipulating both NP length and the relative length of NPs and PPs.

Experiment 2: NP Length and Relative Length Manipulations

Experiment 2 used the same production task to investigate whether absolute NP length, in addition to relative length, affects shifting behavior. Three conditions were compared. Two conditions were matched for relative length but varied in NP length. Both had a 5-word length difference between the object NP and the PP, but they varied in the length of these phrases—in one condition (the 5-word, long NP condition), the absolute lengths of the NP and PP were 10 words and 5 words respectively, whereas in the 5-word, short NP condition, the NP was 7 words long and the PP was 2 words long. These conditions were compared to a third condition in which the PP and NP were each two words long (so that there was no length difference between the two phrases). If relative length is a driving force of heavy-NP shift, then the percentage of shifted orders produced in the two 5-word difference conditions

should be larger than in the 0-word difference condition. If object NP length also affects the production of heavy-NP shift structures above and beyond the effects of relative length, then the 5-word difference condition with the longer (10-word) NPs should yield more shifting than the 5-word difference condition with shorter (7-word) NPs.

Method

Participants—Thirty-six undergraduates were either paid or received extra credit in psychology courses for their participation. All were native speakers of English.

Materials and Procedure—A sample of the materials is shown in Table 2. The stimuli were similar to those from Experiment 1. Specifically, they included subject-verb phrases, NPs and PPs, with length modifications to form three conditions. The 0-word difference condition contained an NP and a PP of two words each. The 5-word difference/Short NP condition contained a 7-word NP and a 2-word PP, and the 5-word difference/Long NP condition contained a 10-word NP and 5-word PP.

All 10 practice items and 37 of the filler items were retained from Experiment 1. The shorter filler items from Experiment 1 were removed because the experimental conditions in this experiment already included short items.

The procedure was identical to that in Experiment 1. Screen position was again counterbalanced for the experimental items. For the 37 fillers, all of which were grammatical with only one ordering of the two phrases at the top and bottom of the screen, 19 had a required phrase ordering of middle-top-bottom, and the other 18 required a middle-bottom-top ordering.

Results and Discussion

Before analyses, trials were excluded when participants omitted or changed the structure of one of the sentence constituents, had ready-to-speak response times of less than 500 ms, or when the audio recording of the utterance was inaudible. A total of 4.91% of the utterances were excluded. There were no reliable effects of screen position and no interaction of screen position with the relative length factor, $F_s < 1$, so this factor will not be discussed further.

We first analyzed the number of words speakers produced in the three conditions. The 0-word difference condition, with two-word NPs and PPs, was produced at essentially 100% accuracy. In the 5-word/Short-NP condition, participants produced an average of 6.55 words ($SD = 0.79$) for the 7-word NP and 2.06 words ($SD = 0.21$) for the 2-word PP, for a mean relative length difference of 4.50 words. In the 5-word/Long-NP condition, speakers produced an average of 8.44 words ($SD = 1.32$) for the 10-word NP and 4.34 words ($SD = 0.83$) of the 5-word PP, for a mean relative weight difference of 4.10 words.

Phrase Order Choice—The rates of heavy-NP shift in the three conditions are shown in Fig. 2. Analyses showed that there was a robust effect of length $F(2, 70) = 50.339, p < .001$; $F(2, 58) = 51.360, p < .001$, such that the two 5-word difference conditions yielded greater rates of shifted utterances compared to the 0-word difference condition (all $ps < .001$), but they did not differ from one another, $F_s < 1$.

These results confirm the effects of relative length on shifting that were found in Experiment 1. The experiment did not find any evidence for NP length having an effect on shifting beyond the relative length effects. While caution should be used when considering a null result, and other combinations of length and relative length manipulations might further

inform this issue, at this point there is no reason to assume that any length effects beyond the relative length of constituents affect shifting.

General Discussion

Two experiments showed that the choice of the heavy-NP shift versus the more typical Verb NP PP structure during speech production is constrained by the relative length of the constituents in the verb phrase. In both Experiment 1 and Experiment 2, as the difference between the length of the NP and PP increased, shifting rates increased. There was no evidence that length of the NP alone contributed to shifting beyond the relative length effects. These results therefore form an important companion to corpus analyses (Hawkins 1994; Wasow 1997), in which more spontaneous utterances and writing offer naturalistic examples but less control of factors thought to be driving the production mechanisms during utterance planning.

These results contribute to prior work suggesting that properties of the heavy-NP alone cannot entirely explain shifting behavior (Hawkins 1994; Stallings et al. 1998; Wasow 1997); indeed we found that NP length alone had no effect when relative length is considered in Experiment 2. Interestingly, the effect of relative length does not appear to be linear—the shifting rates in the short-, mid-, and long-PP conditions of Experiment 1 (38.7%, 37.0%, 29.7% respectively) did not vary in direct proportion to the actual numbers of words uttered in the short-, mid-, and long-PP conditions (6.10, 3.85, and 3.04 word differences between NP and PP length uttered in the short-, mid-, and long-PP conditions respectively). This pattern, along with prior work showing that properties of lexical items can affect shifting rates (Stallings et al. 1998; Wasow 1997) suggest that other factors are also contributing to shifting rates. We consider the potential role of other factors below, but first we frame the relative length effects, and shifting more generally, within language production research.

Relative Length in Incremental Production

Within current theories of language production, constituents are ordered in an utterance plan as a function of their accessibility—essentially the ease with which they can be planned and articulated (Bock and Levelt 1994). On this view, “shifting” is not literally any shifting of sentence constituents in a mental representation but rather a tendency for the production planning processes to place relatively short elements earlier in the utterance plan compared to longer elements, because, all else being equal, shorter phrases are easier to plan than longer ones (De Smedt 1994). It is also not an obligatory grammatical rule—indeed, our shifting rates never exceeded 40% of utterances, even in the most conducive experimental conditions. Instead, shifted utterances tend to become more frequent as the difference in length between the phrases grows. The role of accessibility on production planning provides a useful perspective for viewing shifting behavior in several respects. First, whereas at least some linguistic accounts of shifting offer no basis for expecting that absolute versus relative weight would determine shifting behavior, relative weight has a natural explanation in a production system in which the relative accessibility of phrases is determining their order in the utterance plan. Second, because phrase length is only one factor that appears to modulate accessibility in other constructions (e.g. McDonald et al. 1993), incremental production naturally accommodates suggestions that non-length effects modulate shifting. For example, a number of researchers have argued that syntactic complexity, rather than phrase length, affects shifting rates (e.g., Ross 1967; Quirk et al. 1972; Kimball 1973; Emonds 1976) or that both length and complexity affect shifting. Wasow and Arnold (2003) collected acceptability judgments for shifted and unshifted sentences in which they controlled both length and syntactic complexity and found higher preferences for shifting with complex phrases than syntactically simpler ones matched for length. Many other factors may also

affect shifting, including lexical and conceptual factors that have been shown to affect structure choice in other domains, including noun animacy, the coherence of a concept expressed by a phrase, or the frequency of words in the phrase (Bock and Warren 1985; McDonald et al. 1993). For example, NPs containing inanimate, low frequency nouns might be more likely to be produced at the end of a clause compared to nouns of the same length and syntactic complexity containing animate high-frequency nouns. Bresnan (2007), using a large corpus of the two dative constructions (prepositional dative, e.g. *gave a present to Mary*, versus double object dative, e.g., *gave Mary a present*), found that speakers' choices of the alternative forms were predicted by a combination of fourteen length-based, semantic, and discourse factors. It seems plausible that structure choice in other constructions, including heavy-NP shift, may be similarly subject to many influences.

The existence of multiple factors may explain one surprising effect of length on shifting, which is that in Japanese, length-based shifting appears to go in the opposite direction, with longer phrases appearing before shorter ones (Hawkins 1994; Dryer 1980; Yamashita and Chang 2001). If factors in addition to relative length shape accessibility, then this result may make more sense. Chang (2009) presented a computational model of several length-based structure choices, including heavy-NP shift. He argued that lexical-semantic properties such as animacy and learning about language statistics from other structures in the language could contribute to accessibility and therefore word ordering. The model also addressed the opposite effects of length on shifting in English and Japanese. Chang suggested that other properties of English and Japanese conspired to promote the different length-based ordering preferences in the two languages. For example, the verb precedes the rest of the verb phrase in English, so that during the sentence planning process, it will be activated and can influence ordering of subsequent constituents (Stallings et al. 1998; Wasow 1997). By contrast, in Japanese, the verb is at the end of the verb phrase, and is not likely to be activated during the planning of the verb phrase. As a result, the verb has little influence on word order of other elements in the verb phrase. Chang suggested that this and other differences between the two languages affect the extent to which phrase length modulates accessibility—in English, length has a substantial effect, with long phrases much less accessible than short ones, leading to the standard heavy-NP shift effect. In Japanese, however, length has a much weaker effect, and other elements such as lexical-semantics and discourse status have a greater role in modulating accessibility of phrases. This view is consistent with the one advocated here, that the relative accessibility of sentence elements influences word order during sentence planning and that at least in English, relative length is a strong contributor to the relative accessibility differences that drive heavy-NP shift. The investigation of relative length in other languages is likely to increase our understanding of utterance planning during the process of grammatical encoding in language production.

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Fig. 1.
Production of heavy-NP shifted structures as a function of prepositional phrase (PP) length

Fig. 2. Production of heavy-NP shifted structures as a function of relative phrase length and NP length

Table 1

Sample materials for Experiment 1

<i>Subject-verb phrase</i>	The radio listeners accepted
10-word object NP	The whole story about the defects in the new Mazda
Manipulated PPs	
Short PP (2 words long)	Without doubt
Mid PP (5 words long)	Without any doubt or concern
Long PP (7 words long)	Without doubt or any bit of concern

NP noun phrase, *PP* prepositional phrase

Table 2

Sample materials for Experiment 2

<i>Subject verb phrase:</i>	The radio listeners accepted
5-word/Long-NP condition	
10-word NP	The whole story about the defects in the new Mazda
5-Word PP	Without any doubt or concern
5-word/Short-NP condition	
7-word NP	The whole story on the recent defects
2-Word PP	Without doubt
0-word condition	
2-word NP	The story
2-Word PP	Without doubt