

Information Structure and Production Planning*

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Abstract

Utterances are planned and realized incrementally. Which information is salient or attended to prior to initiating an utterance has influences on choices in argument structure and word order, and affects the prosodic prominence of the constituents involved. Many phenomena that the linguistic literature usually treats as reflexes of the grammatical encoding of information structure, such as the early ordering of topics, or the prosodic reduction of old information, are treated in the production literature as a consequence of how contextual salience interacts with production planning. This article reviews information structural effects that arise as a consequence of how syntactic and phonological information is incrementally encoded in production, and how we can tell these effects apart from grammatically encoded aspects of information structure that form part of the message.

KEYWORDS: production planning, topic, focus, incrementality, word order, prosody, prominence

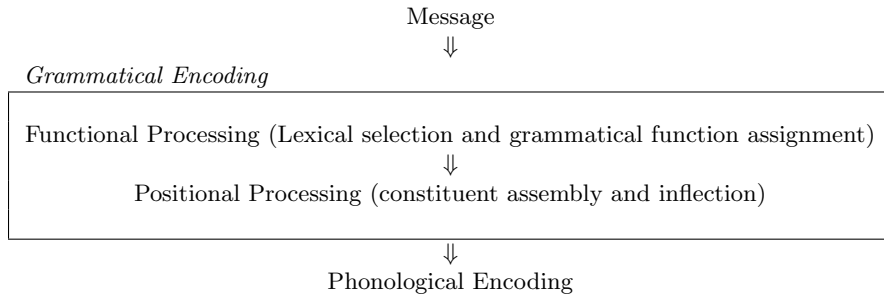
1 Grammar and Processing

The literature on production planning has a rich tradition of work which concerns phenomena that the linguistic literature would feature under the headline ‘information structure’, even if the perspective taken is quite different. Of central concern are the cognitive mechanisms that underlie certain

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choices in planning an utterance, and the incremental time-flow of the planning process. A model of production planning synthesizing insights from different strands of research (Garrett, 1980, 1988; Levelt, 1989, i.a.), and hence sometimes called the *consensus model*, differentiates the following stages in the planning of an utterance:¹

- (1) A model of production planning (Bock and Levelt, 1994)



To make this more tangible, let's consider an example:

- (2) a. Obama was pleased by the decision.
 b. The decision pleased Obama.

These two utterances constitute two ways of conveying the same fact about the world, and will be interchangeable in many situations. Yet the choice is not arbitrary. Studies from the production planning literature have found that one crucial factor in such word order choices is that speakers tend to realize constituents encoding more active and accessible referents earlier in the sentence (Bock and Irwin, 1980; Bock and Warren, 1985; Bock, 1987). These results suggest that speakers should be more likely to use the passive than the active form in (2) than would be expected given the general preference for using active sentences. The reason is that *Obama* is human, animate, more imageable, and hence more available than the referent or linguistic form of *the decision*, and more easily planned constituents tend to be realized earlier. The premise of these studies is that the two sentences in (2) actually encode the same message—that is, the same conceptual intent. Given a particular message, accessibility-based word order choices are then necessarily mediated by the grammatical roles that the referents are assigned to. This decision is taken to happen at the functional level. A

¹It is important to note that *message* here is a technical term—of course choices at the functional level or positional level can be interpreted by listeners as meaningful and hence form part of the message in the intuitive sense of the word.

linguistic account might take a different stance, and posit that the choice depends on which constituent is construed as the sentence topic. Topicality and givenness are often assumed to be grammatically encoded and part of the message.

The idea that there is a representation of a complete message corresponding to the meaning of a sentence that is devoid of linguistic structure may seem counterintuitive—isn't the compositional linguistic structure itself the way to generate complex meanings in the first place? Since production planning is taken to be incremental at all levels, however, it is not necessarily assumed in this model that the entire message has to be completely planned before utterance formulation, or at least not in all models of speech production adhering to (1) (cf. Ferreira and Dell, 2000a). The aspect of production theories of linguistic choices relevant here is that they usually take the information-structural import that the choice between (2) has as a direct result of contextual availability on utterance planning, rather than positing that the difference is encoded more directly in the linguistic structure, for example by requiring the subject of a passive to be a sentence topic, as is sometimes assumed.

Even if the choice between passive and active was indeed driven by extragrammatical factors, it is surely a choice between two objects that differ substantially in their grammatical properties: The two arguments of the predicate will be realized with different grammatical functions, the form of the verb changes, an auxiliary is used, and one of the arguments is realized as an optional prepositional phrase. Consider now a different word order effect: Imagine you are asked to name ten politicians from the US, as fast as possible. Chances are one of the first names you will list (in 2014) will be *Obama*. And yet this word order choice does not affect linguistic structure in the same way as choosing a passive over an active. In the production literature, word order in lists is often assumed to involve choices at the positional rather than the functional level. Both types of choices show accessibility effects, but they differ in interesting ways with respect to the range of factors that affect them (cf. Gleitman et al., 1996, for discussion and references).²

The literature on production planning provides empirical methods to test which planning level is involved in word order choices, a question that is clearly relevant to anyone working on the information structural import of word order variation. If planning considerations at the functional or posi-

²Linear order in coordinate structures plays an important role in the computation of presuppositions, but this fact is usually attributed to incremental interpretation rather than grammatical structure itself.

tional level can account for a particular choice, then accounts which presume differences at the message level—for example the grammatical encoding of topicality—might be simply misguided. The typical methodologies used in linguistics are often unable to directly pinpoint the underlying source of an effect. Intuitions about acceptability, for example, do not wear their provenance on their sleeves, and are affected by many non-linguistic factors (e.g., by how much a linguistic structure taxes memory resources) (cf. Chomsky, 1965; Schütze, 2011, i.a.), which include the factors at play at the functional and positional planning level according to theories of speech production. Certain information-structural effects might be due to the interaction of memory resources and the planning of linguistic structure (under a speaker-oriented view), or maybe they reflect choices on the side of the speaker that are intended to facilitate processing on the listener-side (under a listener-oriented view) (see Jaeger, 2013, for a recent discussion of whether production biases are purely based on the need of the speaker). The promise of looking at the process of production planning is that it could provide a principled explanation of information structuring (for a look at evidence from perception and reading, see Kaiser, this volume).

Two types of phenomena are addressed in this review, contextual effects on prosodic prominence, and choices between different word orders. These are both areas where encoding-level accounts (often assumed in the psycholinguistic literature) and message-level accounts (often assumed in theoretical linguistics) compete for the explanation of overlapping sets of data, and where quantitative studies of production studies have already established some of the basic facts and methods.

2 Prosodic Prominence

Linguistic constituents that encode information salient in the discourse are often prosodically reduced (cf. Féry and Ishihara, 2012, and references therein). Consider the following contrast:

- (3) a. No Antecedent
 Guess what John’s aunt, who is incredibly generous, brought for his birthday: A new bicycle!
- b. Contrastive Antecedent
 Guess what John’s aunt, who deals with old bicycles, brought for his birthday: A new bicycle!

The word *bicycle* is likely to be accented in (3a) and likely to remain unaccented in (3b). How exactly does this difference come about?

2.1 Anaphoricity or Production Facilitation?

Focus theories such as the alternatives theory of focus (cf. Rooth, this volume) or theories of givenness (cf. Rochement, this volume) treat the lack of accentuation *stib* as anaphoric. Just as pronouns are anaphors that require a linguistic antecedent of a certain type, so does deaccentuation require an appropriate antecedent, and this anaphoric requirement is encoded in the meaning of the focus operator whose phonological reflex is the shift in prosodic prominence. With respect to the model in (1), under this view prosodic prominence shifts are assumed to encode an aspect of the message. The semantics of anaphoric contrast is often modeled using alternative semantics (Rooth, 1985, 1992, this volume), which assumes that every constituent has two meanings associated with it, its regular denotation and a set of alternatives, called the ‘focus semantic value.’ A prosodic prominence shift requires that the appropriate set of focus alternatives are contextually salient. In focus theory, prominence shifts act like anaphors, and a pragmatic principle explains why focus and givenness marking often obligatory when possible. Williams (1997) proposes a principle called *Do not overlook anaphoric possibilities*, Schwarzschild (1997) postulates a principle called *Be attentive*, Wagner (2005) and Sauerland (2005) assume the source of the obligatoriness is the principle MAXIMIZE PRESUPPOSITION (Heim, 1991), and sometimes more specific constraints are assumed, for example a constraint on question-answer congruence (cf. Rooth, 1992).

And yet, it is not clear that examples like (3) warrant the introduction of such grammatical machinery. The word *bicycle* is repeated in the response, and the concept that the word *bicycle* refers to constitutes old information. This prior activation may more directly be the source of prosodic reduction. I will refer to accounts of this type broadly as ‘accessibility’ theories. A range of studies in the past thirty years have presented evidence that various factors increasing the accessibility of referents or of the linguistic expressions referring to them result in reduced prosodic prominence. Lack of accentuation has been linked to greater prior activation of referents in a speaker’s discourse representation (Nootboom and Terken, 1982; Terken and Hirschberg, 1994), or to the activation, priming or contextual predictability of linguistic expressions referring to them (Nootboom and Terken, 1982; Fowler and Housum, 1987; Terken and Nootboom, 1987; Aylett and Turk, 2004; Jaeger, 2010; Watson, 2010), both of which could

plausibly be located at the level of lexical selection during functional processing rather than at the message level. Another source of prosodic reduction might be the prior activation of a motor-plan of a particular word or word sequence in cases of repetition (Terken, 1984; Lam and Watson, 2010; Kahn and Arnold, 2012), a type of effect that could plausibly be attributed to the level of phonological encoding. (see Arnold and Watson, 2015, for a detailed overview of processing effects on prominence).

The existence of accessibility effects on prosodic prominence at the encoding level is not controversial: There is general agreement that frequency, predictability and repetition can have effects on prosodic prominence at least under certain circumstances. But is it a sufficient explanation for the effects usually discussed in the linguistic literature under the headlines ‘focus’ and ‘givenness’? A challenge for answering this question is that processing explanations and linguistic accounts often make similar predictions, and a lot of the evidence used in the relevant literature to motivate each account does not actually distinguish them (see Wagner, to appear, for a detailed discussion).

Consider now the following example (cf. Wagner, 2005, 2006; Büring, 2008):

- (4) Non-Contrastive Antecedent
Guess what John’s aunt, who produces expensive bicycles, brought for his birthday: A new bicycle!

Once again, *bicycle* is repeated. But would it remain unaccented? If a repetition of *bicycle* sufficient to license its prosodic reduction, then we would expect a prominence shift, just as it is likely in (3b); if a prominence shift does not occur here, it would suggest that it matters that *expensive* and *new* are not typically understood as alternatives to each other. Such an effect unexpected if all that matters is the prior activation of the concept or the word *bicycle*, but expected if a prominence shift actually encodes a semantic contrast at the message level (cf. Wagner, 2012a; Katzir, 2013; Repp, this volume, for relevant discussions of the notion ‘contrast’). The comparison between (3b) and (4) thus offers a potential testing ground for which level of production planning contextual effects on prosody occur at.

2.2 An Experiment on Prominence Shifts in English

A production experiment was carried out looking at contrasts like (3b) vs. (4), which to my knowledge have not been experimentally tested, although evidence from a German speech corpus was presented in (Riester, to appear)

in favor of the claim in Wagner (2005) that indeed, contrastive alternatives are necessary for prosodic prominence shifts. The question we are interested here are the conditions under which speakers will spontaneously shift prominence in the target sentence to the adjective when producing these types of utterances. The experiment manipulated whether a contrastive alternative was contextually salient by providing an explicit alternative in the discourse. Wagner (2005) notes that having such an overt antecedent is not necessary in order to shift prominence (see also Rooth, 1996), as long as the intended contrast set can easily be accommodated. Riester (to appear) show that in fact, in naturally occurring speech the antecedents for focus marking are frequently not overtly realized in the context.

A set of 12 triplets similar to (3) and (4) were created. Participants were told to imagine saying them to a friend in a casual conversation. On each trial they had time to familiarize themselves with the materials. Every participant saw all conditions from each item. However, the presentation order was such we could analyze the data in a latin-square design: The 36 sentences were partitioned into 3 playlists of 12 trials with one condition from each item, and 4 trials in each condition. The stimuli were presented in a pseudo-random order within playlist such that the same condition was only repeated at most once, otherwise the order was random within each block. The order of the three blocks in turn was randomly varied between participants. The latin square design avoids repetition effects and prevents participants from guessing the purpose of the study. The fully-within-subjects-design offers greater power and allows us to test the development of the effect over time. Eighteen native speakers of North American English participated, with an age range between 19 and 31, 12 of which were female. The recordings were hand-checked for whether speakers actually produced utterances according to script and checked for speech errors, which led to the exclusion of about 5% of the trials.

The recordings were forced-aligned using the HTK-based (Young et al., 2006) prosodylab forced aligner (Gorman et al., 2011), which provides a segment-by-segment and word-by-word alignment. We then automatically extracted acoustic measures in Praat (Boersma and Weenink, 1996) from words of interest. The adjective and the noun in each target sentence in particular were looked at. The acoustic measures considered were the maximum intensity over the word, the maximum pitch, and the duration. These measures have proven to be reliable correlates of prosodic prominence in earlier studies (Breen et al., 2010; Wagner, 2012b). We computed relative measures of prominence between adjective and noun. In particular, we looked at the difference in log duration (effectively a measure of the duration ratio between

the two words), the difference in pitch in semitones, and the difference in intensity. A shift in prominence toward the adjective would be reflected by an increase in the relative prominence measures. In addition to acoustic analysis, two RAs were asked to annotate a prominence shift when the noun remained unaccented and the adjective hence carried the last accent of the utterance.³ They were only played the final part (e.g. *a new bicycle*) and hence did not have access to the context.

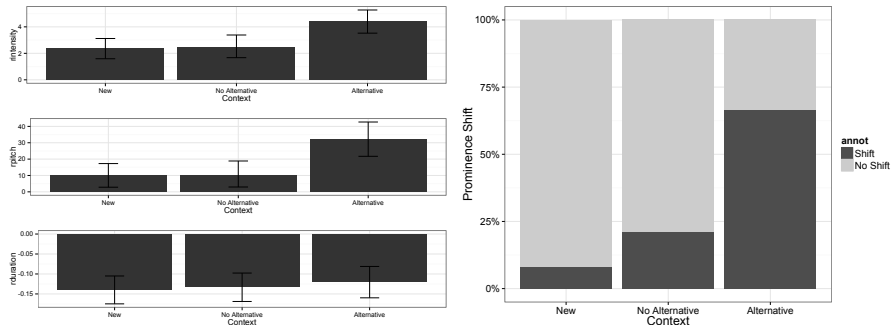


Figure 1: Measures of Relative Acoustic Prominence between adjective and noun. On the left: Acoustic Measures ($>$ means adjective is more prominence compared to the noun it modifies); on the right: RA annotation of prominence shifts to the adjective.

Using the `lme4`-package in R (Bates and Maechler, 2010), we fitted a mixed model regression with Context as fixed effect, and participants and items as random effects which included random slopes for Context. All models report estimates and standard errors. The determination of p-values in mixed models is not trivial, since the degrees of freedom can only be estimated (Baayen et al., 2008). We report p-values estimated by the R-package `texreg` (Hlavac, 2013).

The results show that there is a clear acoustic difference in terms of pitch and intensity between the Alternative condition and the other two conditions, but the acoustic measures used here did not detect a difference between the No Alternative condition in which the head noun was repeated but the adjectives weren't mutually exclusive, and the control condition. The perceptual prominence annotation was more sensitive, however. A lo-

³The annotation scheme is based on the assumption that the grammatically relevant aspect for prosodic focus marking is relative prominence, rather than accentuation of individual constituents (cf. Wagner, 2005).

	RelIntensity	RelPitch	ProminenceShift
(Intercept)	3.10 (1.38)*	18.93 (6.75)**	1.25 (0.36)***
ContextAlternative.vs.Other	-1.99 (0.43)***	-24.18 (6.86)***	2.51 (0.46)***
ContextNew.vs.NoAlternative	-0.11 (0.43)	-1.82 (6.17)	1.56 (0.79)*

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 1: Linear Mixed Effect Regression Model for Relative Intensity and Relative Pitch, and logistic mixed effects model for the occurrence of a prominence shift

gistic mixed effects regression with random slopes and intercepts for Context for item and participants found a significant difference both between the Alternative condition and the other two, and between the No Alternative and the Control condition. The model estimates the odds for a prominence shift to be more than ten times higher in the Alternatives condition compared to the other conditions, and estimates the odds for a prominence shift to be 4 times higher in the No Alternative condition than in the control condition.

Just as predicted by at least certain versions of the alternatives theory of focus, a prominence shift is much more likely to occur when a mutually exclusive alternative is salient. The results are incompatible with theories that try to explain all prominence shifts with accessibility effects that simply require a constituent or its referent to be salient for it to remain unaccented. The smaller effect showing a tendency of deaccentuation in the case where the head noun was merely repeated but the noun phrase was not contrastive might suggest that sometimes, the adjective was interpreted as contrasting with the contextually mentioned adjective after all, or else it might indicate that there is a smaller but also significant pure repetition effect on accent placement.⁴

2.3 Prominence and Production Planning: Summary

The evidence presented here suggests that an account of contextually induced prosodic prominence shifts purely due to planning or retrieval facilitation cannot account for the accent placement pattern in all cases. At least

⁴In order to control against learning or strategy effects, a regression model with trial order as a covariate was fit, not repeated here for space reasons, which did not show any effects other than a change of the effect on pitch over time. An analysis of the first third of the trials of all participants—effectively analyzing the experiment under a latin-square design in which every participant only sees one condition from each item—yielded qualitatively the same pattern as the results reported in 1. In other words, there is no hint in the data that the results might be an artefact of the experimental design.

some prominence shifts involve the encoding of pragmatic contrast between mutually exclusive alternatives, and hence form part of the message. But there is no general lesson that we can draw from this, other than that which planning stage(s) of an utterance are involved is an empirical question that we need to address for each phenomenon individually.

Many of the factors that affect prosodic prominence also affect the choice of the lexical and morphological form of a referent. Whether a full noun phrase, for example, or a pronoun is chosen, depends on how salient the referent is and whether there are competing salient referents that would fit the features of the pronoun. Again, various processing factors have been identified that affect the choice of the form of referential expressions (Arnold, 2010, for a review), many of which relate to the accessibility of the referent. And yet also here, similar to the case of accent placement, it is possible that the choice between a full noun phrase and a pronoun has further grammatical underpinnings. Consider the following observation (cf. Evans, 1977):

- (5) a. John has a wife and she hates him.
b. #John is married and she hates him.

According to the marriage laws in 1977, the sentence *John is married* warranted the inference that *John has a wife*. And yet this inference is not (and was not then) quite sufficient to enable the pronoun *she* to pick up John's wife as a referent. Evans argued that such examples show that there are syntactic conditions on pronominalization, and the choice of pronouns over full phrases might not be entirely reducible to accessibility factors. This type of restriction on pronoun use is an on-going question in current research in semantics (cf. Heim, 1990; Schlenker, 2011).

3 Word Order

More available or accessible constituents, that is, constituents that are easier to activate or to retrieve from the mental lexicon, have not only been argued to have a tendency to be prosodically reduced, they also tend to be realized earlier in an utterance than material that is less available (Ferreira and Dell, 2000b, and references therein). This propensity is often taken to be a result of efficient processing in the incremental production of utterances: Once a lexical lemma is activated, it's best to realize it at once, and more costly to keep it in memory while other less available material is processed. Ferreira and Dell (2000b) call this the *principle of immediate mention*: "Production proceeds more efficiently if syntactic structures are used that permit quickly

selected lemmas to be mentioned as soon as possible.”

The relative order of constituents is also one of the most important issues in the study of information structure. Time and again it has been observed that given or topical information tends to precede new information, even if the terminology varies widely between different accounts (Halliday, 1967; Daneš, 1974; Clark and Haviland, 1977; Lambrecht, 1994, i.a.); a related observation is that shorter and simpler constituents tend to precede more complex constituents (Hawkins, 1994, 2004). These preferences have been observed across many languages, although not without exceptions.

How can we tell when such a word order effect is simply a result of the speed with which particular constituents can be planned, or whether it has become part of the grammatical encoding of information structure, as is often assumed for givenness- or topic-related reordering in the linguistic literature (cf. Neeleman and Van De Koot, this volume)? This section will review some of the relevant literature that bears on this question, with a special focus on coordinate structures.

3.1 Order in Coordinate Structures

Coordinate structures are interesting in that they can include several referring expressions with the same grammatical and thematic role. Due to the parallelism between coordinates, a number of factors that might otherwise affect word order choices will not play a role here. And yet, the order of coordinates is far from random, and a complex set of tendencies have been observed in the ordering of coordinate structures, starting with Behaghel (1909)’s influential corpus study of coordinate structures.

Behaghel (1909) made the important observation that longer and more complex constituents are much more likely to be ordered after shorter and simpler constituents, a tendency he called the *Law of Increasing Constituents* (‘Gesetz der wachsenden Glieder’). Behaghel established this pattern based on data from modern and historical German, and from Latin, and Ancient Greek, drawn from sources in prose and verse. As Behaghel observed, this tendency is often trumped by overriding factors, for example a particular order might make more sense for conceptual reasons, among which are the chronological order or causal relations between events. Furthermore, an anaphoric dependency to a constituent in another conjunct obligatorily requires a later ordering (cf. Behaghel, 1909, 110, for the German equivalent):

- (6) a. Karl_i and his_i Paladin.
- b. *His_i Paladin and Karl_i

Why should more complex constituents be ordered later? Behaghel considered a number of ideas, all of which are still relevant today. He speculated that the later constituents are more easily remembered by a listener, and hence it is more beneficial to the listener if a complex constituent comes last. But he also speculated, taking the the speaker's perspective, that ordering more complex tasks later might be a general principle of action planning. Behaghel furthermore emphasized the importance of rhythm, and observed that in coordinations of four elements there is a tendency to break it up into a grouping of two times two constituents, and within each a more complex constituent is ordered last.

Cooper and Ross (1975) similarly speculate that there must be something 'adaptive' about particular orders that makes them more likely to be chosen. They focus on 'frozen' word orders in idiomatic collocations (e.g., *play cat and mouse*), and identify a number of semantic and phonological factors that make it more likely that a particular order is observed in a frozen expression that include considerations of complexity. More specifically, they propose that constituents that are easier to process are ordered first. This hypothesis is made plausible by the observation that the first conjunct is often the one that takes the more self-oriented perspectives ('Me-first') of the two (e.g., *here and now*), since these are comparatively more accessible. Similarly, the preferential ordering of *up* and related words before their antonyms like *down* correlates with a processing advantage for upward terms (Seymour, 1969, cited after Cooper & Ross).

Such differences in processing complexity might reflect deeper properties of conceptual structure. Cooper and Ross (1975) note that some of the generalizations in freezes (e.g., vertical dimension before horizontal dimension) are mirrored by order preferences in prenominal adjectives and adverbials in sentences. Some other asymmetries observed in coordinate structures (e.g., humans > animals > inanimate entities) play an important role in the grammar of agreement system of many languages. And yet, at least for the semantic preferences in English, Cooper and Ross (1975) observe that there seem to be languages that show the exact opposite preference (e.g., in Finnish, distal terms precede proximal ones).

Since it is usually assumed that the order of coordinates is free from the point of view of grammatical structure, and we can look at coordinate structures to establish some basic facts about processing-based constituent ordering. Behaghel's law, for example, certainly seems to be operative outside of coordinate structures, (cf. Wasow, 2003; Hawkins, 2004).

3.2 Pronouns in Coordinate Structures

In many languages, pronouns (and clitics) and other topical and given constituents tend to precede focused and new constituents, although again there are exceptions (see below). This tendency led Behaghel (1932) to posit another law affecting word order (Behaghel's Second Law): That which is less important (or already known to the listener) is placed before that which is important.

Such word order effects are often analyzed as the grammatical encoding of information structure, but in fact they might be a simple consequence of incremental production planning, based on the principle of immediate mention discussed in Ferreira and Dell (2000b). Coordinate structures allow us to test this idea while holding other factors constant, for example grammatical role. If greater accessibility leads to earlier production relative to less accessible constituents, pronouns, for example, should be ordered early in coordinations. This preference was indeed observed by Behaghel in his corpus study (Behaghel, 1909, 111), and yet it cannot be very strong, since clearly both orders are possible in principle, at least in English:

- (7) Bobby was going to take part in the game.
a. But then the referee disqualified the goalie and him.
b. But then the referee disqualified him and the goalie.

Pronouns might be easy to plan and hence tend to be realized early because they don't involve a lot of phonological substance, and/or because they refer to given information. We can test which of these factors is more important by comparing them to full noun phrases that also refer to given information but have more phonological substance:

- (8) Bobby was going to take part in the game.
a. But then the referee disqualified the goalie and Bobby.
b. But then the referee disqualified Bobby and the goalie.

The preference predicted by Behaghel is also predicted by more recent theories of how referential expressions are realized, for example Gordon et al. (1999) argue that within complex NPs, constituents with more salient referents should be ordered first. A small production experiment was conducted to test whether there are indeed such ordering effects in coordinate structures, and whether pronouns differ from full noun phrases in this regard.

One reason why pronouns and full noun phrases might differ, apart from their phonological content, is an effect called the 'repeated-name-penalty':

Realizing a constituents as full noun phrases when the context would have warranted the use of a pronoun leads to a processing cost (Gordon et al., 1993). This effect is observed in subject position, but also in direct object position as in our examples, at least if the subject is not itself anaphoric (Gordon and Chan, 1995, 228). An additional factor is the prosodic realization of given constituents. At least according to Wagner (2006), a pronoun in a coordinate structure is typically accented, while in direct object position a pronoun is typically unaccented. Deaccenting a pronoun in a coordinate structure in fact requires a contrasting antecedent that provides an alternative coordinate structure:

- (9) a. They nominated JOHN and HER. (requires no focus antecedent)
- b. They nominated JOHN and her. (requires antecedent of form: X AND HER)

While Gordon et al. (1999) found evidence that the repeated names penalty also applies in coordinate structures, the extent to which this interacts with word order and prosody has not been investigated. Intuitions about these sentences are subtle, and neither the order effect nor the prominence effect have been tested experimentally. The experiment tested 8 items of the form (7) and (8). These were compared to sentences with an uncoordinated direct object, realized again either as a pronoun or as a full name. The experiment thus had a 2x2x2 design. The order of the given constituent within the coordinate structure was manipulated between participants. The manipulation of referential form (pronouns vs. full noun phrase) was within participant, as well as the manipulation of whether the direct object was coordinated or simplex. While we originally planned to run 20 participants in each group, we accidentally ran 26 participants in the first group (given constituent last in the coordinate structure) and 19 in the other (given constituent first in the coordinate structure). The reported results are qualitatively identical irrespective of whether an equal number of participants in the two groups was considered or all participants were. The figures and stats reported here are based on all participants. Participants produced all conditions from each item in a pseudo-random order, separated by filler trials from an unrelated experiment. At the end of each trial participants rated the naturalness of the sentence given the context sentence on a 5-point Likert scale. The data was hand-annotated by trained RAs for to mark whether the given constituent was accented or not.⁵

Our first set of questions relates to the acceptability of coordinate struc-

⁵I will not discuss acoustic measures here for reasons of space.

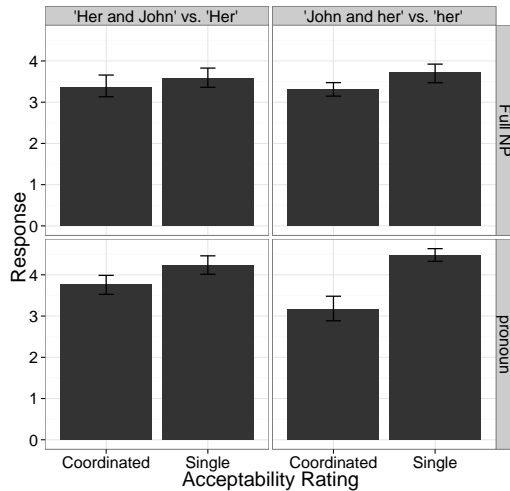


Figure 2: Acceptability Ratings

tures in which one constituent encodes given information. Fig. 2 summarizes the result. Overall, the differences in ratings were not very big, indicating that as expected, all structures seemed relatively natural to the speakers, with some crucial variation depending on our manipulations. A mixed effects regression model with the ordering of the given constituent (early vs. late), referential form (pronoun vs. proper name), and the complexity of the NP (coordinated vs. single), and the three-way interaction was fitted, which included random slopes for all main effects.⁶

There was a significant main effect of coordination, such that utterances with coordinated direct objects were rated as less natural than utterances with single direct objects. This could be because one conjunct was previously mentioned and the other was not, which might lead to some oddness, or simply because coordinations are more complex and difficult to process. Of more interest here is that effect of coordination interacted with word order: When the pronoun was ordered last, the difference between single vs. coordinated was significantly greater. This provides direct evidence for Behaghel’s observation that pronouns are preferentially ordered early in

⁶Interaction terms were excluded from the random slopes since the model otherwise did not converge. It is controversial whether data based on Likert scales should be analyzed using parametric statistical methods. We also analyzed the data using cumulative link mixed effects regression, and the found the relevant comparisons to be significant as well.

coordinate structures.

There was no significant interaction between referential form and word order preference. The absence of the interaction effect is not very informative, however, especially since there is a clear trend in this direction. A significant interaction might have been expected if it was true that accessibility effects (such as givenness effects relevant for Behaghel’s second law) exert their effect at the functional level via the assignment of grammatical role, while effects of complexity (such as the phonological difference between pronouns and full noun phrases relevant for Behaghel’s first law) also show effects at the positional level (cf. Gleitman et al., 2007, for discussion, and some evidence to the contrary).

There was also a significant main effect of referential form, such that a full noun phrase was rated as a less natural realization of the given constituent than a pronoun. This effect interacted with whether or not the given constituent was in a coordination structure or not: using the proper name was significantly more natural relative to using a pronoun in the coordinated case. This provides the evidence that the repeated-names-penalty is significantly smaller in coordinations. This is a new observation, as a prior study looking for such an effect based on reading times failed to find a significant difference (Gordon et al., 1999, 361). The results of the statistical model are summarized in Table 2.

	Coeff (SE)
(Intercept)	0.00 (0.13)
PositionEarly.vs.Late	0.06 (0.17)
FormFull.vs.Pronoun	-0.41 (0.11)***
CoorCoordinated.vs.Single	-0.59 (0.14)***
PositionEarly.vs.Late:FormFull.vs.Pronoun	-0.16 (0.17)
PositionEarly.vs.Late:CoorCoordinated.vs.Single	0.50 (0.17)**
FormFull.vs.Pronoun:CoorCoordinated.vs.Single	0.58 (0.15)***
PositionEarly.vs.Late:FormFull.vs.Pronoun:CoorCoordinated.vs.Single	-0.54 (0.29)

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 2: Mixed Effect Regression Model for Acceptability Ratings

Now turning to the prosodic realization of the given constituent: Wagner (2006) predicts that in the absence of a contrasting antecedent in the form of a coordinate structure, pronouns should be accented when they occur finally in a coordinate structure.⁷ This is indeed what the participants did about

⁷When they are ordered early, they are also predicted to be accented, but we focus on the cases where they are ordered last here, since the difference in placing an accent or not

90% of the time, both in the case of full proper names and pronouns. Figure 3 illustrates the results. Pronouns were essentially always unaccented when they occurred as single arguments, and essentially always accented when they occurred in coordinations.

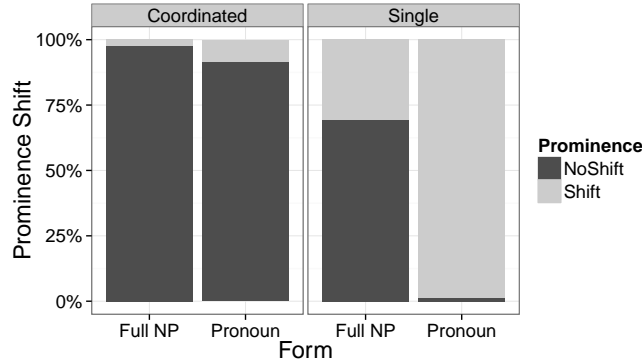


Figure 3: Percentage of times prominence was shifted away from the given constituent. Only cases in which the given constituent came second are reported in this plot.

These results are compatible with the idea that the accentuation status of a pronoun is not intrinsic, but rather derived by the same principles that guide the accentuation of constituents more generally. A pronoun requires a unique antecedent matching in person and number features, and that antecedent has to be contextually salient. The conditions on their use will usually also allow satisfy the conditions of prosodic givenness marking, hence they tend to be unaccented. Pronouns in coordinations behave differently, arguably because of the contrast with their conjunct(s), or due to an interaction of focus marking and syntax: constituents cannot move out of coordinate structures, a fact which leads to interesting predictions about interactions with focus marking (cf. Wagner, 2006, for more discussion).

Interestingly, even in the uncoordinated case full names referring to contextually salient referents were accented about two thirds of the time.⁸ This

is much more salient for the final word.

⁸The ratings for utterances with accented and unaccented uncoordinated proper names were not different from each other. There was actually an effect in the coordinated case, such that accented full noun phrases were rated as less natural. This is arguably due to the fact that in this case, the very same lexical word was accented twice at the end of consecutive sentences, triggering a ‘givenness illusion’ effect (Wagner, 2012b).

difference in accentuation rate between given pronouns and given full names in the uncoordinated case lends credence to the idea that there is pronouns might be inherently unlikely to be accented after all.⁹ On the other hand, it could be that proper names differ in the experiment because the choice of a proper name over a pronoun lead speakers to assume that a contrast to some other referent was intended.

	Coeff (SE)
(Intercept)	-0.74 (0.38)
CoorCoordinated.vs.Single	-5.17 (0.71)***
FormFull.vs.Pronoun	-3.44 (0.68)***
CoorCoordinated.vs.Single:FormFull.vs.Pronoun	4.29 (1.35)**

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 3: Logistic Regression Model for Prominence Placement

The idea that the choice of a full noun phrase where a pronoun would have been possible suggests to a reader that a contrast was intended potentially sheds new light on the earlier findings on the repeated-names-penalty: We found the repeated-names penalty to be weaker precisely in the case in which both a pronoun and a full noun phrase are usually accented. There is therefore a correlation between repeated-names penalty and accentuation status. This suggests that the additional processing time a full name incurred in self-paced reading studies (Gordon et al., 1993; Gordon and Chan, 1995) might have been due to the processing of alternatives to that word (if indeed it was understood contrastively), or alternatively it might have been due to the processing of prosodic prominence itself, as a result of the implicit prosody assigned by a reader (Bader, 1998; Fodor, 2002; Kentner, 2012). The former interpretation is more likely, since, as argued in Kennison and Gordon (1997), the processing cost associated with the repeated name penalty is not actually exclusively located where the referential expression occurs.

In Sum: The experiment found evidence for a preference of pronouns to be ordered early in coordinate structures. Given the plausible account of preferential early ordering in terms of ease of planning of pronouns, no grammatical explanation in the narrow sense seems necessary to account for the word order preference observed in the acceptability judgments. It is clear though that other word order preferences related to pronouns have become

⁹Brenier et al. (2006) conversely found that nouns tend to be accented, and that in fact most of the variability in accent placement in their corpus study was predicted by the likelihood of particular words to carry an accent.

part of grammar in the more narrow sense, be it through *grammaticalization* (Hopper and Traugott, 2003), or some other mechanism. In Romance languages, clitic pronouns often have to precede the verb, this has become part of the grammar of the language, not just because a violation of it leads to complete unacceptability, but because of complex interactions with other factors, for example clitics cannot occur in coordinate structures, and they cannot be dislocated or contrastively stressed. Such ‘grammaticalized’ patterns often mirror independently motivated processing preferences, just as phonetic tendencies that appear to recur across many unrelated languages (e.g., the lengthening of vowels before voiced obstruents) are sometimes phonologized into more categorical and exaggerated patterns that form part of the grammar of some languages (e.g., the lengthening of vowels preceding voiced obstruents in English).

The word order preference observed here was rather small, which might or might not be a general property of accessibility-based word order effects. However, the case of coordination production might be special. Let’s now turn our attention from coordinate and list structures to how some of the recent literature on sentence production.

3.3 Word Order in Sentence Production

Bock and Irwin (1980) reports that constituents in sentences are likely to be ordered early if either their referent or their lexical content is contextually given. The method used was sentence recall: participants were read a list of questions and then a list of answers, and afterwards were prompted again with each question and were asked to use the appropriate answer from the answer list. The dependent variable in this paradigm is whether participants use the same word order or a different word order in their response, for example by choosing a passive construction instead of an active one. Participants tended to switch the order in their own response in order to pronounce given constituents first. While Bock and Irwin (1980) propose an accessibility-based explanation, given-before-new order effects are often attributed to message-level mechanisms in the theoretical literature (e.g. Kucerova, 2007, and references therein).¹⁰

The mechanism through which accessibility factors affect word order is often assumed to be attention-based. Accessibility factors might simply affect the likelihood that a perceiver attends to particular referent at an early

¹⁰An earlier ordering might also decrease prominence. Some theories directly relate prosodic prominence modulation and word order choices as two strategies to achieve similar goals. I will not discuss interactions between the two in this review.

point in apprehending an event. This idea that attention is at the heart of accessibility effects was tested in a round-about way in Tomlin (1997), who reports on several experiments in which the attention is guided by arrows to particular elements in visually presented a scene they are asked to describe. Most famously, in one experiment participants were shown to chose passive or active descriptions depending on whether their attention was guided to a fish that was eating another fish, or to the one that was eaten, despite of an overall bias against the use of passives in English.

Since the arrow in Tomlin's experiments was visible to the participants, these results have sometimes been attributed to participant's guesses about the intention behind the experiment. But Griffin and Bock (2000) found similar (if less dramatic) results with more sophisticated and techniques to guide attention that left participants unaware of the manipulation. Gleitman et al. (2007), looking at a range of linguistic alternations, showed strong support for Tomlin's hypothesis using a similar method. Interestingly, Gleitman et al. (2007), also found that without any attention manipulation, early looks to certain elements in a scene was predictive of constituent order in a later utterance describing the event, compatible with the idea that attention to a particular element in a scene leads to earlier planning of correspondent linguistic description, which can then form the starting point for an utterance (nut see Griffin and Bock, 2000, for evidence to the contrary). The idea that word order choices are due to faster lemma activation of certain constituents (Ferreira and Dell, 2000a; Gleitman et al., 2007), rather than necessarily happening at the at the message level where the 'gist' of a thought corresponding to an utterance is determined, has an important conceptual advantage: It does not presuppose the potentially problematic idea that the basic message of an utterance can somehow be generated prior to the choice of the linguistic material encoding it, and it seems more compatible with the plausible hypothesis that the message itself is only generated by way of incrementally computing the compositional linguistic structure.

The effect of attention on word order let Tomlin (1997) to conjecture that notions such as 'theme' and 'topic' might become obsolete once the role of attention in utterance planning is properly understood. And yet, there are effects observed in other production studies that do not seem reducible to attention alone. This can be seen in differences in the presence or absence of such attention-based effects depending on the linguistic structure involved, for example in figure-ground effects. Attention has been shown to have an effect of figure-ground perception, for example Vecera et al. (2004) show that guiding a participant's attention to one side of visually ambiguous stimuli determines which side will be perceived as figure and which as ground. Such

figure-ground effects have been argued to map to topic-comment structure in linguistic descriptions of scenes, for example it is often argued that subjects are the figure and the predicate the ground in simple SVO predications (Talmy, 1978; Gleitman et al., 1996, 2007). It turns out that these effects are absent in list structures, at least according to Gleitman et al. (1996, 2007). This is expected if figure-ground-based word order effects are not just effects of accessibility or attention, but linguistically and part of the message: linguistic theories typically do not posit topicality-based reordering or topic projections within lists and coordinate structures.

Compatible with the idea that figure-ground is at least sometimes encoded at the message-level, Cowles and Ferreira (2011) showed that while contextually given information is more likely to be produced early both in sentences and in lists, a contextually given constituent that in addition is linguistically marked as a topic in a prior utterance in the context is *even more likely* to be ordered early in a subsequent production—but crucially, this is only true in sentences, and not in lists. Such findings confirm the role of accessibility in early constituent-placement, but also that there are interactions with grammar that would be unexpected if accessibility alone played a role. Cowles and Ferreira (2011) attribute the additive effect of topicality to the existence of topic-marking at the message-level in sentences, but not in lists.

So one potential argument that message-level encoding of topicality and givenness is needed is that sentences seem to differ from lists and coordinate structures that the latter don't seem to single out constituents as topics. Various linguistic theories posit 'functional projections' that encode givenness, focus, or topicality that trigger word order changes (e.g. in 'cartographic approaches' Rizzi, 1997; Cinque, 1999). Constituents in coordinate structures are usually not assumed to negotiate word order in this way. Evidence for such a difference between sentences and lists was indeed found in Bock and Warren (1985), who also used the sentence-recall paradigm and showed that constituents which are more easily accessible, in this case more imageable constituents, tend to be ordered early in sentences, but not in lists. Sentences, but not list, distinguish constituents by their different grammatical role, and grammatical subjects (compared to objects) tend to be more animate, more concrete, more imageable, more salient, more given, receive more attention by the speaker, and tend to refer to entities that the speaker empathizes with to a greater extent (Bock and Warren, 1985, 48), and all of these factors also make them more likely sentence topics (Givón, 1983).

However, the observed difference between sentences and lists does not

necessarily speak for a message-level analysis. The explanation proposed in Bock and Warren (1985) is actually that accessibility-based word order choices are always mediated by grammatical role, and occur at the *functional level* of grammatical encoding: More accessible constituents are more likely to be mapped to grammatical roles that are ordered early, driving the choice between active and passive and between the double-object and the dative constructions in ditransitives. At the positional processing stage, where linear order is fixed and agreement morphology and other types of inflection are added, such accessibility on word order are absent, at least according to some (cf. also Griffin and Bock, 2000). This model therefore predicts a difference between sentences and lists, without positing that givenness or topicality are part of the message itself. Under this view, the differences between coordinate structures and sentences relates in how word is affected by information structure is due to differences between different levels of planning rather than to a direct encoding of information structure in grammar. In contrast to Griffin and Bock (2000), other studies have actually found accessibility effects in purely positional word order changes (Prat-Sala and Branigan, 2000; Ferreira and Yoshita, 2003; Gleitman et al., 2007), casting doubt on this hypothesis. These purely linear effects might however be less strong than the ones mediated by grammatical role assignment (Myachykov et al., 2011). This on-going debate is of relevance to anyone interested in information structure and how it affects word order.

The viability of processing explanations for word order variation can be further tested by looking at patterns across languages. A prediction of the incremental models of word order choices discussed here is that word order choices should make production planning easier since they allow the early ordering of a constituent where beneficial, while the alternative that such choices cause competition and hence processing costs predict the opposite. Sometimes, the prediction of the incremental view is borne out (Ferreira, 1996, for the case of the English dative alternation), but evidence from Korean suggests this is not always the case (Hwang and Kaiser, 2013). While early pronoun placement is a recurring tendency across languages, it is not universal, in Irish and other Gaelic languages, for example, pronouns are often postposed and in fact unacceptable if ordered early (Bennett et al., 2015, and references therein). Likewise, Behaghel’s Law of Increasing Constituents, does not seem to hold in some languages that have been reported to show the opposite preference, for example Japanese (Dryer, 1980; Hawkins, 1994), a fact often related to headedness (Hawkins, 1994, i.a.). An alternative view that speakers of these languages favour semantic ordering factors over processing-related ones, and for some order more contentfull material

first (e.g. Yamashita and Chang, 2001).

The division of labor between functional and positional processing levels in word order choices might also vary between languages. Certain languages have been characterized as being ‘non-configurational’ and allowing for much greater word order flexibility compared to others, following insightful work on Warlpiri syntax reported by Hale (1983). However, there has been relatively very little work looking at production planning processes in flexible word order languages (but see Prat-Sala and Branigan, 2000; Kaiser and Trueswell, 2004; Myachykov et al., 2011), and less described languages more generally (cf. Jaeger and Norcliffe, 2009, for an excellent recent overview). It could be that what appear to be purely positional choices in word order in non-configurational (or less configurational languages) are in fact grammatical choices as well. This position has been defended in the syntactic literature by Legate (2001), among others. In some analyses, so called non-configurational languages are in fact discourse-configurational (cf. Kiss, 1995), and notions such as focus and topic are represented in syntax through focus and topic operators. And yet the relevant linguistic literature only rarely tries to rule out alternative production-based explanation of the information-structural import of word order choices, leaving much room for further studies that try to combine insights from both domains.

In sum, whether or to what extent the information-structural import of word order variability is due to grammar or to processing considerations is often not obvious. This also applies to the information-structural import of dislocation constructions (Lopez, this volume; Neeleman and Van De Koot, this volume). Does a particular type of left-dislocation encode topicality, or does it simply correlate with, say, topicality because speakers use these constructions in order to be able to realize more accessible constituents first?

4 Looking Forward

This review focused on two particular aspects of utterances, prominence and word order. By looking at two specific aspects of utterance planning we saw that the question which level of planning is involved and whether grammatical structure is necessary to capture a phenomenon is not a question of taste or theoretical affinity, it is an empirical question. The literature on production planning provide insights and methods that help tackle this question. Most importantly for linguistic research, there is no a priori answer for what constitutes part of the message and what is a result of the process of encoding the message, and when trying to understand information structure,

both aspects of an utterance will likely be relevant.

Many areas of the study of production planning have not been addressed here, for example the study of speech errors (cf. Fromkin, 1971; Garrett, 1988), disfluencies (cf. Clark and Fox Tree, 2002), turn-taking in spontaneous conversations (cf. Levinson, 2013), or issues of the exact incremental time course of planning at different levels in the production model (cf. Wheeldon et al., 2003). We also did not scrutinize certain assumptions built into the consensus model in (1), which would clearly merit extensive discussion, for example the precise relationship between message and linguistic structure. This review of how production planning relates to information structure should therefore be seen as a starting point for further exploration rather than a comprehensive overview.

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