

## Unaccusativity in sentence production

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## 1. Introduction

Linguistic analyses suggest that there are two types of intransitive verbs: unaccusatives, whose sole argument is a patient or theme (e.g., *fall*), and unergatives, whose sole argument is an agent (e.g., *jump*).<sup>1</sup> In psycholinguistics, researchers have sought to find how this distinction modulates comprehension (Bever and Sanz 1997, Friedmann et al. 2008) and production processes (Kegl 1995, Kim 2006, Lee and Thompson 2004, 2011, McAllister et al. 2009). However, especially in production, the processing consequences of this distinction are unknown, beyond the suggestion that unaccusatives somehow involve more complex processing than unergatives (cf. Lee and Thompson 2011). Here we examine how real-time planning processes in production differ for unaccusatives and unergatives. We build on previous studies on look-ahead effects in sentence planning that show that verbs are planned before uttering a deep object but not before uttering a deep subject (Momma, Slevc and Phillips 2015ab). This line of research sheds light on the broader issue of how the theory of argument structure relates to sentence production.

### 1.1 Unaccusativity and the timing of verb planning in sentence production

The unaccusative hypothesis claims that the subject of an unaccusative verb originates as the object of the verb (e.g., Burzio 1986, Perlmutter 1978). Supporting this hypothesis, a range of linguistic phenomena, including *ne*-cliticization and auxiliary selection in Italian (Burzio 1986), English resultatives (Levin and Rappaport Hovav 1995), and possessor datives in Hebrew (Borer and Grodzinsky 1986), suggest that the subjects of unaccusative verbs behave like objects. Reflecting this object-like nature of unaccusative

subjects, in transformational theories such as Government-Binding Theory (Chomsky 1981) unaccusative subjects are considered to be base-generated in the object position and moved to the subject position (e.g., Burzio 1986).

In sentence production, recent studies on the time course of sentence planning suggest that speakers plan verbs before they articulate a deep object, but not before a deep subject. Momma et al. (2015a) showed that verbs are planned before uttering the object noun but not before uttering the subject noun in Japanese active sentences. They subsequently showed that the verbs are planned before uttering the subject noun in passive but not in active sentences in English (Momma et al. 2015b). These studies together suggest that verbs are planned before the deep object, regardless of case marking or whether a non-canonical word order is involved. This finding makes an interesting prediction about the production of intransitive sentences. If unaccusative subjects are deep objects unlike unergative subjects, then unaccusative sentences but not unergative sentences should require advance planning of the verb before the subject noun is articulated. If this prediction is borne out, it would show that the subject of unaccusative sentences is processed like a deep object in sentence production, and that split intransitivity directly impacts the time course of speaking.

But how can one study the timing of verb planning in sentence production? This issue can be investigated using the extended picture-word interference (ePWI) paradigm (Meyer 1996, Schriefers, Teruel and Meinschausen 1998; Momma et al. 2015ab). In an ePWI experiment on verb planning, participants see a picture depicting an action/event

which they describe in sentential form. At the same time, or slightly before/after they see the picture, they also see or hear a distractor word. This distractor word is sometimes semantically related to the target verb, which could cause interference in verb processing. This interference can delay verb-related computation, which surfaces as a delay in production. Interference is always measured by comparison with an unrelated distractor word. The critical question is when this interference effect is observed. If it delays the onset of the subject noun it can be inferred that the verb is planned before the subject noun is uttered. On the other hand, if an interference effect is observed after the onset of the subject noun one can infer that the verb is planned after the subject noun is sent for articulation. In the current study we used ePWI to examine the timing of verb planning in unaccusative and unergative sentences.

## 2. Experiment

### 2.1 Participants

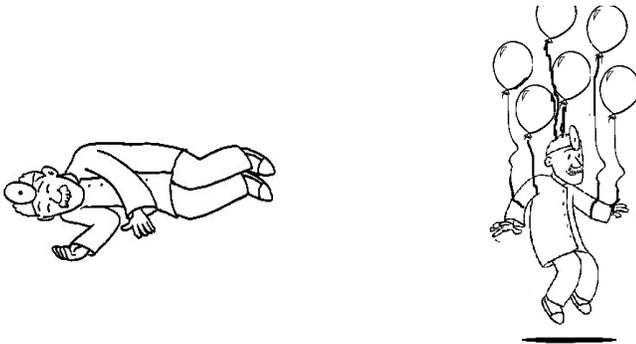
20 native speakers of English participated for either class credit or monetary compensation.

### 2.2 Materials and Design

24 pictures of events were selected. Half corresponded to unergative verbs (e.g., *sleep*), and the rest corresponded to unaccusative verbs (e.g., *float*), as illustrated in Figure 1. The participants of the events corresponding to the unergative verbs were all animate. In contrast, half of the participants of the events corresponding to the unaccusative sentences were inanimate. This imbalance in the number of animate subjects in

unergative vs. unaccusative conditions was due to the practical difficulty of drawing a picture in which animate participants undergo the action denoted by certain unaccusative verbs (e.g., *melt*). The 6 animate participants in the unaccusative pictures were exactly matched to the 6 animate participants in the unergative pictures. This identical subset of nouns was used to test whether any difference between unaccusative and unergative conditions could be solely attributed to the difference in verbs. A full list of target sentences is available in the Appendix.

Figure 1: Example pictures for unergative sentences (left; *the doctor is sleeping*) and unaccusative sentences (right: *the doctor is floating*).



For each picture, a semantically related distractor verb was selected from the set of target verbs for the other pictures. These distractors always corresponded to one of the other target verbs to maximize the chance of obtaining an interference effect (Roelofs 1992). Semantic relatedness was estimated based on the cosine distance measure from latent semantic analysis (Landauer and Dumais 1997). This measure reflects how close two words are in multi-dimensional semantic space in a numerical value ranging from 0 to 1. As a point of reference, the clearly related pair *cat* and *dog* receives a value of 0.36,

while *cat* and *desk* receives a value of 0.01. The average cosine distance between each target verb and its related distractor verb was 0.31 for the unergative verbs, and 0.35 for the unaccusative verbs, with no significant difference between them ( $p > 0.5$ ). Each of the related distractor words was re-paired with a picture from the same verb type to create the unrelated picture-distractor pairs. The average cosine distance between each target verb and its unrelated distractor verb was 0.08 for the unergative verbs, and 0.14 for the unaccusative verbs. Unsurprisingly, two-tailed t-tests revealed a significant difference in the cosine distance between related and unrelated pairs both with unergative verb pairs ( $p < 0.001$ ) and with unaccusative verb pairs ( $p < 0.001$ ). Importantly, the mean cosine distance between the related and related pairs differed by 0.23 for unergative verbs and by 0.21 for unaccusative verbs, so the relatedness manipulation was comparable for the two verb types.

In sum, the current study had a 2 x 2 design, with Verb Type (unergative vs. unaccusative) as a between-items factor and Relatedness (related vs. unrelated) as a within-items factor. Both of these factors were within-subjects factors. There were 24 filler trials where distractors were replaced with a string of four x's (i.e., xxxx). In total, there were 72 trials, and each participant saw the same picture three times, once with a related distractor, once with an unrelated distractor, and once as a filler with xxxx. Note that this number of repetitions is many fewer than in some previous picture-word interference studies (e.g., Schriefers, Meyer, and Levelt 1990).

### 2.3 Procedure

Participants first studied a booklet containing the pictures that they were going to see in the experimental session, with the target sentences corresponding to each picture, until they felt comfortable with each picture and sentence. This familiarization session was used in order to increase the accuracy and reaction time stability of their production and it is a standard procedure in picture naming studies (e.g., Schriefers, Teruel, and Meinshausen 1998). The experimental session directly followed these familiarization sessions. At the beginning of the experimental session participants were instructed to ignore the written distractor word (in red font) on top of the picture and to describe the picture in sentential form as soon as they could, except when they saw xxxx as a distractor. When they saw xxxx, they were instructed to not describe the picture and instead press a space key. This step prevented participants from visually ignoring the distractor, thereby ensuring that the distractor words were processed at least to the extent that they could be distinguished from xxxx. Each experimental trial was structured as follows. First, the participant saw a fixation cross at the center of the screen for 750ms. Then, a distractor verb or xxxx appeared at the center of the screen for 500ms in red font. The distractor verb was related to the target verb in 50% of trials with word distractors, and it was unrelated to the target verb in the other 50% of relevant trials. 150ms following the appearance of the distractor a picture from the studied set appeared on the screen for 1500ms. A 2000ms blank screen separated the trials. The speech onset time from the picture onset to the utterance onset, as well as the duration of the subject noun

head were measured manually using Praat (Boersma and Weenink 2015). These measures were log-transformed and then submitted to statistical analysis.

## 2.4 Results

The results are summarized in Table 1 (onset) and Table 2 (duration) below. A mixed effects model with maximal random effects structure in the sense of Barr et al (2013) was constructed. For the model of subject noun duration, the number of syllables of the noun was included as a predictor.

Table 1: Mean speech onset latency for each condition, with standard error of means (SEM) in square brackets.

	Mean latency		Onset interference effect
	Related	Unrelated	(Related - Unrelated)
Unaccusative	1176 [41]	1079 [34]	97
Unergative	1180 [49]	1167 [40]	13

Table 2: Mean subject noun articulation duration for each condition [SEM]

	Mean latency		Duration interference effect
	Related	Unrelated	(Related - Unrelated)
Unaccusative	555 [20]	555 [20]	0
Unergative	589 [24]	558 [21]	31

The model of onset latency revealed a main effect of Relatedness ( $\beta = 0.08$ ,  $SE = 0.02$ ,  $|t| = 4.49$ ,  $p < 0.01$ ), but no main effect of Verb Type. The interaction between Verb Type and Relatedness was significant ( $\beta = 0.07$ ,  $SE = 0.03$ ,  $|t| = 2.65$ ,  $p < 0.01$ ). A

following planned comparison revealed that distractor relatedness affected onset latency in unaccusative sentences ( $t(19) = 5.21$ ,  $p < 0.001$ ;  $t(11) = 4.22$ ,  $p < 0.01$ ) but not in unergative sentences ( $t(19) = 0.33$ ;  $p > 0.7$ ;  $t(11) = 0.49$ ,  $p > 0.6$ ).

In contrast, the duration measure showed a significant interaction in the opposite direction ( $\beta = 0.04$ ,  $SE = 0.02$ ,  $|t| = 2.14$ ,  $p < 0.05$ ), with no main effect of Verb Type or Relatedness. The number of syllables in the pre-verbal noun was also significantly related to duration ( $\beta = 0.12$ ,  $SE = 0.03$ ,  $|t| = 4.20$ ,  $p < 0.001$ ), but did not interact with Verb Type. A planned comparison revealed that the participants lengthened the utterance of the subject in unergative sentences ( $t(19) = 3.20$ ,  $p < 0.01$ ;  $t(11) = 2.86$ ,  $p < 0.05$ ) but not in unaccusative sentences ( $t(19) = 0.01$ ,  $p > 0.8$ ;  $t(11) = -0.22$ ,  $p > 0.8$ ).

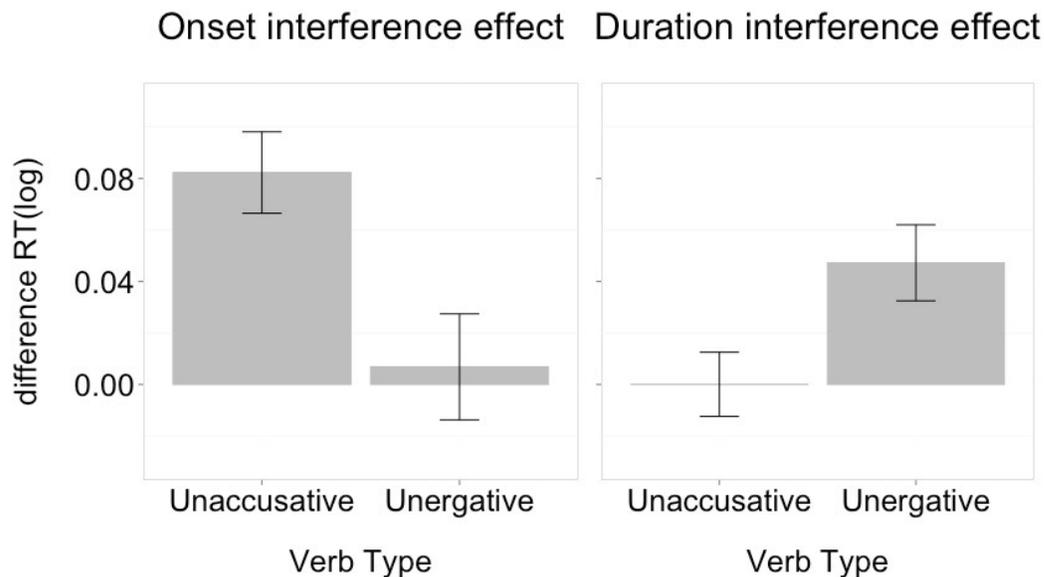
To ensure that these effects were not due to idiosyncratic differences between items, a secondary analysis examined the subset of 12 items that elicited exactly the same set of animate subject nouns in the unergative and unaccusative conditions. This yielded the same qualitative pattern of results, with a 85 ms onset interference effect for unaccusatives compared to a -8 ms onset effect for unergatives. Similarly, these items showed a greater duration interference effect for unergatives than unaccusatives (16 ms vs. -4 ms respectively).

### 3. Discussion

Based on past evidence that verbs must be planned before uttering a deep object but not before uttering a deep subject, the current study tested the unaccusative hypothesis by investigating whether verbs are planned before (surface) subjects in

unaccusative but not in unergative sentences. As predicted, verb interference was found before subject onset in unaccusative sentences, but during subject articulation in unergative sentences (Figure 2). This suggests that verbs are indeed planned *before* the utterance of subject nouns in unaccusative sentences, but *during* the utterance of subject nouns in unergative sentences. Thus, we conclude that the unaccusative-unergative distinction is realized by the producer, and that this distinction is reflected in the selective advance planning of verbs in unaccusative sentences.

Figure 2: Effect of verb associates (Related-Unrelated) on subject NP onset latency (Left) and duration (Right).



The selective advance verb planning in unaccusative sentences is naturally explained if the subject of unaccusative sentences is like an object at some level of representation. This is because advance verb planning was selectively found before direct object nouns in Japanese sentences and before the subject of English passive sentences,

but not before the subject in Japanese sentences or before the subject of English active sentences (Momma et al. 2015ab).

### 3.1 Relation to previous production research on unaccusativity

Unaccusativity has been mainly studied in the context of agrammatic aphasia in sentence production research (Kegl 1995, Lee and Thompson 2004, 2011, McAllister, et al. 2009, Thompson 2003). These studies tested whether the increased complexity of the computation/representation involved in unaccusatives as compared to unergative sentences leads to increased difficulty (and hence increased error rates) in producing unaccusative sentences. In general, these results suggest that unaccusative sentences are more difficult than unergative sentences for agrammatic aphasics, both in natural speech (Kegl 1995) and elicited speech (Lee and Thompson 2004), although these results are not entirely consistent across different methodologies of eliciting speech (Lee and Thompson 2011). Notably, however, little work has investigated the production of unaccusative vs. unergative sentences in normal speakers.<sup>2</sup> One exception is Kim (2006), who studied unaccusative production in neurologically healthy participants and found that unaccusative sentences prime passive sentences. This study suggests that there is some shared representation or processes between unaccusative and passive sentences, which could reflect a shared movement operation in unaccusative and passive sentences. The current study goes beyond these earlier findings in that it tells us specifically how unaccusative and unergative sentences are processed differently in speaking.

Despite the difference in the goals of previous studies and the current studies, it is interesting to note that the majority of the errors that agrammatic aphasics made in Lee and Thompson (2004) in unaccusative sentences (e.g., *the ball is bouncing*) were sequencing errors (e.g., *bouncing the ball*). This could be understood as consistent with the current results, suggesting that verbs are planned before the articulation of the subject. From this pattern, we may infer that the lexical planning sequence in sentence production is guided by deep syntactic/semantic dependencies, only after which linearization occurs. On this view, the production deficit in agrammatic aphasics reported in Lee and Thompson (2004) might be attributed to a linearization problem. Under this account, the production deficit surfaces when the required linearization does not correspond to the relative timing of noun vs. verb planning, either due to a deficit in computation involved in linearization, or to deficits in the cognitive mechanisms needed to reliably perform such computations (e.g., working memory).

### 3.2 Unaccusativity, argument structure, and sentence production

The question remains: why is the verb selectively planned before uttering a deep object? One reasonable explanation is that some computation needed to encode deep object nouns depends on the lexical representation of the verb. Given that Momma et al. (2015a) found advance verb planning before canonical objects in Japanese, this is unlikely to be due to computations involved in establishing a non-canonical mapping between thematic roles and grammatical functions, i.e., this is not due to movement operation per se. Also, given that advance verb planning was found in unaccusative sentences in the current

study and in English passive sentences (Momma et al. 2015b), this is not likely due to computations related to accusative case assignment. The remaining candidates include (i) phrase structure building for the deep object position and/or (ii) assignment of internal argument roles. Both candidates have to do with the role of the argument structure of verbs in sentence production. The first possibility relates to the claim that the phrase structure rules for VPs are dependent on the lexical properties of the verb (i.e., subcategorization) that are not deducible from the conceptual representation alone (Grimshaw 1990). The second possibility is based on the linguistic analysis of argument-predicate relationships by Kratzer (1996), in which she argued that only the internal arguments are true arguments of verbs. Under this view, the assignment of argument roles to the object might selectively require selecting a specific verb, while the assignment of agent argument roles to an external argument might be done independently from the verb head. Future studies should aim to distinguish between these possibilities, and this line of research will inform how theories of argument structure relate to the theories of sentence production.

#### Footnotes

[1] Some claim that unaccusative verbs that can participate in a transitive alternation are not truly unaccusative verbs, suggesting that the subject of those alternating verbs do not undergo movement and instead are base-generated in the subject position (Haegeman 1994). Here we adopt the more common view that both alternating and non-alternating unaccusatives are unaccusative verbs (e.g., Pearlmutter, 1978).

[2] Lee and Thompson (2011) also investigated healthy participants' production of unaccusative verbs with a task in which participants produced unergative (*the black dog is barking*) vs. unaccusative (*the black tube is floating*) sentences by rearranging written words on a screen. Using eye-tracking, they found that healthy participants fixated on the noun more than the adjective when producing the noun in unaccusative sentences but not in unergative sentences. They used this finding to argue that unaccusative sentences are processed more sequentially. We do not think, however, that this result is informative about how unaccusative sentences are processed differently from unergative sentences, since the observed contrast is not motivated by a model of production, since the unergative sentences showed numerically the same pattern and no interaction analysis was reported, and since the written word rearranging task does not engage normal production process.

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