Non-linear lexical planning in sentence production

Shota Momma, Yashna Bowen & Victor Ferreira (University of California, Psychology)
smomma@ucsd.edu

In sentence production, it is generally assumed that lemma selection occurs linearly from "beginning to end." This assumption is held in many models of sentence production (e.g., Chang et al., 2006; Dell, 1986; Slevc & Ferreira, 2006; cf. Lee et al. 2013). Here we argue that lexical planning in sentence production is not strictly linear but is guided by argument-predicate dependency. In two experiments, we show that the lemma retrieval of sentence-final verbs temporally precedes the lemma retrieval of sentence-medial nouns, selectively when the 'true' argument of verbs (i.e., logical objects; Kratzer, 1996) are spoken sentence-initially as in unaccusative sentences (intransitive sentences with a verb that take patient arguments as their subject e.g., *the dog is spinning* unlike the other intransitive sentences, e.g., *the dog is barking*).

Design: In both experiments, participants described complex pictures while ignoring distractor words visually presented on top of each of the four picture components redundantly (Fig. 1). Participants were instructed to describe what is pointed to by the red arrow on the picture, and they were pre-trained to describe the picture stimuli in a certain format. An example sentence hat participants uttered and related distractors are presented below.

Unaccusative: *The octopus below the spoon is boiling.* N dist.: *knife*; V dist. *melt*
Unergative: *The octopus below the lemon is swimming.* N dist.: *peach*; V dist. *run*

All the semantic distractors were re-paired with other pictures (within the same condition) to create unrelated picture-distractor pairs, which served as the unrelated control condition. The semantic similarity between target words and distractors are matched using latent semantic analysis (Landauer & Dumais, 1997). All unaccusative verbs passed transitivity alternation test. In Exp. 1 (n = 26), distractors preceded pictures by 150ms (i.e., SOA = -150ms). In Exp. 2 (n = 26) distractors and pictures were presented simultaneously (i.e., SOA = 0ms). In both experiments, we measured the utterance onset latency relative to picture onset, and duration of each word using a text-to-speech alignment algorithm (*PennForcedAligner*; Yuan & Liberman, 2008). We expected that both noun and verb distractors slow production at some point in a sentence. Critically, **the timing at which noun/verb semantic interference effect occurs should correspond to the timing at which the selection of noun/verb occurs.**

Results: In Exp. 1 (Fig. 2a, boxed graph), verb distractors slowed the onset latency of subject noun articulation in unaccusative but not unergative sentences (paired t: *p*s < 0.05; interaction: p < 0.05). This replicates the previous study that showed that unaccusative verbs but not unergative verbs are planned in advance (Momma, Slevc & Phillips, 2016). In Exp. 2 (Fig. 3a), unergative verb distractors slowed the articulation of adjunct noun head (Fig. 2a, boxed graph; *p*s < 0.05). In both experiments, noun distractors slowed the production of the preposition (*below; p*s < *0.05* in Exp.1 and ps < 0.01 in Exp. 2; Fig. 2b & 3b, boxed graphs). This pattern suggests that adjunct nouns are selected after unaccusative verbs but before unergative verbs.

Previous standard PWI experiments show that distractor presentation timing is critical to observe the effect of semantic interference. Unaccusative verb distractor effect was only observed in Exp. 1 (Fig. 2a) but not in Exp 2 (Fig. 3a). This may be because unaccusative verbs are selected early on, so the distractors need to be processed early enough to interfere with the verb selection, as in Exp. 1. Unergative verb distractor effect on auxiliary verb production was observed only in Exp. 2 (Fig. 3a), but not in Exp. 1 (Fig. 2a). This may be because semantic interference effect weakens as the distractor presentation and lexical selection timing get temporally further apart.

Conclusion: The temporal patterns of semantic interference effects suggest that planning of sentence final unaccusative verbs precedes the planning of sentence-medial adjunct nouns, which in turn precedes the planning of unergative verbs. This suggests that lexical planning is guided by abstract argument-predicate dependency beyond the linear structure in sentence production, challenging the view that lemma selection occurs linearly from "beginning-to-end."

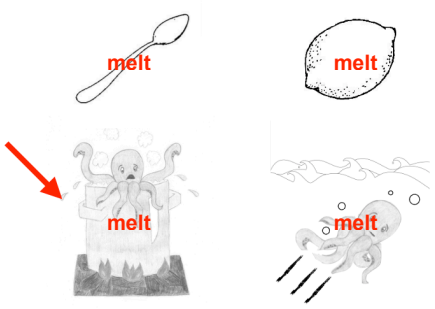

Fig. 1: Two example pictures with example distractors for both experiments.

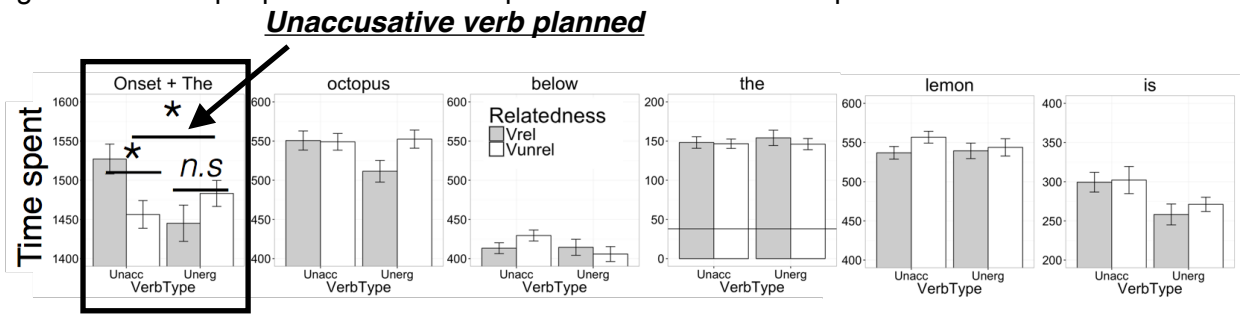

Fig. 2a: Time spent at each pre-verb region in **verb** distractor conditions in Exp. 1. Errors bars are within-subject standard errors.

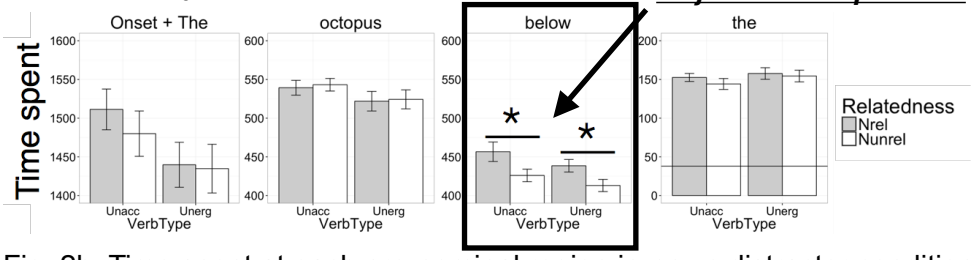

Fig. 2b: Time spent at each pre-nominal region in **noun** distractor conditions in Exp. 1.

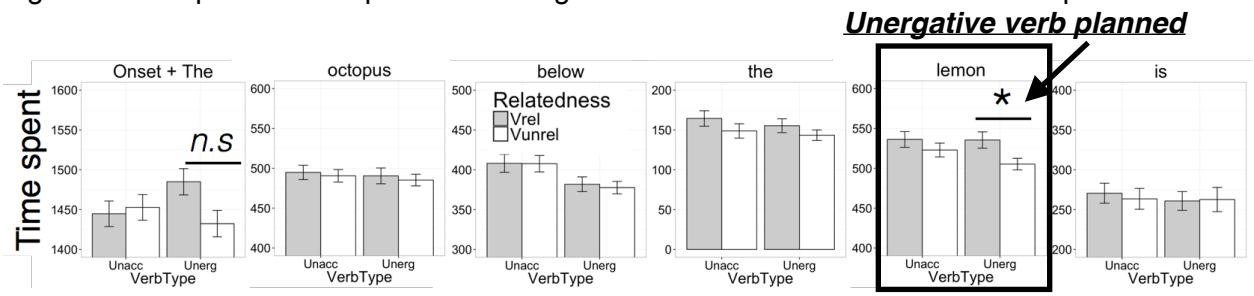

Fig. 3a: Time spent at each region in **verb** distractor conditions in Exp. 2.

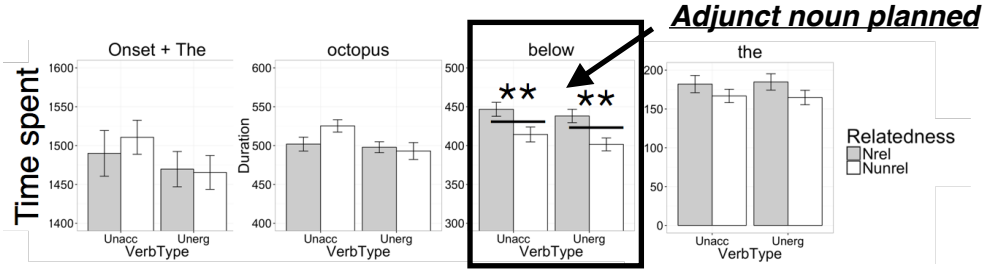

Fig. 3b: Time spent at each region in **noun** distractor conditions in Exp. 2.