Timing of syntactic and lexical priming reveals structure-building mechanisms in production

Shota Momma (UC San Diego), L. Robert Slevc, Rebecca Kraut & Colin Phillips (U. Maryland)
smomma@ucsd.edu

In sentence production, it is often assumed either that the structure of a whole clause precedes retrieval of lexical items (as in some slot-and-filler models; e.g., Garrett, 1975) or structure building occurs incrementally after lexical retrieval (as in some lexicalist models; e.g., Kempen & Hoenkamp, 1987). Here we provide evidence that structure building in sentence production occurs incrementally but still precedes lexical retrieval, partially supporting each model's core intuitions. We measured the effect of ditransitive structural repetition vs. lexical repetition on production speed for each word of a sentence, using a text-to-speech alignment algorithm (*PennForcedAligner*, Yuan & Liberman, 2008). The effect of structural repetition in production is normally measured as an increased likelihood to produce previously used structures, but here we demonstrate that it also increases the speed of production in ditransitive sentences, but only at a specific sentence-medial point. This speed-up effect occurs earlier than the speed-up effect of lexical repetition of verb phrase internal nouns. From this pattern, we argue that structure building in sentence production has a small grain size (as in incremental lexicalist models), but still precedes lexical retrieval of the relevant parts of the sentence (as in slot-and-filler models). We note that this manner of structure building resembles a well-accepted model of parsing, specifically the left-corner parser and its variants (e.g., Resnik, 1992), suggesting that structure building might be characterized analogously in comprehension and production.

Design: Participants (n = 30) described pictures of ditransitive events using prepositional dative (PD) sentences (constrained by including written PD-only verbs (e.g., *donate*) (Fig. 1), uttering sentences like the following: *The swimmer is donating a shoe to the clown. Before describing the picture,* participants read aloud a prime sentence (see Table 1) that either manipulated structure (prepositional (PD) vs. double object (DO) dative), lexical repetition (a transitive structure mentioning either the theme or goal argument of the following picture), or was an intransitive sentence, serving as a baseline for the lexical repetition conditions. Although participants always uttered PDs in the experimental trials, they also produced an equal number of DOs, and also intransitive and transitive sentences in filler trials.

Results: ***Structural repetition effect***: Speakers took less time to say the verb region (the verb itself and any following pause) when the VP structure was repeated (i.e., when preceded by a PD prime sentence) compared to when preceded by a DO prime (Fig 2; $p < .05$). There was no evidence of a facilitatory effect prior to this region. This suggests that speakers plan the internal structure of a ditransitive verb phrase *as they utter the verb itself*. This suggests that the grain size of structural planning is small, possibly even smaller than a single verb phrase. ***Lexical repetition effect:*** Speakers took less time to say the determiner region when the theme noun was repeated compared to the intransitive baseline prime. (Fig. 3; $p < 0.05$). Speakers also took less time to say the preposition region when the goal noun was repeated compared to the intransitive baseline prime. (Fig. 4; $p < 0.05$). This pattern suggests that the planning of a theme/ goal argument noun occurs right before speakers utter that noun, on a 'just-in-time' basis. That these lexical repetition effects were temporally preceded by the structural repetition effects suggests that structural planning occurs earlier than lexical planning within the ditransitive verb phrase.

Conclusion: The current study examined the temporal effect of structural repetition to assess the relative timing of verb phrase structure planning vs. verb phrase noun planning. The results suggest that the grain size of structure building is as small as, or even smaller than, a single verb phrase (supporting the core intuition of incremental lexicalist models), but still precedes the lexical retrieval of verb internal arguments (supporting the core intuition of slot-and-filler models). We believe this is the first study to show an effect of structural repetition on *local* production speed. In addition, this study illustrates the utility of a resource-efficient text-to-speech alignment algorithm for evaluating speech planning processes within utterances.

Donate

Fig. 1: an example picture.

Type of prime sentences	Example prime sentences
PD prime:	*John gave the book to Mary*
DO prime:	*John gave Mary a book*
Theme prime	*John saw a shoe*
Goal prime	*John saw a clown*
Intransitive control	*John sneezed*

Table 1: Example prime sentence from each condition

Fig. 2: Effect of structural repetition (DO prime - PD prime) on production speed by each region.

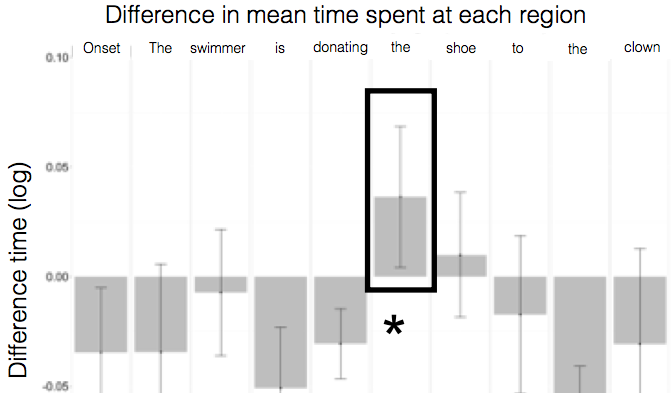

Fig. 3: Effect of theme nouns repetition (Intransitive prime - theme prime) on production speed by each region. Note: the effect at 'the' is significant ($p < 0.05$) when the statistical model takes other regions into account.

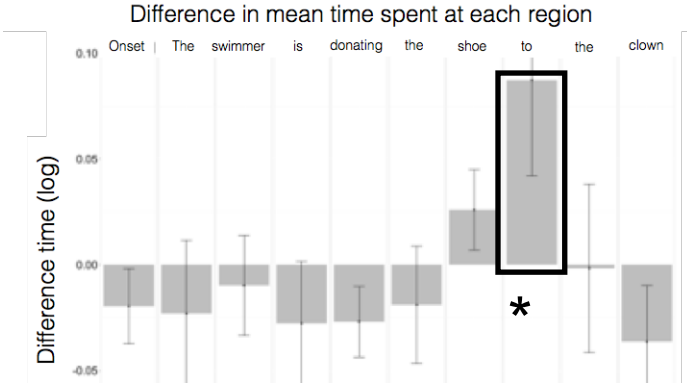

Fig. 4: Effect of goal noun repetition (Intransitive prime - goal prime) on production speed by each region.