Structure before content: Long-distance dependency in sentence production

Shota Momma (UCSD), Masaya Yoshida (Northwestern U.) & Victor Ferreira (UCSD)

shotam2@gmail.com

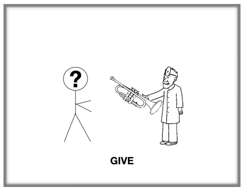
In long-distance dependency processing, it is widely known that comprehenders predict the gap before encountering gap-hosting verbs, without knowing the words intervening between the filler and the gap (Stowe, 1986; Omaki et al., 2016, a.o). Here we show that, in sentence production, speakers plan the syntactic structure of the verb phrase containing the gap before producing the filler and before planning the words between the filler and the gap. We argue that speakers establish the syntactic dependency between the filler and the gap before planning the intervening words, just like comprehenders do.

<u>Design:</u> We took advantage of the syntactic constraint that prohibits the extraction of goal arguments from double object sentences (henceforth Kuroda constraint; Kuroda, 1968; Merchant, 2001). This constraint prohibits sentences like **Who$_i$ is John giving t_i the book?* but does not prohibit the minimally different sentences like *Who$_i$ is John giving the book to t_i.* The main purpose of the current experiment is to exploit this constraint to probe when speakers plan the verb phrase containing the gap. On each trial, participants were first syntactically primed for either prepositional datives (PD, e.g., *the girl is reading the book to the boy*) or double object datives (DO, e.g., *the girl is reading the boy the book*; Bock, 1986), and then described picture stimuli (n = 72) using the target verb given to them (e.g., *give, show, hand*). Fig. 1 and Fig. 2 show sample picture stimuli. The participants (n = 74) were pre-trained to produce sentences like the following as a response:

(1) *Who is the doctor giving the trumpet to.* [goal extraction]

(2) *Who is giving the trumpet to the burglar.* [agent extraction]

When speakers were primed with a DO, they were expected to experience processing difficulty in goal extraction sentences like (1). This is because the DO priming conflicts with the constraint on goal extraction that prohibits the use of double object dative structures. Critically, the timing of this "adverse dative-priming effect" should correspond to the time point at which speakers plan the verb phrase structure containing the gap. This is because, without planning the VP structure, speakers cannot represent whether the constraint in question is relevant to the sentence they are producing. Independently, we assessed the effect of codability of the theme argument depicted in the picture on production (how hard it is to choose a specific name given a picture), using norms obtained by Szekeley et al. (2004). Codability affects the lemma selection process (e.g., Griffin, 2001), and therefore the timing at which this effect is observed should indicate the timing of lemma selection for theme arguments. We localized the adverse dative-priming and codability effects to a specific word in sentence production using a text-to-speech alignment algorithm (Yuan & Lieberman, 2008). By comparing the relative timing of the adverse dative-priming effect and the codability effect, we can estimate the relative timing of planning the verb phrase structure containing gap vs. theme nouns. **<u>Results:</u>** Speakers almost never produced DO sentences when in goal extraction sentences like (1) (< 1%), suggesting that the Kuroda constraint is robust. In contrast, they readily produced DO sentences in agent extraction sentences like (2) (around 19%). Critically, given DO-primes, speakers were slower to start speaking the goal extraction sentences like (1), but not agent extraction sentences like (2) (Fig. 3, interaction $p < .05$, see also Table 1). In contrast, speakers were <u>not</u> slower to start producing sentences with less codable theme arguments, but they were slower to speak the verb (e.g., *giving*) in both agent and goal extraction sentences (Fig. 4). This suggests that speakers planned the VP structure containing the gap before sentence onset, and later planned the theme nouns on a *just-in-time* basis. **<u>Conclusion:</u>** Speakers plan the VP structure containing the gap before the onset of sentence-initial wh-words, and before planning the theme arguments intervening between the filler and the gap. This time-course of planning suggests that speakers establish syntactic dependencies between the filler and the gap before planning intervening words using a top-down structure-building algorithm, just like comprehenders. We suggest that the same top-down structure-building algorithm for establishing long-distance dependency is shared between comprehension and production.



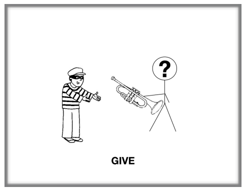


Fig. 1 (left) and Fig 2 (right). The sample picture stimuli used. With proper pre-training, the left picture elicited: *Who is the doctor giving the trumpet to* (goal extraction). The right picture elicited: *Who is giving the trumpet to the burglar / the burglar the trumpet* (agent extraction).

ExtractionType	PrimeType	Onset	Who	is	the/giving	doctor/the	giving/trumpet	the/to	trumpet/the
Goal	DO	2420	272	248	145	466	571	131	477
Goal	PD	2307	275	244	133	465	582	148	473
Agent	DO	2264	254	211	610	143	564	215	284
Agent	PD	2295	253	213	589	136	576	222	265

Table. 1: Average onset latency + word-by-word production time by condition.

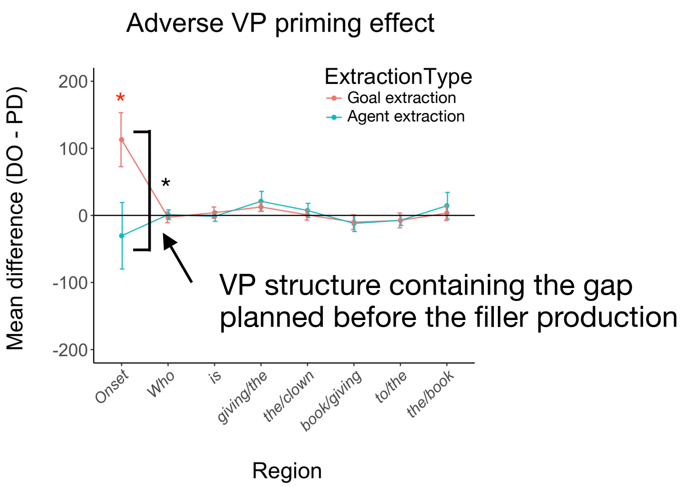


Fig. 3: Adverse syntactic priming effect in the onset latency + word-by-word production duration (difference plot). The error bar represents the standard error of the means.

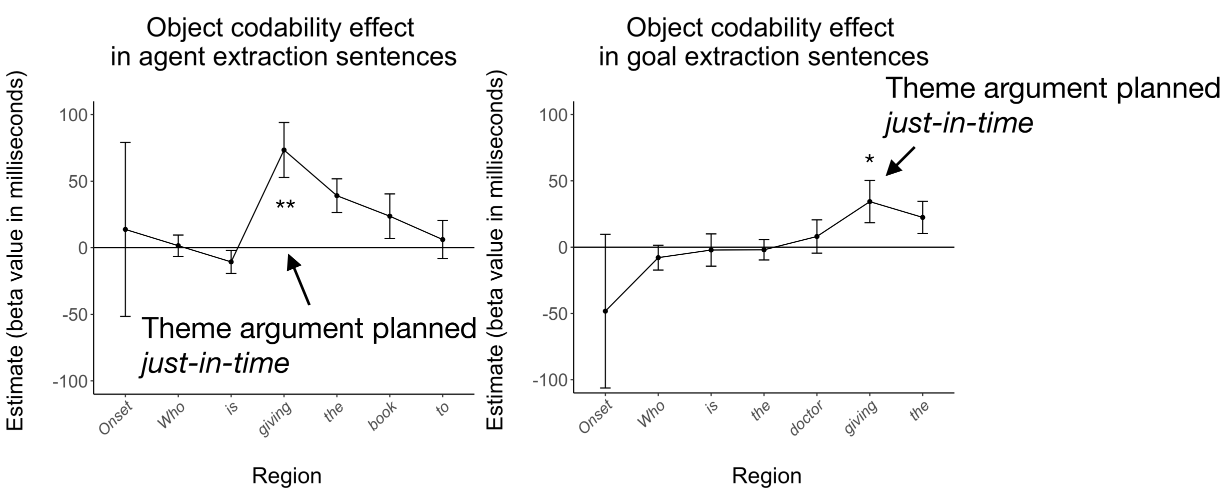


Fig. 4: Object codability effect in the onset latency + word-by-word production duration in agent extraction sentences (left) and goal extraction sentences (right). The y-axis represent the beta value of the codability variable, based on mixed effects models constructed for each region.