Syntax guides verb planning in sentence production

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In production, it has been suggested that speakers plan verbs before they start uttering verbs' patient arguments, but not agent arguments (Momma et al. 2019). However, why verbs are planned selectively before their patient arguments is not clear. One possibility is that speakers plan verbs to establish a conceptual relation between verbs and their patients (*the conceptual account*). The other possibility is that speakers plan verbs to encode a syntactic relation between verbs and their underlying objects, which are often patients (*the syntactic account*). Here we provide evidence for the syntactic account. We show that speakers plan verbs before uttering patient noun phrases, but only when they are verbs' underlying syntactic objects.

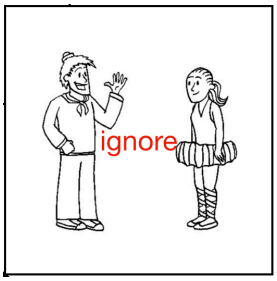
We used a version of an *extended picture word interference* task (ePWI, Meyer, 1996), in which speakers produce sentences in response to action pictures while ignoring distractor verbs presented visually (Fig. 1). If speakers are slower to start speaking given related distractor verbs, it suggests speakers plan verbs before starting to speak. In contrast, if speakers elongate pre-verb words instead, it suggests that speakers plan verbs just before they speak them. Using this logic, Momma et al. (2014) found that speakers plan verbs before uttering passive subjects, but not before uttering active subjects, that is, selectively before uttering patient arguments. Here we applied ePWI to sentences involving raising and control constructions (Table 1). Both in (1a) and (1b), the subject (*the ballerina*) has the same conceptual relation to the embedded verb (*greeted*), but it holds the direct syntactic relation only in (1a). In (1b), the relation between the subject and the embedded verb is not direct but is mediated by a silent pronoun (*PRO*). Thus, the syntactic account predicts that speakers plan the embedded verb before the utterance onset in (1a), but not (1b). This is because, only in (1a), the initial argument (*the ballerina*) is the underlying syntactic object of the embedded verb (*greeted*), so the embedded verb should be planned sentence-initially. Meanwhile, the conceptual account predicts that speakers plan the embedded verb before the utterance onset across the board.

Exp. 1: After pre-training, participants (n = 53) produced passive sentences like (1a) and (1b) (see Fig 2 for the task structure). The sentence fragments contained either raising (e.g., *happen*) or control (e.g., *want*) predicates. The pictures were accompanied by visual distractor verbs that are either related (e.g., *ignore*) or unrelated (e.g., *chase*) to the embedded target verb (e.g., *greeted*). The unrelated distractors were used as related distractors in other trials. The utterance onset latency and the duration of pre-verb phonological phrase (e.g., *wants to be*) were measured. The results show that speakers were slower to start uttering the raising sentences like (1a), but not control sentences like (1b) in the related distractor condition (Fig. 3, first panel). In contrast, speakers were slower to utter the pre-verb words in control sentences (e.g., *wants to*), but not significantly in raising sentences, given the related distractor verbs (Fig. 3, second panel). This pattern suggests that speakers plan embedded verbs selectively before the utterance onset in raising sentences only, supporting the syntactic account. **Exp. 2** aimed to test the selectivity of the advance verb planning effect shown in Exp. 1. After pre-training, participants (n = 48) produced the active variant of sentences used in Exp. 1, like (2a) and (2b) in Table 1, given the same task and same materials as in Exp. 1. The results show that onset latency was not affected by related distractors in either raising or control sentences (Fig. 4, third panel). Instead, speakers elongated the duration of pre-verb words in both types of sentences given related distractors (Fig. 4, last panel). Thus, the advance verb planning in the raising sentences found in Exp. 1 is selective to when the raised subjects are underlying syntactic objects. When the subjects are not underlying syntactic objects, speakers plan verbs on a *just-in-time* basis in both raising and control sentences.

These results suggest that speakers plan verbs selectively before uttering verbs' underlying syntactic objects. Because the conceptual relation between the subject noun phrase and the verb is constant between raising and control sentences, this result cannot be explained in terms of the conceptual relation between the events denoted by verbs and their patients. Therefore, the current results show that verb planning is guided by abstract syntactic relations that are not reducible to conceptual relations.

(1) a. *The ballerina happens t_ballerina to be greeted t_ballerina by the sailor.* [raising]
(1) b. *The ballerina wants PRO_ballerina to be greeted t_PRO by the sailor.* [control]
(2) a. *The chef happens t_chef to greet the ballerina.* [raising]
(2) b. *The chef wants PRO_chef to greet the ballerina.* [control]

Table 1. Example sentences. Note that *ballerina* and *chef* were both used as the subject/object equally often in all four conditions.



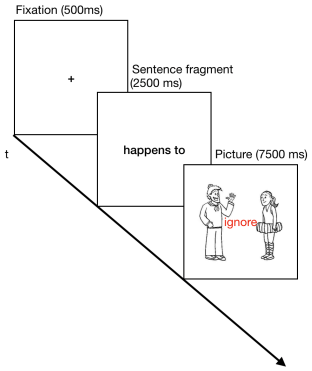


Fig. 1 (left). Example picture stimulus with a related distractor. **Fig. 2** (right). Illustration of the task. Participants were instructed to combine the sentence fragment that contained either a raising or control predicates (e.g., *happens to / wants to*) with the appropriate active or passive sentence corresponding to the picture to produce sentences like in Table 1, e.g., *The ballerina happens to be greeted by the sailor / The chef happens to greet the ballerina*.

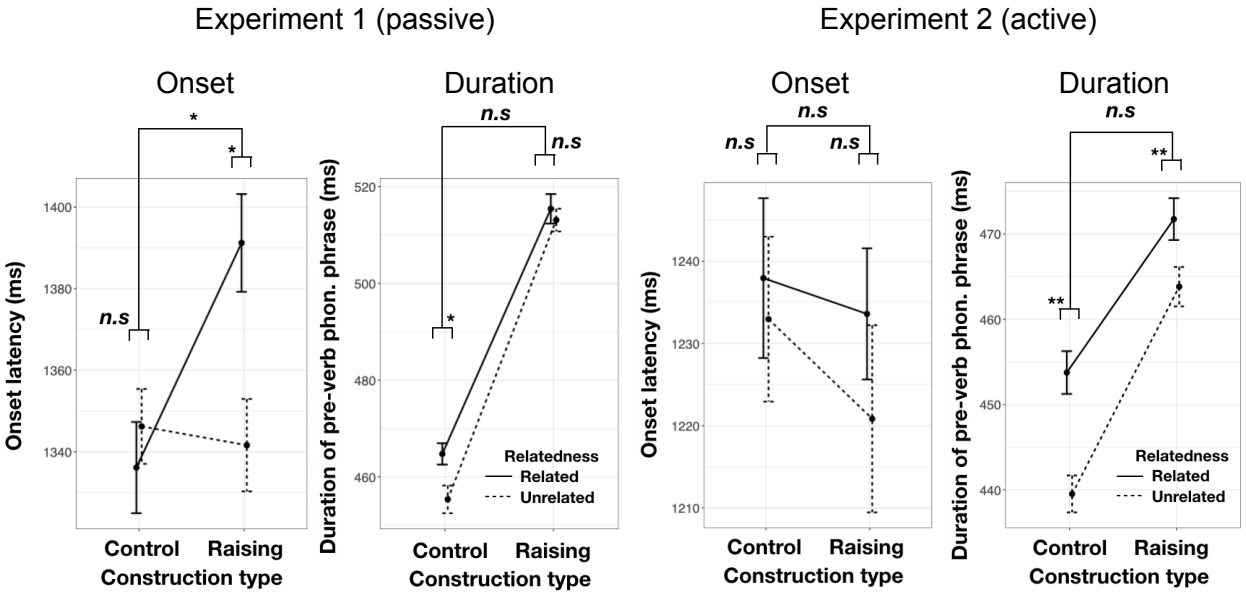


Fig. 3. Results of Experiment 1 (first two panels) and 2 (last two panels).