Experimentally extracting implicit instruments

Models of events represent the interactions of the entities involved. In the event “The chef chopped an onion," a chef and an onion are explicitly involved, and the event results in a chopped onion. However, it is also implied that an instrument, e.g., a knife, must interact with the chef and the onion [1, 2, 3]. In this study, we investigate how robustly people model *implicit instruments*, and to what extent other related items are modeled in the event. **Method:** We use the covered box paradigm [4], in which participants (N=96) are presented with incomplete English sentences, followed by a choice between a specific word and a black box. If the word is a valid continuation of the sentence, participants are instructed to select the word; else, they should select the box and write their preferred completion. We constructed a set of 24 stimuli consisting of a description of an event (“The chef chopped an onion.”), followed by a sentence to be continued (“Then, {using/taking} a different …”). The word presented as a continuation fits one of four conditions: a primary implied instrument (P; “knife”); a secondary instrument related to the event, but less directly involved (S; “bowl”); an associated item related to the setting but not to the event (A; “oven”); and the object itself (O; “onion”). We manipulated two factors: the verb in the second sentence, and its tense. Because “use” is associated with instrument activation [1, 2], we also tested the verb “take”, which should be unlikely to specifically bias participants towards instrument completions. Previous work suggests that instruments are more available in ongoing actions than in completed ones [3], so we tested the verbs in both the progressive and past tense (“Then, the chef {used/took} a different …”). **Analysis 1:** The selection rate of P was highest for both the used/progressive and used/past conditions[1] (Fig. 1, top row). The selection rate was also highest for P in the take/progressive condition (Fig. 1, bottom left). In the take/past condition, the selection rate of P was still high, but the highest selection rate was for O (Fig. 1, bottom right). We also collected RTs, measured from the start of the display to when the option was selected. The RTs of P were faster than those of A and S (Fig. 2). **Analysis 2:** To understand the completions that participants thought were behind the covered box, six annotators categorized the answers provided when participants selected the box. Across all conditions, the participants generally provided answers that were either P, a close synonym of P, or O (Fig. 3). **Discussion:** Analysis 1 shows that the only consistently preferred continuation of the sentence is the primary implied instrument, despite not being explicitly stated in the event. Analysis 2 demonstrates that participants are inclined to complete an event with the primary implied instrument or a similar instrument, even when the primary instrument is not a provided option. These analyses suggest that instrument representations are generated to encode events even when they are not explicitly mentioned. Additionally, availability of such instruments is sensitive to tense (past/progressive). The results of these experiments support a theory of event representation where people track some kinds of implicit material, and event representations are constructed from both explicitly-mentioned items and implicitly-involved instruments that are necessary for the events; histories are *not* tracked for contextually-available – but not directly involved – items. Models such as the recent Intersecting Object Histories (IOH) framework [5], in which events are composed of representations of the entities involved in them, can easily accommodate this.

[1] {Word/Box} ~ Verb*Tense*AnswerCondition+(1+AnswerCondition+Tense|Subject)+(1|Item)

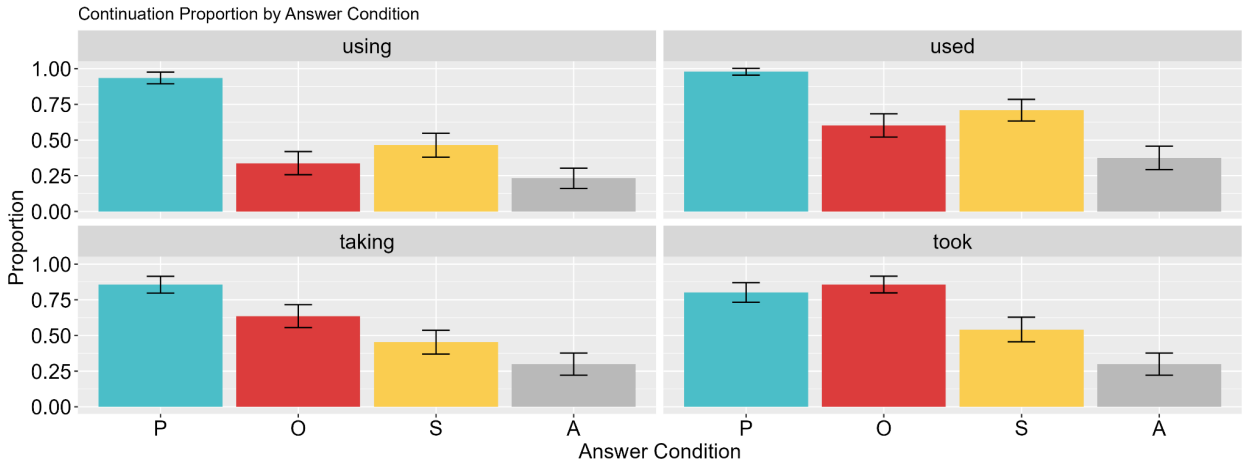

Figure 1: Selection rate by answer condition.

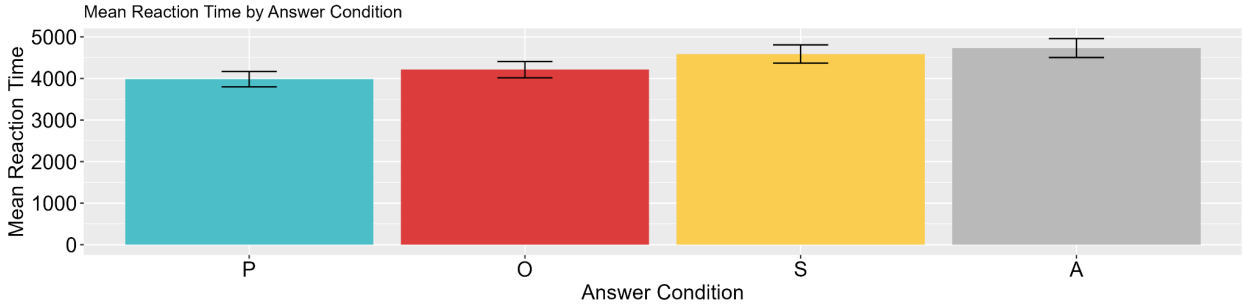

Figure 2: Reaction time by answer condition.

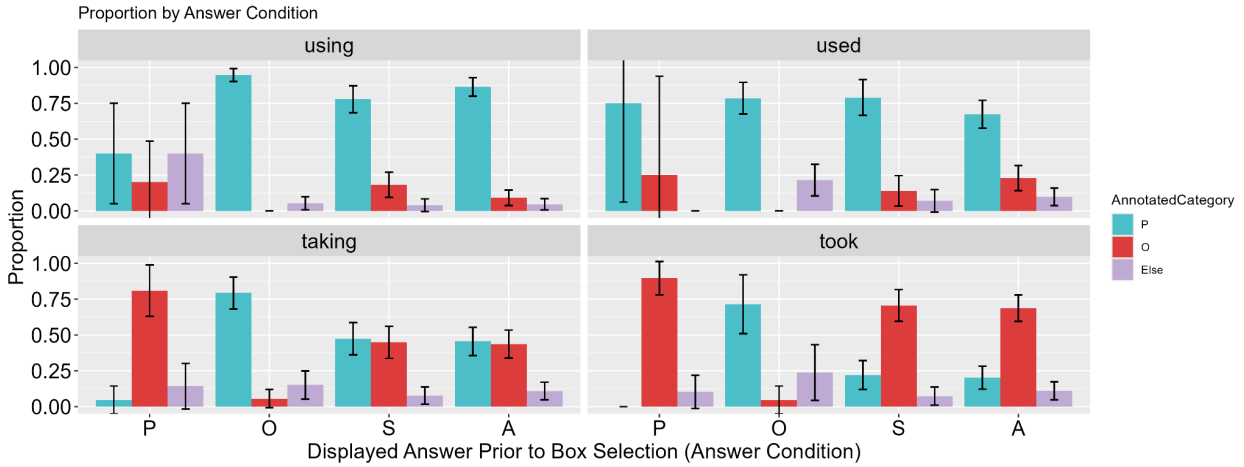

Figure 3: Categories of objects provided as alternative answers.

References [1] Koenig et al. (2008), *Journal of Semantics*. [2] Rissman & Majid (2019), *Psychonomic Bulletin Review*. [3] Zwaan & Radvansky (1998), *Psychological Bulletin*. [4] Huang et al. (2013), *Language Learning and Development.* [5] Altmann & Ekves (2019); *Psychological Review.*