Constraints on syntactic-conceptual mapping: the learnability of 'inverse verbs'

What constraints—linguistic or otherwise—govern lexicalization? We explore this question in the domain of verb learning, beginning with the observation that languages lack 'inverse verbs'. For instance, English has "kick" but no verb "blick" such that "Jill blicked Jack" means that Jack kicked Jill [e.g., A-F]. In other words, in simple transitive clauses, the syntactic subject names the agent and the object names the patient. The cross-linguistic lack of verbs inverting this mapping is not because it is impossible to express such meanings (e.g., as in the passive "Jill was kicked by Jack"). Yet while most acquisition theories assume that learners track some aspects of the syntax-semantics mapping, they typically stop short of positing knowledge of specific constraints on how syntactic roles map onto conceptual ones—assuming at most that children grasp the number and type of categories (e.g., nouns) in an utterance [e.g., G,H]. The cross-linguistic absence of inverse verbs, however, suggests a deeper constraint [I-K]. This invites a thus-far untested prediction: **Inverse verbs should be difficult (if not impossible) to learn**. Across 5 pre-registered experiments with over 1,400 English- and German-speaking participants, we offer initial support for this prediction.

Participants attempted to learn the meaning of 3 novel verbs by reading affirmative and negative instances of those verbs describing scenes depicting shapes (Exps. 1-3) or a boy-girl pair (Exps. 4-5) interacting. For the 2 target verbs ("gleeb", "frell"), participants were randomly assigned to either the **Standard** condition, in which the syntactic subject named the agent (e.g., a square launching a circle via zig-zagging would be described as "the square frelled the circle"), or the **Inverse** condition, in which the syntactic object named the agent (e.g., "the circle frelled the square"). A filler verb described a non-causal event intransitively (e.g., moving side to side → "the circle and the square are blooging"). Following 8 training trials per verb (4 affirmative, 4 negative), participants were tested on the verbs' meanings.

In Experiment 1 (n=300), both critical verbs described launching events differing in the agent's manner of motion (twirling vs. zig-zagging) before contact with the patient (see Fig. 1)

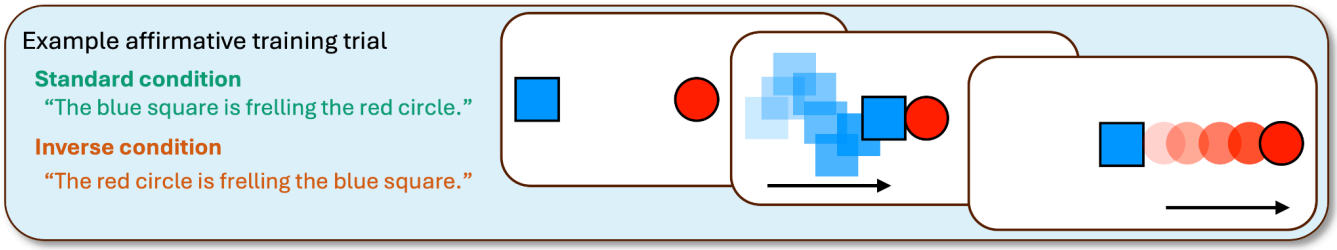

Fig. 1: Example affirmative training trial from the Standard (green) and Inverse (orange) conditions of Exp. 1. In Exps. 1-3, a square and a circle participated in launching-type events which differed in the manner of motion of either the agent (Exps. 1-2) or the patient (Exp. 3). The events were named by different verbs ("gleeb" vs. "frell").

Then participants answered 8 questions about each target verb (e.g., "Is the circle frelling the square?") and 4 about the filler verb. For half, the answer was "yes"; for half, the agent's manner of motion was wrong (i.e., swapped with the other verb's manner); see demo here. Confirming our predictions (Fig. 2), **those in the Standard condition learned the target verbs better than those in the Inverse condition** (β=0.69, z=4.48, p<.001). This difference did not obtain for the filler verb (β=0.27, z=1.44, p=.151; Interaction: β=-0.37, z=1.87, p=.062).

Exp. 2 (n=300) confirmed that participants attended to the whole sentence, not just the verb, by using negative test questions that altered the order of the sentential arguments instead of the agent's manner of motion. The overall pattern was similar to Exp. 1 (Target: β=1.43, z=8.77, p<.001; Filler: β=-0.34, z=0.35, p=.727; Interaction: β=-1.80, z=4.68, p<.001).

Exp. 3 (n=300) tested whether the Inverse-condition's difficulty arose because the *agent's* motion distinguished the verbs, rather than from syntactic-conceptual mapping constraints per

se. The experiment was otherwise identical to Exp. 1, except that the *patient*, rather than the agent, embodied the distinct manner of motion (e.g., the square moved straight and collided with the circle, which zig-zagged away). Here too, the overall pattern was similar (Target: β=0.86, z=2.86, *p*=.004; Filler: β=0.28, z=1.33, *p*=.184; Interaction: β=-0.55, z=1.93, *p*=.053).

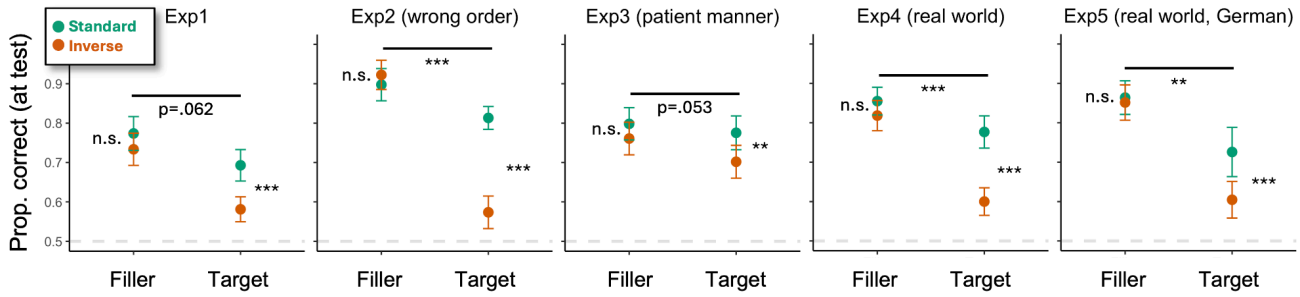

Fig. 2: Performance on the 20 test trials in Exps. 1-5. **Exp. 1:** shapes engaging in launching events with different manners of motion; negative test questions manipulated agent's manner. **Exp. 2:** identical to Exp. 1, but negative test questions altered sentential argument order. **Exp. 3:** identical to Exp. 1, but the unique manner of motion was bound to the patient. **Exp. 4:** used videos of a boy-girl pair interacting rather than shapes. **Exp. 5**: identical to Exp. 4, but in German. Error bars reflect 95% within-participant CIs; ***p* < .01, ****p* < .001; n.s.: *p* > .15.

Exp. 4 (n=300) shared the structure of Exp. 1, but used real-world videos to support generalizability to more realistic word-learning. A boy-girl pair engaged in pushing events distinguished by the agent's manner of motion (pushing via jumping vs. pushing via side-stepping; Fig. 3). See demo here. The same pattern emerged (Target: β=1.34, z=6.86, *p*<.001; Filler: β=0.35, z=1.41, *p*=.159; Interaction: β=-0.96, z=3.36, *p*<.001).

Fig. 3: Example affirmative training trials from the Standard (green) and Inverse (orange) conditions of Exp. 4. In Exps. 4-5, a boy-girl pair engaged in pushing events which differed in the agent's manner of motion (e.g., jumping vs. side-stepping before pushing). The distinct manner is highlighted in the figure by a bolded border.

Exp. 5 (ongoing) replicates Exp. 4 with German speakers. German case marking provides an explicit cue to subjecthood, ruling out the possibility that English participants in the Inverse-condition struggled not because the intended meaning ran afoul of the Subject-Agent link, but because they were trying to reinterpret the word order (e.g., treat "the girl" as the displaced subject in "The boy is gleebing the girl"). In German, "Der Junge gribbelt das Mädchen" unambiguously marks "Der Junge" as nominative, signaling subjecthood, making such reinterpretation impossible. Initial results (n=279/300) show the same pattern (Target: β=1.20, z=4.97, *p*<.001; Filler: β=0.10, z=0.28, *p*=.716; Interaction: β=-1.07, z=3.16, *p*=.002).

Together, our results show that **inverse verbs pose serious learning challenges**. Future work will test children to rule out first-language transfer. For now, the findings support the view that the link between syntactic and conceptual role reflects a deep-seated constraint.

[A] Dowty (1991) Thematic proto-roles and argument selection **[B] Fillmore (1970)** The grammar of "hitting" and "breaking" **[C] Williams (2015)** Arguments in syntax and semantics **[D] Carter (1976)** Some linking regularities **[E] Perlmutter and Postal (1984)** Toward a universal characterization of passivization **[F] Baker (1988)** Incorporation: A theory of grammatical function changing **[G] Fisher, Jin, & Scott (2019)** The developmental origins of syntactic bootstrapping **[H] Lidz & Gleitman (2004)** Argument structure and the child's contribution to language learning **[I] Pinker (1984)** Language learnability and language development. **[J] Pinker (1989)** Learnability and cognition: the acquisition of argument structure **[K] Perkins, Knowlton, Williams, & Lidz (2024)** Thematic content, not number matching, drives syntactic bootstrapping