

## A causal influence of domain-general cognitive control on sentence comprehension

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Real-time language processing often generates conflict between incompatible representations of sentence meaning. For example, when listeners confront temporary ambiguity, they commit to an interpretation using reliable evidential cues from the input and context that guide comprehension; but sometimes listeners must adjust processing when other cues suggest an alternative analysis. We test how such conflict is resolved to define the mechanisms that enable listeners to regulate interpretations, by examining whether manipulating cognitive-control engagement affects eye-movement indicators of comprehension. We hypothesized that the up-regulation of cognitive-control procedures – which help resolve conflict by biasing processing toward task-relevant information – adapt listeners' parsing strategies when competing cues to interpretation unfold in time. Alternatively, increasing focused attention to *collect* information on a difficult task should have limited effect when *re-characterizing* a sentence interpretation. We studied ambiguous “Put” sentences (e.g., “*Put the horse on the binder onto the scarf*”), where “*on the binder*” is initially misinterpreted as a Goal until “*onto the scarf*” signals the need to revise.

In E1 (N=26), we pseudorandomly interleaved nonverbal Flanker items (conflict resulting from incongruency of arrow directions vs. no-conflict for congruent arrow directions) on trial *n-1* with “Put” sentences (Ambig vs. Unambig, Fig. 1A). Flanker-arrow congruency was varied to determine if cognitive-control engagement sustained to influence successful revision via correct-goal looks (e.g., scarf) after disambiguation (“*onto the scarf...*”). Using mixed-effects regression models, we observed a Current x Previous Trial-Type interaction ( $\chi^2=3.8$ ,  $p=.05$ ): Listeners made more correct-goal looks during Ambig sentences after Conflict vs. No-Conflict Flankers ( $p=.005$ , Fig. 2A), with no effect on Unambig sentences ( $p=.71$ ). This replicates an earlier study [1] that manipulated Stroop conflict to engage cognitive control and suggests that more general, non-verbal mechanisms can impact syntactic revision. As further evidence of domain-general, we manipulated perceptual difficulty in E2 (N=26) to induce response conflict on trial *n-1*: Visual degradation of congruent Flanker-arrows created directional ambiguity (left or right; Fig. 1B). This may recruit domain-general conflict-resolution mechanisms [2] to resolve uncertainty about arrow direction that also assist sentence parsing. Replicating E1, after resolving perceptual conflict (vs. no-conflict) there were more correct-goal looks ( $p=.002$ ) during Ambig (but not Unambig;  $p=.30$ ) sentences following disambiguation (interaction:  $\chi^2=5.6$ ,  $p=.02$ , Fig. 2B), suggesting causal effects of general-purpose cognitive control on syntactic revision.

E3 (N=26) tested an alternative interpretation that these effects arose from “paying more attention” to sentences after a harder task, rather than engaging conflict-control mechanisms per se, by manipulating perceptual *difficulty* (but not conflict) on trial *n-1*. We retained the visual degradation, but arrows faced right or up, thus providing a horizontal/vertical orientation cue that disambiguated arrow direction despite perceptual difficulty (Fig. 1C). Degradation resulted in longer response times ( $p<.01$ ), but the increased difficulty did not affect subsequent correct-goal looks (interaction:  $\chi^2=1.9$ ,  $p=.17$ , Fig. 2C). Comparing E2 and E3 *between* subjects suggests that greater attention by itself in hard conditions may not bias parsing enough to keep comprehension on track. In further support of this, E4 (N=26) manipulated both perceptual conflict (from E2) and difficulty (from E3) on trial *n-1* *within subjects*. Preliminary results suggest more looks to correct goals after perceptual conflict than difficulty. Thus, fluctuations in cognitive control within listeners may impact revision strategies more than attention alone.

These findings begin to define the cognitive mechanisms involved during syntactic “reanalysis”: Cognitive-control engagement, but not simply attending to input, yields causal impact on the ability to regulate interpretations, informing a framework that clarifies a mental architecture in which domain-general cognitive procedures assist language processing.

References: [1] Hsu, N & Novick, JM (2016). *Psych Science*, 27, 572-582. [2] van de Meerendonk, N., Rueschemeyer, SA, & Kolk, HHJ. (2013). *Brain and Lang*, 126(3), 291–301.

