Online parsing strategies are influenced by verb-specific and language-general biases

Zoe Ovans, Kathleen Oppenheimer, & Yi Ting Huang (University of Maryland)
Contact: zovans@umd.edu

Background: During comprehension, listeners recruit disparate sources of information to build structures on the fly. For example, they parse ambiguous sentences like (1) based on knowledge of the distributions of verbs in syntactic contexts. While *with*-PP could either adopt VP-attachment (i.e., *the carrot* is an instrument) or NP-attachment (i.e*., the carrot* modifies an elephant), "*cover*" is biased toward the instrument interpretation, "*choose*" toward the modifier interpretation, and "*point at*" is relatively equi-biased. Importantly, as the contrast with (2) shows, verbs also vary in frequency. Frequency tracks adults' past experience with abstracting the bias of a specific verb, and indeed recent work suggests that verb biases continue to be malleable over one's lifetime [1]. Importantly, variation in lexical frequency raises questions of how listeners parse sentences when verb-specific knowledge is limited. One possibility is that listeners avoid making parsing commitments when lexical biases are uncertain. For *with*-PP sentences, this predicts that attachment decisions should be random for infrequent verbs (mix of VP- and NP-attachment). Another possibility is that listeners rely on verb-general tendencies when estimates of verb-specific biases are noisy. This frequency x bias-regularity interaction would mirror patterns found in children's overgeneralizations [2] and adult production of binominal expressions [3]. Since most verbs favor VP-attachment in *with*-PP sentences [4,5], we hypothesized that adults would predict instruments for infrequent verbs, irrespective of their lexical biases. This would suggest that experience quantity and syntactic distributions have distinct effects on shaping verb-specific biases. While instrument-biased verbs can inherit lexical biases with minimal input, substantial input may be needed to overcome verb-general preferences for modifier and equi-biased verbs.

Method: To examine how experience quantity affects parsing through verb-specific biases and verb-general regularities, we presented participants with ambiguous *with*-PP sentences, see (1) and (2). Verb biases and frequency were manipulated in a 3 x 2 design. Norming of cloze probability confirmed that there were more modifier responses for modifier-biased verbs than instrument-biased verbs (p<.001), modifier-biased verbs had at least 55% modifier-continuations (mean=81%), and instrument biased verbs fewer than 20% (mean=11%). Based on Google n-gram data, frequent verbs were at least 16x more frequent than low-frequency verbs, and across frequency groups, verbs were grouped into pairs with similar meanings. Syntactic parsing was assessed through an eye-tracking task. During sentences, eye-movements were measured to displays like Fig.1. Looks to the target animal were taken to index a modifier interpretation (elephant holding a carrot), and looks to the target instrument were taken to index instrument interpretations (large carrot).

Results + Conclusions: We calculated preference for a modifier interpretation as the proportion of fixations to the modifier object/the instrument object. First, we collapsed across frequency to examine verb-bias effects. Subjects looked more to the instrument object when words were instrument biased, and looked more to the modifier object when verbs were modifier-biased (p<.05) (Fig. 2a). This replicates [4] and supports the notion that adults generate syntactic predictions on the basis of verb-specific biases. To examine frequency effects, we compared modifier preferences for high and low frequency verbs during a 1000ms time window after sentence offset. While high frequency increased modifier preferences overall (Fig. 2b) and in modifier- and equi-biased verbs, it did not alter parsing preferences for instrument-biased verbs (p<.05) (Fig. 3). This suggests that adults track both lexical-specific biases and consistencies across syntactic categories during parsing. Listeners make predictions based on the general pattern of verbs in their language for low-frequency verbs. This enables sensible interpretations of sentences with limited experience. Overriding verb-general tendencies requires experience with the idiosyncratic bias of a particular verb. We will discuss implications of these findings for the development of parsing biases.

(1) [a. Cover / b. Point at / c. Choose] the elephant with the carrot
(2) [a. Conceal / b. Swat at / c. Select] the elephant with the carrot

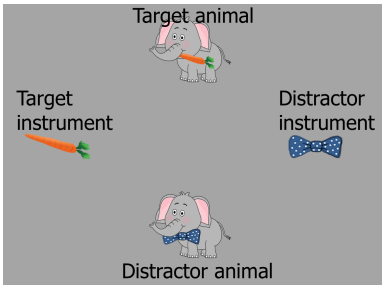

Figure 1: Participants saw this image while hearing "[Choose(high freq) / Select(low freq)] the elephant with the carrot." Looks to the top (elephant) image were analyzed as indexing NP-attachment, while looks to the left (carrot) image were analyzed as indexing VP-attachment. Participants then acted out the action on the touch screen (either poking the elephant with their finger or dragging the carrot to the elephant in a sharp manner).

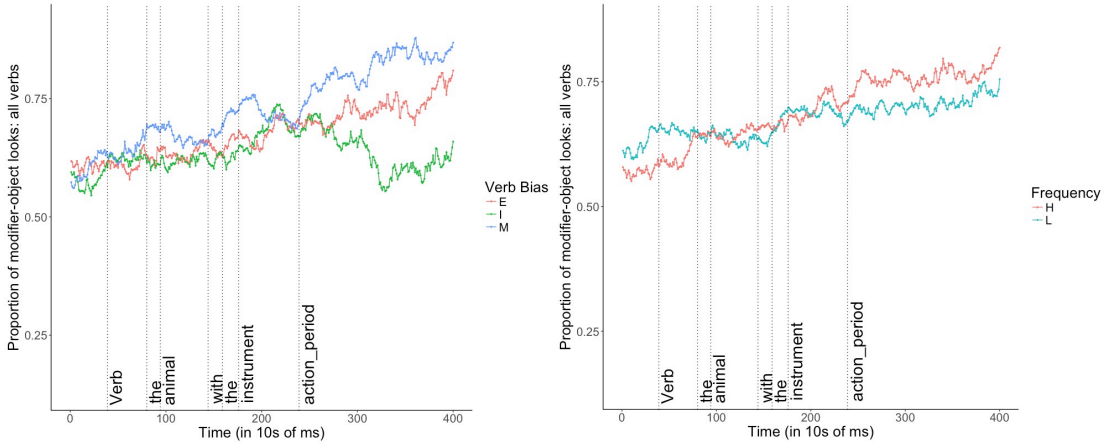

Figure 2 (above): Main effects of verb bias (modifier>equi>instrument, 2a) and verb frequency (high > low, 2b) were found (all p<.05).

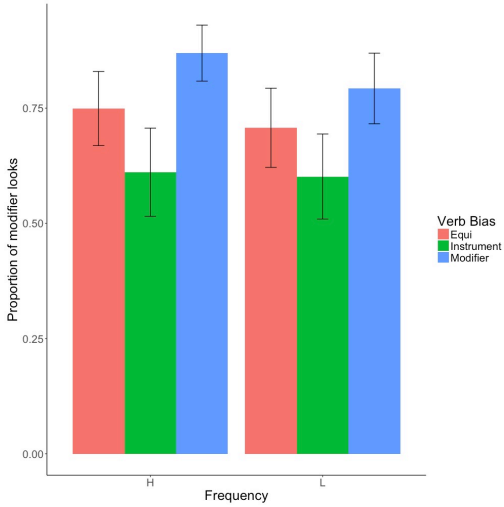

Figure 3: Proportion of modifier looks during the action period by verb bias (modifier, instrument, or equi-biased) and verb frequency (high or low). The effect of frequency was found to be greater for modifier-biased verbs than instrument-biased verbs (bias x frequency, p<.05).

References:

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