# WHERE DOES VERB BIAS COME FROM? EXPERIENCE WITH PARTICULAR VERBS AFFECTS ONLINE SENTENCE PROCESSING

Verbs' probabilistic subcategorization biases affect sentence processing in adults and children (Snedeker & Trueswell, 2004). For example, in "Tickle the pig with the flower", the underlined prepositional-phrase (PP) could stipulate an instrument for tickling, or a modifier specifying which pig to tickle. Children's interpretations of such sentences depend on whether the verb takes instrument-PPs often ("tickle"), or rarely ("choose"). These effects emerge quickly as children listen, showing that verb bias guides incremental sentence comprehension.

Where does verb bias come from? One possibility is that verb bias results entirely from verb meaning. Perhaps children expect "tickle" (but not "choose") to take an instrument-PP because this verb's meaning implies an instrument. Another possibility is that verb bias is influenced by the statistics of language experience. Perhaps we learn that "tickle" predicts instrument-PPs because we encounter it in sentences with instrument-PPs.

Artificial-grammar-learning experiments suggest that adults can learn verb biases from the statistics of language experience, independent of meaning differences among verbs (Wonnacott et al., 2008). Moreover, 2-year-olds learned a novel verb's transitivity through listening experience, before learning the verb's semantic content (Yuan & Fisher, 2009). Here we asked whether listening experience influences the biases of familiar verbs, as reflected in measures of children's online sentence-processing.

Five-year-olds watched training dialogues in which 8 familiar verbs ("equi-bias" verbs; Snedeker & Trueswell, 2004) appeared in sentences including "with"-PPs (see Fig-1). Discourse context and noun-phrase content strongly promoted either instrument or modifier interpretations of the PPs in the dialogues. In the test phase, children followed instructions containing ambiguous "with"-PPs (e.g., "Pinch the cow with the barrette!"), by moving toys in a display while a camera recorded their eye-movements. Test-sentence displays included a target and distracter animal (e.g., cow with barrette; giraffe with lollipop), and a target and distracter instrument (large barrette; large lollipop). Each child heard 4 instrument-training and 4 modifier-training dialogues, then received instructions containing either the instrument-trained or modifier-trained verbs.

Children's eye-movements during the test sentences revealed effects of training (Fig-2). Children who were tested on instrument-trained verbs looked reliably more at instruments, and less at the target animal, than did children who were tested on modifier-trained verbs. These effects emerged following the onset of the object of the PP (e.g., "barrette"), and even earlier, during an analysis-window including the direct-object and preposition (e.g., "cow with ..."). Thus, hearing familiar verbs combined with clear instrument- or modifier-PPs influenced 5-year-olds' later incremental interpretation of sentences containing the same verbs. Verbs that had appeared in instrument-training dialogues, but not in modifier-training dialogues, biased children to assume that 'with' heralded an instrument.

These findings yield new evidence that the statistics of language experience influence verb bias. During the dialogues, children attached to each verb new information about its occurrence with instrument versus modifier phrases, and retrieved that information when encountering the same verb at test. Future experiments will manipulate the relationship between training dialogues and test sentences to explore the nature of this learning, moving toward disentangling the effects of syntactic-distributional and semantic-plausibility learning.

Word count = 500

## Figure 1

**Training Phase**



**Instrument-training dialogue (pinch):**
A: ... How did Chris pinch the monkey?
B: She pinched the monkey with the paper clip!
A: Right, she pinched the monkey with the paper clip. ...
**Modifier-training dialogue (pinch):**
A: ... Which monkey did Chris pinch?
B: She pinched the monkey with the long eyelashes.
A: Right, she pinched the monkey with the long eyelashes. ...

**Test Phase**



Look at the camera.
**Pinch the cow with the barrette.**
Now, make him lick the lollipop.

**Figure 1:** Children saw dialogue videos including 8 equi-bias verbs, 4 in instrument-training dialogues and 4 in modifier-training dialogues. At test, children followed ambiguous instructions including "with"-PPs. Critical instructions contained either the instrument- or the modifier-trained verbs. We provided only 1 referent for the direct-object noun (e.g., one cow), to permit later comparison with adult data. Children's baseline preference for modifier interpretations is similar to adults' in 1 but not 2-referent contexts (Snedeker & Trueswell, 2004).
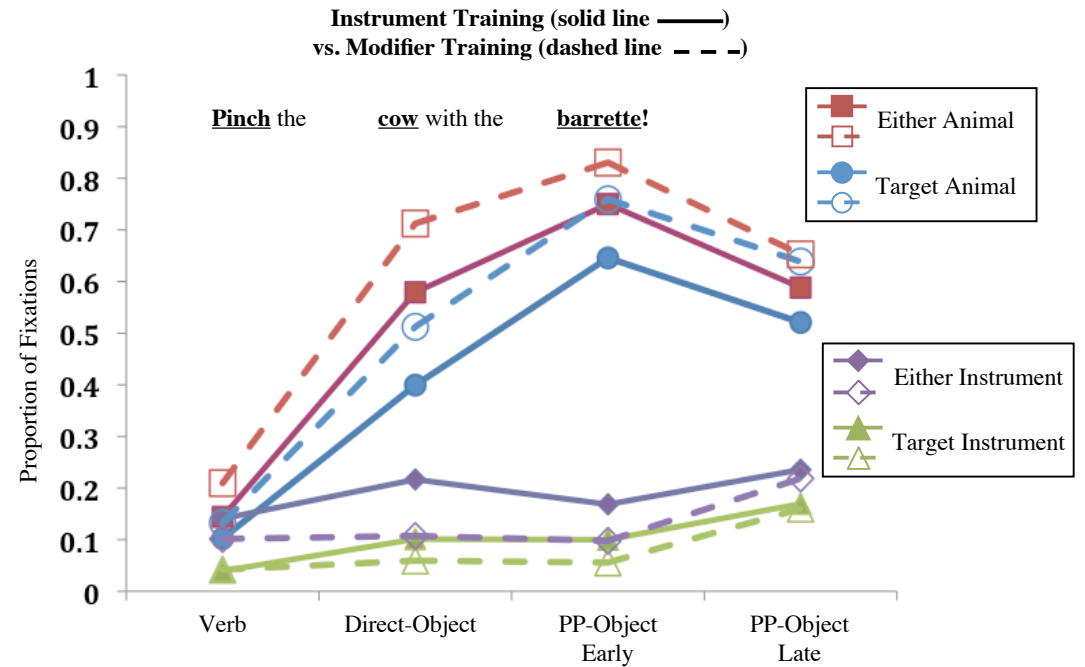
## Figure 2



**Figure 2**
Mean proportion of fixations in four time-windows. (a) <u>Verb</u>: from verb onset to direct-object noun onset (mean window duration 710 ms); (b) <u>Direct-Object</u>: a 467-ms window starting at direct-object noun onset; (c) <u>PP-Object Early</u>: a 467-ms window starting at the onset of the PP-object noun; (d) <u>PP-Object Late</u>: the next 467-ms window after PP-object onset. All analysis time windows were offset by 200 ms from word onset to allow for the time needed to program an eye movement. The top 4 curves represent fixations to either animal and to the target animal in each training condition. The bottom 4 curves represent fixations to either instrument and to the target instrument in each training condition.