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GENERAL QUESTIONS

- How are linguistic and visual processing integrated during online comprehension?
- Sedivy (1999) has shown that visual processing is facilitated by inferences derived through pragmatic principles (Grice, 1975).
- The current study investigates the role of a subtle linguistic constraint -- information about word order in Noun Phrases (NPs) -- in driving any helpful inferences for the visual system.

CURRENT STUDY

- In English, numerals precede adjectival modifiers in pre-nominal positions as observed in the contrast shown in (1).
(1) a. two orange triangles b. *orange two triangles
- Pre-nominal adjectives of different types (e.g. size & color) are also constrained by their relative order (2).
(2) a. a big red triangle b. *a red big triangle

Research question: Can subjects use word order constraints to make communicative inferences?

- We examined this question in two experiments.
 - **Experiment 1 tests the order between numerals and color adjectives.**
 - **Experiment 2 tests the order between size and color adjectives.**

EXPERIMENT 1

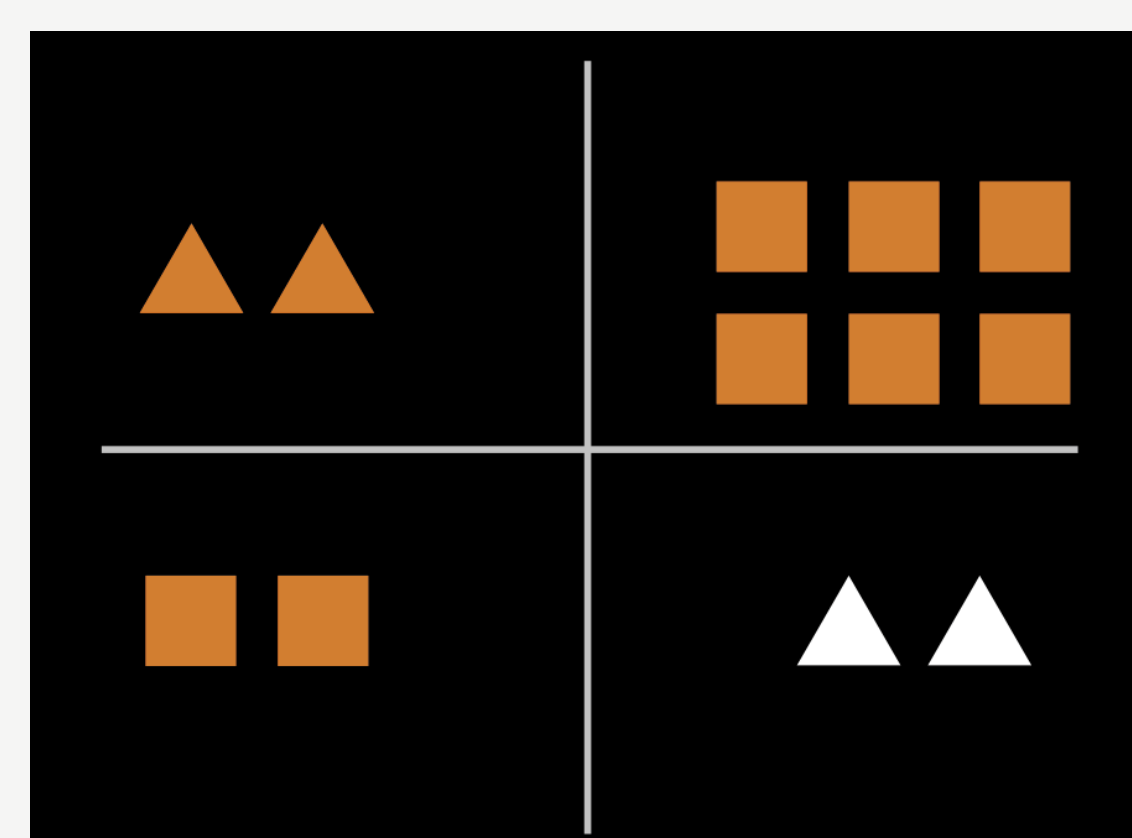
- Design 2 x 2 (adjective type x ambiguity).

Ambiguous instructions:

1. Point to the orange triangles.
2. Point to the two squares.

Unambiguous instructions:

3. Point to the white triangles.
4. Point to the six squares.



PREDICTIONS

At the modifier position we expect:

- More looks to the correct target with the unambiguous instructions (3 & 4) than the ambiguous instructions (1 & 2).
- More looks to the correct target when the modifier is a color adjective rather than a numeral (instruction 1 vs. 2). The reasoning is that for the instruction *point to the orange...*, it is impossible to ask the subject to point to *the orange two/six squares*, so the target can only be the orange triangles. In contrast, for the instruction *point to the two...*, the experimenter

could ask the subjects to point to *the two orange/white triangles*, so the comprehender must wait for more information.

- Same performance for the two unambiguous instructions.

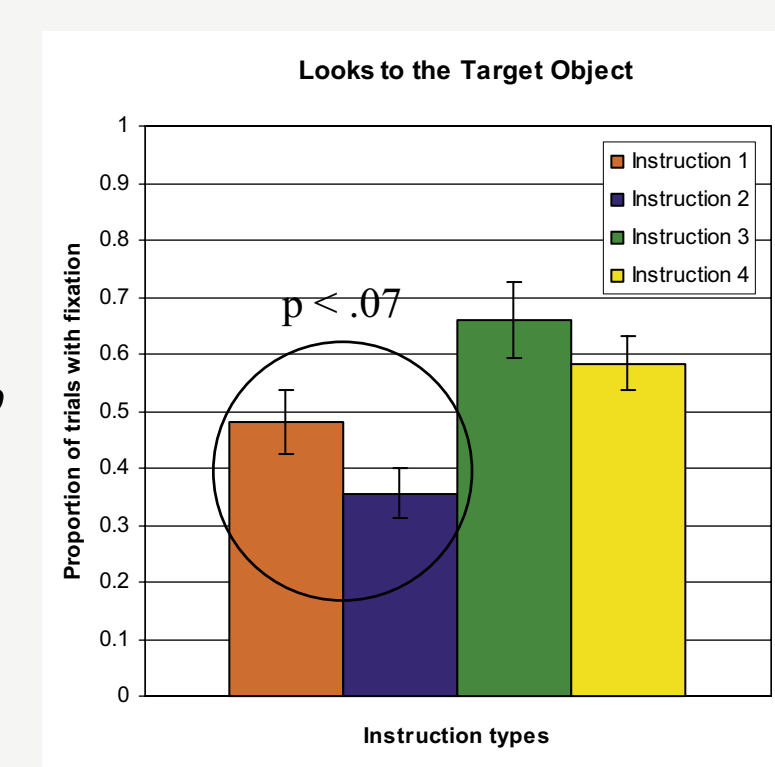
METHOD

- N = 24; 24 critical trials and 72 fillers.
- Participants' task was to point to a target on a computer screen as quickly as possible.
- The dependent measure was the proportion of trials on which a saccade was launched to one of the four regions of the display. Probabilities calculated within each word during the utterance.

RESULTS AND DISCUSSION

Figure 1: Looks to the target object at the modifier (*color/number*) word:

- Main effect of ambiguity $F(1,23) = 14.38, p < .001$. The ambiguous instructions have a lower probability of fixation than the unambiguous instructions.
- Main effect of adjective type $F(1, 23)=3.925, p=.06$. The simple effects analysis shows that this main effect is primarily driven by the difference between Instructions 1 & 2, not Instructions 3 & 4 (see Figure 1).
- These results show that participants are more likely to fixate the correct target when hearing a color adjective compared to a numeral, suggesting very early use of NP order information.



EXPERIMENT 2

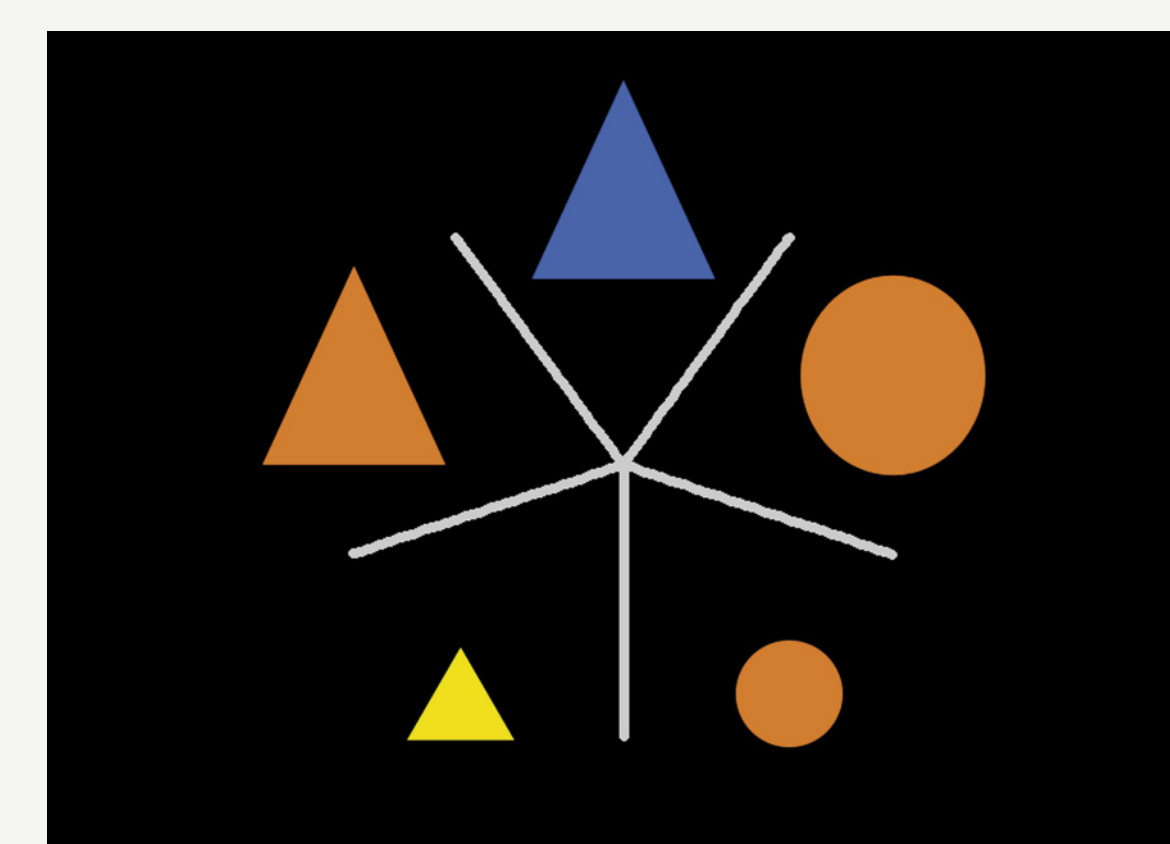
- Design 2 x 2 (adjective type x ambiguity).

Ambiguous instructions:

1. Point to the orange triangle.
2. Point to the big circle.

Unambiguous instructions:

3. Point to the blue triangle.
4. Point to the small circle.



PREDICTIONS

At the modifier position we expect:

- More looks to the correct target with the unambiguous instructions (3 & 4) than with the ambiguous instructions (1 & 2).
- Following the same logic as Experiment 1, we expect more looks to the correct target when the modifier is a color adjective rather than a size adjective (instruction 1 vs. 2).
- No difference is predicted between the unambiguous instructions.
- Methods are the same as Experiment 1 (but N=8).

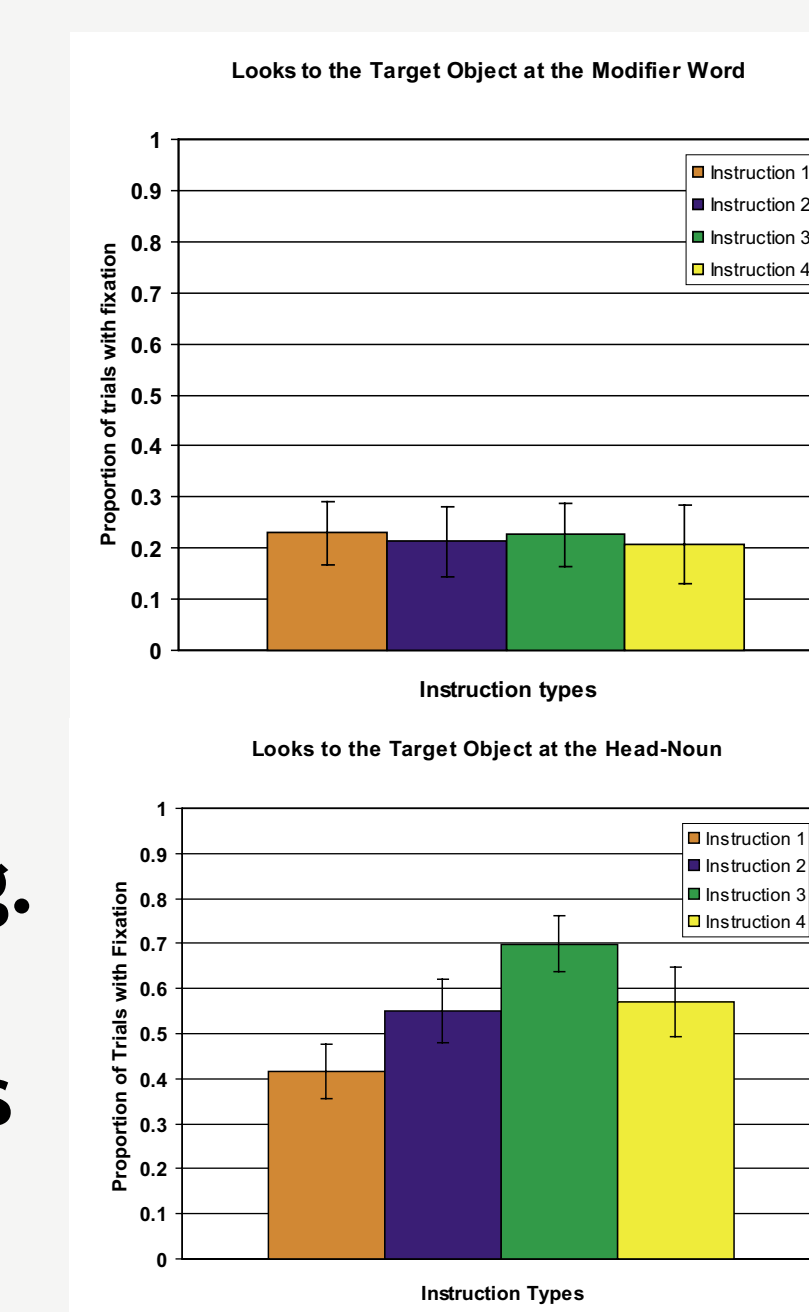
RESULTS AND DISCUSSION

Figure 2: Looks to the target object at the modifier (*orange/big*) :

- None of the predicted differences were observed at the modifier position. At the head noun position there is a marginal effect of ambiguity $F(1, 7)=4.7, P<.07$. The null results could be due to the several factors:

- **The constraint on the relative order between size and color adjectives is not as robust as the order between numerals and adjectives.**
- **Both size and color adjectives can be uttered in post-nominal modifiers (e.g. *the orange triangle that is big* or *the big circle that is orange*), so inferences regarding order are less reliable.**

- **The visual displays were more complex (5 vs. 4 objects) than in Experiment 1 and the objects were closer together, possibly allowing subjects to acquire relevant information parafoveally and thus making a fixation unnecessary.**
- **We also are currently testing additional participants to make sure these results aren't simply due to lack of power.**



CONCLUSIONS

- Our results indicate that subjects can make pragmatic inferences in a strictly incremental fashion, as shown by the early looks to the correct target in Experiment 1.
- Two factors could have driven this result. One is that subjects can make inferences based on their syntactic representations, given that word order is not represented in a flat manner either in the linguistic theory (Abney 1987) or in the psycholinguistic literature (Matthei 1979). The second possibility is that subjects are only using the word order constraint, without relying on any specific syntactic representations, at least for this task. We are running further experiments to differentiate these two alternatives.
- The difference in performance between Experiments 1 and 2 suggests that the comprehension and inferential systems are sensitive to information reliability. If a linguistic constraint can be trusted, it is exploited rapidly; if it is less reliable, the comprehension system is cautious.

ACKNOWLEDGEMENTS

This work was supported by NIH Grant MH-65310, an award from the Michigan Foundation (Strategic Partnership Grants) and the National Science Foundation IGERT grant DGE-0114378. The authors also want thank Ritik Tiwari for help with the data analysis, Elizabeth Davis for recording the sound files, and Karl Bailey for his input on the design and methods.