

## Production expectations modulate contrastive inferences

Listeners, upon hearing an adjective in a definite referring expression such as “the big...,” often draw **contrastive inferences**. These are evidenced as anticipatory eye movements to a *target* item in a *contrast* set, such as a big glass in the context of a small glass, even when an additional big *competitor* object is present [1]. Contrastive inferences are modulated by multiple factors, including adjective semantics [2], property salience [3], speaker reliability [4,5], and expectations of informativity [6]. We focus here on contrastive inferences associated with color adjectives, which have been found to only selectively give rise to contrastive inferences (see [3] for review). Following recent research highlighting the importance of the listener’s generative model of the speaker in generating pragmatic inferences [7,8], we test the following

**expectation-based hypothesis:** The strength of contrastive inferences triggered by an adjective is a function of the relative probability with which the speaker is expected to produce the observed adjective to convey the target relative to the competitor; the more likely the adjective is to refer to the target over the competitor, the greater the contrastive inference. We manipulate expectations about speakers’ probability of modifier production in two ways: 1) by displaying targets with and without a color contrast; and 2) by displaying target and competitor in typical and atypical colors. The latter is motivated by the observation that speakers rarely mention an object’s color, in the absence of a contrast object, when the color is typical for the object (“yellow banana”), but often do when the color is atypical (“yellow strawberry”) [6,9,10]. Thus, contrast presence, target color typicality, and competitor color typicality all provide independent pragmatic reasons for a listener to expect a speaker to produce a color adjective. In Fig 1a, the adjective is most expected to refer to the target because target atypicality, competitor typicality, and contrast presence all support the explanation that the speaker intended to refer to the target. Fig 1b and Fig 1c show contexts with a moderate target expectation and strong competitor expectation, respectively. Modifier production probabilities were normed in a free production study ( $n=68$ ) within an interactive reference game. The results from an interactive reference game show that the modifier production probabilities increase when a contrast is present or the color of the referent is atypical. Crucially, the probability of a color modifier to refer to the target compared to the competitor was greater when there was a contrast present and when the competitor was an atypical color (see Fig. 2).

**Method.** In order to test the expectation-based hypothesis in a web-based offline comprehension paradigm, participants ( $n=80$ ) performed an incremental selection task [11] in contexts such as Fig 1. They clicked on the object they believed the speaker intended at three different points in the utterance, which was gradually revealed on screen: in the prior window (“Click on the”), the adjective window of interest (“Click on the yellow”), and the disambiguating noun window (“Click on the yellow banana!”). Target typicality and contrast presence was a within-subjects and competitor typicality a between-subjects manipulation. There were 55 trials in total with 35 fillers. All stimuli were normed in four separate studies to ensure that: a) Each object was color-diagnostic, i.e., color was among the first three of its associated features and only one color was typical for it. b) Each object was nameable with only one possible label. c) Each object had a typical (e.g., red strawberry) and atypical (e.g., yellow strawberry) instantiation. **Results (Fig. 3).** In the prior window, the probability of object selection was uniform. In the adjective window, the target was more likely to be selected when there was contrast ( $E = 0.59$ ,  $CI = [0.25, 0.93]$ ) and when the competitor was typical ( $E = -0.71$ ,  $CI = [-1.19, -0.21]$ ), supporting the expectation-based hypothesis. Interestingly, we observed no main effect of target typicality, counter to the results reported by [6].

**Discussion.** Methodologically, our results show that contrastive inferences can be elicited in offline clicking paradigms, though we plan to conduct the same study in an eye-tracking paradigm. The combination of the production and comprehension results jointly support a production-centric view of comprehension, in line with other recent developments highlighting the importance of the speaker in comprehension [4,5,7,8]. Under this view, contrastive inferences are inherently Gricean: they are the result of listeners reasoning about the speaker’s most likely intended referent, given their generative model of the speaker.

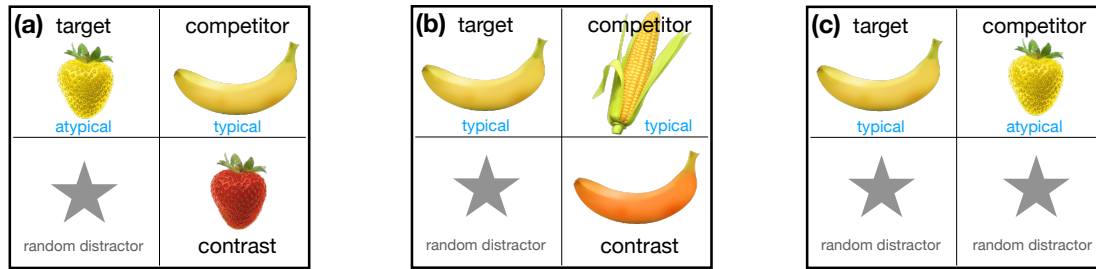


Figure 1: Example contexts that, according to the expectation-based hypothesis, should be a) most conducive to contrastive inference, b) somewhat conducive, and c) least conducive. Labels not present in experiment.

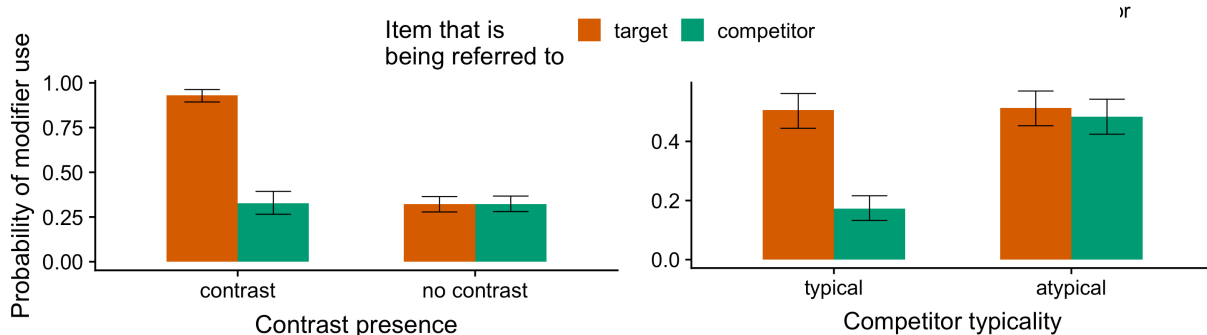


Figure 2: Proportion of color modifier use for the target (red) and competitor (green) when a) the contrast was present or absent and b) the competitor was typical or atypical.

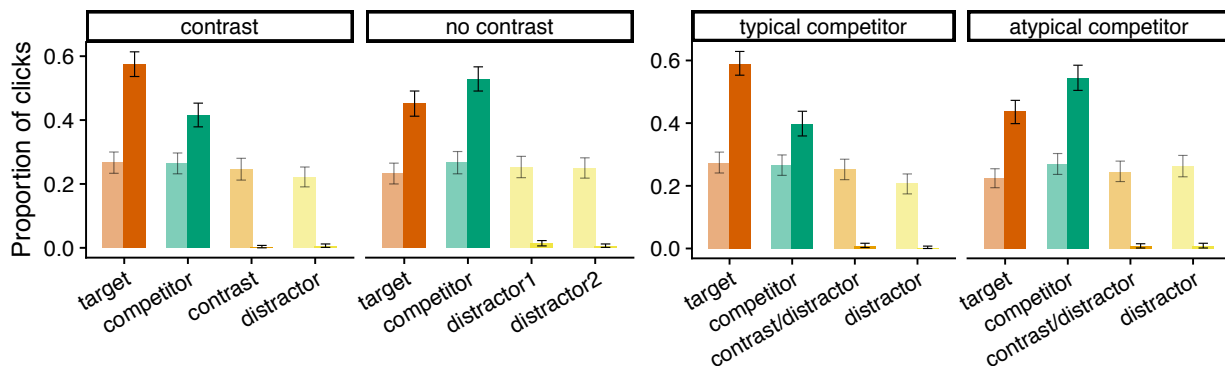


Figure 3: Proportion of object selection in adjective window (dark bars) compared to prior window (light bars) when a) the contrast was present or absent and b) the competitor was typical or atypical.

**References.** [1] Sedivy et al (1999). Achieving incremental semantic interpretation through contextual representation. *Cognition*, 71(2), 109-147. [2] Aparicio, H. et al (2016). Processing gradable adjectives in context: A visual world study. In *Proceedings of SALT*. [3] Rubio-Fernandez, P. et al (under review). Contrastive inferences are sensitive to informativity expectations, adjective semantics and visual salience. psyArXiv preprint <https://doi.org/10.31234/osf.io/mr4ah> [4] Grodner, D., & Sedivy, J. C. (2011). The Effect of Speaker-Specific Information on Pragmatic Inferences. In *The processing and acquisition of reference*. [5] Ryskin, R. et al (2019). Information integration in modulation of pragmatic inferences during online language comprehension. *Cognitive science*, 43(8). [6] Sedivy, J. C. (2003). Pragmatic versus form-based accounts of referential contrast: Evidence for effects of informativity expectations. *Journal of psycholinguistic research*, 32(1), 3-23. [7] Degen, J., & Tanenhaus, M. K. (2016). Availability of alternatives and the processing of scalar implicatures: A visual world eye-tracking study. *Cognitive science*, 40(1), 172-201. [8] Goodman, N. D., & Frank, M. C. (2016). Pragmatic language interpretation as probabilistic inference. *TICS*, 20(11), 818-829. [9] Westerbeek, H. et al (2015). Stored object knowledge and the production of referring expressions: the case of color typicality. *Frontiers in Psychology*, 6, 935. [10] Degen, J. et al (under review). When redundancy is useful: A Bayesian approach to 'overinformative' referring expressions. arXiv preprint <https://arxiv.org/abs/1903.08237> [11] Qing, C. et al (2018). What do eye movements in the visual world reflect? A case study from adjectives. In *Proceedings of CogSci*.