

## Production expectations modulate contrastive inferences

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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. 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 can be predicted by the relative probability that the speaker would produce the observed adjective to convey the target relative to the competitor.

We manipulate production expectations 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 proportion of modifier production for the competitor increases if the object is of an atypical color (see Fig. 2), thus supporting the main assumption of the expectation-based hypothesis.

**Method.** Participants (n=80) performed an incremental decision 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 a 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. We observed no main effect of target typicality.

**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. Our results also suggest that other factors that change listeners’ modifier production expectations affect which object is inferred after observing the adjective. As predicted by a production-centric view of comprehension, the expected behavioral pattern of preference for the target when a contrast is present can then disappear by increasing the listener’s modifier production expectations for the competitor. These results support a highly pragmatic view of comprehension that shifts the explanatory focus away from specific cognitive and linguistic factors that influence contrastive inference and towards listeners’ production expectations.

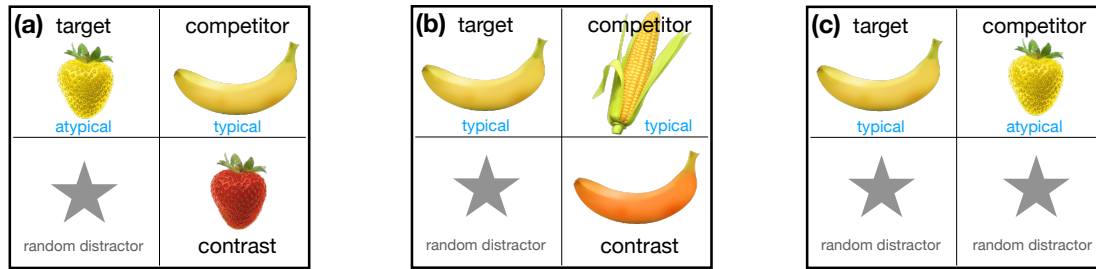


Figure 1: Example contexts that, according to the expectation-based hypothesis, should be a) most conducive to contrastive inference, b) somewhat conducive, and c) least conducive. Labels not present in experiment.

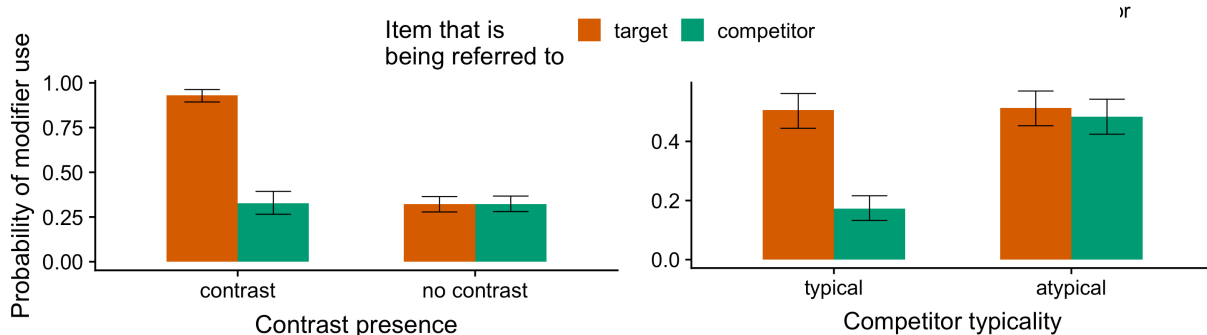


Figure 2: Proportion of color modifier use for the target (red) and competitor (green) when a) the contrast was present or absent and b) the competitor was typical or atypical.

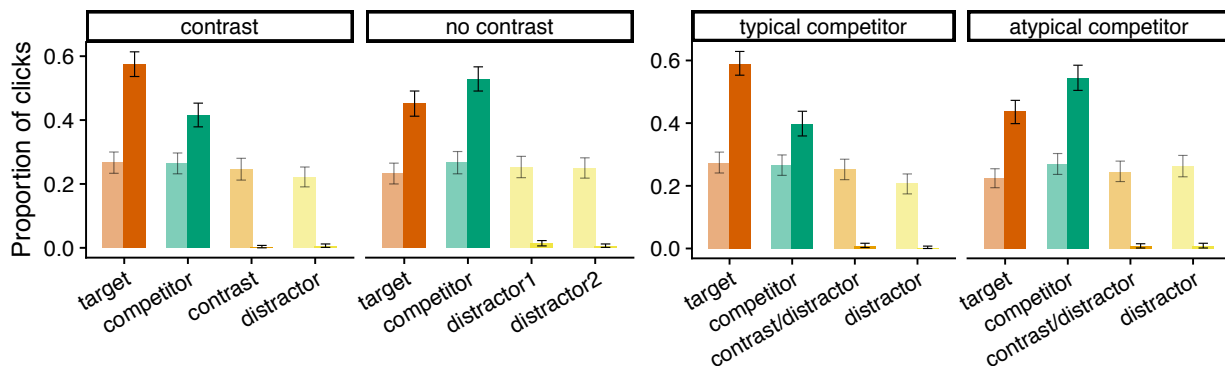


Figure 3: Proportion of object selection in adjective window (dark bars) compared to prior window (light bars) when a) the contrast was present or absent and b) the competitor was typical or atypical.

**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 (in press). 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*.