Rats' Detection of Oriented Visual Target is Impaired by Collinear Flankers

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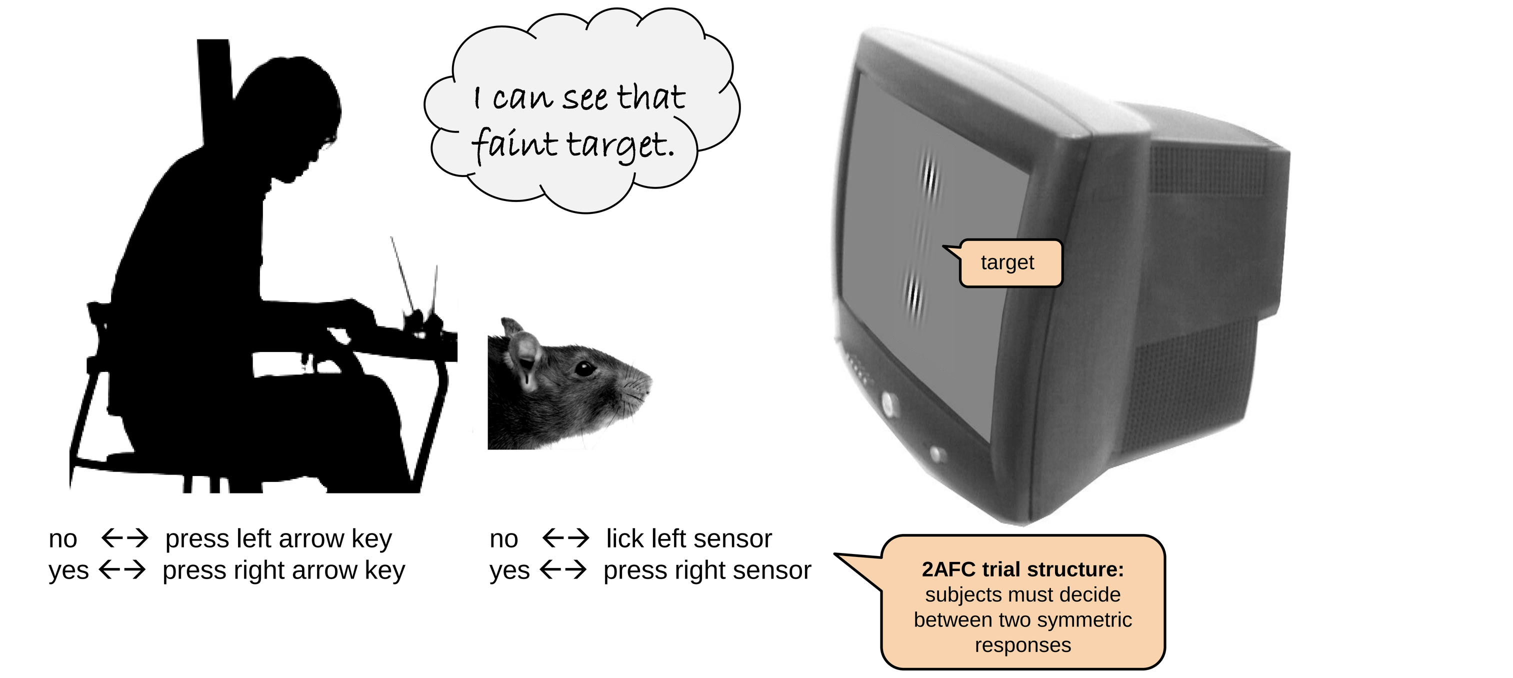
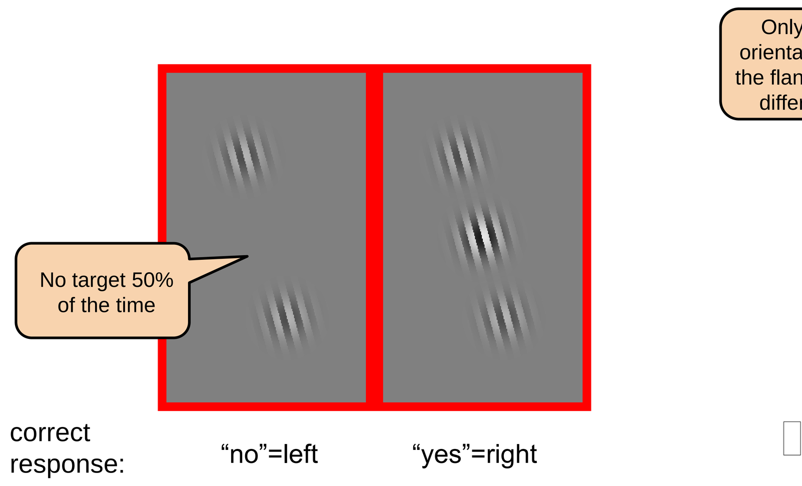
Introduction

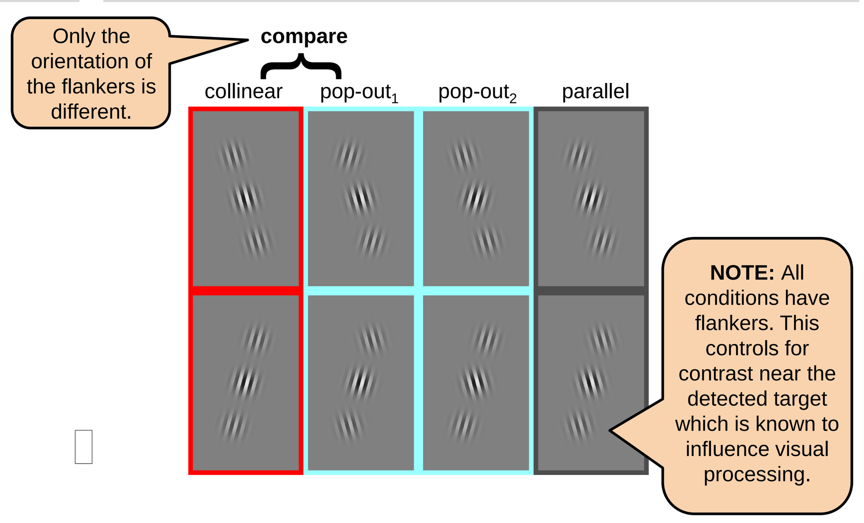
Studies of human psychophysics demonstrate that detection of an oriented grating is influenced by the proximity and relative orientation of nearby "flanker" gratings (ref.1,2,3). Here we ask whether flankers influence rats similarly.



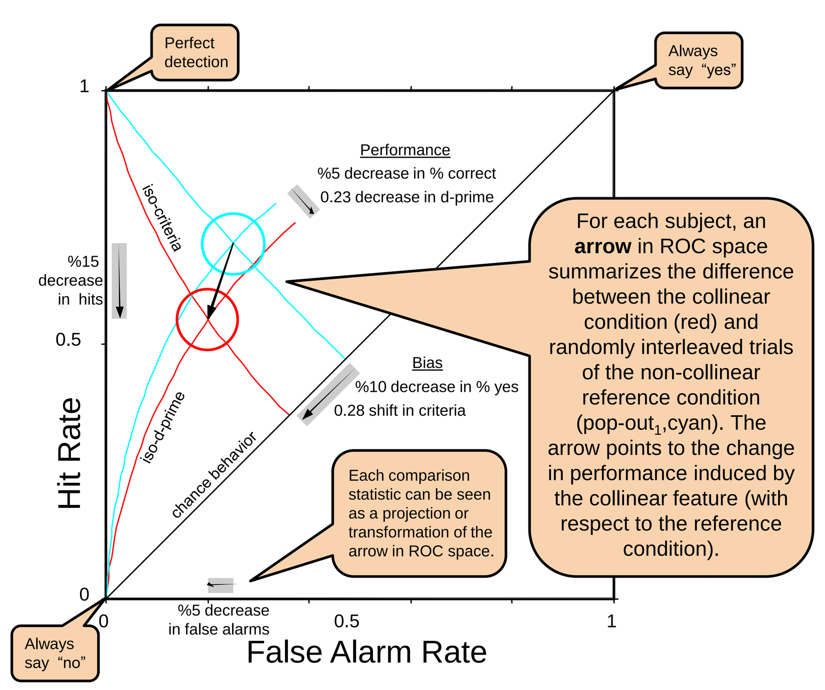
Detection Task



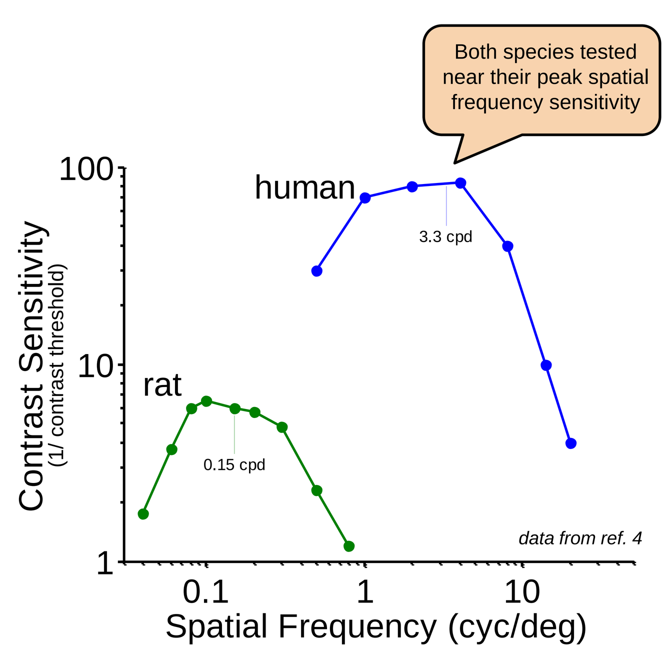
Conditions



ROC Space



Contrast Sensitivity



Methods

Rats were trained in an automated operant chamber. In each trial, a CRT monitor presented a single image composed of multiple square-wave gratings in non-overlapping Gaussian masks. Rats were rewarded with water for correctly reporting the presence or absence of a centrally positioned target grating by licking ports to the left or right. Incorrect responses were penalized with a timeout. Two flanking stimuli were always present, one on either side of the target location. The target was one of two orientations (α). Flankers were either aligned with the target orientation ("collinear"), or alignment was disrupted by a mismatch in either orientation (β), azimuth (ζ), or both. Target presence, target orientation, and flanker configuration were chosen independently for each trial.

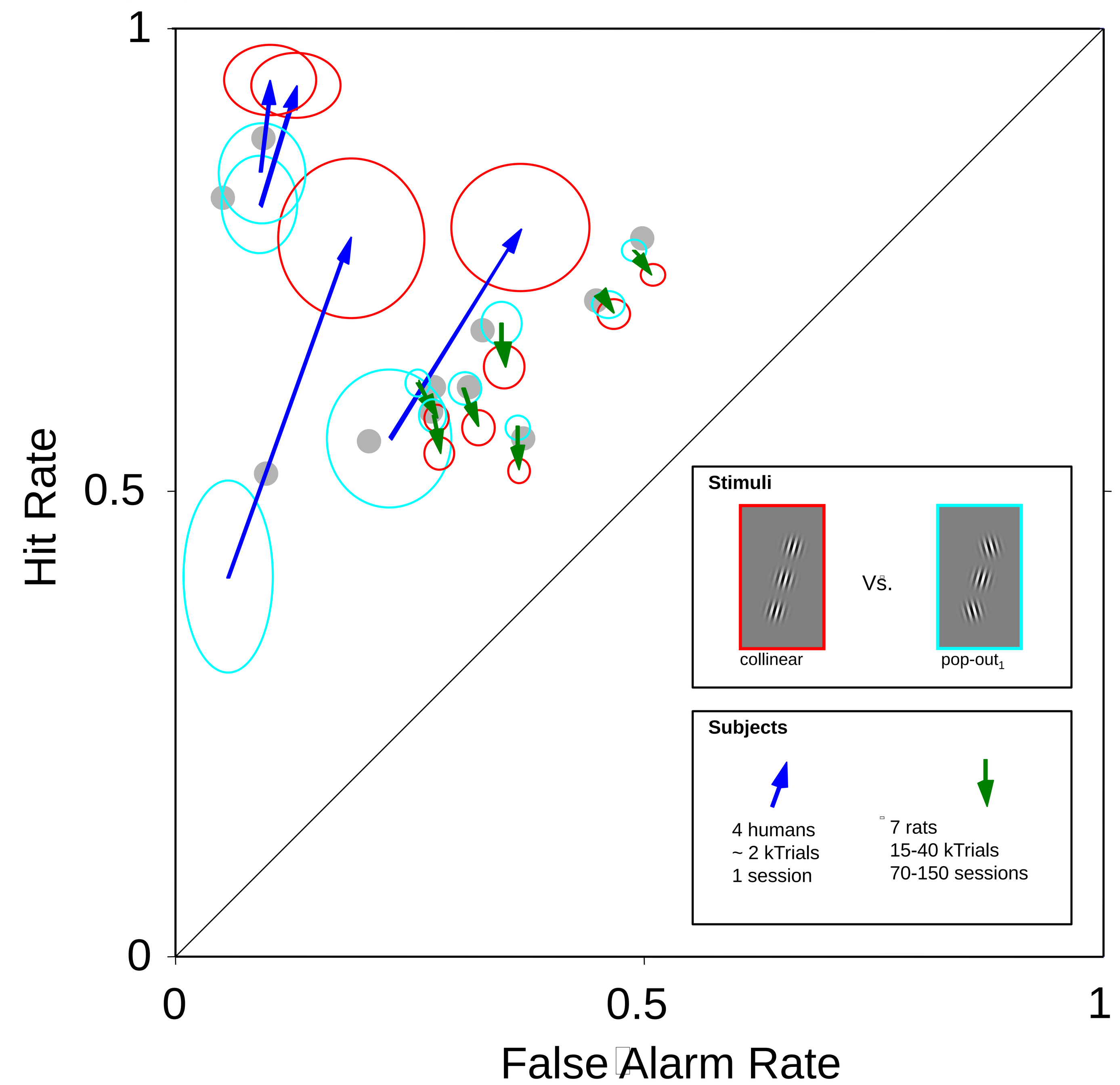
Humans performed the same task as the rats. They used the same monitors and stimulus patterns, the same flanker contrast (40%), the same auditory feedback of correct and incorrect trials, and had to learn the task via exploration.

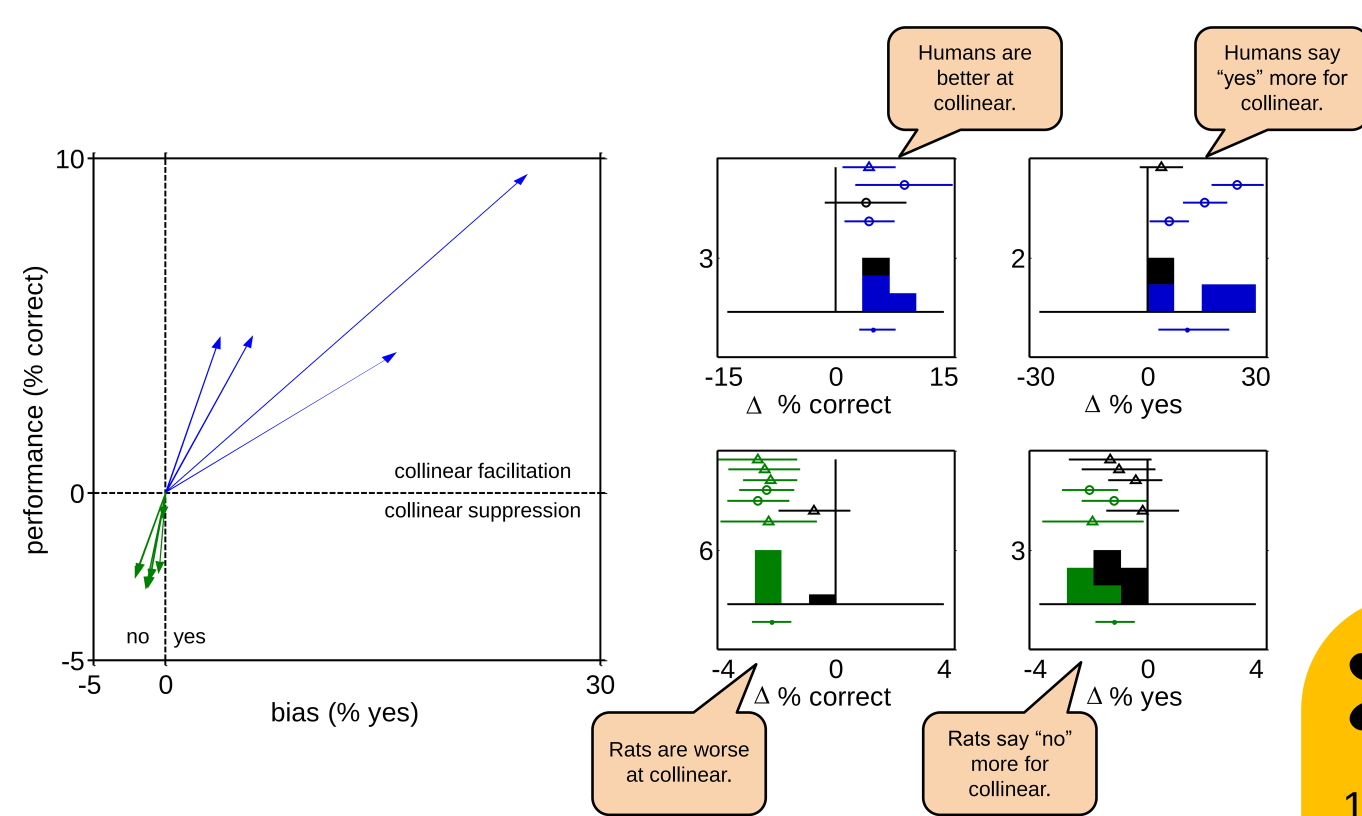
Because humans have a different absolute threshold, we changed a few things to make the task harder. They viewed stimuli at a farther distance (2m vs. 10cm), lower target contrast (2.5% vs. 100%), shorter duration (100ms vs. ~1 s). With these conditions, both humans and rats saw stimuli near their optimal spatial frequency sensitivity.

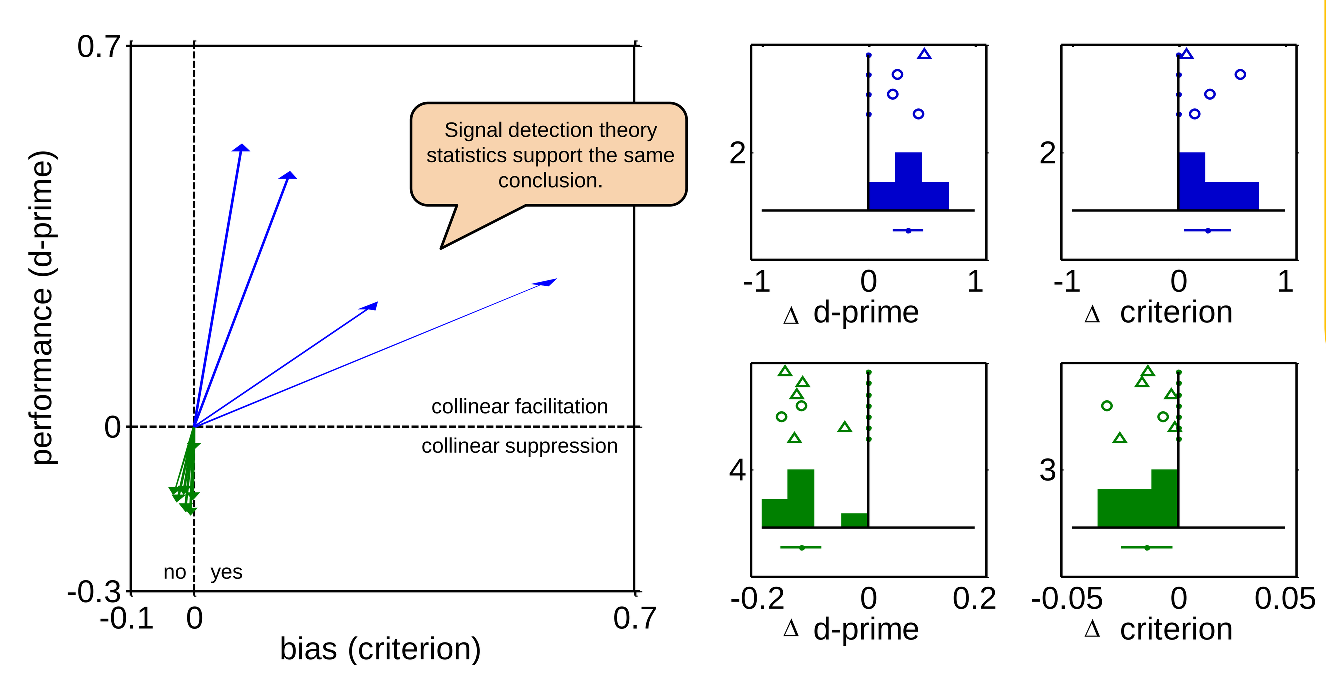
95% confidence intervals for raw proportions were computed using the binofit function in MATLAB. Differences of proportions use the Agresti-Caffo interval. (ref. 5)

Collinear vs. Pop-out

Do collinear flankers influence detection differently than pop-out flankers?

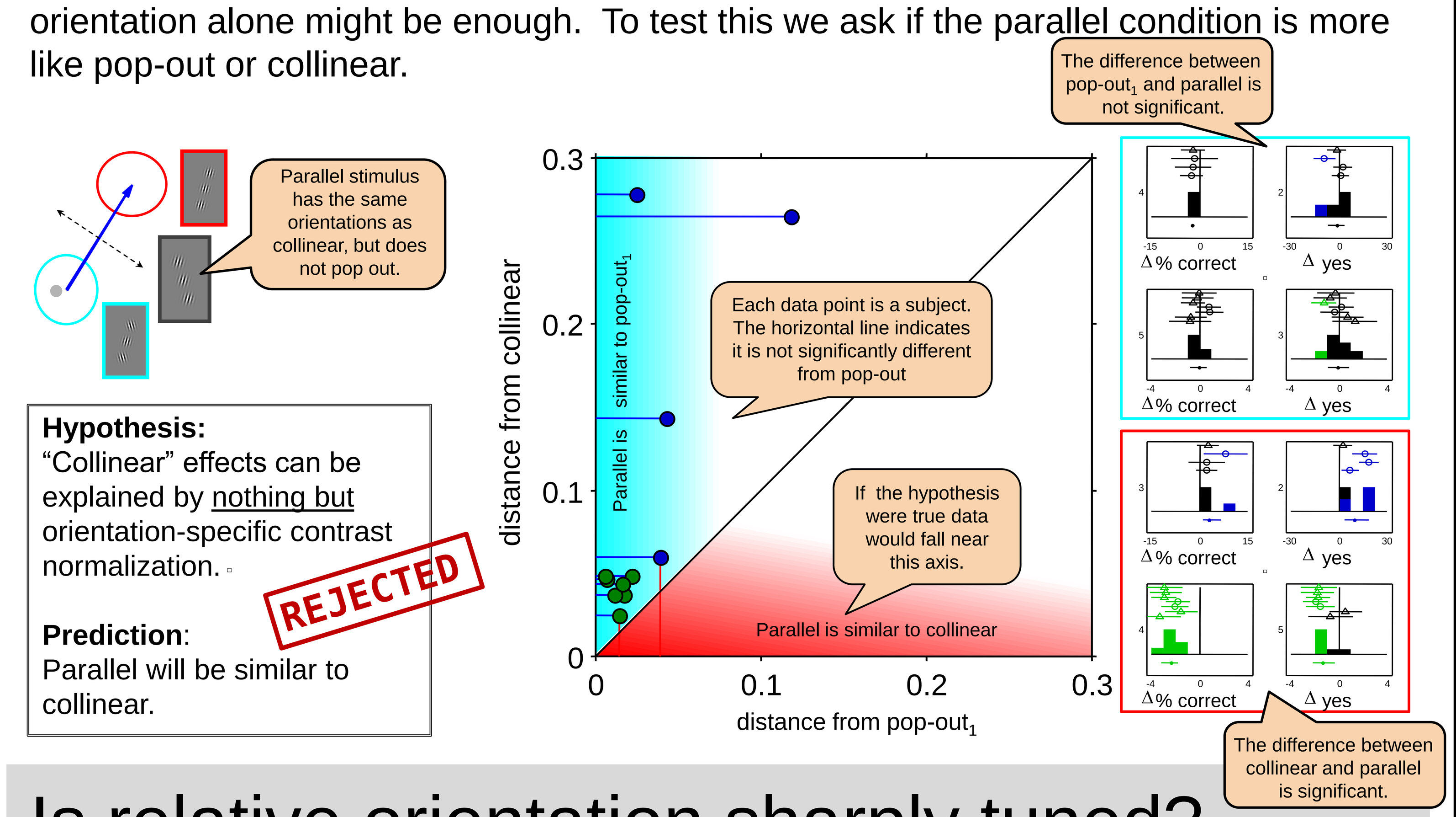






Can orientation normalization explain it all?

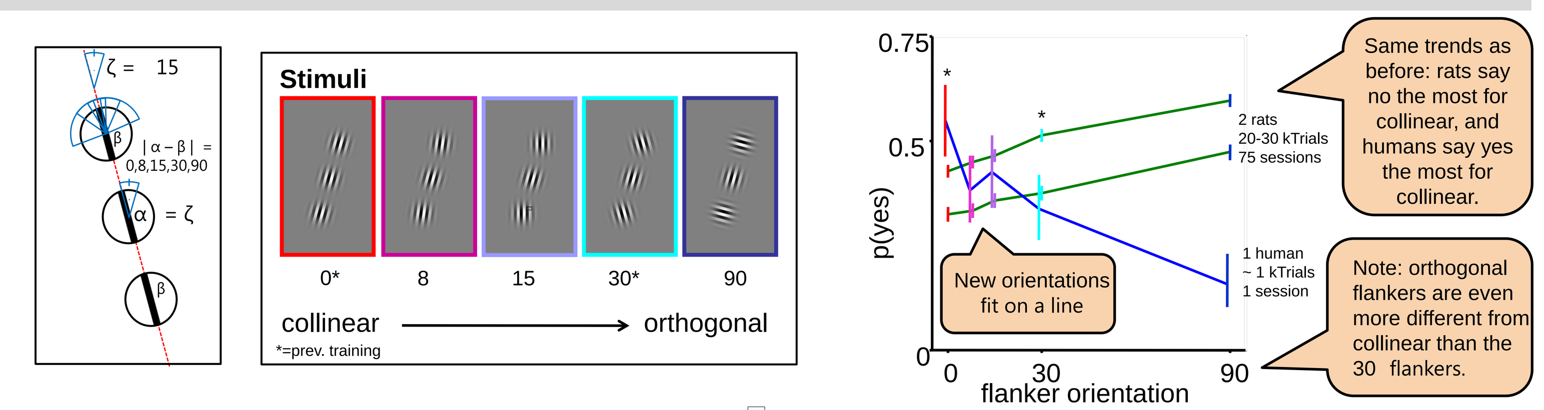
If responses to parallel stimuli are like a collinear stimuli, then the collinear alignment of the flankers might not be needed to explain the effect. A pop-out theory based on orientation alone might be enough. To test this we ask if the parallel condition is more like pop-out or collinear.



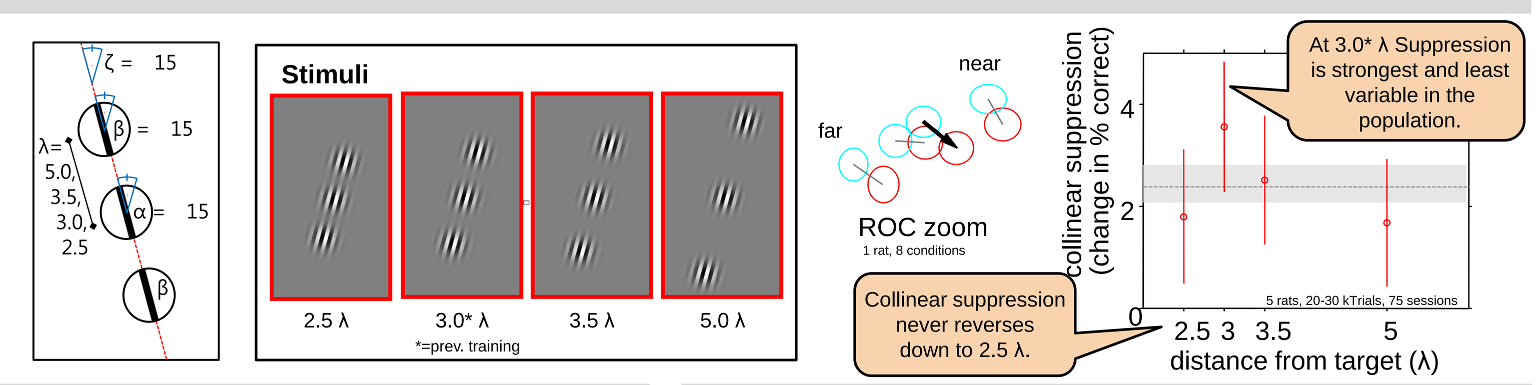
Hypothesis:
"Collinear" effects can be explained by nothing but orientation-specific contrast normalization.

Prediction:
Parallel will be similar to collinear.

Is relative orientation sharply tuned?



Can flanker distance reverse rat's effect?



Conclusion

Main Point

1. Rats are more biased to say **no**, and perform worse on collinear stimuli than pop-out stimuli.

2. Humans are more biased to say **yes**, and perform better on collinear stimuli than pop-out stimuli.

3. In both species we reject the hypothesis that the observed effect is merely orientation-specific contrast normalization.

Discussion

Why do rats and humans have different collinearity effects?

~~spatial stimulus pattern~~
~~trial structure (interleaved, 2AFC, yes/no)~~

visual system (fovea, cones, etc)
ethological stimulus statistics & costs
performance trade-off (contrast & acuity)
stimulus duration (100ms vs. ∞)
experience (instruction vs. hyper-training)
reinforcement learning ($h_2$0 vs. $)

References

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(4) Keller, Strasburger, Cerutti & Sabel (2000) Assessing spatial vision -- automated measurement of the contrast-sensitivity function in the hooded rat. J. of Neuroscience Methods

(5) Agresti & Caffo (2000). Simple and effective confidence intervals for proportions and differences of proportions result from adding two successes and two failures. Amer. Statist.

(6) Lee (2008) BayesSDT: Software for Bayesian inference with signal detection theory. Behavior Research Methods