Change of Mind: How to avoid collision with obstacles

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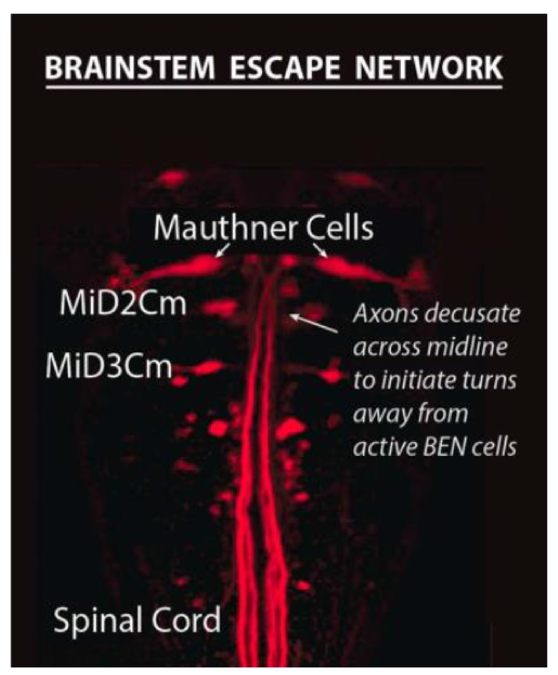
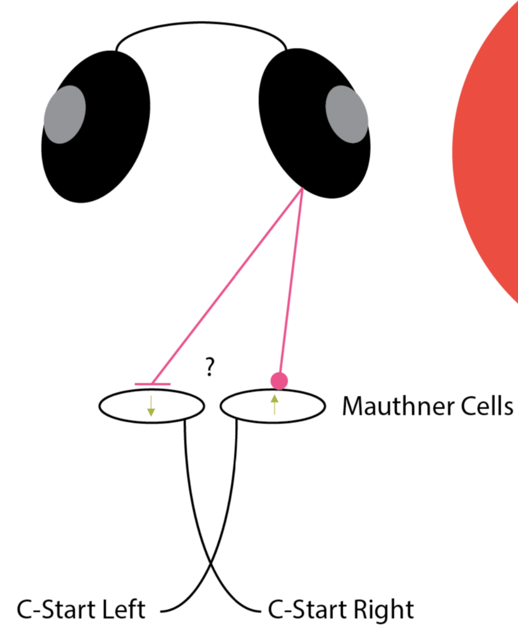
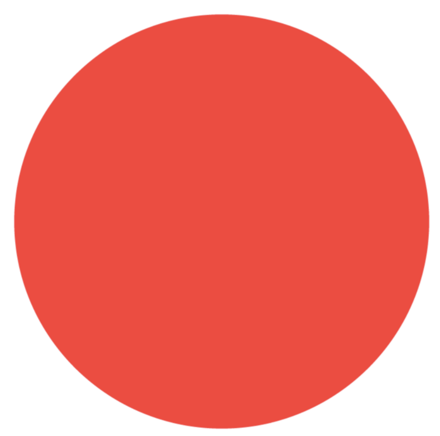
Introduction

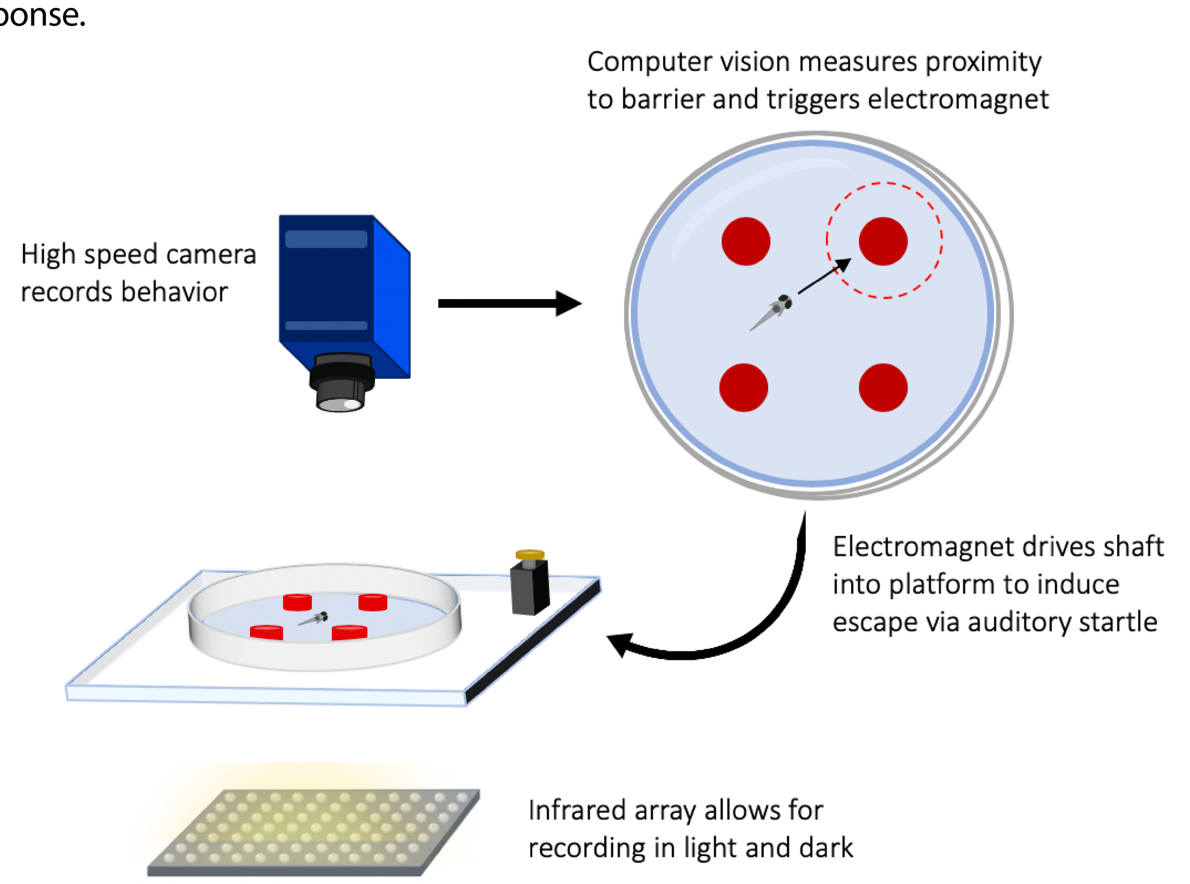
Navigational strategies are crucial to life in a three-dimensional world. Escape behaviors are one example of a complex navigational program influenced by cognitive capacities and are exhibited by organisms across the animal kingdom. Indeed, successful evasion of threats determines survival for many animals, particularly prey like the larval zebrafish. Zebrafish engage in highly stereotyped, adaptive escape responses exquisitely tuned to features of the physical universe that are generated by a well-studied escape circuit called the brainstem escape network (BEN).



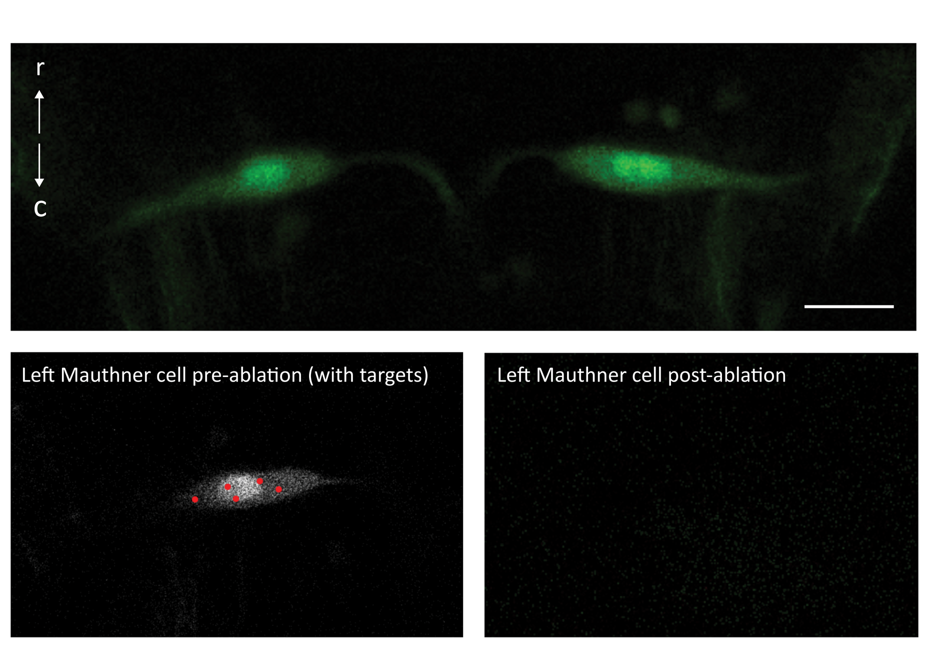


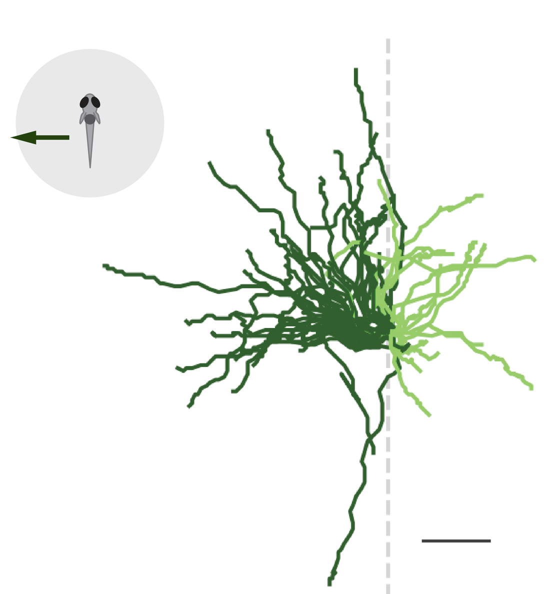


We posited that avoidance of collision with obstacles upon escape should be a primary goal of zebrafish's escape strategy, and intriguingly that this strategy appears to require elements of physical knowledge – namely, a representation of object solidity. In order to test this hypothesis, we designed an escape arena outfitted with barriers to carefully describe how obstacles modulate zebrafish's escape response.

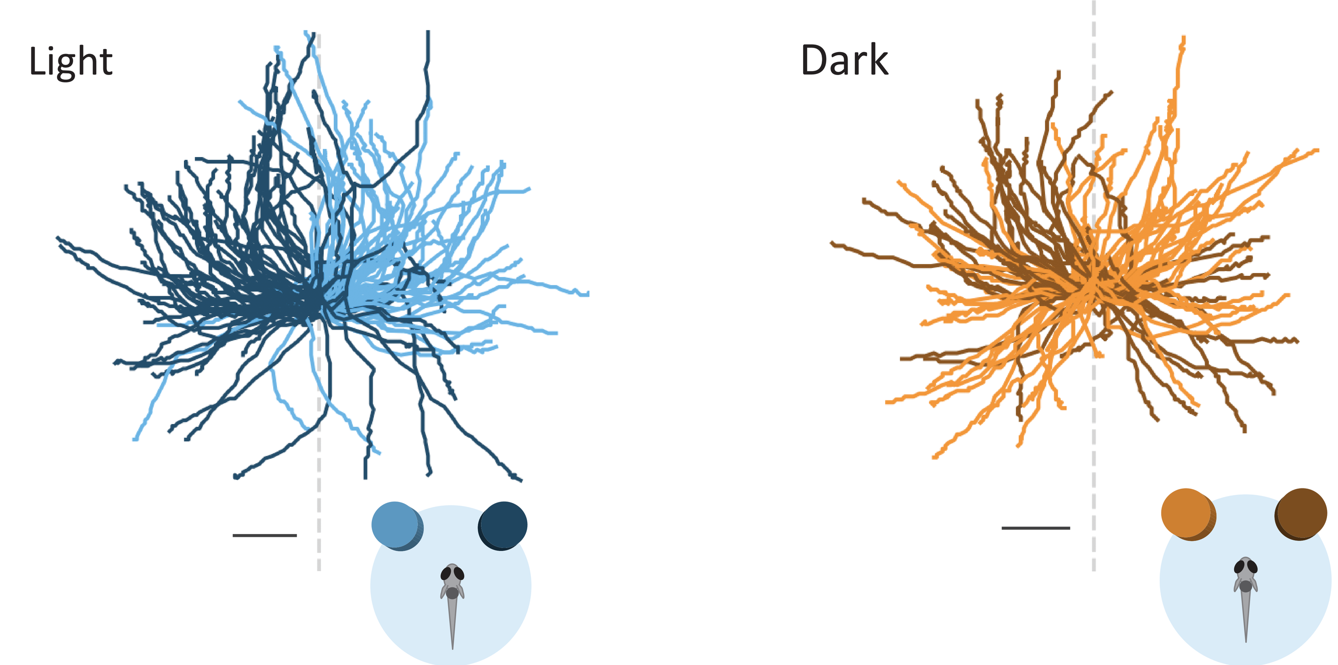


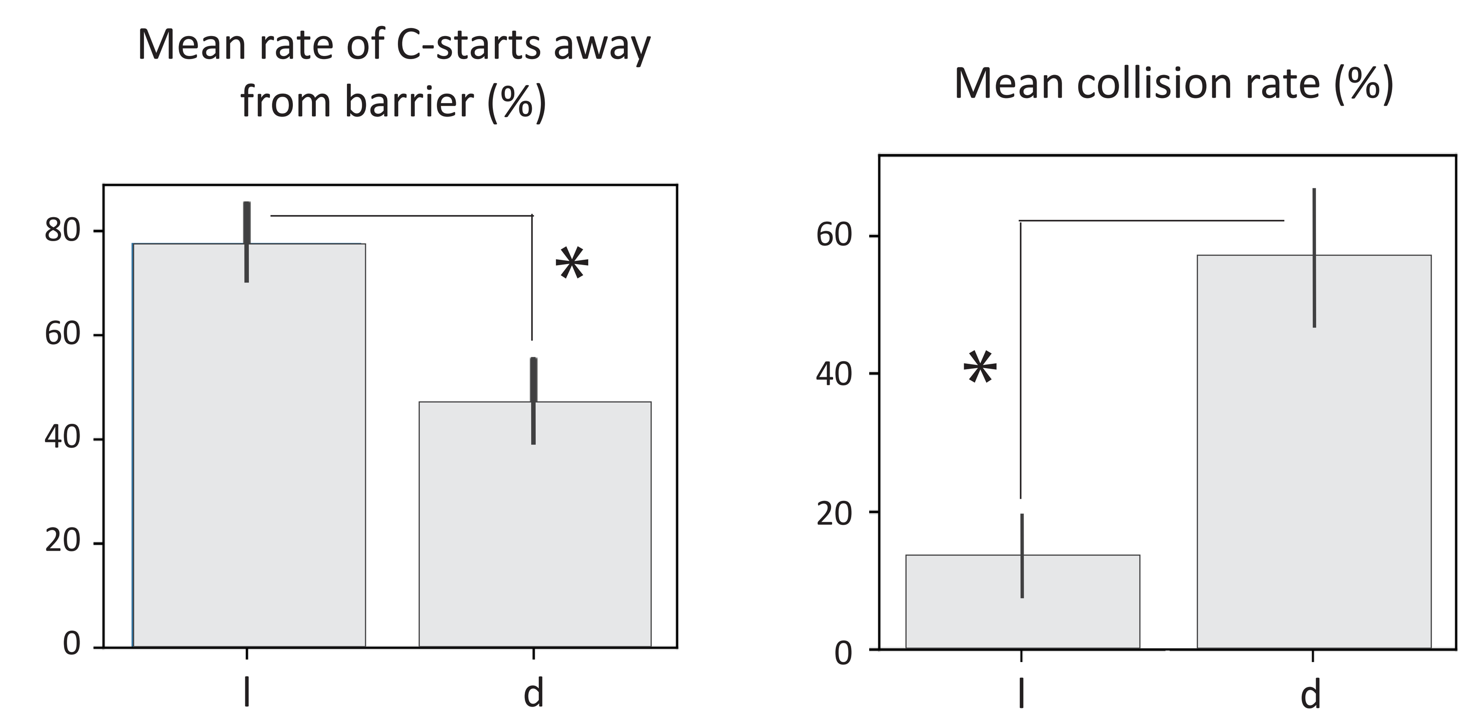
What is the neural implementation of this bias?



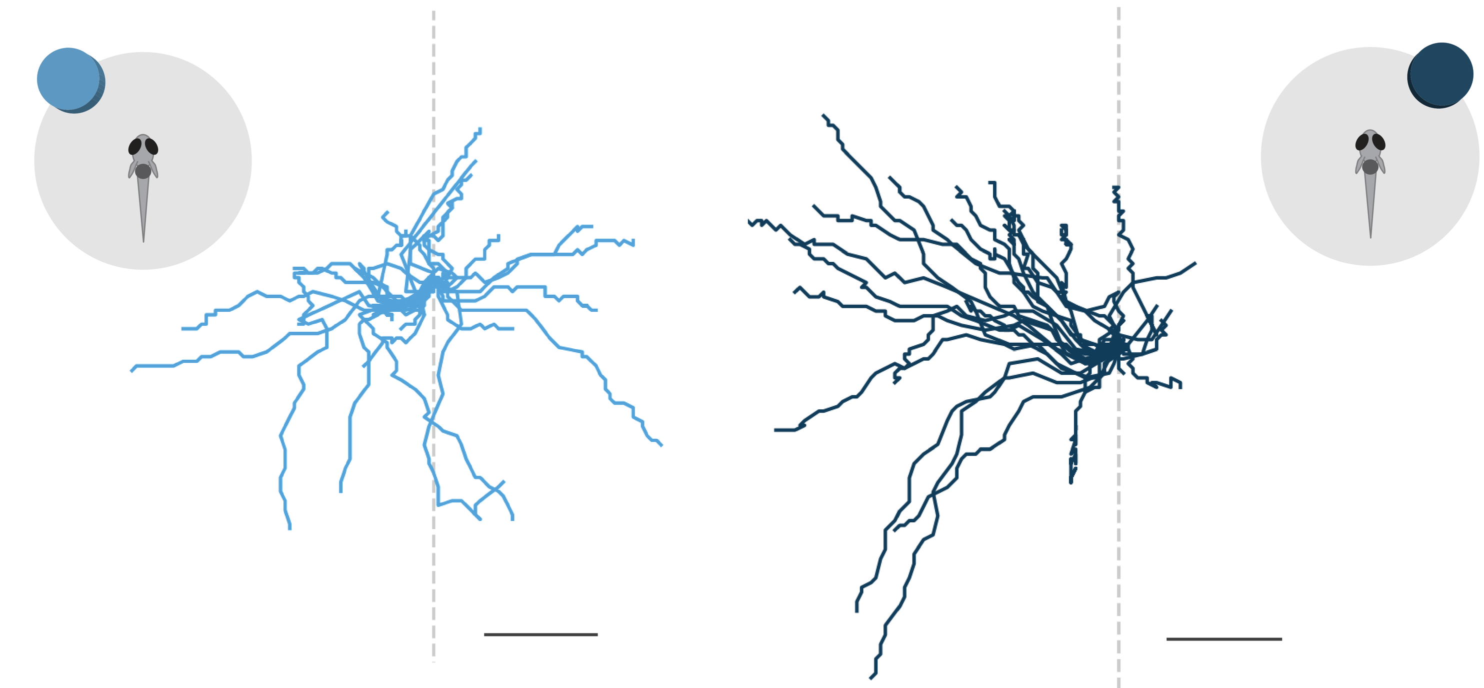


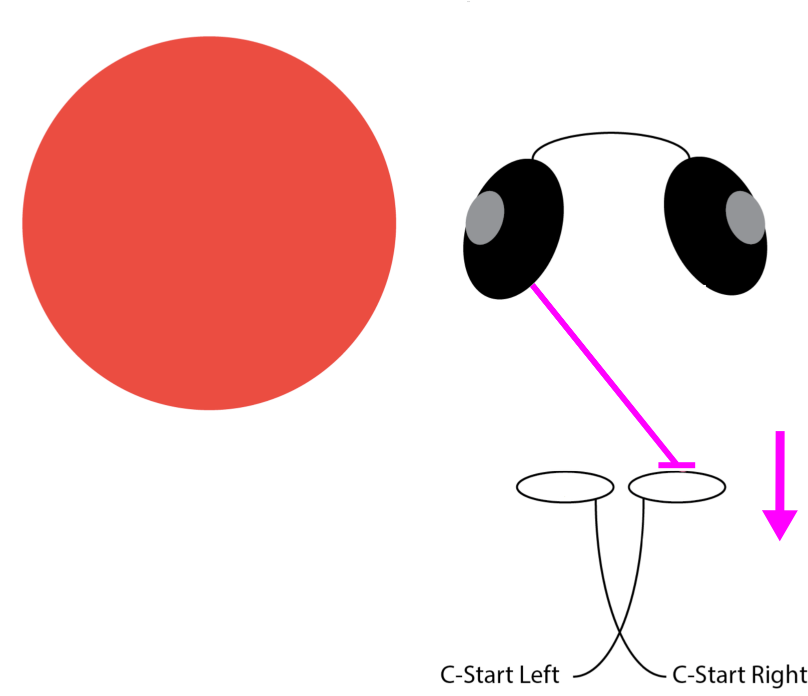
Directional bias is visually mediated

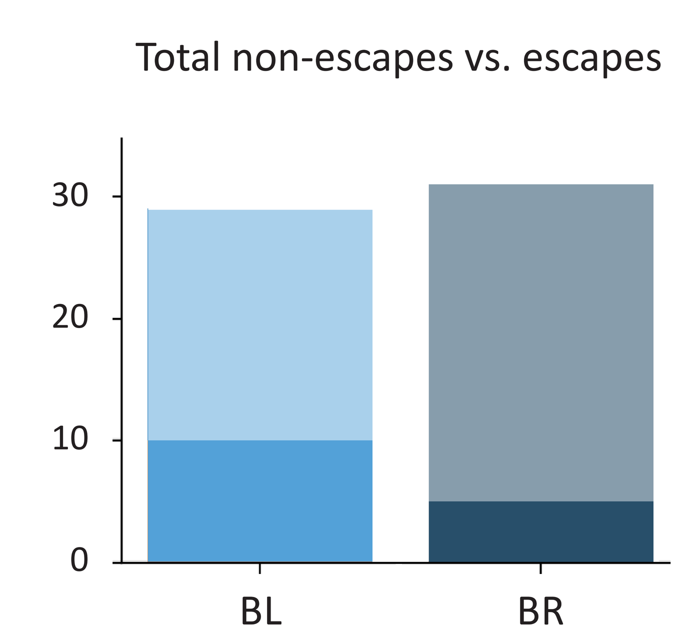




Ablation reveals likely inhibitory bias



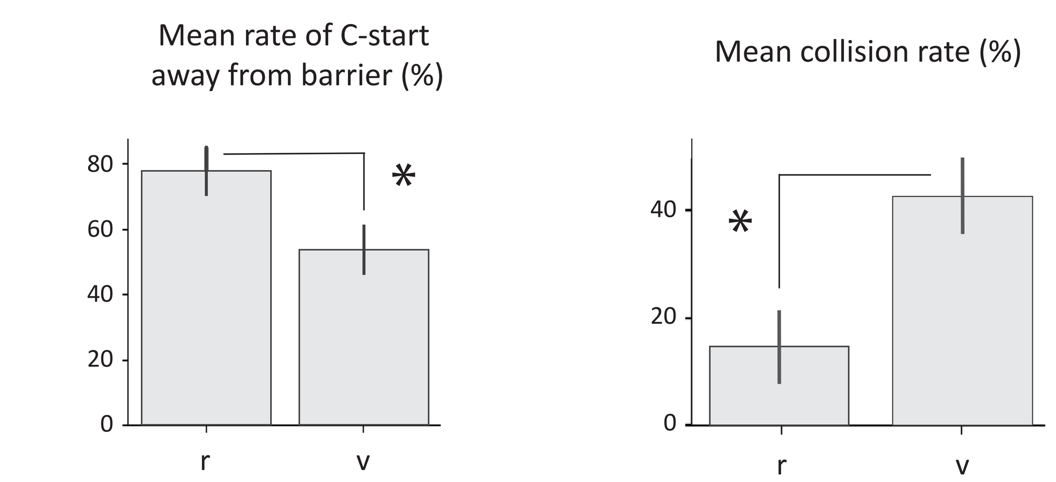




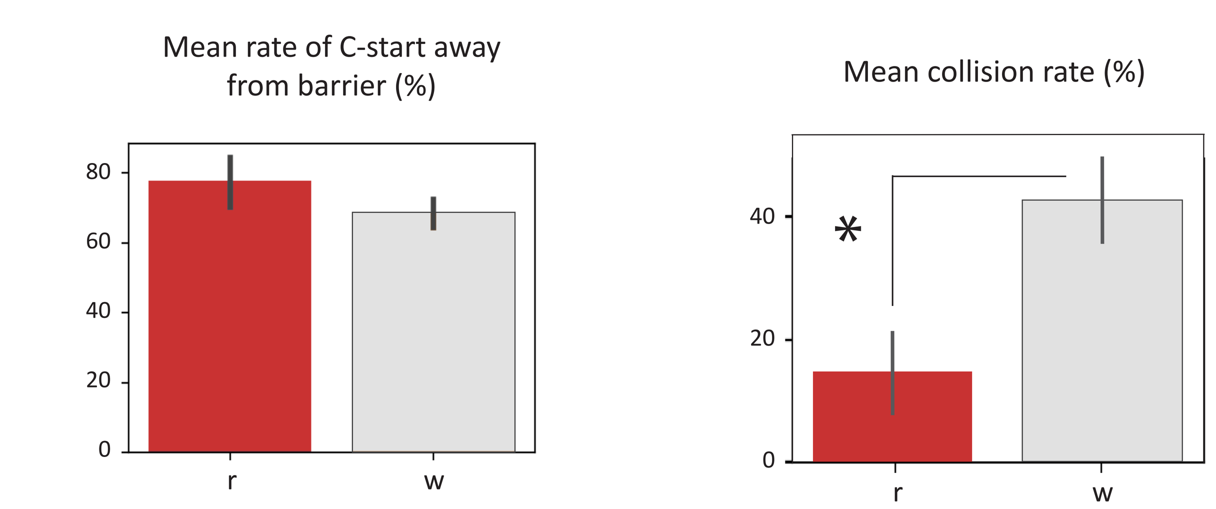
Multiplexed behavioral algorithm biases escapes

By encoding three-dimensional forms, color and luminance cues, and distances, zebrafish robustly bias their escapes away from visually-perceived solid, three-dimensional shapes. Zebrafish build behavioral rules around each of these three features that when employed simultaneously, encode the principle of object solidity in their physical knowledge of the environment.

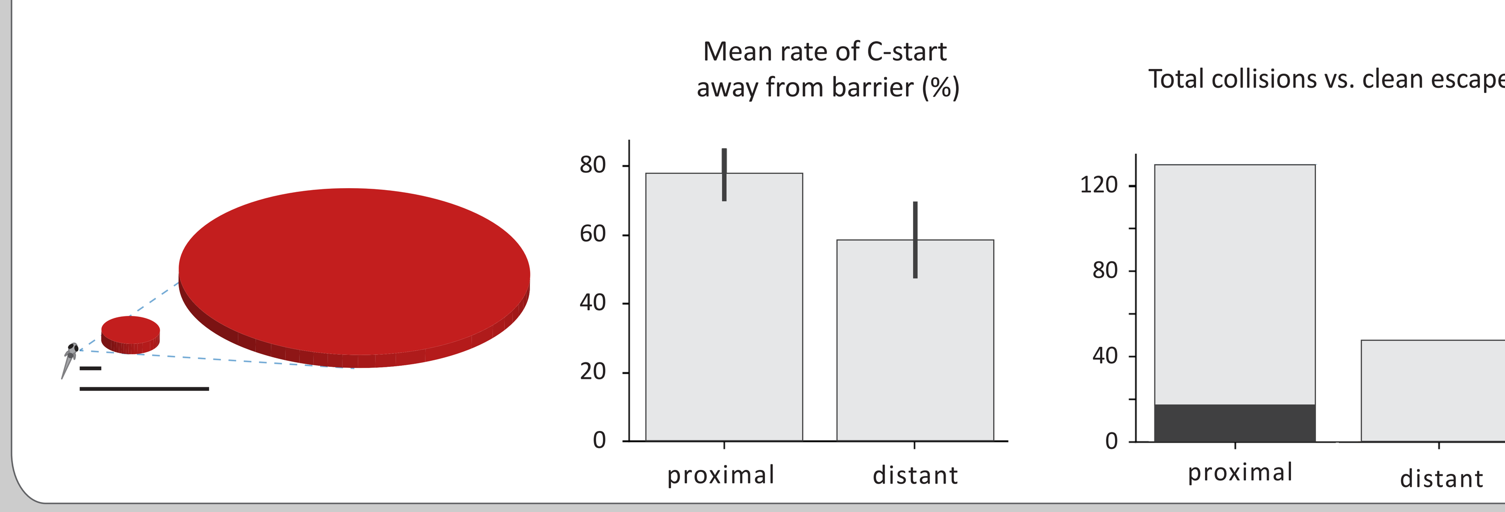
Rule #1: Bias escapes away from 3D barriers



Rule #2: Phototactic cues maintain minor influence over escape directionality



Rule #3: Distance from barrier modulates strength of bias



Future Directions

Neural identity of bias?

- Spiral fiber neurons
- Dopaminergic neurons of caudal hypothalamus
- Serotonergic modulation

Fictive 3D Virtual Environment