A Model of Self-Consistent Perception

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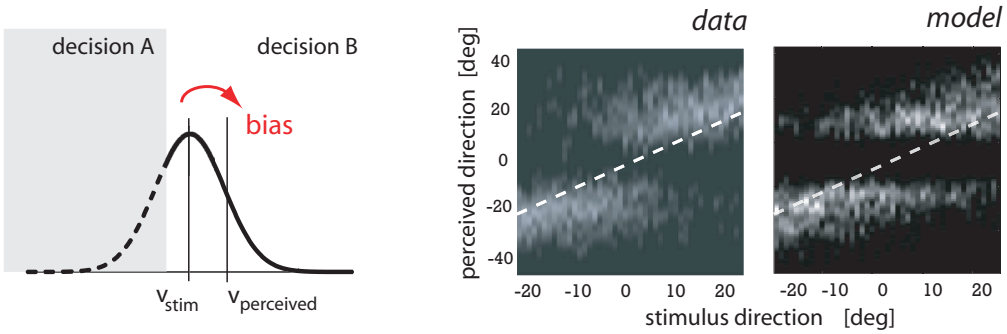
Human perception is context-dependent. In addition to sensory context, two recent psychophysical studies have shown that context can also include previous perceptual decisions [1, 2]. In both studies, subjects were asked to estimate a stimulus parameter (orientation [1], or direction of motion [2]) after being forced to make a categorical decision (orientation to the left or right of vertical [1], direction of motion to left or right of a visual reference [2]). On each individual trial, the subjects' estimates were consistent with their preceding decision (i.e., a decision of "left of the reference" was followed by an estimated direction to the left of the reference). The distribution of estimates were bimodal, indicating repulsion away from the decision boundary (middle panel - data from [2] for a single subject).



We present an observer model that can account for this perceptual behavior. Specifically, we adopt the general hypothesis that the brain attempts to perform optimal estimation of stimulus parameters based on noisy sensory evidence and prior expectations. However, we augment this hypothesis by assuming that the brain performs the secondary estimation task in the belief that its previous decision regarding the data was correct. Noisy sensory evidence may initially support both decisions, although with different probability (left panel: a portion of the likelihood falls under each decision region). However, after being forced to make a decision (e.g. decision B), the observer discards all potential estimates that are not in agreement with the choice (thus all values in the gray shaded area), performing inference conditioned only on the decision made. This leads to the observed repulsive bias away from the decision boundary (right panel).

It is worth noting that the behavior of the model (and the human subjects) is suboptimal in terms of estimation performance. An optimal (Bayesian) observer model [3] would compute estimates from the sensory evidence under each possible decision value, and then average these estimates, weighting each according to the probability that the corresponding decision is correct. Thus, our model implies that humans sacrifice performance in order to maintain *self-consistency*.

References

[1] S. Baldassi, N. Megna, D.C. Burr. Visual clutter causes high-magnitude errors. *PLoS*, 4(3):e56, 2006.

[2] M. Jazayeri and J.A. Movshon. A new perceptual illusion reveals mechanisms of sensory decoding. *Nature*, 446:912ff, April 2007.

[3] D.C. Knill and W. Richards, eds. *Perception as Bayesian Inference*. Cambridge University Press, 1996.