The Bounded Log-Odds Model of Frequency and Probability Distortion

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Similar patterns of distortion of frequency/probability information have been found in a variety of perceptual and cognitive tasks that involve frequency/probability (Zhang & Maloney, 2012, *Frontiers in Neuroscience*). The subjective probability (π) can be expressed as a linear transformation of the objective probability (p) on the log odds scale: $Lo(\pi)=\gamma Lo(p)+Lo(\beta)$, where $Lo(p)$ denotes the "logit" or log odds, $\log\left(p/(1-p)\right)$. The slope parameter γ and intercept parameter β were found to vary with task and individual. Zhang & Maloney (2012, *MODVIS*) developed a model that was intended to quantitatively predict the variation of γ and β in frequency estimation. Here we present an updated version of the model, along with tests from new datasets.

In our model, we propose a form of probability representation that may allow neurons with limited dynamic ranges to maximize their discriminability in a changing environment. We assume that (1) the brain maintains and operates probability information on the log odds scale; (2) at any specific moment, the representation is bounded, with log odds outside the range clipped to the boundaries (log odds, in theory, can run from minus infinity to plus infinity); (3) the center and the span of the bounded log odds representation are adaptable; and (4) an anchoring point is used to compensate for the loss of information due to the adaptation process.

We tested a visual frequency estimation task in two experiments, where we found patterned changes in γ and β with task settings. These patterns could hardly be explained by previous theories on probability distortion, but could be precisely produced by the bounded log odds model. We also verified that all the four assumptions are necessary for the success of the model. We will discuss the potential of the bounded log odds model as a general framework for frequency and probability distortion.

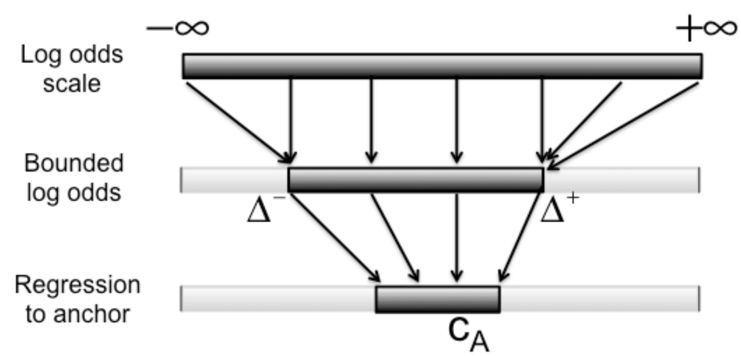

Figure 1. Illustration of the bounded log odds representation.