Online Supplement 1: Calculating Optimal *d'* for Aided Conditions

Assuming that payoffs for positive and negative responses are symmetric, ideal bias in a signal detection task is given by $\beta^* = \frac{1 - p(\text{signal})}{p(\text{signal})}$, where $p(\text{signal})$ is the marginal probability of a signal + noise event. Given equal-variance normal evidence distributions for *N* and *S*+*N* trials, β^*corresponds to point c^*on the decision axis (Wickens, 2002),

$$c^* = \frac{\log(\beta^*)}{d'}.$$

Here, *c** is the signed distance of the ideal cutoff from the point of unbiasedness, measured in standardized units of the common standard deviation.

In an aided signal detection task, the optimal cutoff position following a cue from the aid is conditional on the cue. For example, following a positive cue, Cue^+, ideal bias is,

$$\beta_+^* = \frac{1 - p\left(\text{signal}\middle|\text{Cue}^+\right)}{p\left(\text{signal}\middle|\text{Cue}^+\right)},$$

corresponding to cutoff point,

$$c_+^* = \frac{\log(\beta_+^*)}{d'}.$$

Under the contingent cutoff strategy, the user's hit rate for aided conditions reflects a mixture of trials on which the aid correctly detected the signal and trials on which the aid failed to detect the signal (Robinson & Sorkin, 1985). The hit rate produced by an optimal contingent cutoff strategy is thus,

$$HR^* = \Phi\left(\frac{d'_{\text{Unaided}}}{2} - c_+^*\right) \times HR_{\text{Aid}} + \Phi\left(\frac{d'_{\text{Unaided}}}{2} - c_-^*\right) \times (1 - HR_{\text{Aid}}),$$

where Φ denotes the cumulative normal transformation, HR_{Aid} is the HR for the automated aid, and d'_{Unaided} is the user's d' for unaided trials. Likewise, the false alarm rate for aided conditions reflects a mixture of trials on which the aid reached a correct negative judgment and trials on which it falsely reported a target. The false alarm rate produced by an optimal contingent cutoff strategy is thus,

$$FAR^* = \Phi\left(-\frac{d'_{\text{Unaided}}}{2} - c_+^*\right) \times FAR_{\text{Aid}} + \Phi\left(-\frac{d'_{\text{Unaided}}}{2} - c_-^*\right) \times (1 - FAR_{\text{Aid}}),$$

where FAR_{Aid} is the FAR of the automated aid. Sensitivity corresponding to the optimal strategy, is then,

$$d'_{\text{Aided}^*} = \Phi^{-1}(HR^*) - \Phi^{-1}(FAR^*),$$

where Φ^{-1} is the inverse normal transformation.

Meyer and Kuchar (2021) provide an approximation to d'_{Aided^*}, assuming that the aid's cutoff itself is chosen to maximize aided performance:

$$d'_{\text{Aided}^*} = \sqrt{d'^2_{\text{Unaided}} + d'^2_{\text{Aid}} - .3d'_{\text{Unaided}}d'_{\text{Aid}}}.$$

References

Meyer, J., & Kuchar, J. K. (2021). Maximal benefits and possible detrimental effects of binary decision aids. *2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS)*, 1–6. https://doi.org/10.1109/ICHMS53169.2021.9582632

Robinson, D. E., & Sorkin, R. D. (1985). A contingent criterion model of computer assisted detection. In *Trends in Ergonomics/Human Factors: Vol. II* (pp. 75–82). North-Holland.

Wickens, T. D. (2002). *Elementary signal detection theory*. Oxford University Press.