# S1 Choice Probability and Choice Correlation

Neuronal choice probability ($CP_k$) is, roughly, the probability of correctly guessing the behavioural response on a given trial based only on the response $r_k$ of that particular neuron *k*. More precisely, it is the probability that a neural response drawn randomly from one choice-conditioned distribution $p(r_k|\text{choice} > 0)$ is greater than another neural response from the same neuron but drawn from the other choice-conditioned distribution $p(r_k|\text{choice} < 0)$. In our model, choice is taken to be the sign of the estimated stimulus $\hat{s}$.

Choice correlation ($C_k$) is simply the trial-by-trial correlation coefficient between neuronal responses and the animal's internal estimate of the stimulus $\hat{s}$. For a task with only two possible behavioural responses, like heading discrimination, and for Gaussian-distributed neural responses, these quantities are related according to [3]:

$$CP_k = \frac{1}{2} + \frac{2}{\pi}\arctan(2{C_k}^{-2} - 1)^{-1/2}$$

The following equation provides an excellent approximation [3] and was used throughout the paper instead of the above equation.

$$CP_k \approx \frac{1}{2} + \frac{\sqrt{2}}{\pi} C_k \tag{S1.1}$$

For convenience, we will express all relations in terms of choice correlations. Corresponding expressions for choice probabilities will follow from equations above.