Perception and Attention
G89.2223
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Homework: Signal Detection Theory and RT

Use Matlab and the SDT tutorial to do the following calculations and to answer the questions. Write up a report that explains your solutions, including graphs, and the relevant snips of Matlab code. For each question, please write a brief explanation of what you did, including any equations that you used to do the calculations, and write a brief interpretations of your results. Please submit a single pdf file (not MS Word) that contains everything.

1) Simulate a two-alternative, forced-choice experiment. Each trial consists of one interval with stimulus A or stimulus B. In each 100 ms, the observer collects evidence for whether the stimulus is A or B. The evidence in each 100 ms time step consists of a single number. The expected value of that number is +2 * *c* for an A stimulus, and -2 * *c* for a B stimulus, where *c* is the stimulus contrast. However, that number is noisy, perturbed by independent random draws each time step from a standard Gaussian distribution (mean zero, SD = 1).

(a) Simulate this experiment for stimulus durations ranging from 100 ms to 2 s and a contrast of 0.2. Assume A and B are equally likely, payoffs are symmetric and an optimal criterion. Thus, for example, for a 500 ms stimulus there are 5 time steps. And, if the stimulus has contrast 0.2, that means each time step is a random draw from a Gaussian with mean 0.4 and variance 1.0. The observer will optimally combine those bits of evidence by summing the 5 numbers from the 5 time steps. Thus, for an A stimulus, the total evidence is expected to be 5*.4 = 2, on average, and -2 for a B stimulus. What is the optimal criterion? Plot your results as percentage correct as a function of stimulus duration. Replot the results as d' as a function of duration. Compare your simulation results with theoretical predictions. Now, repeat the above (determine optimal criterion, simulate, plot results, compare to theoretical predictions) for an experiment in which the duration is fixed at 0.2 s and contrast ranges from 0.05 to 1.

(b) Change the probability of an A stimulus to 0.75. Use a single fixed duration of 0.4 s and contrast of 0.1. What is the optimal criterion now? Simulate performance with that optimal criterion, and then simulate it with the criterion you used in part (a), comparing the performance across the two for 100 trials each. You should be able to compute the optimal criterion. However, you can also determine/estimate that criterion by doing large-scale simulations for a range of criteria (I'd prefer the closed-form computation if you can manage it).

2) With the same setup as in (1), switch to a reaction-time experiment using the accumulated evidence values in a drift-diffusion framework. That is, accumulate the sum across time steps until the sum hits a bound representing a decision to respond "A" (with bound value +*b*) and another for response "B" (with value -*b*). Use simulations to

characterize the reaction-time distributions for correct vs. error trials. Do this for contrasts of 0.1 and 0.5. For each contrast, run simulations for a near decision boundary (relatively small value of *b*), a distant decision boundary (large value of *b*), and an asymmetric pair of decision boundaries (+*b* and -*d*). What happens to the hit and false-alarm rates (treating stimulus B as “noise” and A as “signal”) and RT distributions with each manipulation of the model?