Signal Detection Theory Assignment

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 two intervals, one with a stimulus and the other with no stimulus. The simulated subject’s task is to pick which of the two intervals contained the stimulus.

   (a) Assume that performance accuracy is limited by Poisson noise, i.e., that the number of photopigment isomerizations depends on the number of photons (which is a random draw from a Poisson distribution) and on the number of spontaneous isomerizations (dark light). Set the dark light to have a mean of 3 isomerizations per trial. Choose stimulus intensities corresponding to a range of values from 1 to 12 isomerizations. Simulate a large number of trials and plot a psychometric function (accuracy vs stimulus intensity).

   (b) Assume that performance instead is limited by normally distributed internal noise, with variance that is independent of the stimulus intensity. Set the mean response in the absence of a stimulus to be 10, and noise standard deviation to be 4. Choose stimulus intensities corresponding to a range of values from 1 to 12 isomerizations. Simulate a large number of trials and plot a psychometric function (accuracy vs stimulus intensity).

   (c) Extra credit. Derive theoretical predictions for the psychometric functions in parts (a) and (b) and plot them along with the simulated data. Characterize how the simulated psychometric function approximates the theoretical prediction as a function of the number of trials.

2) Simulate a simple-forced choice experiment in which only 1/10th of the trials have a stimulus present. Each trial consists of a single interval, in which a stimulus is present on 1/10th of the trials and absent on the other 9/10ths. The simulated subject’s task is to say (forced choice) whether or not the stimulus was present. Assume normally distributed noise. Choose stimulus intensity and noise so that d’=1. Choose a criterion. Simulate a number of trials. Compute hit rate and false alarm rate.

   (a) Use simulations to characterize how the simulated estimates of hit rate, false alarm rate and d’ depend on the number of simulated trials.

   (b) Use simulations to characterize how the simulated estimates of hit rate and false alarm rate depend on the criterion.
(c) Compute the theoretically optimal criterion for $d' = 1$ assuming that the costs/payoffs are balanced (i.e., cost of false alarm = cost of miss and payoff for hit = payoff for correct reject). Show through simulations that this theoretically optimal criterion maximizes payoff.

3) Recreate Figure 3.2 from Appendix A3 of Wandell’s book. Use equation 1.14 from Wandell, Ch. 2 (Image Formation) for the line spread function of the human eye.