PMPC Tutorial Sheet 6

1. Go back to exercise 1 on the first tutorial sheet. Read again about what you planned to do to get an A in this class. Did you follow your plan so far? If not, why did you deviate from it? What would you do differently now after you have taken the mid-term exam?

2. We haven't discussed exercise 8 on the last tutorial sheet yet. So if you haven't worked on it, you can still do it.

3. Memory and ROC [7]. You get a study list of nonsense words. A few days later you get a test list of words, half of which are new and half of which are old. Your task is to say whether each word on the test list is old or new. Assume that memory works in an all-or-none fashion, i.e. there is a certain probability that an item on the study list will be stored and will be recognized later. Items that are not on the study list aren't stored and therefore cannot be recognized. Assume your strategy is that you always say old to words on the test list that you recognize. For the words that you don't recognize you say that they are old with probability q. What does the ROC curve look like when you vary q? Can you think of experiments that test this model?

4. Luce's low threshold model for simple detection tasks [2]. Assume there is a sensory threshold and a human observer will go into a detect state ($D = y$) if the threshold is crossed and into a no-detect state otherwise ($D = n$). If a stimulus of a certain magnitude is presented this will happen with $P(D = y \mid S = y) = p_y$. Contrary to what we assumed in class the threshold is *low* and the observer will sometimes end up in a detect state even if there was no stimulus, i.e. $P(D = y \mid S = n) = p_n$ with $p_n > 0$ (for a *high* threshold model $p_n = 0$). If the observer always reports her detection state (she will say yes if she detects something and no if she doesn't) the hit rate will be $P(H) = p_y$ and the false alarm rate will be $P(FA) = p_n$. However, the subject might want to adapt her hit rate and false alarm rate to different pay-off situations. How could she do this? If she wanted a lower false alarm rate (i.e. $P(FA)$ should be smaller than p_n) she could report no detection in no-detect states and say yes only with probability $t < 1$ in detect states. Similarly, if she wanted a higher false alarm rate (i.e. $P(FA)$ should be greater than p_n) she could always say yes in detect states but also say yes with probability $u > 0$ in no-detect states. What does the ROC curve for such an observer look like? Make a plot.

5. Consider a subject in a detection experiment. On each trial there is a signal or not. Simulate an observer under the assumption of the equal variance Gaussian model, i.e. there is a decision axis X with the following signal-plus-noise and noise-only distributions:[1]

$$\begin{aligned} P(X = x \mid S = y) &= \frac{e^{-\frac{1}{2}\left(x-d'\right)^2}}{\sqrt{2\pi}} \\ P(X = x \mid S = n) &= \frac{e^{-\frac{1}{2}x^2}}{\sqrt{2\pi}} \end{aligned}$$

[1] in Matlab and Octave the standard normal distribution is given by `p=normpdf(x,0,1)`. The cumulative distribution function and its inverse are `P=normcdf(x,0,1)` and `x=norminv(P,0,1)`. You can draw a random sample with `r=normrnd(0,1)`. You can change the mean and the standard deviation by changing the parameters to something different than 0 and 1.

First plot the ROC curves for an observer with $d' = 0, \frac{1}{2}, 1, 2, 3$. How does the ROC curve relate to d'?

Now, assume that the subject has a d' of 1 and you are running an experiment with three different conditions. The stimulus is always the same in all conditions but the pay-offs, and hence the subject's criterion, are changed in each condition. Each condition has 200 trials, half of which are signal-plus-noise trials and half of which are noise-only trials. Assume that in condition 1 the subject's decision criterion is $\frac{1}{4}$, i.e. the subject will say yes if $X > \frac{1}{4}$. In condition 2 the criterion is $\frac{1}{2}$ and in condition 3 it's $\frac{3}{2}$. Simulate this subject for the three conditions: For each trial draw an X from the right Gaussian distribution and check whether it is greater than the criterion to generate the subject's response. Plot the empirical hit rate and false alarm rate on top of the theoretical ROC curve.

6. Rating data in detection experiments. Assume the same setup as in the previous exercise. Here, instead of reporting whether there was a signal or not the subject has a 4-point categorical response scale (0 = pretty certain that there was no signal, 1 = I lean towards no, 2 = I lean towards yes, 3 = pretty certain that there was a signal). There is just one condition with 600 trials and no pay-offs. Simulate a subject that says 0 if $X < \frac{1}{4}$, 1 if $\frac{1}{4} \leq X < \frac{1}{2}$, 2 if $\frac{1}{2} \leq X < \frac{3}{2}$, and 4 if $X \geq \frac{3}{2}$. Make a plot of the signal-plus-noise and noise-only distributions and mark the decision criteria for the 4 possible responses. How does the rating data relate to the detection data in the previous exercise? Can you translate the rating data to hit rate and false alarm rate and plot it on top of the ROC curve?

7. In case you later want to read up on signal detection theory, the classic book is [1]. A useful book is also [3]. Papers that provide an introduction to basic ideas are [4, 6]. In the lecture on Monday I closely followed [5].

References

[1] D. M. Green and J. A. Swets. *Signal Detection and Psychophysics (Reprint Edition)*. Peninsula Publishing, 1988.

[2] R. D. Luce. A threshold theory for simple detection experiments. *Psychological Review*, 70(1):61–79, 1963.

[3] N. A. Macmillan and C. D. Creelman. *Detection Theory: A User's Guide*. Cambridge University Press, 1991.

[4] J. Swets, W. P. Tanner, and T. G. Birdsall. Decision processes in perception. *Psychological Review*, 68:301–340, Sep 1961.

[5] J. A. Swets. Is there a sensory threshold? *Science*, 134:168–77, 1961.

[6] J. A. Swets, R. M Dawes, and J. Monahan. Psychological science can improve diagnostic decisions. *Psychological Science in the Public Interest*, 1(1):1–26, 2000.

[7] A. P. Yonelinas and C. M. Parks. Receiver operating characteristics (ROCs) in recognition memory: a review. *Psychological Bulletin*, 133(5):800–832, 2007.