MIE 1403F (2003):
ANALYTICAL METHODS IN HUMAN FACTORS RESEARCH

Assignment 1: Psychophysical Thresholds and Signal Detection Theory

The global objective of this assignment is to provide you an opportunity to experience experimentation and analysis in psychophysics. The assignment is in four (not independent) parts, involving:

- Direct scaling, using classical psychophysical methods;
- Estimation of threshold of detecting differences, using classical psychophysical methods;
- Assessing thresholds of detecting differences, using Signal Detection Theory (SDT);
- Estimation of limits of absolute judgement, using information theory.

The particular objective in this assignment is to generate some fundamental baseline data regarding perception of ***a stimulus modality of your choice*** – preferably something that is *interesting* and *relevant,* rather than trivial and uninteresting. In other words, in keeping with the subtitle of the course, "Measuring the Unmeasurable", you should choose a "signal" which you might not otherwise have considered as being measurable. In particular, it should be interesting if you choose some (not necessarily well-known) *illusion*, and investigate the parameters that influence it.
Some suggestions include the following:

- perception of transparency (or opacity) in computer graphic displays (this has been done in the past);
- perception of topological incline information from contour graphs (related to one of my MASc projects);
- perception of pain intensity (this might be very difficult to do, but think about it!);
- perception of depth intervals using stereoscopic displays (feasible only if you have a stereoscopic display at your disposal);
- perception of numerosity (e.g. estimating the size of crowds at rallies);
- perception of time intervals;
- estimation of time-to-arrival / contact (very relevant to my own research);
- some other interesting aspect of visual displays, including *derivatives* of different parameters;
- some interesting aspect of sound/music perception;
- some interesting aspect of haptic (force or tactile) perception;
- you might also want to look at http://www.psychtoolbox.org//intro.html for some cool ideas

Make sure to give careful thought to the appropriateness of your stimulus, in terms of not only "coolness", but also to what extent it is amenable to the analyses that you are being asked to make.

Caveats:

- Although, technically speaking, we are not required to secure the permission of the university's Ethical Review Board for such class projects, please try to adhere to the constraints published there: http://www.library.utoronto.ca/rir/forms/ethics_protocol.pdf . (Please take a look; the material published there is very relevant to this course!)
- Try to keep your stimulus unidimensional (in order not to make your life (too) miserable).
- Make sure that you choose a stimulus that you can *control* …. easily.
- Give some thought as to whether or not your stimulus is (for the purpose of this project) continuous or discrete.
- When deciding on the range of stimuli which you intend to investigate, give careful consideration to potential *floor* and *ceiling effects.*
- Although this entire project can be considered a 'pilot project', you might consider running a pilot study for your pilot study.

A set of assignments/experiments follows. You may run separate experiments for each subsection, or you may combine two or more into a single experiment, as you see fit. Please note that, whereas psychophysical experimentation is typically very labour intensive, the objective of this project is *not* to generate a MASc (or PhD) thesis, so use your judgement in designing the *scope* of your experiments! For example, I suggest that you try to run your experiments using a single standard stimulus level throughout. Also, it's probably sufficient, from the point of view of becoming acquainted with the associated analytical techniques, to use only one subject (e.g. yourself, your kid sister, you family pet) for your experiments.

as well as what sort of results to expect. (See Q f below.) You will also want to write some sort of Introduction in your report.

2. If you haven't done so already, work your way through Ono's Mac-based tutorial on "Precision and Accuracy in Perception"

3. Use one of the methods of direct scaling to derive a graph relating subjective perception of your stimulus versus objectively presented stimulus level.

4. Select a suitable "intermediate" comparison level of your stimulus, around which the stimulus can easily be varied. Using this nominal level, say X_O, estimate the threshold of discrimination, i.e. jnd, of adjacent levels of your stimulus from the comparison level, using a suitable classical technique (method of limits, continuous adjustment, or constant stimuli). Do this for two more different comparison levels, so that in the end you will have estimated jnd at 'high', 'medium' and 'low' levels of your stimulus.

5. Repeat the experiment from part 4 using SDT, for the same three comparison standards (ie. low, medium and high), using stimulus levels at either the lower or upper boundaries of each jnd, as determined in part 3. Don't bother with costs and payoffs (unless you want to), but make sure that your subjects understand the given probability of the stimulus' occurring. For each frequency level, use the confidence rating method to generate a ROC curve (i.e. three ROC curves).

6. Using information theoretic techniques, estimate the maximum "degree of information transmission" for perception of your stimulus. In other words, how many different levels of the stimulus is the "average person" able reliably to judge?

Questions:

a) From the results of part 3, do your data appear to follow an identifiable power law relationship? If so, express it mathematically.
b) From parts 4 and 5, what appears to be the relationship between d' and jnd? Do your results match your expectations, based on theory?
c) From part 5, how well do your subjects' ß's compare with the theoretical optimal ß ? If they are not compatible, speculate on why not.
d) From part 5, does the assumption $\square_N = \square_{S+N}$ appear to hold here?
e) From part 6, what do your data tell you about the number of levels at which one is able to classify your stimulus, in terms of Absolute Judgement?
f) Are there any relevant data published in the literature? If so, how well do your data support those in the literature? (Sample Reference: Boff & Lincoln: Engineering Data Compendium)

Deliverables:

A report, due on **Oct. 16 (2003).**

Note: Report writing is an integral part of doing such projects. If you have little or no experience with (formal) report writing, you are encouraged to exploit the services of the Engineering Writing Centre. The staff there is available, for example, to critique your reports before you hand them in.

Take a look at: http://www.ecf.toronto.edu/~writing/ , where you can find interactive tutorials, on-line handbooks, and even an on-line appointment booking system.

Potential References:

1. Boff, K.R. & Lincoln, J.E. *Engineering Data Compendium: Human Perception and Performance*. AAMRL, Wright-Patterson AFB, OH, 1988.
2. Boff, K.R., Lincoln, L., Thomas, J.P. *Handbook of Perception and Human Performance. Vol. I + II,* Wiley, 198(
3. Bonnet, C. *Manuel Pratique de Psychophysioque*, Armand Colin, 1986.
4. Engen, T. "Psychophysics: I. Discrimination and Detection". Ch. 2 in JW Kling & LA Riggs (ed's), *Woodworth & Schlosberg's Experimental Psychology, Ed 3,* Holt, Rinehart & Winston, 1971, 11-46.
5. Engen, T, "Psychophysics: II.Scaling Methods". Ch. 3 in JW Kling & LA Riggs (ed's), *Woodworth & Schlosberg's Experimental Psychology, Third Edition,* Holt, Rinehart & Winston, 1971, pp. 47-86.
6. Gescheider, G.G. *Psychophysics: Method, Theory, and Application. 2nd Edition*, Erlbaum, 1985.