

Essay (1500 words):
Psychophysics of Vision

Theme:
Measurement of perceptual ability as applied to medical imaging

Background reading:

Bear MF, Connors BW, & Paradiso MA. Neuroscience:exploring the brain. 2007 Lippincott Williams & Wilkins Baltimore, Md. 3rd Ed. Chapters 9, 10 and 21.
Hall JE. Guyton and Hall Textbook of medical physiology. 2011 Saunders/Elsevier Philadelphia, Pa. 12th Ed. Chapters 49, 50, 51 specifically consider "Optics of the eye", "Neuronal patterns of stimulation during analysis of the visual image"

Suggested references:

Martin K. 1994. A brief history of the "feature detector." *Cerebral Cortex* 4:1-7
Posner MI, Snyder CRR, Davidson BJ. 1980. Attention and the detection of signals. *Journal of Experimental Psychology General* 109:160-174

Advanced reading:

Dakin SC, Tibber MS, Greenwood, LA, et al. 2011 A common visual metric for approximate number and density. *Proceedings of the National Academy of Science* 108(6):19552-7

To be successful, you will also need to access the following narrated presentations:

1. Decision making
2. Measuring performance in radiography reporting
3. Visual perception

Psychophysics refers to a general class of methods that can be applied to study a perceptual system - in the case of medical imaging, this is the visual system. Regardless of the sensory domain, there are three main areas of investigation: absolute thresholds, discrimination thresholds and scaling.

A threshold (or limen) is the point of intensity at which the observer can just detect the presence of a stimulus or presence of a difference between two stimuli. Stimuli with intensities below the threshold are considered not detectable (hence: sub-liminal). Stimuli at values close enough to a threshold will often be detectable some proportion of occasions; therefore, a threshold is considered to be the point at which a stimulus, or change in a stimulus, is detected some proportion p of occasions. An absolute threshold is the level of intensity of a stimulus at which the subject is able to detect the presence of the stimulus some proportion of the time (a p level of 50% is often used). An example of an absolute threshold is the number of line pairs per millimetre that can be detected under the experimental conditions imposed. A difference threshold (or just-noticeable difference) is the magnitude of the smallest difference between two stimuli of differing intensities that the participant is able to detect some proportion of the time (again, 50% is often used). To test this threshold, several different methods are used. The subject may be asked to adjust one stimulus until it is perceived as the same as the other, may be asked to describe the magnitude of the difference between two stimuli, or may be asked to detect a stimulus against a background. The just-noticeable difference is not a fixed quantity, rather it depends on how intense the stimuli being measured are and the particular sense being measured. Weber's Law (Weber–Fechner law) states that the just-noticeable difference of a stimulus is a constant proportion despite variation in intensity.

Absolute and difference thresholds are sometimes considered similar because there is always background noise interfering with our ability to detect stimuli, however study of difference thresholds still occurs, for example in modulation transfer function studies.

The visual system involved in medical imaging involves:

1. The image source and its presentation – film, lightbox, monitor
2. The environment in which the image is presented to the reader – room lighting, surroundings
3. The eye as a receptor
4. Image interpretation within the optic nerve and visual centres of the brain – integration of new stimuli into already conceptual frameworks

In this essay, you are asked to discuss how the effect of each of these can be measured and the effect each has on accuracy of diagnosis.

Some examples to consider:

1. As the eye ages, its ability to convert light into neural signal decreases. This impacts on the ability to discriminate low intensity signal. How can this be measured and what effect could this have on diagnostic outcomes?
2. If a radiologist or reading radiographer has astigmatism, should they have this measured regularly? And why would you answer that way?
3. Spatial resolution is usually expressed in line pairs per millimeter (lp mm^{-1}). How does ambient light affect perception of spatial resolution? What impacts does this have on interpretation of low intensities in medical images?
4. After having interpreted a number of fractures during a shift in the emergency centre, what type(s) of error could affect a reading radiographer?
5. A radiologist usually views an image monitor in a dimly lit environment. How can the most appropriate contrast and brightness settings be determined? What about the most appropriate type of monitor – eg. CRT, LCD, LED?
6. You have to advise your supervisor on the best method of image presentation. What measurements would offer as a base for your recommendations?

NOTE:

These are suggestions only. It is up to you to determine the questions to be answered. Your essay will be assessed on the criteria in the following table. The criteria are weighted to the contribution each aspect makes to your understanding of research methods and writing. The maximum achievable outcome is 10. A result greater than 5 is required to pass this assignment.

Psychophysics of Vision: Marking Criteria

Student Name: _____ Student ID: _____

Content	
1.5	Little material referred to, unidentified or irrelevant material. No examples provided.
3	Some relevant material used, from limited sources, to support claims.
4.5	Clear discussion, demonstrating understanding of the rationale, within the context. A range of literature cited.
6	Critical analysis of the rationale, within the context. Wide variety of evidence used to support the analysis.
7.5	A thorough critical analysis of the rationale, within the context. A wide variety of evidence to support the analysis, with reflection on practice
Selection and use of material; written style	
0.5	Little material referred to, unidentified or irrelevant material. Difficult to understand, lacking fluency. Inaccurate spelling, grammar, punctuation and/or referencing.
1	Some relevant material used, from limited sources, to support claims. Understandable, with generally accurate spelling, grammar, punctuation and referencing.
1.5	Relevant material, from differing sources, used to support claims and illustrate points. Understandable. Accurate spelling, grammar, punctuation and referencing.
2	Relevant material, from a wide range of different sources, Used effectively to support claims and illustrate points. Clear and appropriate use of language and style. Accurate spelling, grammar, punctuation and referencing.
2.5	Highly relevant material, from a wide range of different sources and used effectively. Sources themselves are evaluated. Fluent writing with effective use of language and style. Accurate spelling, grammar, punctuation and referencing.
Total mark: /10	