Lecture 40 – ROC Curves, Magnitude of Sensation

REVIEW THEORY OF SIGNAL DETECTION

Review Schwartz Fig. 11-7 and understand all features of all the graphs.

ROC CURVES

The subjective responses obtained for different criteria levels and different stimulus intensities (detectibility, d') can be plotted on a **receiver operating characteristic**, or **ROC curve**. It plots the hit rate (true positives) as a function of false alarm (false positive) rate for many repeated trials (Figure 1, below and Schwartz Fig. 11-9).

Each ROC curve represents one level of detectibility—that is, a level of stimulus intensity above the background. When detectiblity is small, the stimulus is hard to see and you get a large number of false alarms as well as hits. An extreme example is represented by an ROC curve A in Figure 1. ROC curve A represents a detectibility of d'=0.

Q. Why?
A.

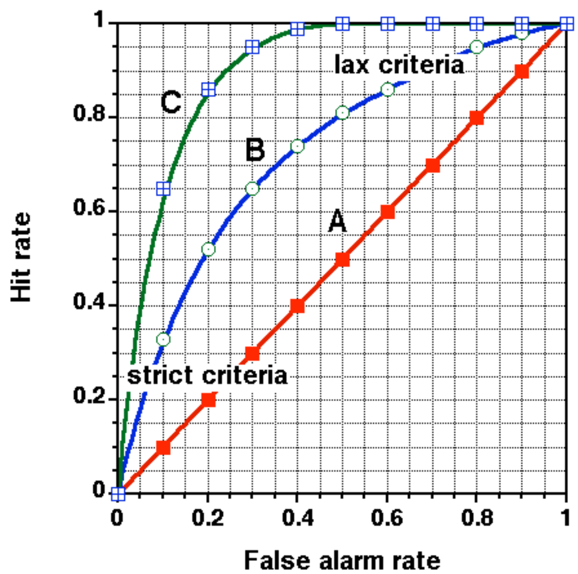

Figure 1. Three ROC curves

For higher stimulus intensities, detectibility increases, and the target will become easier to see. There will be fewer false alarms and more hits, such as that shown in Curve C.

Within one ROC curve, a particular *detection criterion is associated with a single point on the curve*, as shown in Schwartz Fig. 11-9A and Figure 1. This is because the criterion determines the probability of both the hits and false alarms.

EXAMPLE OF DECISION THEORY IN GLAUCOMA

The use of ROC curves and the theory of signal detection are not limited to psychophysical experiments. The Scientific American article (handout) illustrates how the same methods can be applied to decision making in glaucoma. ROC curves are frequently used to evaluate medical diagnostics tests that are designed to detect something such as a disease in a population (like the stimulus+noise) from a normal population (the noise). These techniques are also been used to evaluate diagnostic instruments such as the GDx machine, to evaluate how good it is for diagnosing the disease.

Sometimes the hit rate is called the "**sensitivity**" of the diagnostic test. Sensitivity of the test is the probability of correctly diagnosing the disease when it is present (a true positive).

The correct rejection is also sometimes referred to as the "**specificity**." Specificity is the probability of correctly diagnosing a normal condition when it is actually normal (a true negative); that is, correctly saying that the disease in not present, when it is, in fact not present.

Since,

(false alarm) = 1 - (correct rejection),

you can also say,

(false alarm) = 1 - (specificity)

Table 1. Four possible outcomes in a detection task.

Do you think it's present?	**The diseased is present**	**The disease is not present**
"Yes"	Hit True positive Sensitivity	False alarm False positive Type I Error (1-specificity)
"No"	Miss False negative Type II Error	Correct rejection True negative Specificity

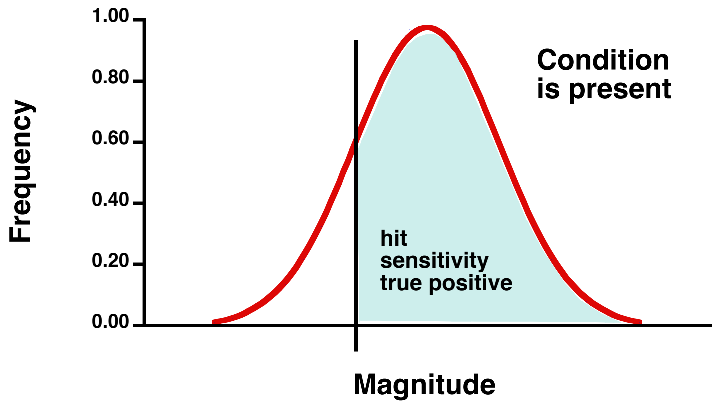

Figure 2. Sensitivity in a detection task.

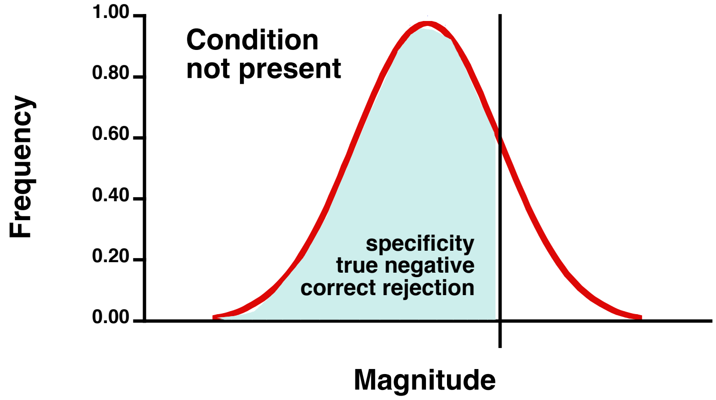

Figure 3. Specificity in a detection task. False alarm rate = 1 - specificity.

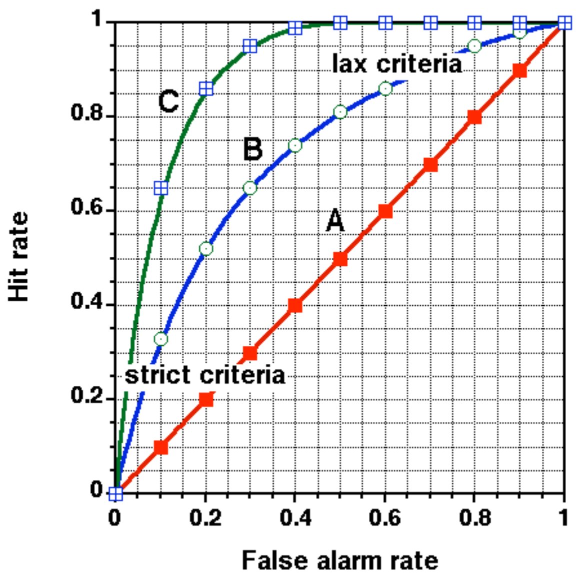

Figure 4. ROC curve

ROC curves associated with diagnostic tests may be plotted with hit rate along the y-axis and false alarm rate along the x axis, or you may see ROC curves with sensitivity plotted along the y-axis and **1-specificity** plotted along the x-axis. The example below comes from a glaucoma research article (Johnson C, Samuels SJ. Screening for Glaucomatous Visual Field Loss With Frequency-Doubling Perimetry. Invest Ophthalmol Vis Sci. 1997; 38: 413-425.) .

A good diagnostic test is one that has a high detectiblity; that is, an ROC curve that extends closer to the upper-left corner or top of the ROC plot. Another statistic used is the **area under the ROC curve**. A better diagnostic test would be one that has a larger area under the ROC curve.

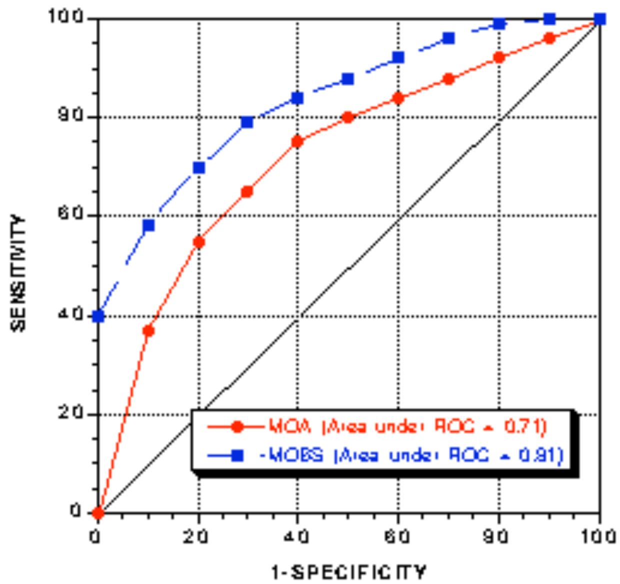

Figure 5. Use of ROC curves to compare two diagnostic tests for glaucoma, the MOA and MOBS test. The higher detectibility or greater area under the ROC curve indicates a better test. (Redrawn from: Johnson C, Samuels SJ. Screening for Glaucomatous Visual Field Loss With Frequency-Doubling Perimetry. Invest Ophthalmol Vis Sci. 1997; 38: 413-425.)

Figure 6. Another example from, Lemp MA, Bron AJ, Baudouin C, et al. Tear Osmolarity in the Diagnosis and Management of Dry Eye Disease. Am J Ophthalmol 2011.

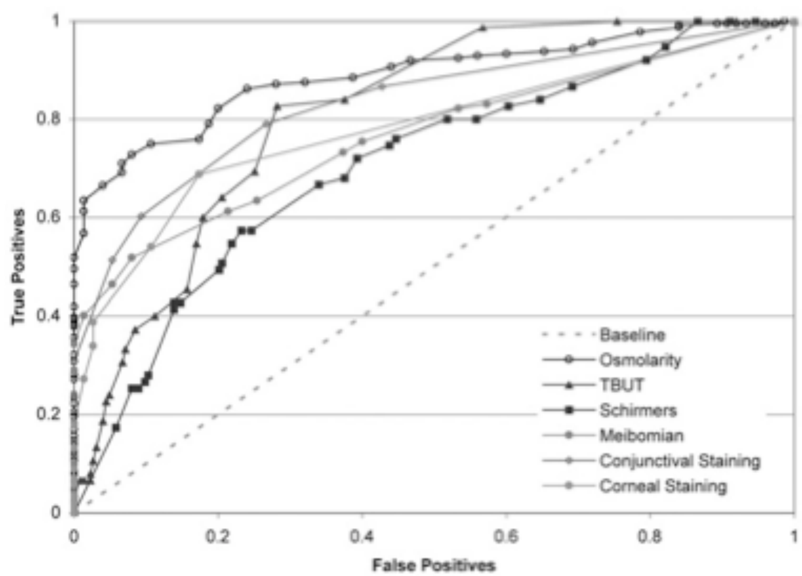

FIGURE 1. Receiver operator characteristic (ROC) curves of objective clinical signs of dry eye disease. Osmolarity exhibits the greatest area under the curve of the common clinical signs for dry eye disease. Tear film break-up time (TBUT) achieves a higher sensitivity toward the upper right side of the graph, although it shows poor performance against most other signs in specificity (when less than 40% false positives are required). Also of note, Schirmer strips consistently are inferior to all other signs across the full range.