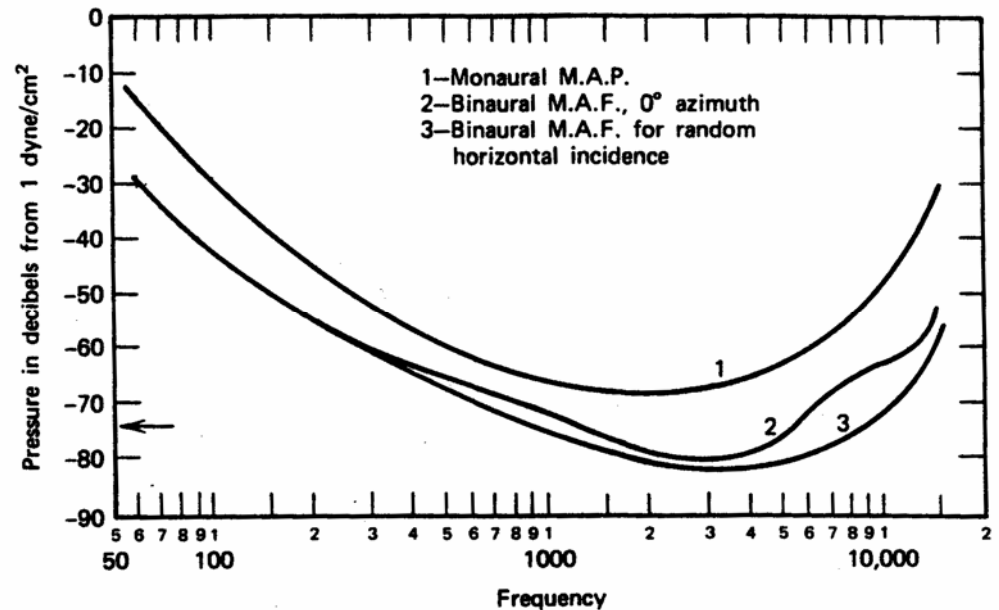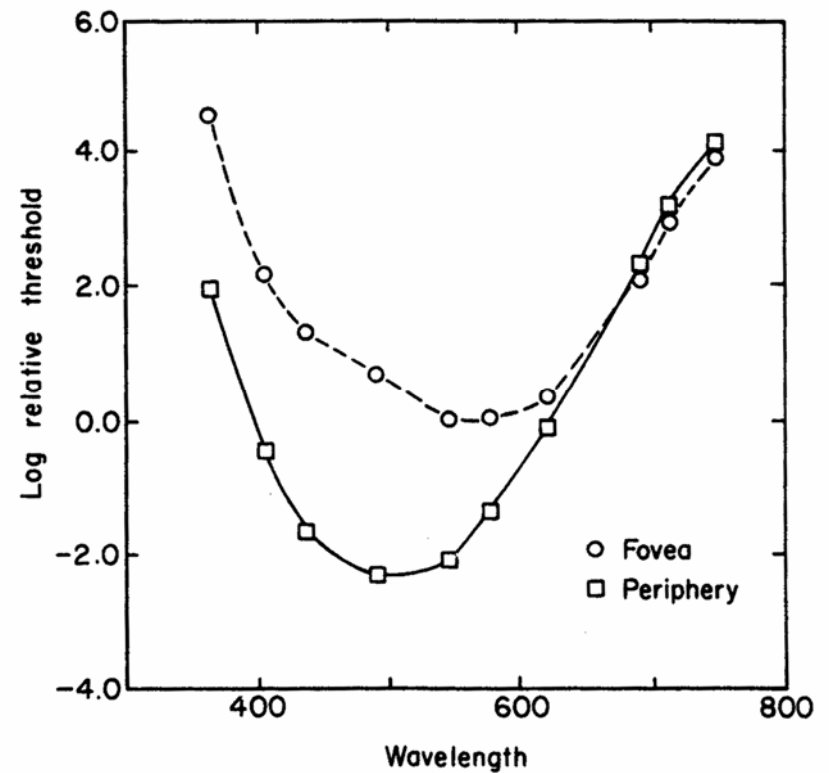# Study Question

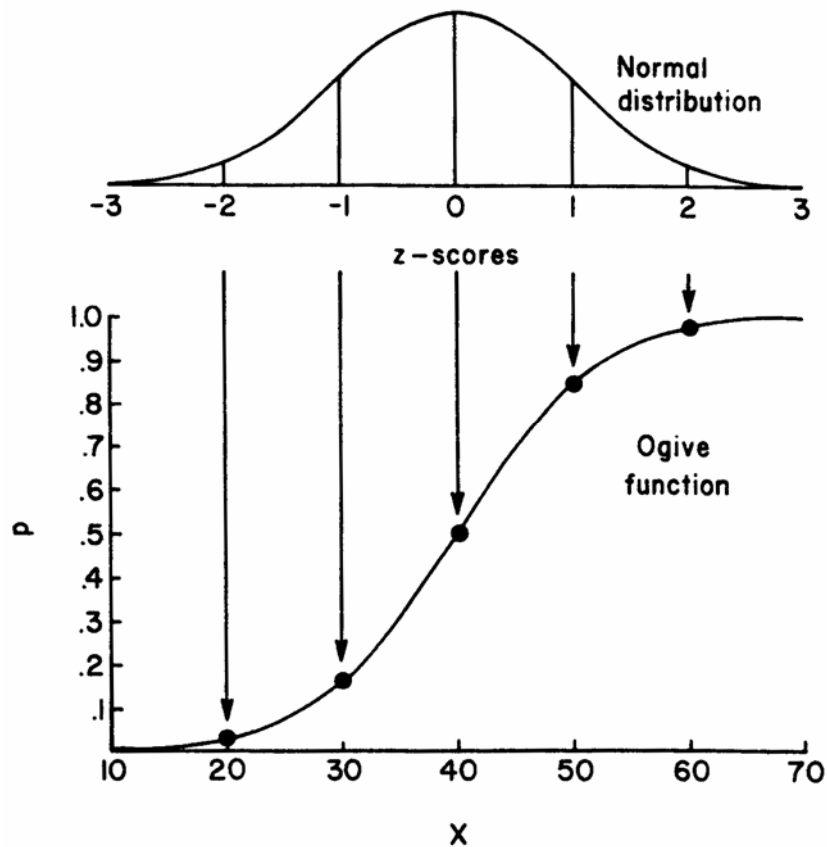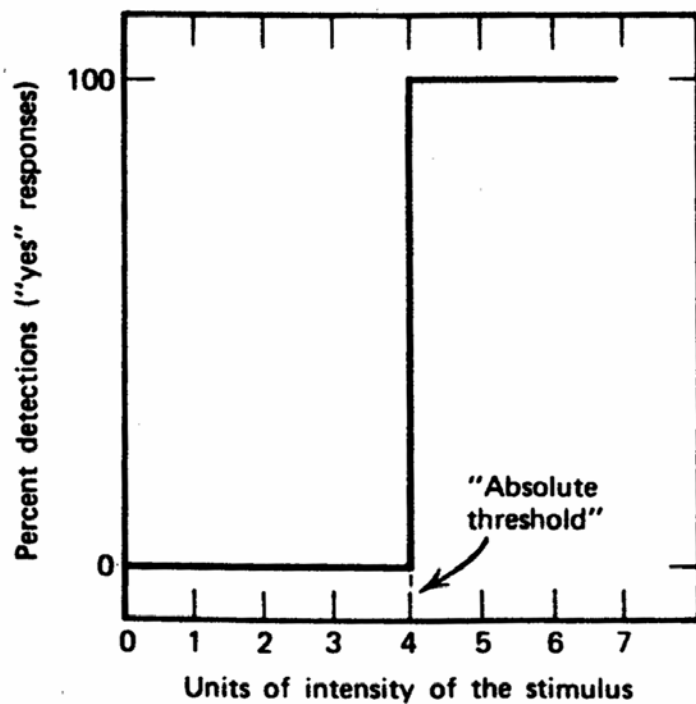*What advantages do modern psychophysical methods (e.g., TSD-based measures) offer over the classical methods? What are their disadvantages, if any?*

The Sensory Threshold Concept

TABLE 2.3 Approximate Detection Threshold Values in Representative Terms (after Galanter, 1962)

Sense modality	Detection threshold
Light	A candle flame seen at 30 miles on a dark clear night (about 10 quanta).
Sound	The tick of a watch under quiet conditions at 20 feet (about 0.0002 dynes/cm²).
Taste	1 teaspoon of sugar in 2 gallons of water.
Smell	1 drop of perfume diffused into the entire volume of a 3-room apartment.
Touch	The wing of a bee falling on the cheek from a distance of 1 cm.

Percent detections ("yes" responses) vs. Units of intensity of the stimulus — "Absolute threshold"

Normal distribution — z-scores

Ogive function — p vs. X

Classical Psychophysics

METHOD OF CONSTANT STIMULI
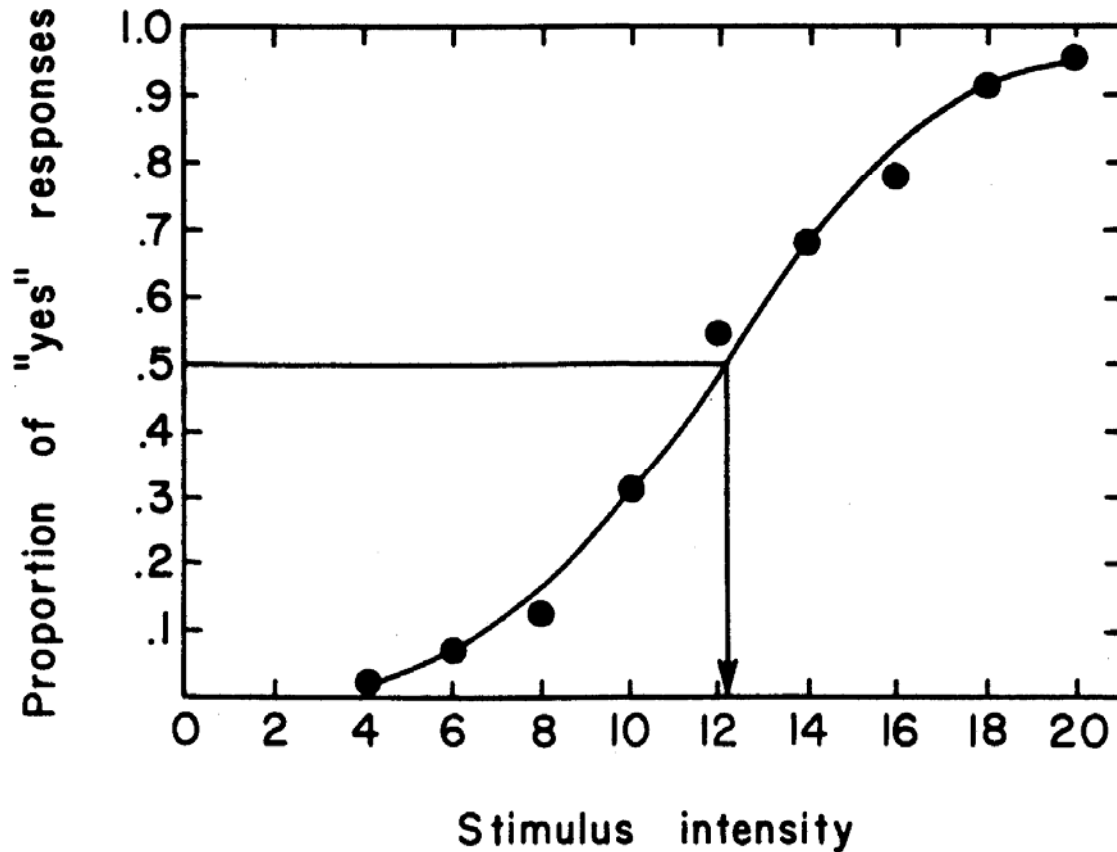
Typical psychometric function obtained when the absolute threshold is measured by the method of constant stimuli. An ogive curve has been fitted to the points. The threshold is the stimulus intensity that would be detected 50% of the time.

Determination of the Absolute Threshold for Hearing by the Method of Limits[a]

Stimulus intensity (dB)	A	D	A	D	A	D	A	D	A	D
10						Y				
9		Y				Y				Y
8		Y				Y				Y
7		Y		Y		Y				Y
6		Y		Y	Y	Y		Y		Y
5	Y	Y		Y	N	Y	Y	Y		Y
4	N	Y	Y	N	N	N	N	Y	Y	N
3	N	N	N		N		N	Y	N	
2	N		N		N		N	N	N	
1	N		N		N		N		N	
0	N		N				N		N	
−1	N		N				N			
−2	N						N			
−3	N						N			
−4	N									
−5	N									
−6	N									
−7	N									
−8	N									
−9	N									
−10	N									
Transition points =	4.5	3.5	3.5	4.5	5.5	4.5	4.5	2.5	3.5	4.5

[a] Mean threshold value = 4.1

Difference Thresholds or Just Noticeable Differences (JNDs)

Table 2–1. The Range of Luminances Affecting the Human Eye. From Graham (240).

	Scale of luminance (millilamberts) ↓	
	10^{10}	
Sun's surface at noon	10^9	Damaging
	10^8	
	10^7	⎫
Tungsten filament	10^6	
	10^5	
White paper in sunlight	10^4	Photopic
	10^3	
	10^2	
Comfortable reading	10	⎭
	1	Mixed
	10^{-1}	⎫
White paper in moonlight	10^{-2}	
	10^{-3}	
White paper in starlight	10^{-4}	Scotopic
	10^{-5}	
Absolute RL	10^{-6}	⎭

|	Decibels	Relative power
Threshold of hearing	0	10^0
Rustling leaves	10	10^1
Talking (3 feet)	65	
Toilet flushing	67	
Toilet flushing and vent fan	70	
Hair dryer	80	
Inside car in city traffic	90	
Car without muffler	100	10^{10}
Live rock concert	120	10^{12}
Threshold of pain	130	10^{13}

Weber's Law: $\Delta I / I = k$

Figure 9.19. Intensity discrimination as a function of luminance. Data from König (open circles) and Brodhun, 1889 (solid circles). Separate curves have been fitted to the high-and low-luminance portions. (After Hecht, 1934.)

Signal frequency = 1000 Hz
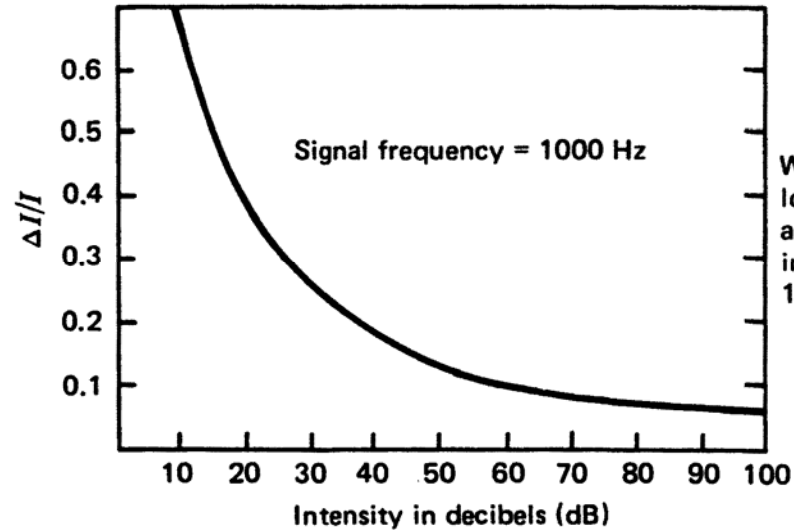
Weber fractions for the loudness of a pure tone as a function of stimulus intensity. (From Boring, 1942.)
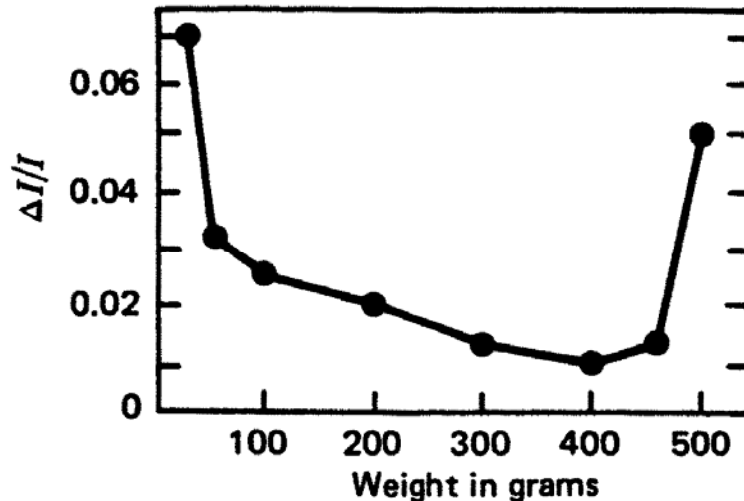
Weber fractions for pressure applied to the skin as a function of weight. (From Boring, 1942.)

TABLE 2.4   Weber Fractions for Various Sensory Discriminations (after Boring, Langfeld, and Weld, 1939)

	Weber Fraction
Deep pressure, from skin and subcutaneous tissue, at about 400 gm	1/77
Visual brightness, at about 1000 photons	1/62
Lifted weights, at about 300 gm	1/53
Tone, for 1000 cycles per second, at about 100 db above the absolute threshold	1/11
Smell, for rubber, at about 200 olfacties	1/10
Cutaneous pressure, on an isolated spot, at about 5 gm per mm	1/7
Taste, for saline solution, at about 3 moles per liter concentration	1/5

Theory of Signal Detection

Hypothetical Sensory Continuum

Criterion 1

Criterion 2

Criterion 3
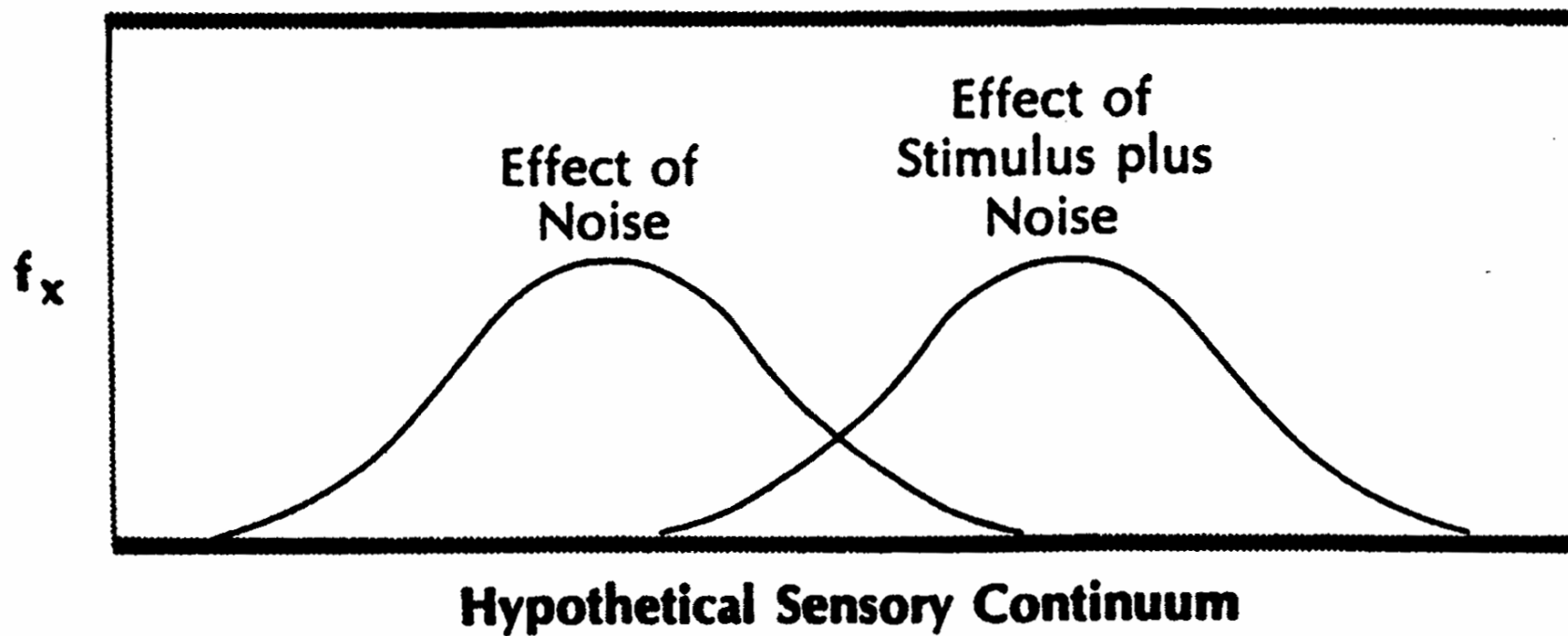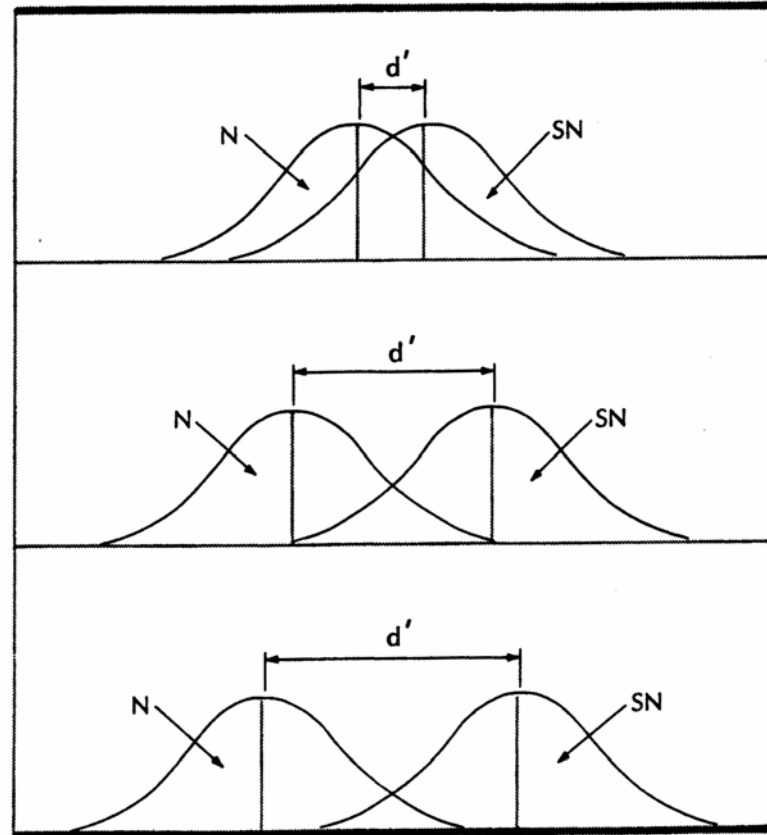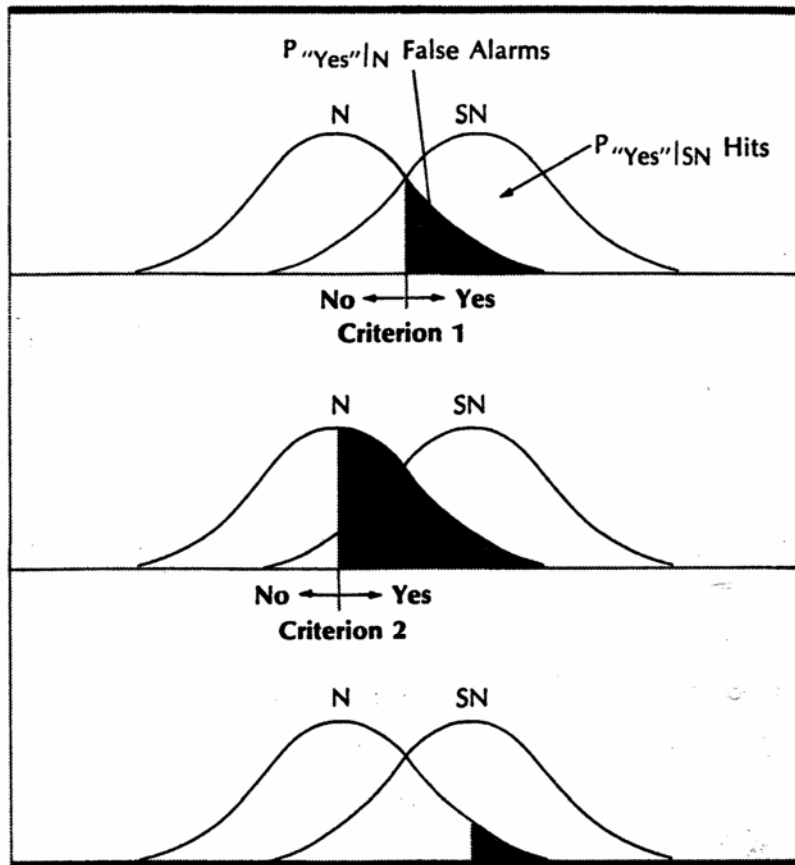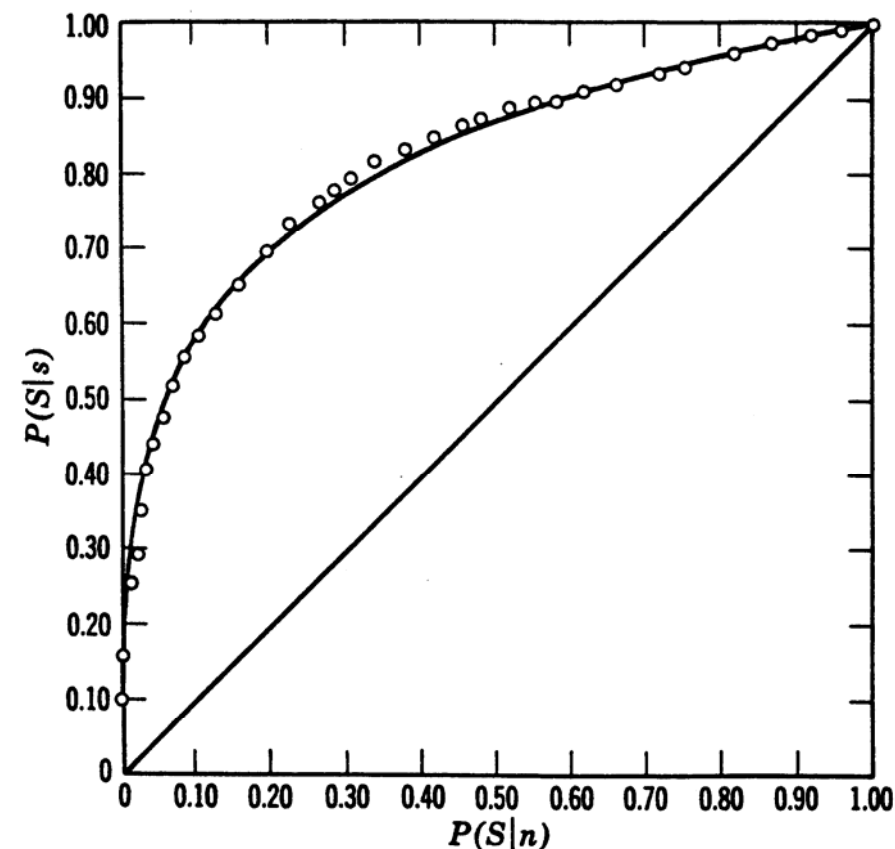
Hypothetical Decision Axis
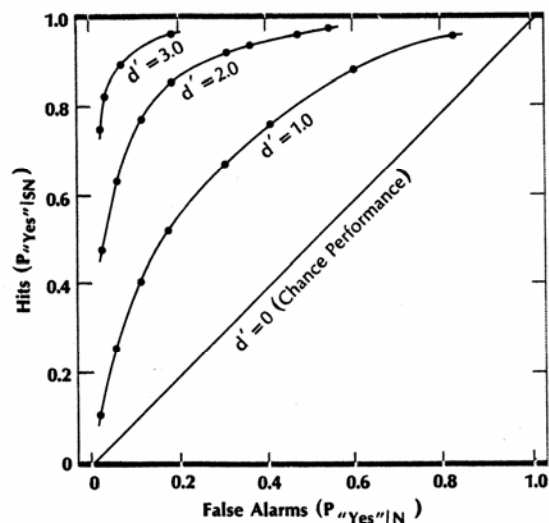
FIG. 4-8 An empirical ROC graph obtained by the rating method using a scale and sliding pointer. The theoretical curve is based on the assumption of normal probability distributions of unequal variance, specifically on the assumption that $\Delta m/\Delta \sigma = 4$. One thousand observations were made. (Data from Watson, Rilling, and Bourbon, 1964.)
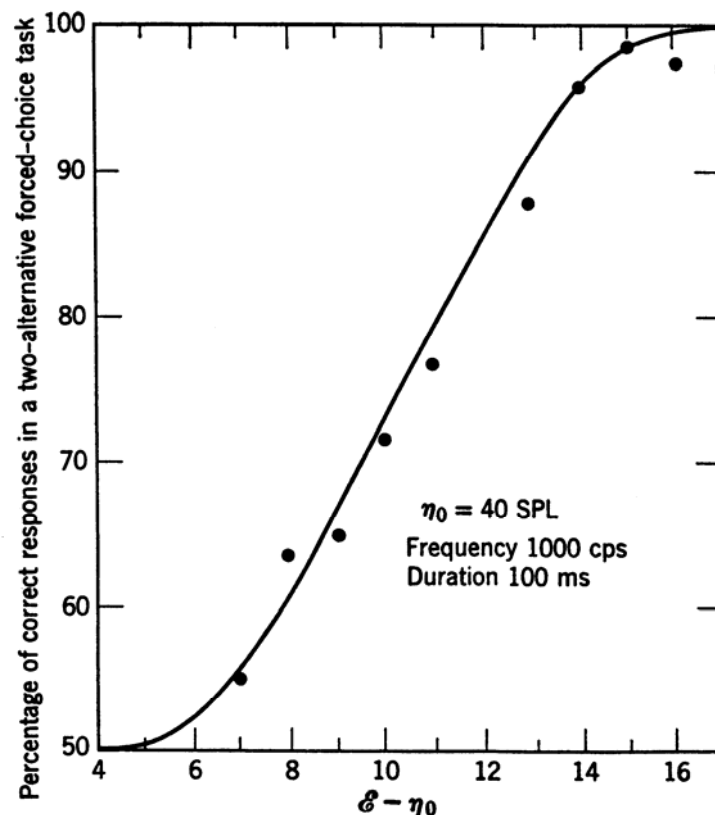

FIG. 7-3 Typical psychometric function for the simple detection experiment. The percentage of correct responses in the two-alternative forced-choice task is plotted against $\varepsilon - \eta_0 = 10 \log E/N_0$. E/N_0 is the ratio of signal energy to noise-power density. As the signal increases about 10 db, the percentage of correct responses rises from near chance to 100% correct. The signal parameters are indicated on the graph. About 400 observations were used to estimate each point. The spectrum level of the noise was 40 db SPL; that is, the noise power in a 1-cps band had an average power equal to a sinusoid of 40 db re 0.0002 dyne/cm². (After Green, 1960b.)
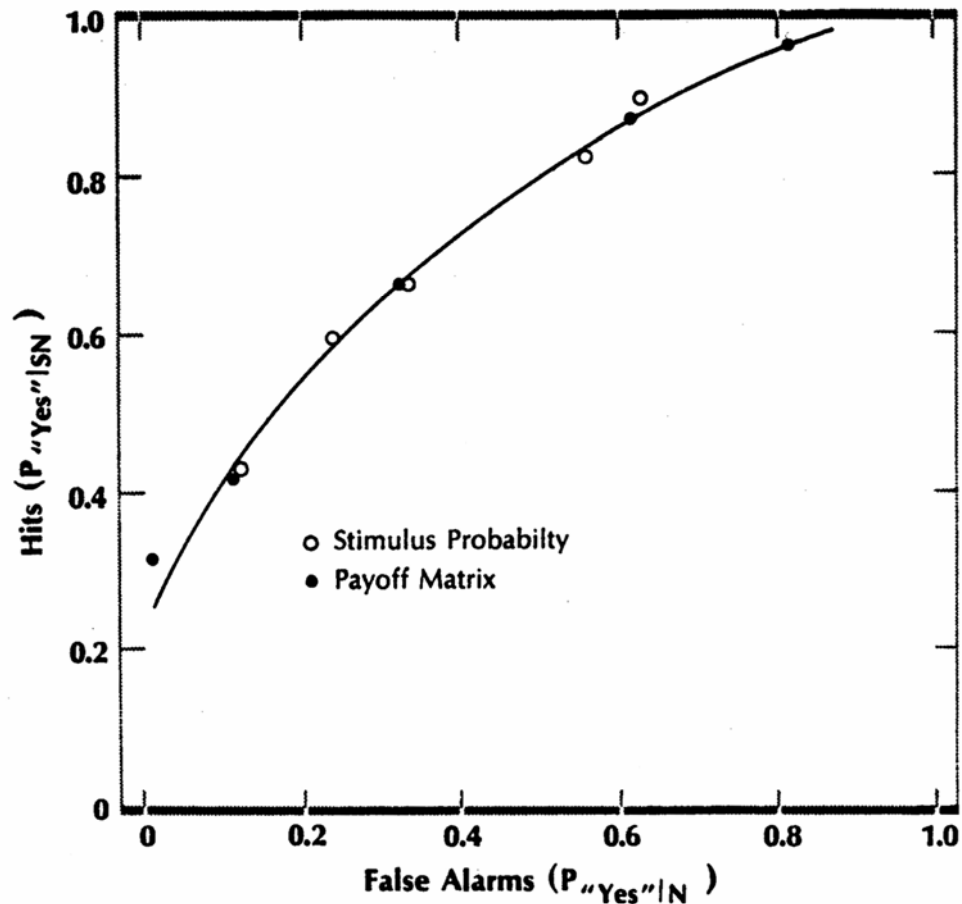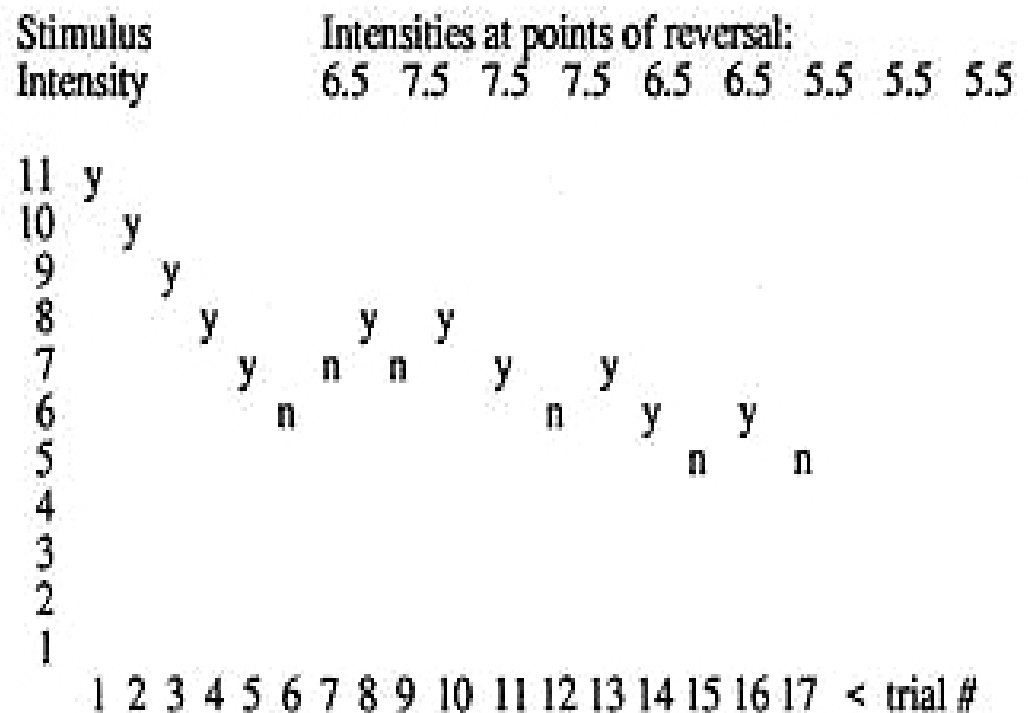
The effects of stimulus presentation probabilities and pay-off matrices in an auditory detection experiment involving one stimulus magnitude. All the data seem to be described by the same isosensitivity function.

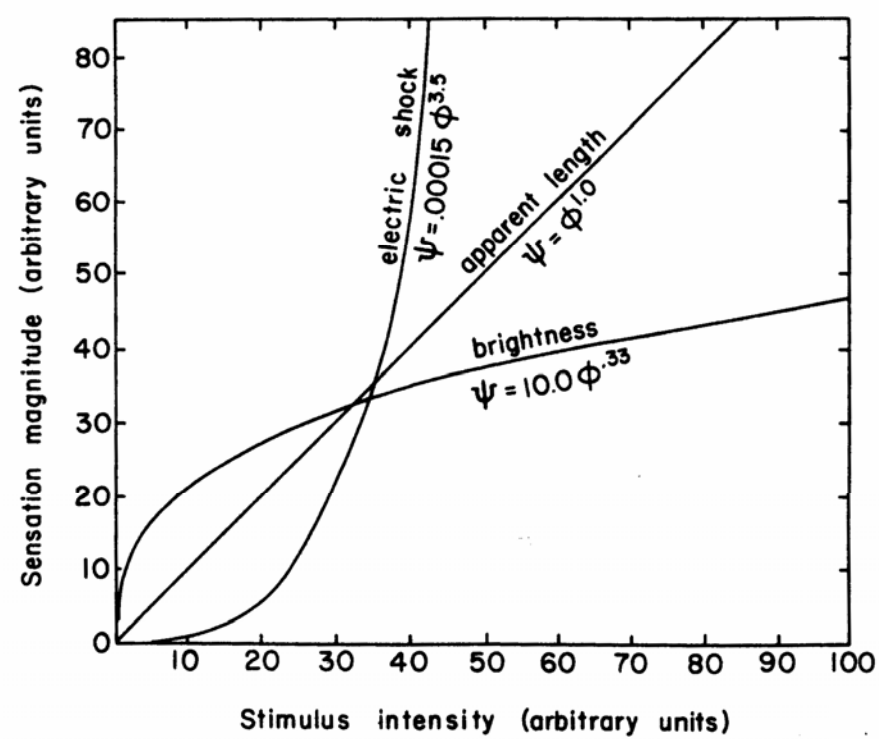# Modern Forced-Choice Psychophysical Methods

Staircase Method - a more efficient version of the Method of Limits in which the level of the stimulus is adjusted in steps until observer changes her response, but doesn't start over with each trial.

When observer says "yes", the level is decreased on the next trial. When the observer says "no", the level is increased on the next trial.
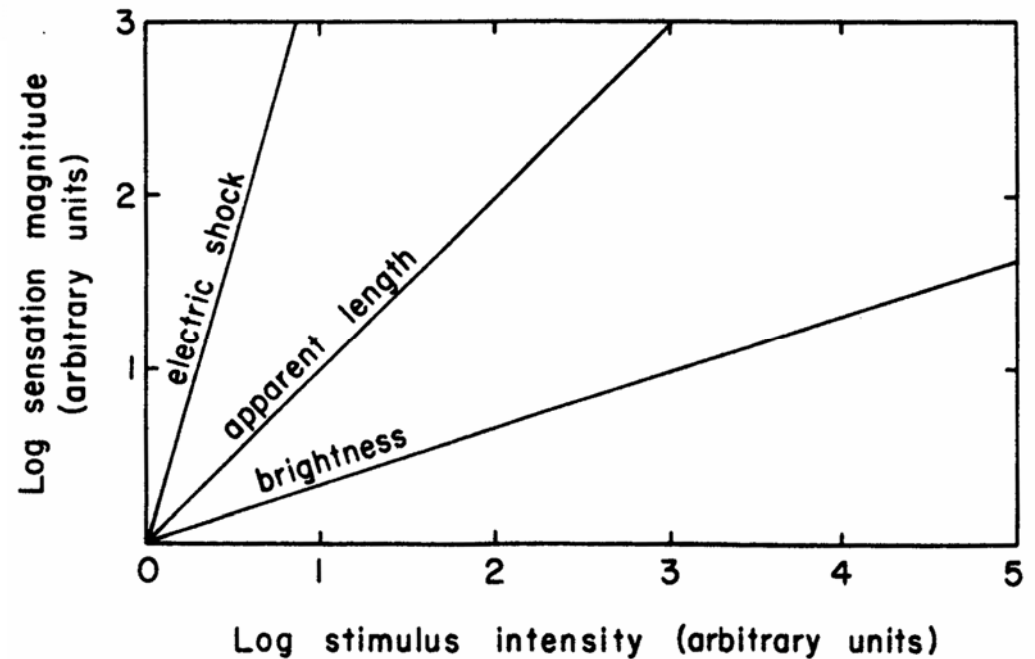
Absolute Threshold = mean of intensities at points of reversal
= 6.5

Stimulus Intensity

Intensities at points of reversal:
6.5 7.5 7.5 7.5 6.5 6.5 5.5 5.5 5.5

```
11  y
10     y
 9        y
 8           y           y     y
 7              y     n     n        y        y
 6                 n              n     y        y
 5                                     n        n
 4
 3
 2
 1
    1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17  < trial #
```
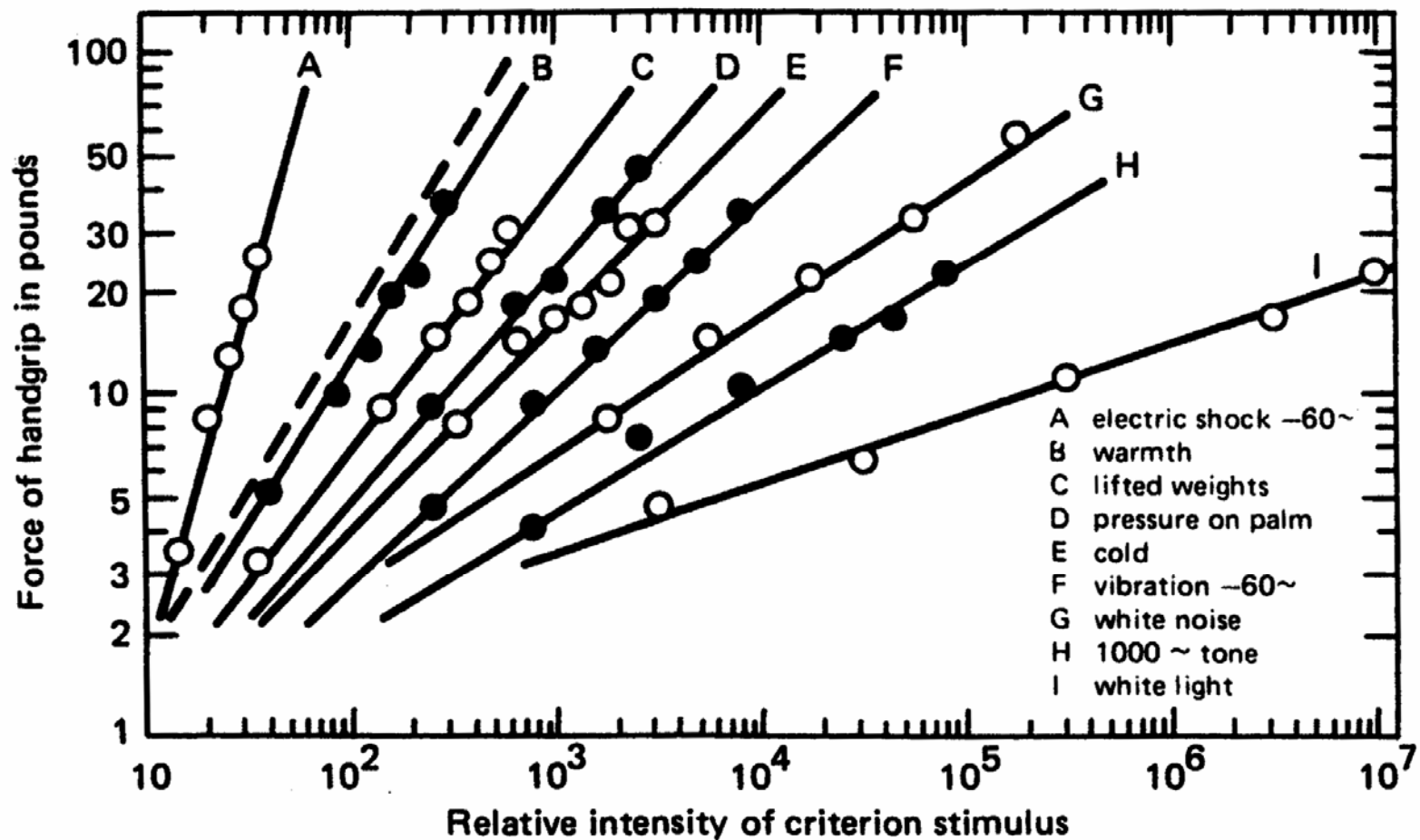
Psychophysical Scaling

Stevens' Power Law:
$P = kS^n$

Equal-sensation functions obtained by matching force of handgrip to nine different criteria stimuli. Each point stands for the median force exerted by 10 or more observers to match the apparent intensity of the criterion stimulus. The relative position of a particular function along the horizontal axis (abscissa) is arbitrary. The dashed line shows a slope of 1.0 in these coordinates. (From Stevens, 1962)

TABLE 5.2
Predicted and Obtained Exponents for Matching Force of Hand Grip to Nine Other Continua[a]

	Exponent obtained by hand grip	Predicted value
Electric shock	2.13	2.06
Warmth on arm	0.96	0.94
Heaviness of lifted weights	0.79	0.85
Pressure on palm	0.67	0.65
Cold on arm	0.60	0.59
Vibration, 60 Hz	0.56	0.56
Loudness of white noise	0.41	0.39
Loudness of 1000-Hz tone	0.35	0.39
Brightness of white light	0.21	0.20