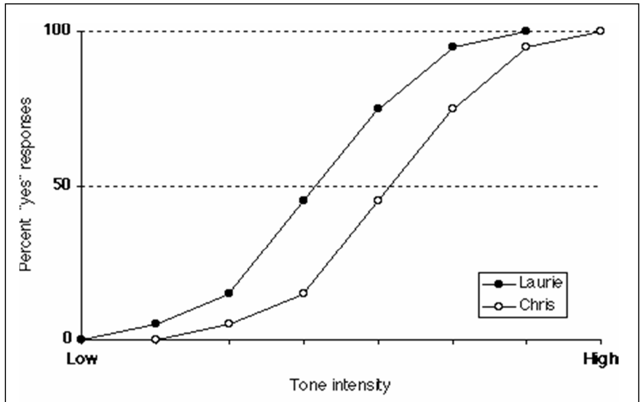
Signal Detection Theory

all judgments are made in the presence of uncertainty

The simplest case: 1-interval yes/no

- To determine an absolute threshold.
- During a pre-determined time interval, either present a 125 Hz tone burst, or not.
- Listener responds either …
  - yes, I heard something
  - no, I didn't hear anything
- Sound familiar?

A psychometric function only for trials when a signal is presented, but at various levels



A threshold for hearing a tone is determined for Laurie and Chris by means of the method of constant stimuli. These data indicate that Laurie's threshold is lower than Chris's. But is Laurie really more sensitive to the tone than Chris?

Or just more willing to *say* she hears one?

Role of bias

- Perhaps especially strong in 1-interval yes/no experiments
  - some people are much more likely to say yes for a given level of perceptual evidence; others need a lot of convincing!
- Less strong in 2-interval forced choice
  - no obvious reason to prefer 1st or 2nd interval

Terminology

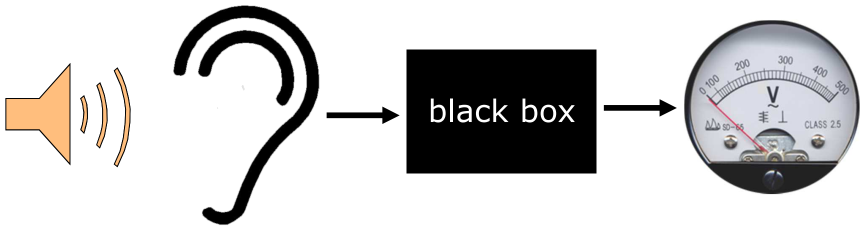
		signal	
		present	absent
decision	present	hit	false alarm
	absent	miss	correct rejection

Knowing the proportion of 'hits' and 'false alarms is sufficient. Why?

Mapping the physical stimulus into the psychological world

- Each interval has 'noise' in it, internal or external so …
- the psychological 'effect' of the presented stimulus varies randomly from trial to trial.
- Sometimes, you think you hear a tone when none was presented, and …
- you don't hear it when one was.

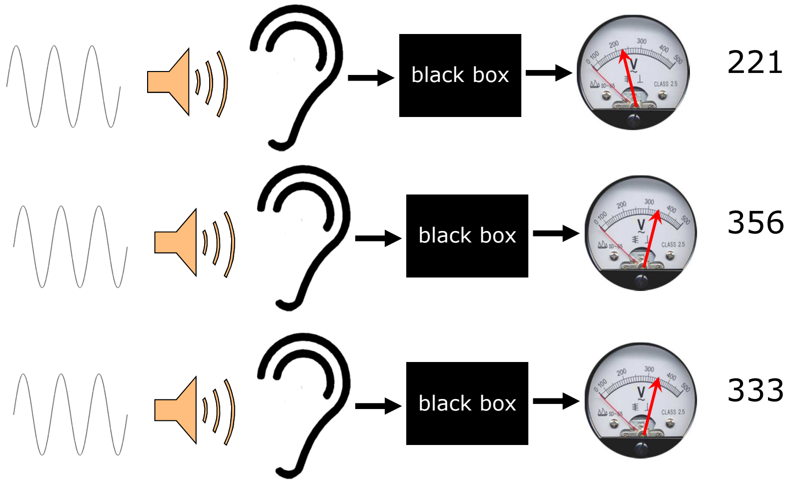
A simple model of a tone detection experiment



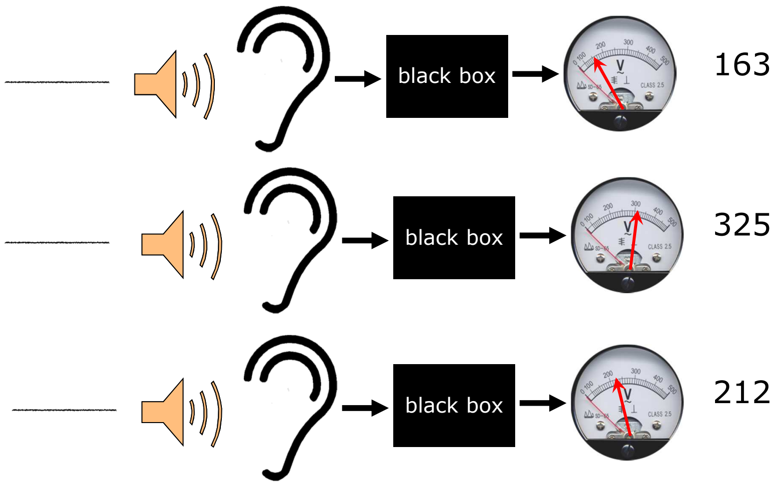
Enter the homunculus

apologies to Jules Feiffer

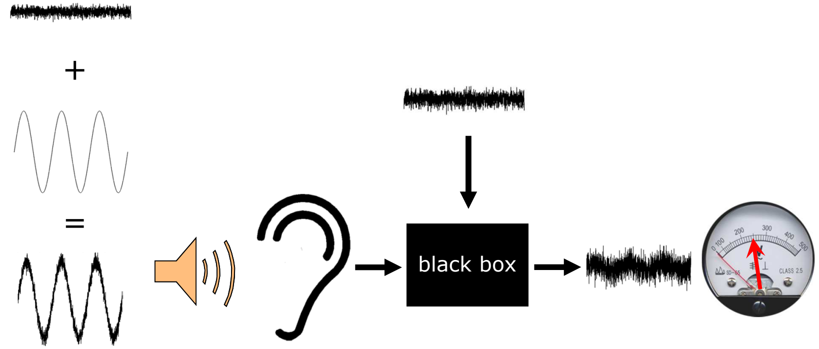
Present 125 Hz sinusoid at 30 dB SPL



But what happens with no input?



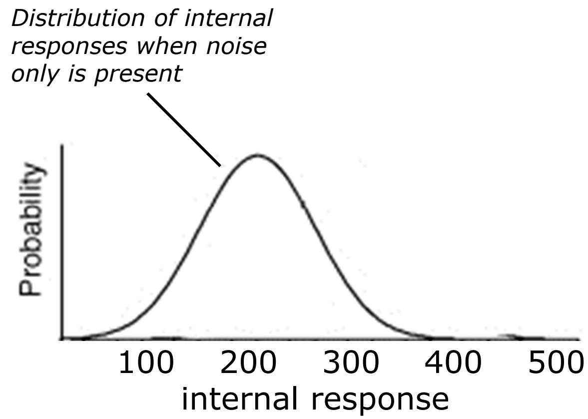
Why do the values vary?



Must consider a *distribution* of values

- The meter reading varies from trial to trial, even when the experimenter does exactly the same thing …
- So the meter reading can be thought of as a *random variable*, which can be described by its *distribution*.
  - normally assumed to be Gaussian (*i.e.*, bell-shaped)

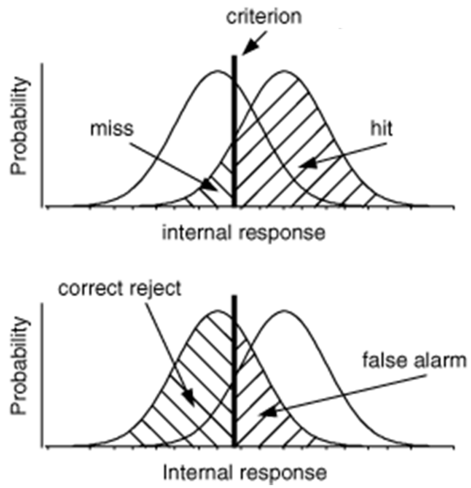
Internal response distributions



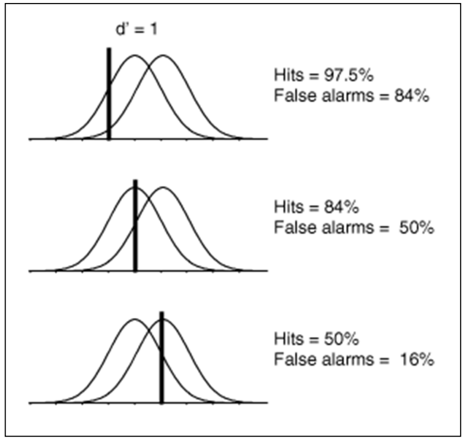
Internal response distributions

Generally speaking, the bigger the meter reading, the more likely there is to be a signal but …
Given any particular value of the internal response, how do you decide to say 'yes' or 'no'?

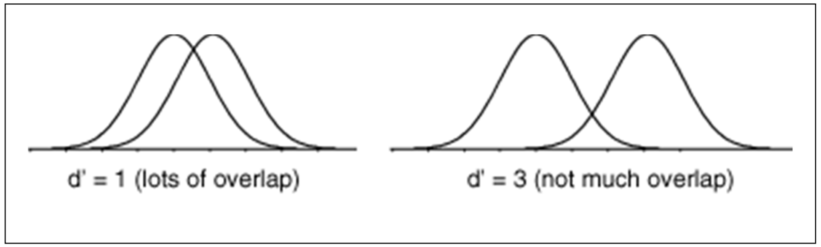
Need to set a criterion



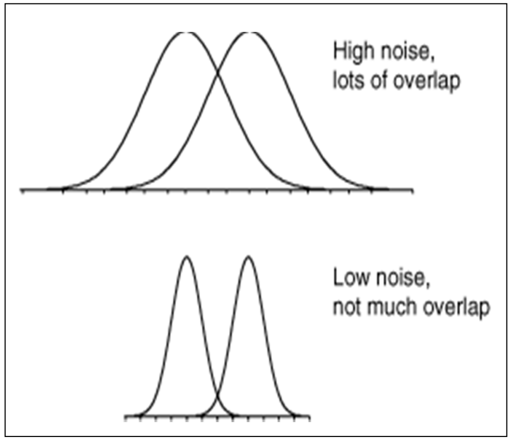
Shifting the criterion: You can't improve your hit rate without also increasing the number of false alarms



Performance determined by the distance between the distributions, and …



… by the variance of each



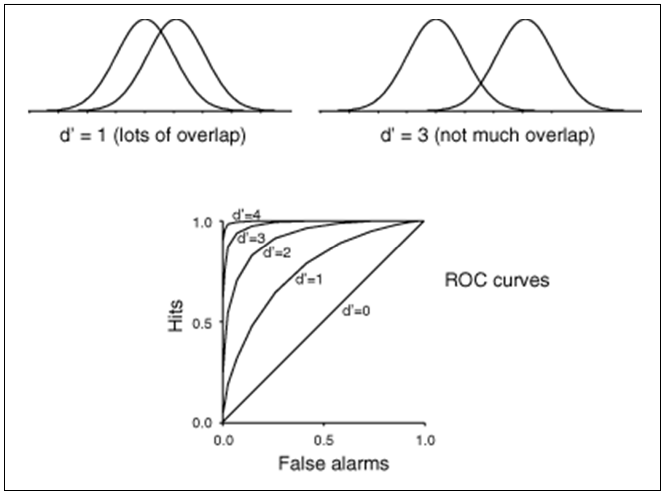
Discriminability index (*d′*):

d′ = separation of the distributions / spread of the distributions

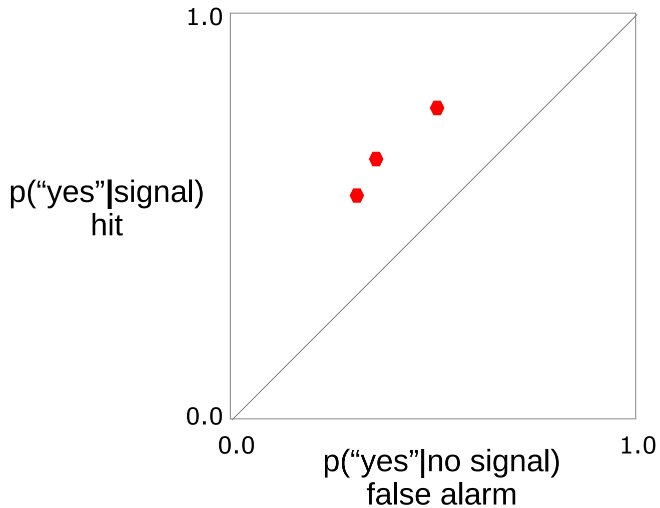
$$d' = (\mu_2 - \mu_1) / \text{s.d.}$$

Related to the statistic known as ***effect size:***
Unlike significance tests,
effect size is independent of sample size, so does not suffer the 'problem' that a tiny difference between samples can be highly significant if sample sizes are sufficiently large.

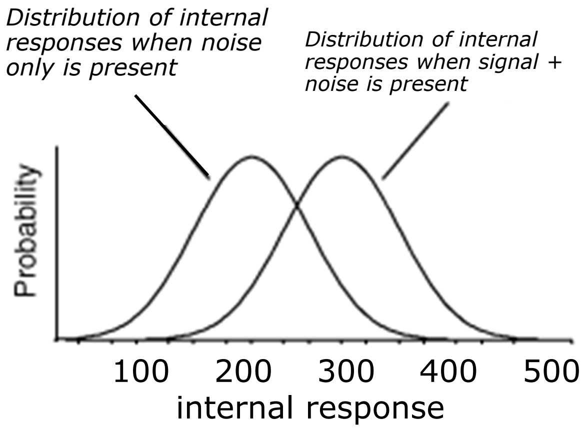
ROC curves show how shifting the criterion affects judgements



This is what we know: ROC curve

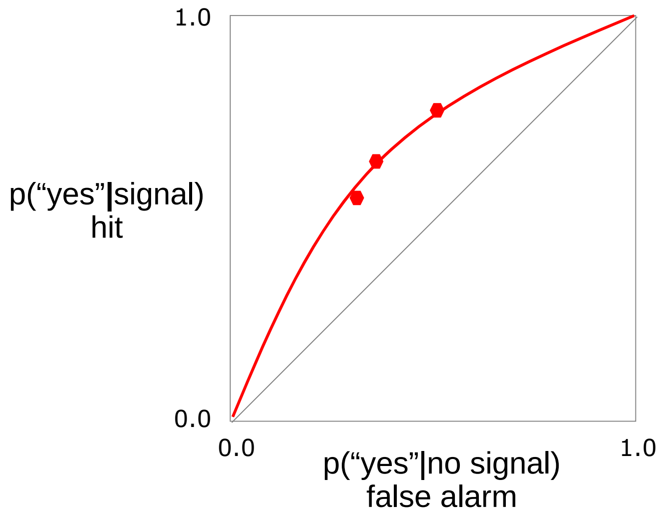


Internal response distributions



This is what we don’t know

We use what we know to infer what we don’t



How d’ varies with hit and false alarm rates

constant ‘hits’

hits	false alarms	d'
0.9	0.1	**2.56**
0.9	0.2	**2.12**
0.9	0.3	**1.81**
0.9	0.4	**1.53**
0.9	0.5	**1.28**
0.9	0.6	**1.03**
0.9	0.7	**0.76**
0.9	0.8	**0.44**
0.9	0.9	**0.00**

constant ‘FAs’

hits	false alarms	d'
0.9	0.1	**2.56**
0.8	0.1	**2.12**
0.7	0.1	**1.81**
0.6	0.1	**1.53**
0.5	0.1	**1.28**
0.4	0.1	**1.03**
0.3	0.1	**0.76**
0.2	0.1	**0.44**
0.1	0.1	**0.00**

constant d’

hits	false alarms	d'
0.9	0.50	**1.28**
0.8	0.33	**1.28**
0.7	0.22	**1.28**
0.6	0.15	**1.28**
0.5	0.10	**1.28**

Signal Detection Theory has often been used to account for the variation in thresholds found in different paradigms.

Most research now uses a relatively small subset of procedures to minimise bias.