Research methods in sensation and perception

(and the princess and the pea)

Sensory Thresholds

- We can measure stuff in the world – like pressure, sound, light, etc.
- We can't easily measure your psychological (Ψ) reaction to physical stuff, though.
- Can we tell **anything** about Ψ reactions to physical stimuli? (We're asking questions about ***psychophysics*****.**)
- At the very least, we'd like to know if you can detect when a stimulus is present, and we'd like to know if you can discriminate between two stimuli of differing *intensities*.

- When the evil queen inserted the pea under the mattress of the princess, she was trying to determine her sensory threshold. If her threshold was low enough, she qualified for real-princess-hood. If not low enough, she was merely a peasant pretending to be a princess.
- Are there more reliable ways to tell where her threshold is?

- *Absolute Sensory Threshold*: What is theminimum intensity of a stimulus that allows you to **only just** notice its presence? ("Can you hear me now?" "Can you see better with A or with B?")
- One problem: people seems to report different thresholds under different conditions.
- 3 methods for determining AST:

  1) *Method of adjustment*: participant adjusts intensity (using a knob or lever, like the volume control on a stereo) until he or she is right at the threshold.

     - Not usually the most accurate method; a person can be lazy and provide misleading data.
     - Often the threshold is determined by averaging several trials
     - Usually used for pilot data.

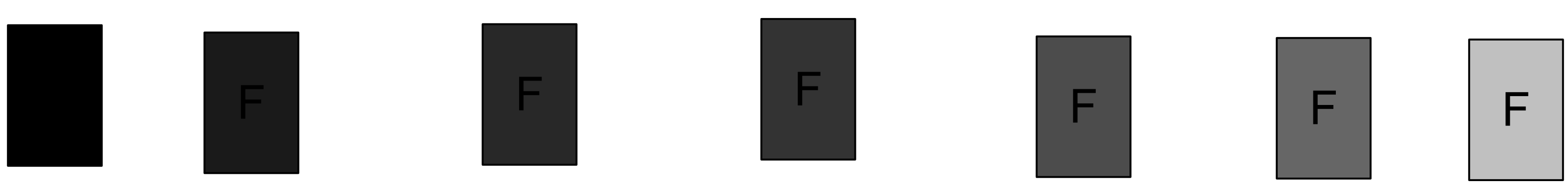
- Methods for determining sensory thresholds (cont.)

2) *Method of limits*

- Experimenter changes stimulus intensity in small steps; on each change, participant indicates whether or not they can detect it.

“Yes” “Yes” “Yes” “Yes” “...Yes” “No” “No”

- Decreasing series



“No” “No” “Yes” “Yes” “...Yes” “Yes” “Yes”

- Increasing series

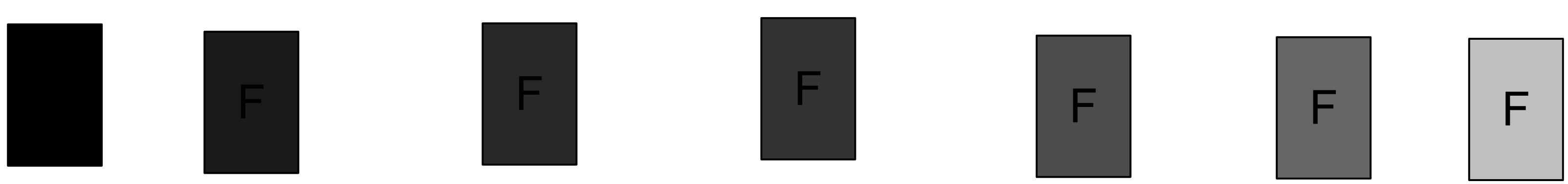
- Methods for determining sensory thresholds (cont.)

  2) *Method of limits* (Cont.)

  - People can make particular kinds of errors if they prepare for the threshold before it appears, or if they don't pay careful attention to the task.

"Yes" "Yes" "No" "No" "No" "No" "No"

  - *Error of Anticipation* (You switch answers before you hit threshold)



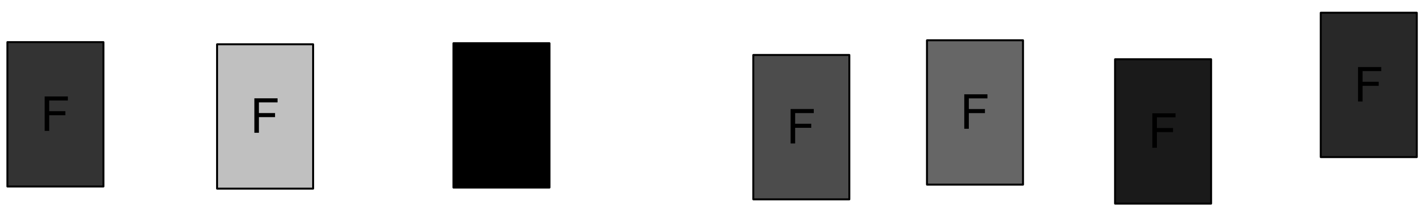
"No" "No" "No" "No" "Yes" "Yes" "Yes"

  - *Error of Habituation* (You respond the same way until well after you hit the threshold)

- Methods for determining sensory thresholds (cont.)

  3) *Method of constant stimuli*

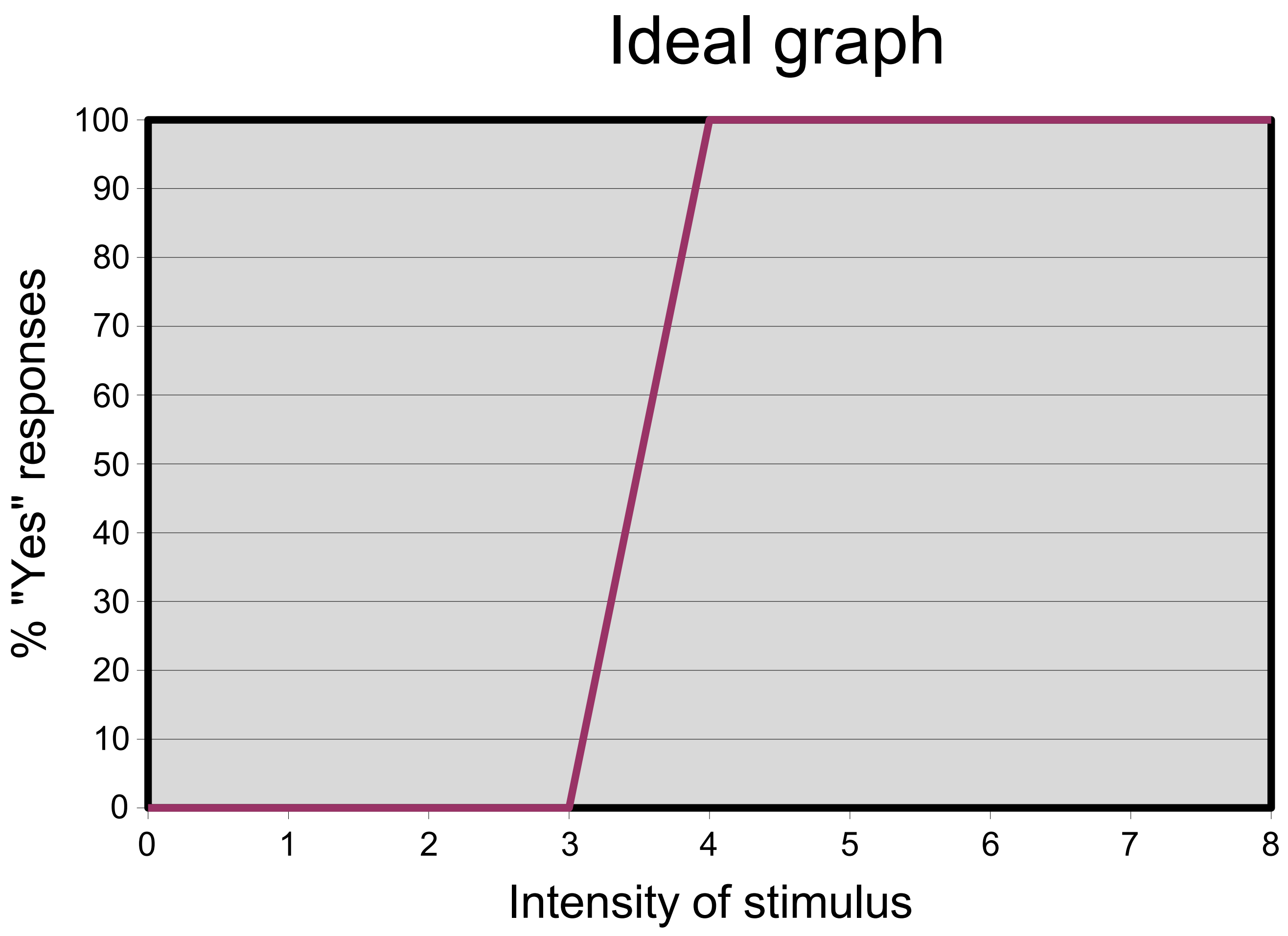
  - Fixes the problem of errors of habituation and anticipation.
  - A single member of a certain fixed (constant) set of stimuli is selected at random; subject indicates whether or not he can see it, then the process repeats.



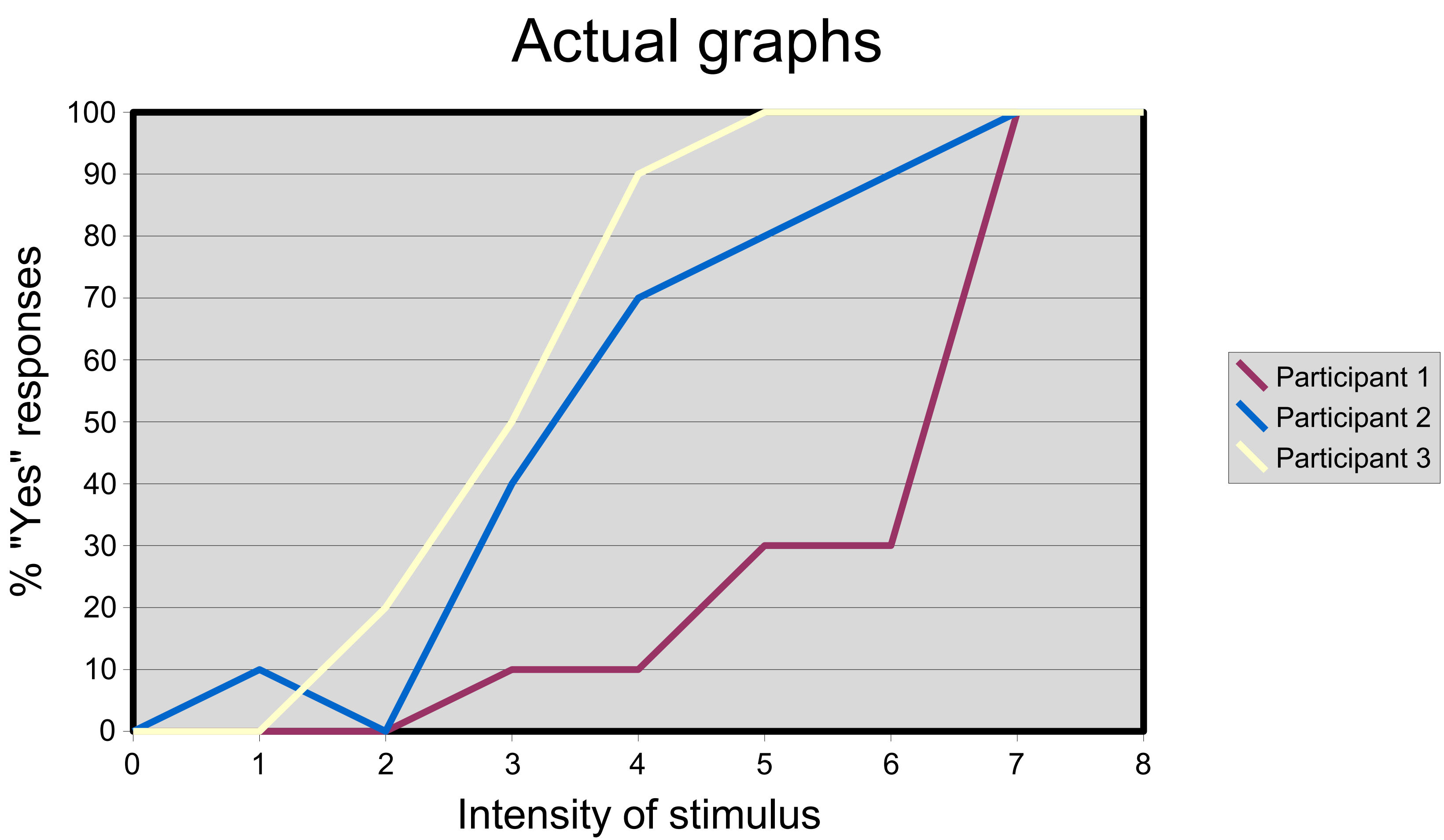
“Yes” “Yes” “No” “Yes” “Yes” “No” “No”

  - For all three methods, plot a graph of stimulus intensity (x-axis) vs. % of time people (correctly) answer “yes”

What does a threshold look like?



What does a threshold look like?



Sensory thresholds (cont.)

- We don't have to limit ourselves to studying absolute thresholds; we can also study

  Difference thresholds: If you experience one stimulus at intensity level I, what is the smallest *physical change in I* (ΔI) that will produce a psychological *just-noticeable difference (JND)*?

  – In other words, how much do I have to turn up the light, or increase the volume, or add to your carrying load, for you to notice a change?

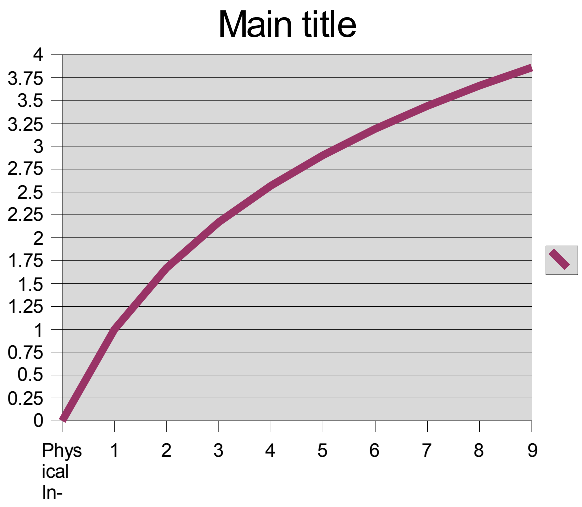
  – Can the princess tell the difference between 1 pea under her mattress and 2? What about 101 and 102?

- *Weber/Fechner law*: Your ability to detect whether or not there has been a change in a stimulus is proportional to the initial intensity of the stimulus.

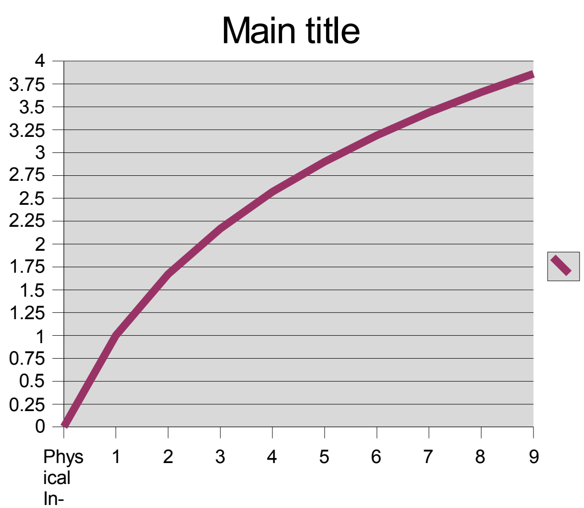
- K= $\frac{(\Delta I)}{I}$ Defines 1 JND
  - Where: I is the physical intensity of the stimulus, ΔI is the change in physical intensity, and k is a constant, depending on the type of stimulus..
  - (It's a little more complicated than that, but that's the essence of it.)

- Weber/Fechner law (cont.)
  - Example: suppose you can detect the difference between 1 pound and 1.1 pound. Then
  - K=$\frac{(\Delta I)}{I}$=$\frac{(.1)}{1}$ =.1
  - If I then ask you how much weight I need to add to 2 pounds for you to detect the change, you can reason in the other direction:
  - K=.1=$\frac{(\Delta I)}{2}$ => (ΔI) =2*.1=.2
  - So since (ΔI) is .2, and I is 2, it'll take 2+.2=2.2 pounds of weight for you to notice the difference.

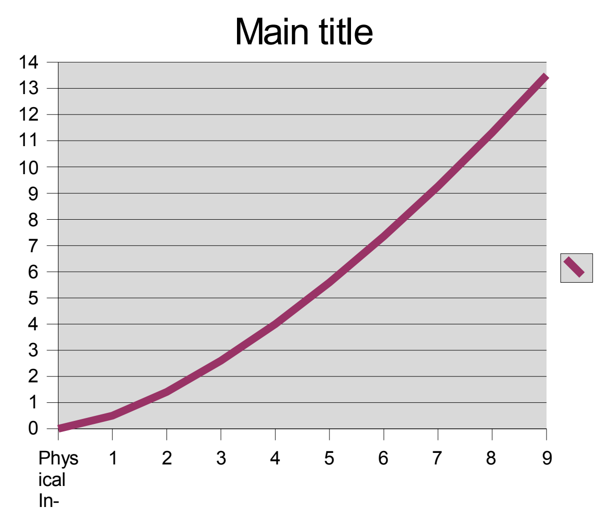
- Because the same increase in weight results in a less-intense psychological experience, we can draw a graph like this:



- *Stevens' law* is a modified version of the Weber/Fechner law, designed to account for stimuli that become <u>more intense</u> psychologically as their physical intensity increases (for example, like an electric shock – the experience becomes more painful at a rapid rate as the stimulus intensity incrases).
- $\Psi = kI^{\alpha}$ (Similar in principle to Weber's law, but accounts not only for graphs like



But also



)

Sensory Thresholds (cont.)

- When the evil queen in the princess and the pea tested the princess, she only gave her one chance – the pea was placed under her mattress, and only if she correctly said “there is a pea under my mattress” was she judged a real princess.
- Note, however, that there are really 4 possibilities if we do this test multiple times, and this leads us to what psychologists (and others) call *signal detection theory*:

Signal detection theory

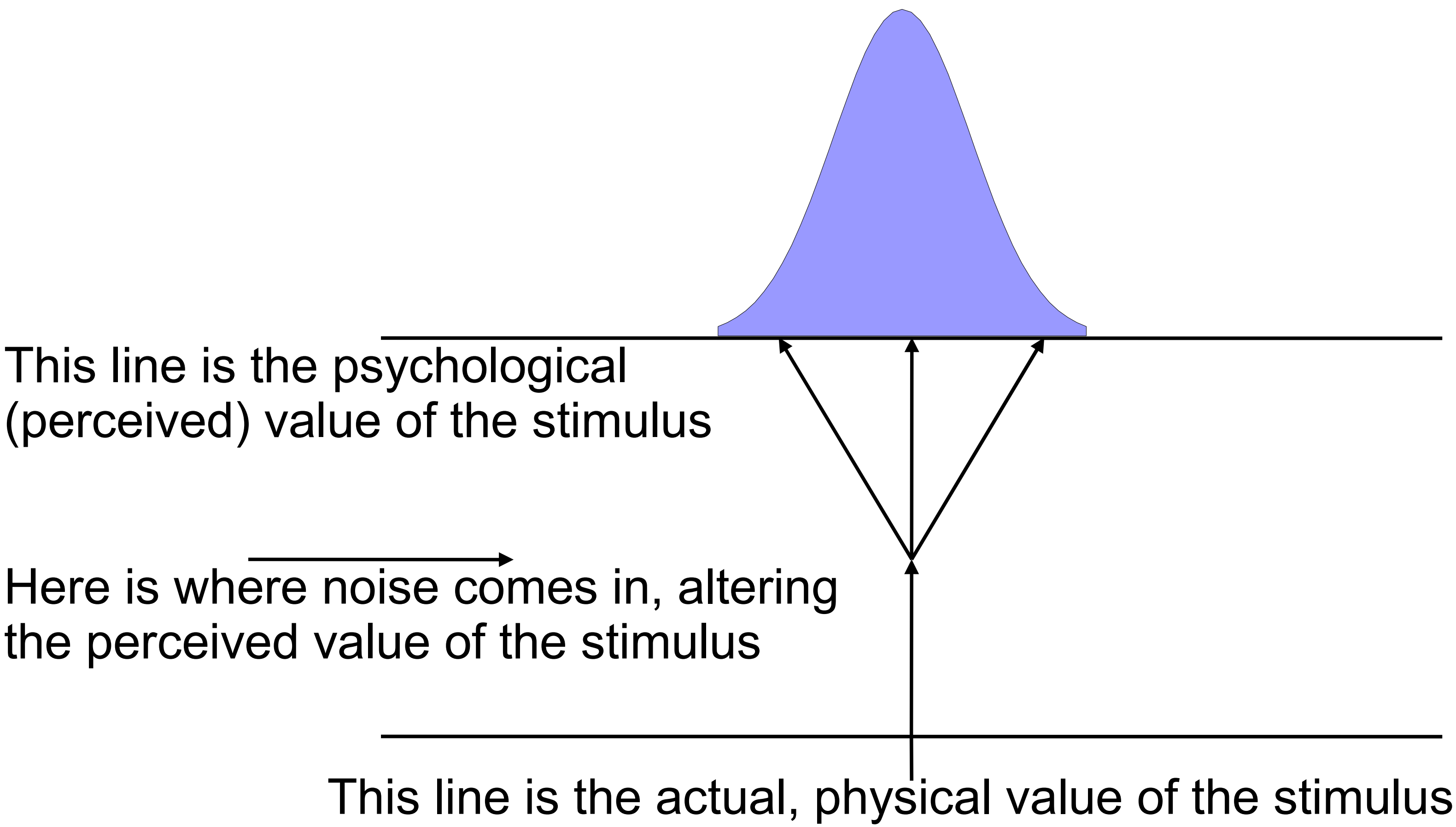
1) Signal (the pea) present, participant says it's present. We'll call this a "*hit*"
2) Signal not present, but participant says it's present anyway (they jumped the gun, or are just twitchy). We'll call this a "*false alarm*"
3) Signal present, but participant says it's not present (this is what the queen assumed would happen when she thought the princess was really a peasant). We'll call this a "*miss*"
4) Signal not present, and participant correctly says it's not present. We'll call this a "*correct rejection*"

Signal detection theory (cont.)

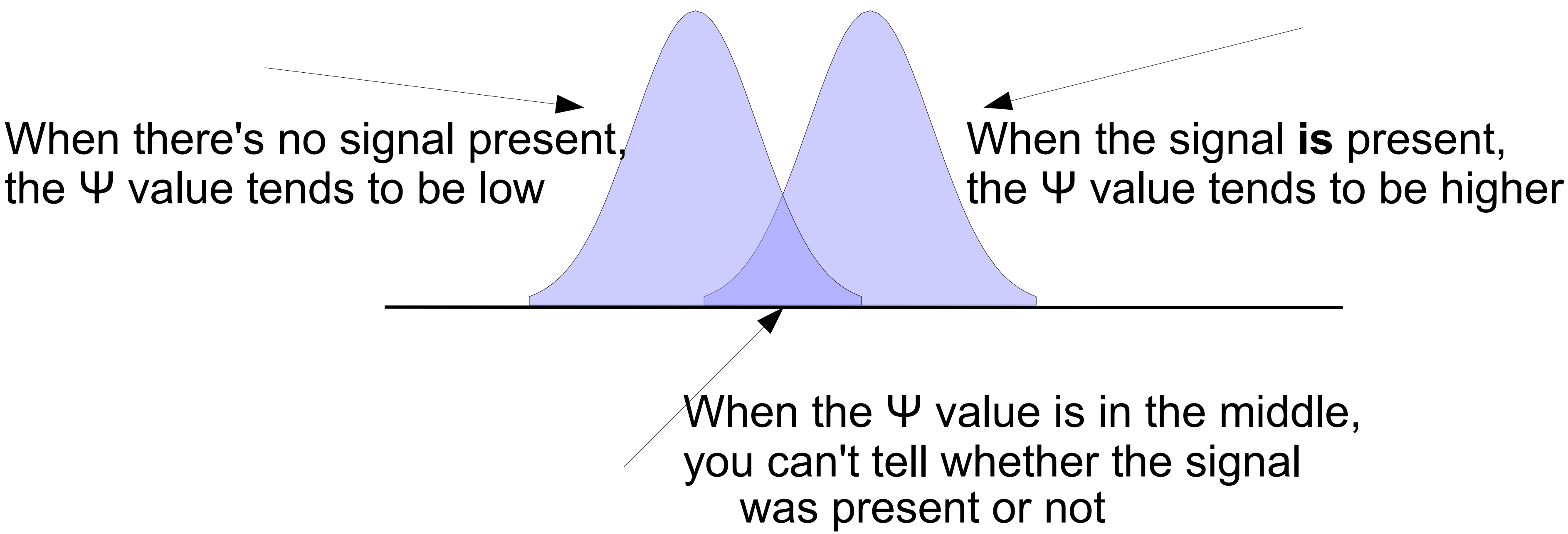
- If you're taking a shower, and think you hear the phone ringing, and run outside to pick it up, and it's that job offer you were waiting for, you've made a hit
- If you're taking a shower, and think you hear the phone ringing, and run outside to answer, only to find nobody called, you've made a false alarm.
- If you're taking a shower, and decide you're not hearing the phone, and when you get out your answering machine indicates a call came in, you've made a miss.
- If you're taking a shower, and decide you're not hearing the phone, and when you get out, there's nothing on your answering machine, you've made a correct rejection.

- Signal Detection Theory (cont.)
  - Your *bias* can influence your number of hits vs. misses, and correct rejections vs. false alarms.
    - For example, if you're waiting for a phone call you're <u>really interested in</u>, you may be more willing to leap out of the shower, increasing both your number of hits and false alarms.
    - Alternatively, if you really <u>don't want</u> to receive a particular call, you may be more willing to stay in the shower, increasing both your number of correct rejections and misses.
    - There are a number of factors that can influence bias, not only your willingness to receive the phone call. For example, if the princess is really tired, her sleepiness may overcome her willingness to complain about the pea.

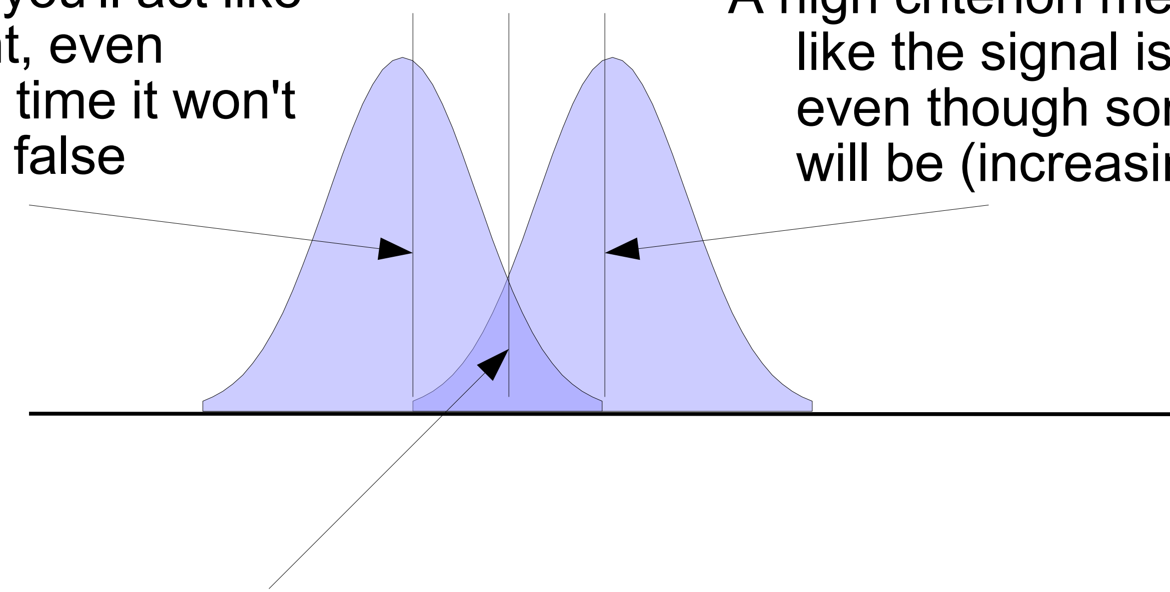
- Signal Detection theory (cont.)
  - How do psychologists think about all that other stuff (attentiveness, sleepiness, interestedness, etc.)? Psychological noise.



- Signal Detection Theory (cont.)

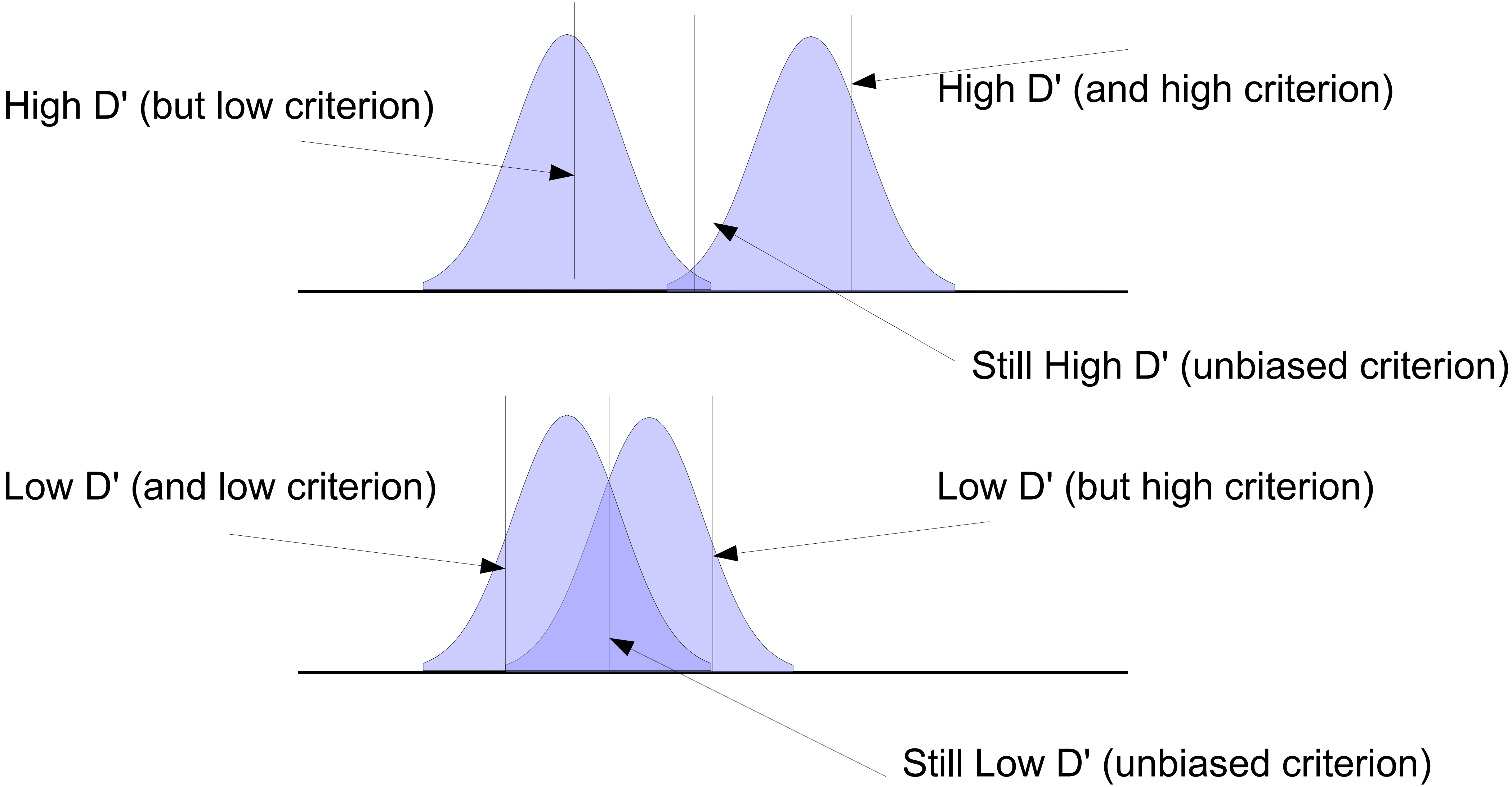


- Signal Detection Theory (cont.)
  - Since, when the Ψ value is in the middle, you don't know whether the signal was present or not, you have to set a *criterion* indicating when you'll act as though the signal was present.



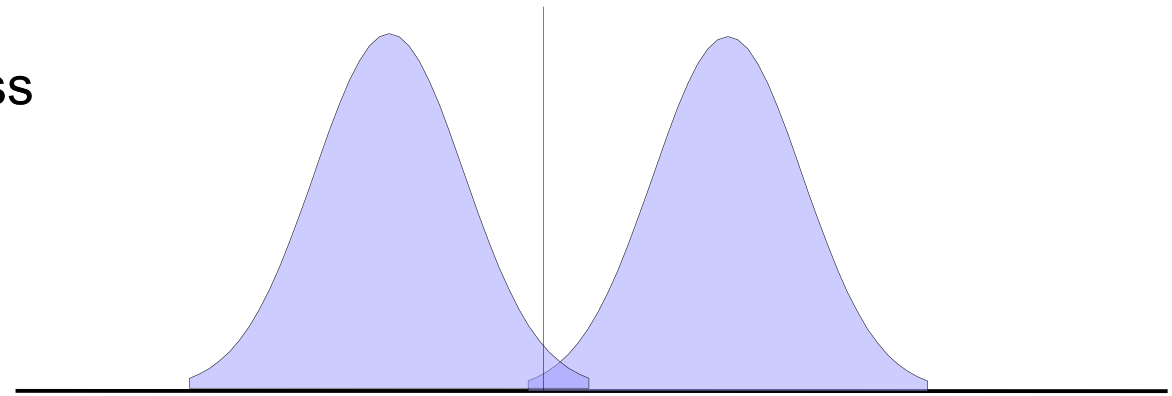
- Signal Detection Theory (cont.): Ψ Noise, Bias, Criterion
  - A low criterion means you have a bias to say “yes, the signal is present.”
  - A high criterion means you have a bias to say “no, the signal is not present.”
  - The degree of overlap of the two distributions (signal present, signal absent) is represented by a number called *d' (“d-prime”*).
    - Regardless of criterion, a low d' means a lot of overlap between distributions, and a lot of mistakes.
    - A high d' means very little overlap between distributions, and few mistakes.

- Bias/Criterion Vs. D'

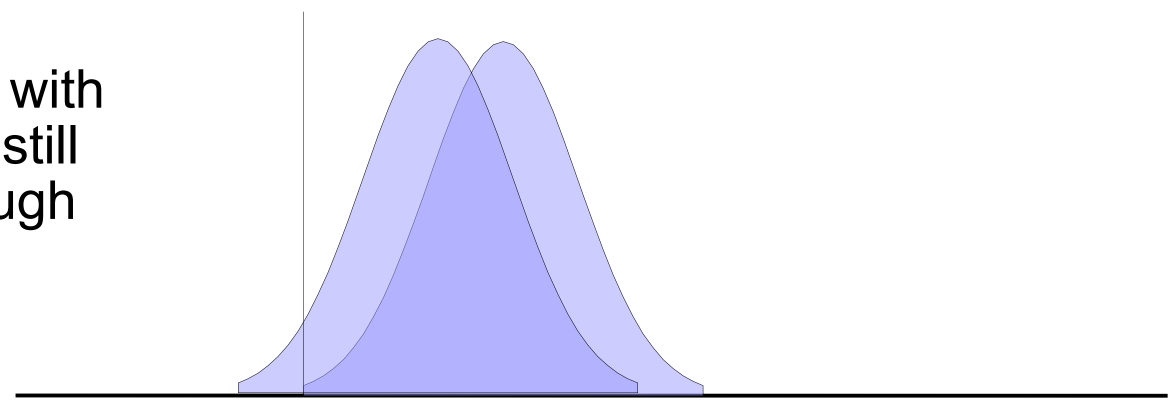


• Bias/Criterion Vs. D' (cont.)

In the princess and the pea, the queen assumes a true princess would have a high d' and an unbiased criterion, like this:

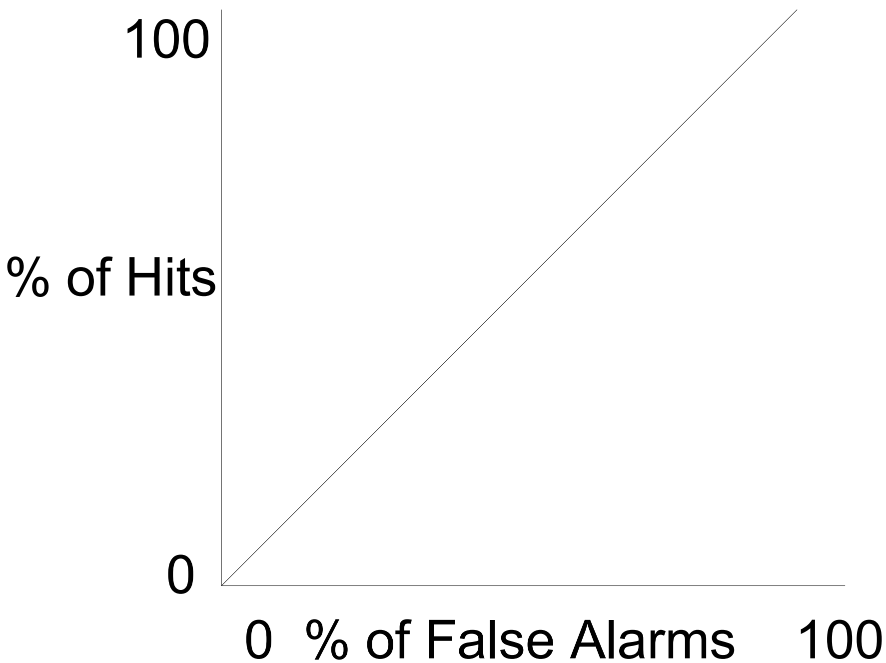


Unfortunately for her, a person with a low d' (like a peasant) will still complain if she's whiny enough (that is, has a low criterion)

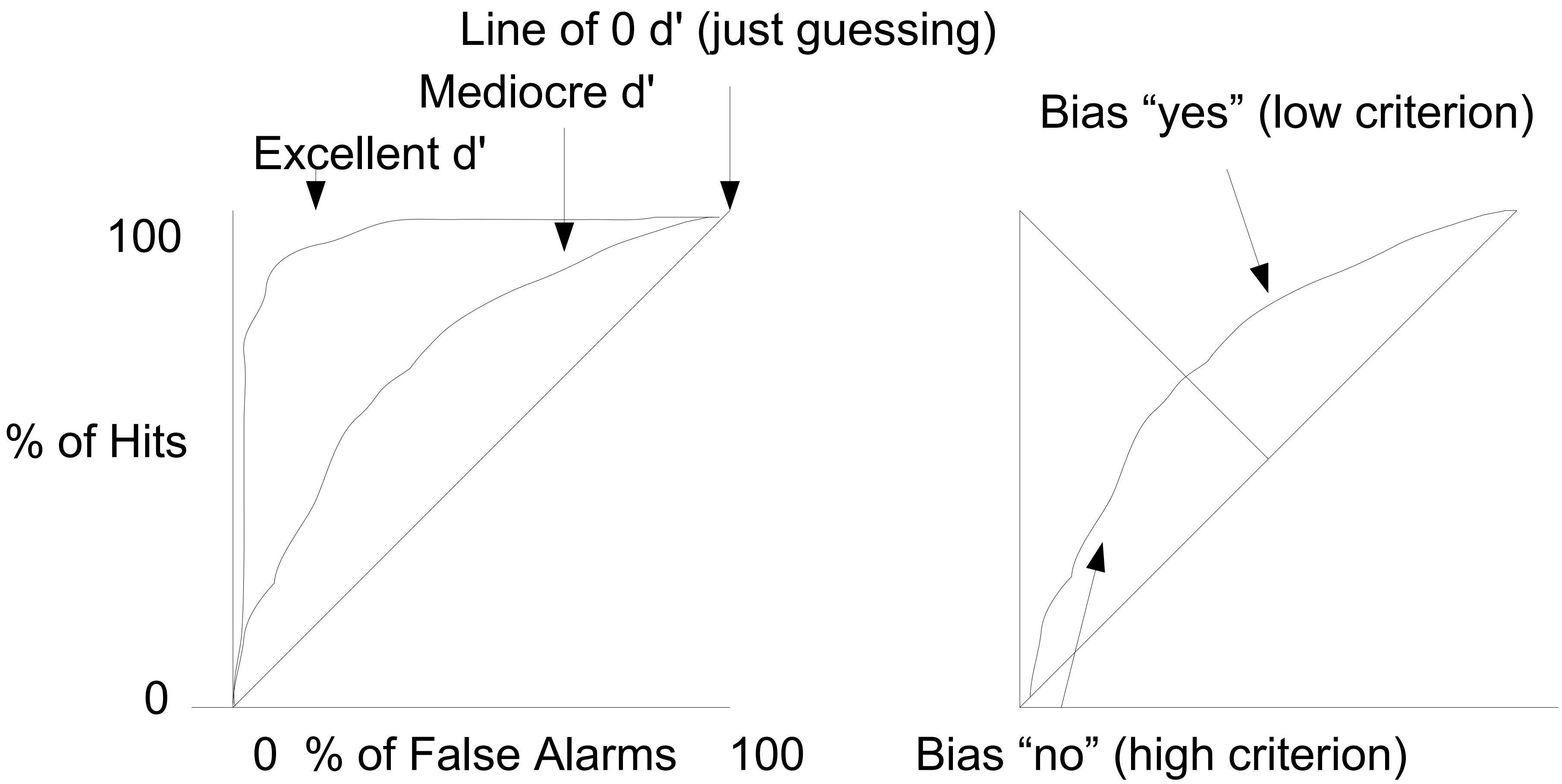


Thus, the queen's single-trial method can't distinguish between an unbiased princess and a whiny peasant.

- Different individuals have different D' and different bias/criterion. It'd be handy if we could represent both in one graph.
  - We can, with the *ROC* (receiver operating characteristic) *graph*:



- ROC graphs(cont.)
  - Both Bias and d' are coded in an ROC graph:



List of terms, section 1

- Psychophysics
- Intensity
- Absolute sensory threshold
- Method of adjustment
- Method of limits
- Increasing series
- Decreasing series
- Errors of anticipation
- Errors of habituation
- Method of constant stimuli
- Difference threshold
- ΔI
- Just Noticeable Difference (JND)
- Weber/Fechner Law (including the formula)
- Stevens' Law (not the formula)
- Signal detection theory
- Hit
- Miss
- False alarm
- Correct rejection
- Bias
- Psychological noise
- Criterion
- D'
- ROC graph