PSY 201: Statistics in Psychology

Lecture 14
Signal detection
Is that your phone?

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DETECTION IN NOISE

- Suppose you have to determine if there is a line of dots in a random field of dots (on-line example)
- Your ability to do the task depends on
  - The number of dots in the field
  - The position of the dots in the field
  - How much effort you put in the task

DETECTION IN NOISE

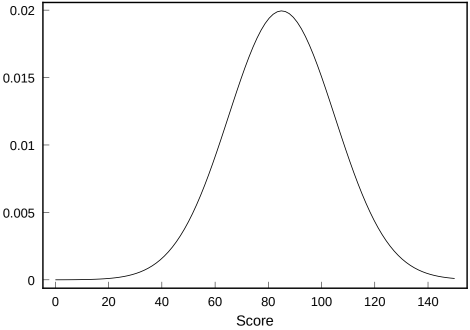
- Lots of tasks are essentially the same kind of situation
- what corresponds to noise in each situation?
    - Did you skip lunch at least one time last month?
    - Is that your phone ringing?
    - Does zinc shorten a cold?
    - Are men taller than women?

MEASUREMENT

- We suppose that there is some number that "measures" what you are interested in
  - Did you skip lunch at least one time last month?: strength of familiarity or memorability
  - Is that your phone ringing?: similarity to your ringtone?
  - Does zinc shorten a cold?: duration of a cold
  - Are men taller than women?: height

DISTRIBUTIONS

- Assume a normal distribution
- Mean is “noiseless” measurement
- Variation from mean is due to noise being added

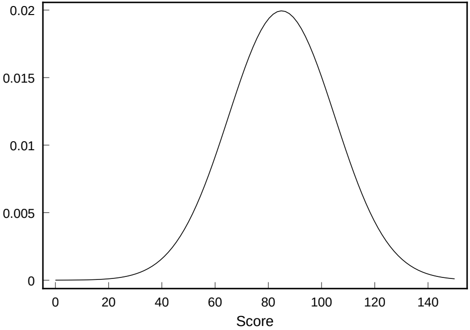


DISTRIBUTIONS

- There may be many sources of noise
  - Variation in the environment
  - Variation in your perceptual systems
  - Variation in your memory
- and many more!

DISTRIBUTIONS

- Suppose your measurement is drawn randomly from the distribution, then the area under the curve indicates the probability of getting a measurement over the specified region



DISTRIBUTIONS

- There are two **distributions** that you have to consider. One when the signal/effect is present and one when it is not:
  - Did you skip lunch at least one time last month?: strength of familiarity when did skip lunch **and** strength of familiarity when you did not skip lunch
  - Is that your phone ringing?: similarity to your ringtone when it is your phone **and** similarity to your ringtone when it is not your phone
  - Does zinc shorten a cold?: duration of a cold when zinc works **and** duration of a cold when zinc does not work
  - Are men taller than women?: height difference when men are taller **and** height difference when men are the same height as women

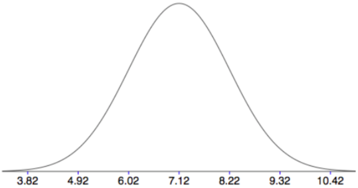
DISCRIMINATION

- To make a decision, you are trying to determine
  - whether your measurement was randomly drawn from a distribution where the signal/effect is present
  - whether your measurement was randomly drawn from a distribution where the signal/effect is not present

ZINC AND COLDS

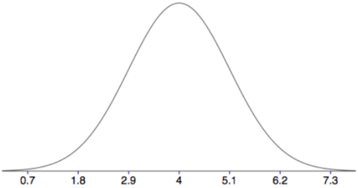
- Based on published research, if you do not take zinc tablets, the duration (in days) of a cold follows a normal distribution with

$$\mu = 7.12, \ \sigma = 1.1$$



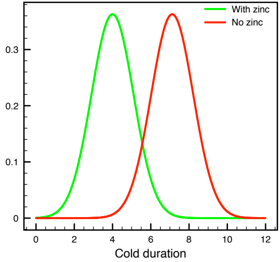
- If you take zinc tablets, the duration (in days) of a cold follows a normal distribution with

$$\mu = 4.00, \ \sigma = 1.1$$



ZINC AND COLDS

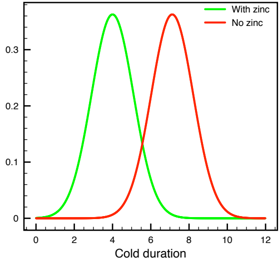
- Together, some overlap of the distributions



- Suppose you sample a person who has a cold and find the duration. Using just that information, you want to decide whether the person took zinc or not.
- Easy cases:
  - X=10
  - X=15
  - X=2
  - X=0.5

ZINC AND COLDS

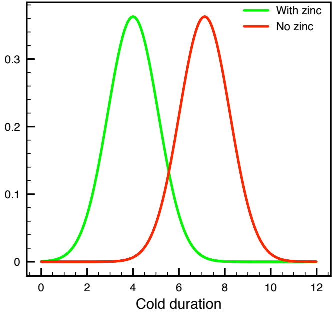
- Together, some overlap of the distributions



- Suppose you sample a person who has a cold and find the duration. Using just that information, you want to decide whether the person took zinc or not.
- Hard cases:
  - X=6
  - X=5

ZINC AND COLDS

- Together, some overlap of the distributions



- We want to quantify how *different* the distributions are
- How much they do **not** overlap
- Signal-to-noise ratio
- (it's a z-score!)

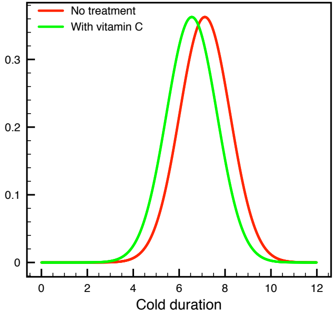
d-prime

- We take the mean of the "no zinc" distribution (noise alone) and compute distance of the mean of the "with zinc" distribution
- in standardized units

$$d' = \frac{\mu_{NZ} - \mu_{WZ}}{\sigma} = \frac{7.12 - 4.00}{1.1} = 2.02$$

VITAMIN C AND COLDS

- Together, lots of overlap of the distributions



- We take the mean of the "no treatment" distribution (noise alone) and compute distance of the mean of the "with vitamin C" distribution
- in standardized units

$$d' = \frac{\mu_{NT} - \mu_{WC}}{\sigma} = \frac{7.12 - 6.55}{1.1} = 0.52$$

DISCRIMINATION

- It is often easy to identify which distribution a measurement came from if d' is big
  - big difference in means, relative to the standard deviation
- It is often hard to identify which distribution a measurement came from if d' is small
  - small difference in means, relative to the standard deviation

DISCRIMINATION

- the same issues apply for lots of situations
- Suppose you are walking your dog who yelps in pain and runs to you
- You think he might have been bitten by a snake
- you have a "measure" of snake-bite evidence (bump on nose, paws are shaking,...)
- you want to determine whether your dog was bitten by a snake

DISCRIMINATION

- is your measurement a random sample from a distribution where your dog was bitten by a snake?
- or
- is your measurement a random sample from a distribution where your dog was not bitten by a snake?
- the separation of the distributions indicates whether the discrimination will be easy or hard
- actually describing the means and standard deviations of these distributions might be challenging!

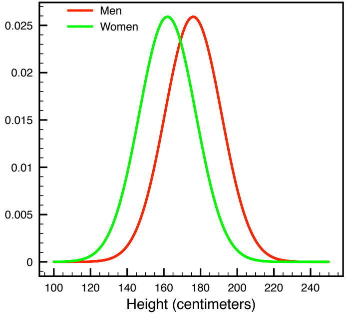
BAD NEWS

- For lots of situations, the d' value is quite small
- Within psychology, some rules of thumb are:
  - d'=0.2 is considered a "small" effect
  - d'=0.5 is considered a "medium" effect
  - d'=0.8 is considered a "large" effect

BAD NEWS

- For lots of situations, the d' value is quite small
- The difference of heights between men and women is roughly

$$d' = \frac{176 - 162}{15.4} = 0.90$$



CONCLUSIONS

- signal-to-noise ratio
- standard score
- d'
- Separation of distributions
- discrimination

NEXT TIME

- Making decisions
- Criterion

Making decisions.