# Stats Primer.  Basic Tests and such.

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# An excellent stats primer:

- 2013 collection of nature columns on stats
- http://www.nature.com/collections/qghhqm/pointsofsignificance
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- Go through the Figs of the first article: “Importance of being uncertain”
- Fig1: Location and Spread.
- Fig2: Sampling.
- Fig3: central limit for large N
- Fig4: Effect of increasing N on mean sd and sem.

# Types of stats:

- Descriptive:
  - Single number (ie, mean) estimated from the sample.
  - This is a point estimate.
  - Range of likely values: confidence interval.
- In contrast to statistical inference:
  - The goal of which is to determine if a claim about a parameter is reasonable.
- Null Hypothesis VS The Alternate!
- There can only be one.

# In general...

- A statistical test is a procedure to use the sample data to determine how reasonable it is reject H0 in favor of Ha
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- It will make use of a test statistic.
- It will have distribution of the test statistic which is valid if H0 is true and a rejection region for the test statistic
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- We saw this process last time with our permutation test:
  - Test stat was the difference of the means of the 2 samples.
  - Distribution was the permutation distribution obtained by resampling.
  - Rejection region was in the left tail of the distribution.
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# But what if I make a mistake?!

- **You probably will.**
- **I.** Since the inference is based on a **random** sample it is still possible that your test statistic is out in the tail (rejection region) even when H0 is true.
- **II.** Likewise it is also possible that your **random** sample gives you a test statistic that is not in the tail when H0 is in fact false.
- These types of errors are called (rather unoriginally) **Type I and Type II errors**
- Your inference is only as good as your data, so it is not possible to know for sure if you have made one of these errors.
- The test procedure can only really tell you how reasonable it is to reject H0 based on the data you have.
- Again there are simply no substitutes for more data points.

# My first stats test. The t-test.

- We have a sample.
- We have a hypothesis as to what its mean is.
- We are willing to assume normality.
- We are willing to assume the sample sd is an ok measure of the population sd.
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- We construct a test statistic:

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- It's distribution can be calculated from other known distributions. So we know the sampling distribution of t under H0. It's called a t distribution. (Analogous to the permutation distribution we saw last time, except the test statistic was more simple, directly the difference of sample means.)
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- Jump over to matlab.

# So, wait a minute...

- That all seems simple enough… But,… how do we know that t is t-distributed?
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- It's a matter of definition and usually glossed over.
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- If you stare at t for a while (recommended hours to days, or minutes with youtube)  and you look at the list of usual suspects for other theoretically tractable distributions you can re-write it, t that is, (ie via some algebra) to be the quotient of something distributed as a standard normal and something distributed as a chi2 with n-1 dof.
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- Then you can “simply” turn the mathematical crank (as it were) and “simplify” the expression and tabulate or program the result.  Which is why we refer to the tables (back in the day) or to computer versions when doing the test.
- Also this is why everything is organized by n-1 dof.  It is inherent in the underlying, **theoretical** distribution.

# Some important terminology...

- **One** tailed vs **two**-tailed.
- This type of terminology when referring to t or other stats tests is talking about where the rejection region is on the null distribition.
- We saw in matlab: 'Tail','right'
- I used this because our Ha was u>10.  Ie we were looking for extreme values of our test stat on the right tail of the distribution.
- Likewise it could have been left. Ie u<10 for Ha
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- Or ie our Ha is slightly different in that we simply want to check if u is not equal to 10, then we split our rejection ratio so half is in the left tail and half on the right.  Extreme values of our test stat in either direction will make us want to give up on H0.
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- The first tests are both called “one tailed”.  The second is “two tailed”.

# Two sample t-test: comparing means between samples.

- Again.  Same idea.  Construct a test statistic.
- Still usually called t
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- Can be shown that with the additional assumption (beyond normality) that the variances are equal, this stat is t distributed with n+m-2 dof.
- Jump over to matlab for example.

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# Ok. Final variant of t test, Paired t test

- Similar idea to last test, except that the items in two samples come from the same individuals.
- Like same person before/after exercise regime for example.
- Since things are paired then there are (should be) equal numbers of observations in the two samples.
- Can write another t stat on the differences between the samples.
- Exactly the same form as a 1 sample test
- Jump back to matlab

# Summary of terminology

- These terms are used beyond t tests so very important to know.  Hopefully the illustration with t test was clear!
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- 1 sample vs 2 sample
- One-tailed vs two tailed
- Paired vs unpaired.
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# As time permits, KS test

- Wing it in matlab.