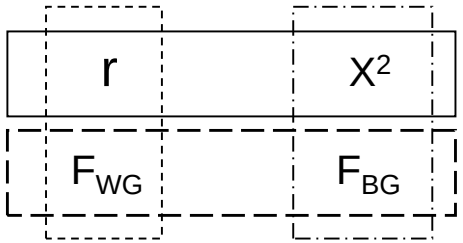
Some Details about Bivariate Stats Tests

- Conceptualizing the four stats tests
- Conceptualizing NHST, critical values and p-values
- NHST and Testing RH:
- Distinguishing Type III error from "results contrary to our RH", among others…

Let's work with this "arrangement" of the 4 tests …

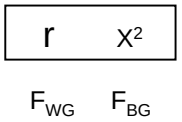
we'll examine these by contrasting each of the following pairs…

- tests of bivariate association (2 quant vs. 2 qual variables)
- tests of mean differences (between groups vs. within groups)
- between groups comparisons (quant mean vs. qual pattern dif.)
- analysis of repeated measures data (assoc vs. mean dif.)



tests of bivariate association (quant vs. qual variables)

- Both of these ask "whether there is a relationship between the variables in the population represented by the sample"



- The difference is whether the two variables are
  - quantitative -- use Pearson's correlation
  - qualitative/categorical -- use Pearson's X^2
- H0:s are similar, but have different "key words"
  - r -- There is no linear relationship between the quantitative variables, in the population represented by the sample
  - X^2 -- There is no pattern of relationship between the qualitative variables, in the pop represented by the sample

Example… (which stat for which?) …

- Is whether or not patients receive therapy related to whether or not they improve ? X^2
- Is #therapy sessions related to decrease in #symptoms ? r

tests of mean differences (between groups vs. within groups)

r X^2

F_{WG} F_{BG}

• Both of these ask "whether there is a mean difference on the quantitative variable between the populations represented by the two conditions"

•The difference is whether the two populations are:

- represented by different sets of parts in each condition -- BG
- represented by the same set of parts in both conditions - WG

• H0:s are exactly the same, because H0:s are about populations

- F_{BG} & F_{WG} - the populations represented by the conditions have the same mean on the quantitative variable

Example… (which stat for which?) …

• Does the mean anxiety change from before to after therapy ? F_{WG}

• Is the mean anxiety different whether or not patients receive therapy? F_{BG}

between groups comparisons (quant mean vs. qual pattern dif.)

• Both of these stats can be applied to the data from a between groups design -- but which is used depends upon the kind of variable being compared

r X^2

F_{WG} F_{BG}

• F_{BG} -- is used when groups are being compared using a quantitative variable -- examination of mean differences

• X^2 -- is used to when the groups are being compared using a qualitative variable -- examination of response pattern differences

Example… (which stat for which?) …

• Is whether or not patients receive therapy related to whether or not they improve ? X^2

• Is the mean anxiety different whether or not patients receive therapy? F_{BG}

Let's take another look at this distinction...

The question was whether different types of computers (PCs or Macs) had different "failure rates". The RH: was that PCs would have a higher failure rate". Two different researchers were hired to run experimental evaluations...

Researcher #1 Acquired 50 computers of each type, had researcher assistants (working in shifts & following a prescribed protocol) keep each machine working continually for 24 hours & count the number of times each machine failed and was re-booted.	Researcher #2 Acquired 50 computers of each type, had researcher assistants (working in shifts & following a prescribed protocol) keep each machine working continually for 24 hours or until it failed.
Data for each computer was: • type of computer • # failures during the 24 hr test	Data for each computer was: • type of computer • whether or not that computer failed during the 24 hr test
H0: PCs will have same # failures as Macs RH: PCs will have more failures than MACs	H0: Same # of PCs will have failures as Macs RH: More PCs will have failures than MACs
Stat? F_{BG}	Stat? X^2

Your turn…
The purpose of the research was to compare the efficacy of two therapies, with the RH: that cognitive-behavior therapy (CBT) would "work better" than peer-counseling therapy (PCT). Again two researchers ran independent projects.

Researcher #1: 30 patients each received one type of therapy, after which their therapist determined whether or not they showed improvement.

Stat: X^2

H0: Same number of patients will improve after each type of therapy.

RH: More of the patients taking CBT will improve than the patients taking PCT.

Researcher #2: 30 patients each received one type of therapy, after which their score on the Beck Depression Inventory (BDI) was obtained.

Stat: F_{BG}

H0: Those patients taking CBT will have same mean BDI scores as those taking PCT.

RH: Those patients taking CBT will have same higher mean BDI scores as those taking PCT.

analysis of repeated measures data (assoc vs. mean dif.)

• Both of these stats can be applied to the data from a repeated measures design -- but they are used to ask different questions

r	X^2
F_{WG}	F_{BG}

• F_{WG} -- is used to ask if there is a mean difference between the measure taken during the two different times/treatments

• r -- is used to ask if we can use a participant's score during one time/treatment to predict their score during the other (prediction based upon the variables being linearly related)

Example… Patients entering therapy for depression were asked to complete the "Beck Depression Inventory" during the first therapy session (pretest) and again during their last session (posttest). The therapist had two questions (which stat for which?) …

• Is the mean posttest score lower than the mean pretest score? F_{WG}

• Does a person's pretest score predict their posttest score ? r

Let's take another look at this distinction...

In a study of recall memory in young adults, participants were given a list of 40 common words to study for 5 minutes. Then they were given a blank piece of paper and instructed to write down all the words they could recall from the list. Data were collected for the two kinds of recall errors -- "exclusions" (words on the list that weren't written down) and "intrusions" (words that weren't on the list that were written down). The researcher has 2 RH: about how the variables are related.

RH #1 There will be more exclusions than intrusions.

Type of research question:
- mean difference? ←
- linear relationship ?

Proper Statistic? WG ANOVA

H0: Mean number of exclusions and intrusions are the same in young adults

RH: Larger mean exclusions than mean intrusions in young adults

RH #2 Those participants who have more intrusions will also be those that have more exclusions.

Type of research question:
- mean difference?
- linear relationship ? ←

Proper Statistic? correlation

H0: No linear relationship between the number of intrusions and exclusions in young adults

RH: Positive linear relationship between the number of intrusions and exclusions in young adults

Your turn…
I have two questions about the relationship between Exam #1 and Exam #2 scores in this class.

Question #1: Those Psyc 350 students who do poorly on Exam #1 will also do poorly on Exam #2

Stat: r

H0:` There is no linear relationship between Exam #1 and Exam #2 scores among Psyc 350 students

RH: There is a positive linear relationship between Exam #1 and Exam #2 scores among Psyc 350 students

Question #2: Psyc 350 students will do better on Exam #2 than on Exam #1

Stat: F_{WG}

H0: Psyc 350 students will have the same mean on Exam #1 and Exam #2

RH: Psyc 350 students will have the a higher mean on Exam #2 than on Exam #1

Summary of Information from Correlation, Chi-Square, BG & WG ANOVA

	Pearson's r	Pearson's X^2	ANOVA
Symbolic H0:	H0: r = 0	H0: $X^2 = 0$	H0: $\overline{X}_1 = \overline{X}_2$
Range of possible values	-1.00 to +1.00	0 to ∞	0 to ∞
Reject H0: when …	|r| > r-critical or p < .05	$X^2 > X^2$-critical or p < .05	F > F-critical p < .05
Relationship Description	direction of linear rel.	specific pattern of relationship	direction of mean dif.

NHST Testing with critical-values & p-values

	|Obt| **>** Critical or p **<** .05	|Obt| **≤** Critical or p **≥** .05
NHST decision ?	**Reject H0:**	**Retain H0:**
Decide relationship b/n variables in pop?	**YES**	**NO**
Results are ?	**Statistically significant^**	**Statistically Non-significant***

^ Remember: don't say "meaningful" or "important" those are value judgements -- not a statistical description

* Remember: don't say "insignificant" that is a value judgement about the finding -- not a statistical description

Does Rejecting the Null Guarantee Support for the Research Hypothesis???

NO !!! For two reasons ….

1) the RH: might be the H0:
   – if so, rejecting H0: does not support the RH:

2) The significant data direction/pattern might not match the RH: data direction/pattern
   – a significant effect opposite the direction/pattern of RH: does not support the RH:

RH: Those with more experience will do better on the task.

Results #1 r (87) = .032, p = .85 Well ?

Retain H0: -- no support for RH:

Results #2 r (87) = -.32, p = .03 Well ?

Reject H0: -- but r is wrong direction

Results #3 r (87) = .52, p = .01 Well ?

Reject H0: -- and r is in correct direction

RH: The 4th graders will have higher geography scores than the 3rd graders

Results #1 4th = 62% 3rd = 58% F(1,48) = 4.3, p = .02

Reject H0: -- mean dif in correct direction

Results #2 4th = 62% 3rd = 60% F(1,18) = 2.3, p = .16

Retain H0: -- no support for RH:

Results #3 4th = 62% 3rd = 68% F(1,28) = 5.3, p = .01

Reject H0: -- mean dif in wrong direction

RH: Clowns will prefer confetti, while jugglers will prefer "thuds"

Result #1 $X^2(1) = 2.12$, p = .25

	clowns	jugglers
confetti	25	20
thuds	22	28

Retain H0: -- no support for RH:

Result #2 $X^2(1) = 6.36$, p = .02

	clowns	jugglers
confetti	25	10
thuds	12	31

Reject H0: -- looks good for RH:!!

Result #3 $X^2(1) = 6.12$, p = .02

	clowns	jugglers
confetti	14	10
thuds	15	31

Reject H0: -- only partial support for the RH:

The whole process goes like this…

1. Determine the RH:
   - specific direction/pattern or H0:
2. Test RH:, based on …
   a. Evaluate p-value from significance test
   b. Examine data pattern
3. If results from similar other studies are available, evaluate possibility of a Statistical Decision Error
   - If reject H0: check for Type I or Type III errors
   - If retain H0: check for Type II error

A quick focus on the two that are most often confused …

Type III Statistical Decision Error

- When our significant findings have a direction or pattern different from that found in the population
- A difference between "the effect we found" and "the effect we should have found"

"Results contrary to our RH:"

- When our findings have a direction or pattern different from what we had hypothesized
- A difference between "the effect we found" and "the effect we hypothesized"

A result can be BOTH!!!!! (Or neither, or one, or the other !!!)

Outcomes & “Truth” ...

In the population there are only three possibilities...

… and three possible statistical decisions

	In the Population		
Decisions	G1 < G2	G1 = G2	G1 > G2
G1 < G2	Correctly rejected H0:	Type I error	Type III error
G1 = G2	Type II error	Correctly retained H0:	Type II error
G1 > G2	Type III error	Type I error	Correctly rejected H0:

outcomes & RH:

There are only three possible Research Hypotheses

… and three possible statistical outcomes

	Research Hypotheses		
Outcomes	G1 < G2	G1 = G2	G1 > G2
G1 < G2	☺	☹	? ? o ? ?
G1 = G2	☹	☺	☹
G1 > G2	? ? o ? ?	☹	☺

So, there are only 9 possible combinations of RH: & Outcomes …

… of 3 types “effect as expected” ☺

“unexpected null/effect” ☹

“backward effect” ? ? o ? ?

RH:, statistical conclusions & statistical decision errors ...

Statistical Decision	**RH: H0:**	☺ **Results supported**	☹ **Results not supported**	
		+ direction/pattern		**- direction/pattern**
+ direction/pattern (p < .05)		☺ **Correct rejection Type I or Type III**	☹ **Correct rejection Type I or Type III**	☹ **Correct rejection Type I or Type III**
H0: (p > .05)		☹ **Correct retention or Type II**	☺ **Correct retention or Type II**	☹ **Correct retention or Type II**
- direction/pattern (p < .05		☹ **Correct rejection Type I or Type III**	☹ **Correct rejection Type I or Type III**	☺ **Correct rejection Type I or Type III**

Consider the following three pieces of information…

Our RH: is that there will be a positive correlation between how much a person likes performing practical jokes and the number of close friends a person reports.

We found r (58) = -.30, p = .02.

These results are "contrary to our RH:" -- a significant, relationship in the opposite direction from the RH:

A literature review revealed 12 other studies of these two variables, each of which found a correlation between -.25 and -.32 (all p < .05).

The consistent findings of these other studies suggests that our finding was correct – it was our hypothesis that was wrong!!!

How'd we not know the results of the other 12 studies!!

Try this one …

Our RH: is that there will be a negative correlation between the severity of depression at the beginning of therapy and the amount of improvement a patient shows during the first six weeks of therapy.

We found r (63) = .27, p = .035.

These results are "contrary to our RH:" -- a significant, relationship in the opposite direction from the RH:

A literature review revealed 34 other studies of these two variables, each of which found a correlation between -.33 and -.41 (all p < .05).

The consistent findings of these other studies suggests that our finding was a Type III error – what we found "doesn't describe the relationship between these variables in the population". Our RH: was correct, but not our data!!!