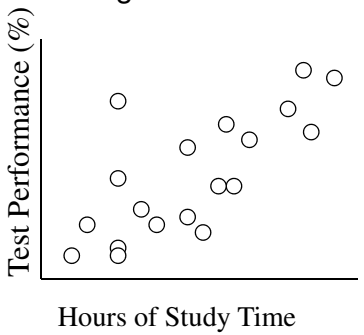
Pearson's r & X^2

- Correlation vs. X^2 (which, when & why)
- Qualitative/Categorical and Quantitative Variables
- Scatterplots for 2 Quantitative Variables
- Research and Null Hypotheses for r
- Casual Interpretation of Correlation Results (and why/why not)
- Contingency Tables for 2 Categorical Variables
- Research and Null Hypotheses for X^2
- Causal Interpretation for X^2 Results

Pearson's r Vs. X^2

- Pearson's Correlation (r)
  - 2 quantitative variables
  - **LINEAR** relationship
  - range = -1 to +1



- Pearson's Chi Square (X^2)
  - 2 qualitative variables
  - **PATTERN** of relationship
  - range = 0 to + infinity

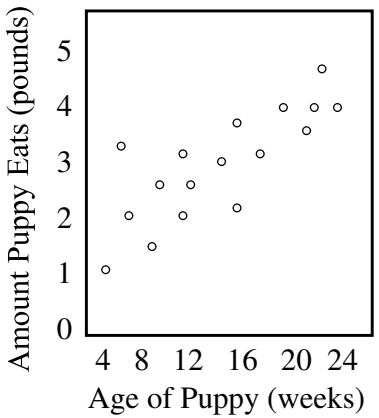
Food Preference	Turtle Type: Painted	Turtle Type: Snapper
crickets	5	15
"duck weed"	19	1

Practice -- would you use r or X^2 for each of the following bivariate analyses?
Hint: Start by determining if each variable is qual or quant !

- GPA & GRE — r
- Age & Shoe Size — r
- Preferred Pet Type & Preferred Toy Type — X^2
- Leg Length & Hair Length — r
- Age and Preferred Type of Pet — ANOVA -- psyche!
- Preferred type of Pet & Preferred Type of Car — X^2
- Grade (%) & Hrs. Study — r

Displaying the data for a correlation:
With two quantitative variables we can display the bivariate relationship using a "scatterplot"

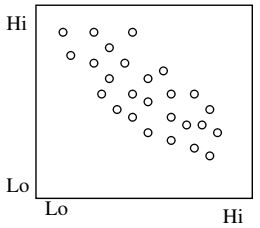
Puppy	Age (x)	Eats (y)
Sam	8	2
Ding	20	4
Ralf	12	2
Pit	4	1
Seff	24	4
…	..	..
Toby	16	3



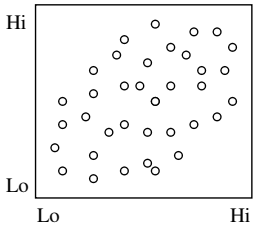
When examining a scatterplot, we look for three things...

- linearity
  - linear
  - non-linear or curvilinear
- direction (if linear)
  - positive
  - negative
- strength
  - strong
  - moderate
  - weak

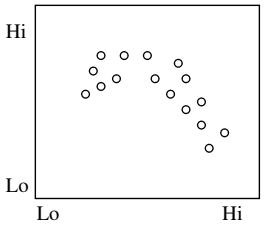
linear, negative, moderate



linear, positive, weak

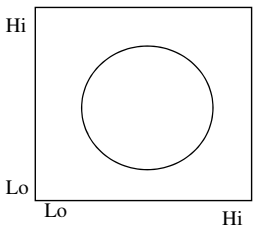


nonlinear, strong

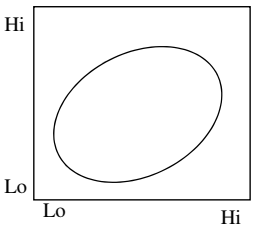


Sometimes a scatterplot will show only the "envelope" of the data, not the individual data points. Describe each of these bivariate patterns...

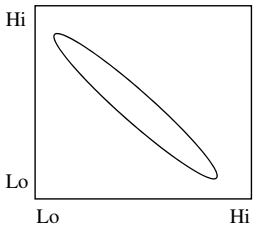
No relationship



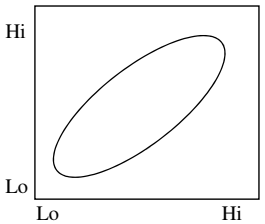
linear, positive, weak



linear, negative, strong

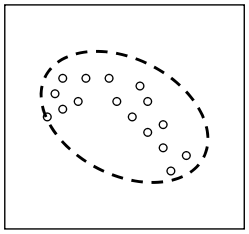


linear, positive, moderate

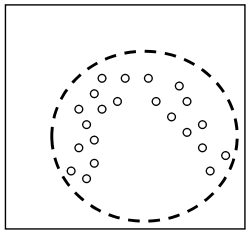


The Pearson's correlation (r) summarizes the direction and strength of the linear relationship shown in the scatterplot

- r has a range from -1.00 to 1.00
  - 1.00 a perfect positive linear relationship
  - 0.00 no linear relationship at all
  - -1.00 a perfect negative linear relationship
- r assumes that the relationship is linear
  - if the relationship is not linear, then the r-value is an underestimate of the strength of the relationship at best and meaningless at worst



For a non-linear relationship, r will be based on a "rounded out" envelope -- leading to a misrepresentative r



Stating Hypotheses with r ...

Every RH must specify ...

- the variables
- the direction of the expected linear relationship
- the population of interest
- Generic form ...

  There is a no/a positive/a negative **linear** relationship between X and Y in the population represented by the sample.

Every H0: must specify ...

- the variables
- that no linear relationship is expected
- the population of interest
- Generic form ...

  There is a no **linear** relationship between X and Y in the population represented by the sample.

What "retaining H0:" and "Rejecting H0:" means...

- When you retain H0: you're concluding…
  - The linear relationship between these variables in the sample ***is not*** strong enough to allow me to conclude there is a relationship between them in the population represented by the sample.
- When you reject H0: you're concluding…
  - The linear relationship between these variables in the sample ***is*** strong enough to allow me to conclude there is a relationship between them in the population represented by the sample.

Deciding whether to retain or reject H0: when using r ...

When computing statistics by hand

- compute an "obtained" or "computed" r value
- look up a "critical r value"
- compare the two
  - if |r-obtained| < r-critical Retain H0:
  - if |r-obtained| > r-critical Reject H0:

When using the computer

- compute an "obtained" or "computed" r value
- compute the associated p-value ("sig")
- examine the p-value to make the decision
  - if p > .05 Retain H0:
  - if p < .05 Reject H0:

Practice with Pearson's Correlation (r)

The RH: was that older adolescents would be more polite.

A sample of 84 adolescents were asked their age and to complete the Politeness Quotient Questionnaire

Retain or Reject H0: ???

Reject -- |r| > r-critical

Support for RH: ???

Yep ! Correct direction !!

obtained r = .453 critical r= .254

Again...

The RH: was that older professors would receive lower student course evaluations.

A sample of 124 Introductory Psyc students from 12 different sections completed the Student Evaluation. Profs' ages were obtained (with permission) from their files.

Retain or Reject H0: ???

Retain -- p > .05

Support for RH: ???

No! There is no linear relationship

obtained r = -.152 p = .431

Statistical decisions & errors with correlation ...

Statistical Decision	In the Population: - r	r = 0	+ r
- r (p < .05)	Correct H0: Rejection & Direction	Type I "False Alarm"	Type III "Mis-specification"
r = 0 (p > .05)	Type II "Miss"	Correct H0: Retention	Type II "Miss"
+ r (p < .05)	Type III "Mis-specification"	Type I "False Alarm"	Correct H0: Rejection & Direction

Remember that "in the population" is "in the majority of the literature" in practice!!

About causal interpretation of correlation results ...

We can only give a causal interpretation of the results if the data were collected using a true experiment

- random assignment of subjects to conditions of the "causal variable" (IV)
  -- gives initial equivalence.
- manipulation of the "causal variable" (IV) by the experimenter
  -- gives temporal precedence
- control of procedural variables
  -- gives ongoing eq.

Most applications of Pearson's r involve quantitative variables that are subject variables -- measured from participants

In other words -- a Natural Groups Design -- with ...

- no random assignment -- no initial equivalence
- no manipulation of "causal variable" (IV) -- no temporal precendence
- no procedural control -- no ongoing equivalence

Under these conditions causal interpretation of the results is not appropriate !!

Moving on to X^2 …

with two qualitative variables we can display the bivariate relationship using a "contingency table"

Puppy	Type (col)	Play (row)
Sam	work	tug
Ding	hunt	chase
Ralf	hunt	tug
Pit	work	tug
Seff	hunt	chase
…	..	..
Toby	hunt	chase

Favorite Play	Type of Dog: Hunting	Working
Ball-Chase	||||| ||	||
Sock-Tug	||	||||| |

When examining a contingency table, we look for two things...

- whether or not there is a pattern
- if so, which row tends to "go with" which column?

Pattern: A&1 B&2

Rows	A	B
2	15	34
1	36	15

no pattern

Rows	A	B
2	25	24
1	26	25

Pattern: A&2 B&1

Rows	A	B
2	35	14
1	16	35

Describe each of the following ...

Chips \ Crackers	Dogs	Cats
Chips	12	44
Crackers	30	16

dogs prefer chips & cats prefer crackers

Chips \ Crackers	Dogs	Cats
Chips	17	14
Crackers	13	16

no pattern

Chips \ Crackers	Dogs	Cats
Chips	42	14
Crackers	10	36

dogs prefer crackers & cats prefer chips

Chips \ Crackers	Dogs	Cats
Chips	32	44
Crackers	30	16

cats prefer crackers & dogs have no preference

The Pearson's Chi-square (X^2) summarizes the relationship shown in the contingency table

- X^2 has a range from 0 to ∞ (infinity)
  - 0.00 absolutely no pattern of relationship
  - "smaller" X^2 -- weaker pattern of relationship
  - "larger" X^2 - stronger pattern of relationship
- However...
  - The relationship between the size of X^2 and strength of the relationship is more complex than for r (with linear relationships)
    - you will seldom see X^2 used to express the strength of the bivariate relationship

Stating Hypotheses with X^2 ...

Every RH must specify ...

- the variables
- the specific pattern of the expected relationship
- the population of interest
- Generic form ...

There is a pattern of relationship between X & Y, such that . . . . in the population represented by the sample.

Every H0: must specify ...

- the variables
- that no pattern of relationship is expected
- the population of interest
- Generic form ...

There is a no pattern of relationship between X and Y in the population represented by the sample.

Deciding whether to retain or reject H0: when using X^2

When computing statistics by hand

- compute an "obtained" or "computed" X^2 value
- look up a "critical X^2 value"
- compare the two
  - if X^2 -obtained < X^2 -critical Retain H0:
  - if X^2 -obtained > X^2 -critical Reject H0:

When using the computer

- compute an "obtained" or "computed" X^2 value
- compute the associated p-value ("sig")
- examine the p-value to make the decision
  - if p > .05 Retain H0:
  - if p < .05 Reject H0:

What "Retaining H0:" and "Rejecting H0:" means ...

- When you retain H0: you're concluding…
  - The pattern of the relationship between these variables in the sample ***is not*** strong enough to allow me to conclude there is a relationship between them in the population represented by the sample.
- When you reject H0: you're concluding…
  - The pattern of the relationship between these variables in the sample ***is*** strong enough to allow me to conclude there is a relationship between them in the population represented by the sample.

Statistical decisions & errors with X^2 ...

Statistical Decision	In the Population: that specific pattern	no pattern	any other pattern
that specific pattern ($p < .05$)	Correct H0: Rejection & Pattern	Type I "False Alarm"	Type III "Mis-specification"
no pattern ($p > .05$)	Type II "Miss"	Correct H0: Retention	Type II "Miss"
any other pattern ($p < .05$)	Type III "Mis-specification"	Type I "False Alarm"	Correct H0: Rejection & Pattern

Remember that "in the population" is "in the majority of the literature" in practice!!

Testing X^2 RH: -- different "kinds" of RH: & it matters!!!

"Proportion" type RH:

RH: A greater proportion of those who do the "on web" exam preparation than of those who do the "on paper" version will pass the exam.

"Implied Proportion" Type of RH:

RH: Those who do the "on web" exam preparation will do better than those who do the "on paper" version.

"Pattern" type RH:

RH: More of those who do the "on web" exam preparation assignment will pass the exam, whereas more of those who do the "on paper" version fill fail the exam.

Testing X^2 RH: -- different "kinds" of RH: & it matters!!!

"Proportion" type RH:

RH: A greater proportion of cats than of dogs will prefer crackers.

	Dogs	Cats
Crackers	12	44
Chips	30	16

$X^2=19.93$, $p<.001$

Both RH:s supported !!

Cats 44/60 = .73

Dogs 12/42 = .29

Cats 44 > 16 & Dogs 12 < 3

"Pattern" type RH:

RH: More cats will prefer crackers and more dogs will prefer chips.

	Dogs	Cats
Crackers	32	44
Chips	30	16

$X^2=6.12$, $p=.013$

Only "Proportion" RH supported !!

Cats 44/60 = .73

Dogs 32/62 = .52

Cats 44 > 16 But.. Dogs 32 = 30

Testing X^2 RH: -- one to watch out for…

Sometime, instead of …

RH: A greater proportion of those do the "on web" exam preparation than of those who do the "on paper" version will pass the exam.

You'll get… → **This is not a good way to express a X^2 RH: !!!!**

RH: More of those who do the "on web" exam preparation assignment will perform better on the exam than those who do the "on paper" version.

You have to be careful about these kinds of "frequency" RH:!!!

X^2 works in terms of proportions, not frequencies! And, because you might have more of one group than another, this can cause confusion and problems…

Testing X^2 RH: -- one to watch out for…

Instead of …

RH: A greater proportion of cats than of dogs will prefer crackers.

You'll get… → **This is not a good way to express a X^2 RH: !!!!**

RH: More cats than dogs will prefer crackers.

	Dogs	Cats
Crackers	20	20
Chips	40	10

X^2=9.00, p=.003

The number of dogs & cats is same 20 = 20 …

But X^2 tests for differential proportion of that category not for differential number of that category…

Cats 20/30 = **.66** > **.33** = 20/40 Dogs

About causal interpretation of X^2 ...

Applications of Pearson's X^2 are a mixture of the three designs you know

- Natural Groups Design
- Quasi-Experiment
- True Experiment

But only those data from a True Exp can be given a causal interpretation …

- random assignment of subjects to conditions of the "causal variable" (IV) -- gives initial equivalence.
- manipulation of the "causal variable" (IV) by the experimenter -- gives temporal precedence
- control of procedural variables - gives ongoing eq.

You must be sure that the design used in the study provides the necessary evidence to support a causal interpretation of the results !!

Practice with Statistical and Causal Interpretation of X^2 Results

RH: Those who do the "on web" exam preparation assignment will perform better on the exam than those who do the "on paper" version.

	Paper	Web
Pass	11	37
Fail	43	14

X^2 obtained = 28.78, $p < .001$

Retain or Reject H0: ??? Reject!

Support for RH: ??? Yep ! 37/51 of Web folks passed versus 11/54 of Paper folks !!

Design: Before taking the test, students were asked whether they had chosen to complete the "on Web" or the "on paper" version of the exam prep. The test was graded pass/fail.

Type of Design ??? Natural Groups Design

Causal Interpretation? Nope!

What ***CAN*** we say from these data ??? There's an association between type of prep and test performance.

Again ...

RH: Those who do the "on web" exam preparation assignment will perform better on the exam than those who do the "on paper" version.

	Paper	Web
Pass	21	27
Fail	23	24

X^2 obtained = .26, p = .612

Retain or Reject H0: ??? Retain!

Support for RH: ??? Nope !

Design: Students in the morning laboratory section were randomly assigned to complete the "on Web" version of the exam prep, while those in the afternoon section completed the "on paper" version. Student's were "monitored" to assure the completed the correct version. The test was graded pass/fail.

Type of Design ??? Quasi Experiment

Causal Interpretation? Nope!

What ***CAN*** we say from these data ??? There's no association between type of prep and test performance.

Yet again ...

RH: More of those who do the "on web" exam preparation assignment will pass the exam and more of those who do the "on paper" version will fail.

	Paper	Web
Pass	21	37
Fail	23	14

X^2 obtained = 6.12, $p = .013$

Retain or Reject H0: ??? Reject!

Support for RH: ??? Partial: 37 > 14, but 23 = 21

Design: One-half of the students in the T-Th AM lecture section were randomly assigned to complete the "on Web" version of the exam prep, while the other half of that section completed the "on paper" version. Students were "monitored" to assure the completed the correct version. The test was graded pass/fail. Only data from students in the T-TH AM class were included in the analysis.

Type of Design ??? True Experiment

Causal Interpretation? Yep!

What ***CAN*** we say from these data ??? That type of prep nfluences test performance.