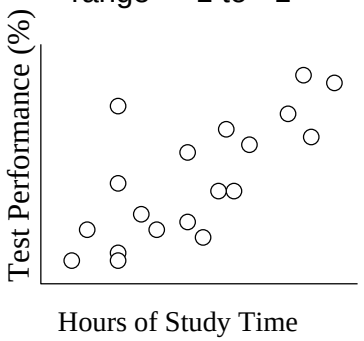
Pearson's r & X^2

- 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

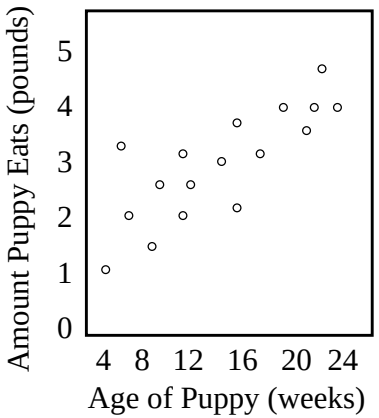
Food Preference	Turtle Type: Painted	Turtle Type: Snapper
crickets	5	15
"duck weed"	19	1

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
- Age & Shoe Size
- Preferred Pet Type & Preferred Toy Type
- Leg Length & Hair Length
- Age and Preferred Type of Pet
- Gender & Preferred Type of Car
- Grade (%) & Hrs. Study

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

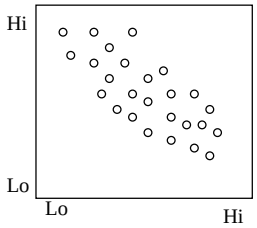
Puppy	Age (x)	Eats (y)
Sam	8	2
Ding	20	4
Ralf	12	2
Pit	4	1
Seff	24	4
…	..	..
Toby	16	3



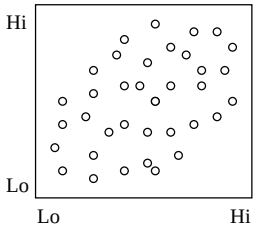
When examining a scatterplot, we look for three things...

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

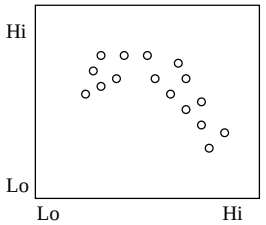
linear, negative, moderate



linear, positive, weak

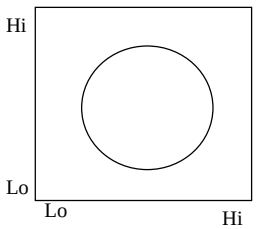


nonlinear, strong

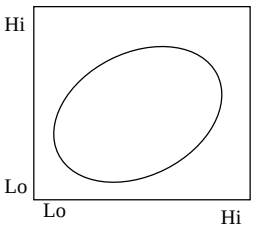


Sometimes a scatterplot will show only the “envelope” of the data, not the individual data points. Describe each of these bivariate patterns...

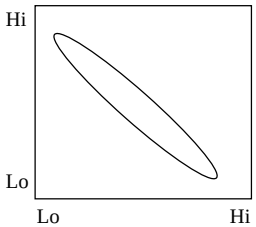
No relationship



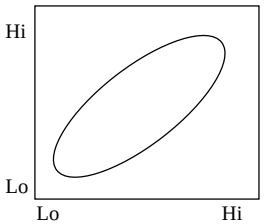
linear, positive, weak



linear, negative, strong

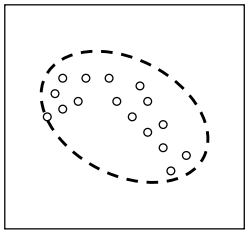


linear, positive, moderate

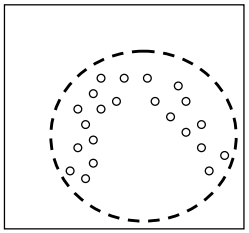


The Pearson's correlation (r) summarizes the direction and strength of the linear relationship shown in the scatterplot

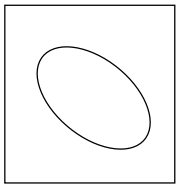
- r has a range from -1.00 to 1.00
  - 1.00 a perfect positive linear relationship
  - 0.00 no linear relationship at all
  - -1.00 a perfect negative linear relationship
- r assumes that the relationship is linear
  - if the relationship is not linear, then the r-value is an underestimate of the strength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

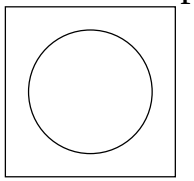


For a non-linear relationship, r will be based on a "rounded out" envelope -- leading to a misrepresentative r



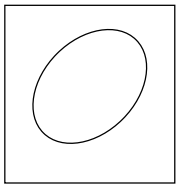
Match the r values and the scatterplots below





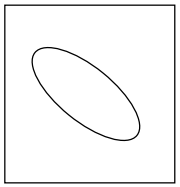
0.00

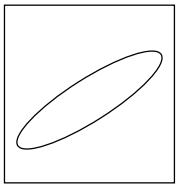
.30



-.40

-.70





.85

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: ???

Support for RH: ???

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: ???

Support for RH: ???

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 ...

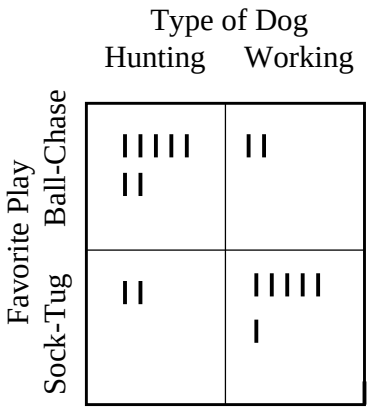
- no random assignment -- no initial equivalence
- no manipulation of "causal variable" (IV) -- no temporal precendence
- no procedural control -- no ongoing equivalence

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



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	Columns A	Columns B
2	15	34
1	36	15

no pattern

Rows	Columns A	Columns B
2	25	24
1	26	25

Pattern: A&2 B&1

Rows	Columns A	Columns B
2	35	14
1	16	35

Describe each of the following ...

Chips \ Crackers	Boys	Girls
Crackers	12	44
Chips	30	16

boys prefer chips & girls prefer crackers

Chips \ Crackers	Boys	Girls
Crackers	17	14
Chips	13	16

no pattern

Chips \ Crackers	Boys	Girls
Crackers	42	14
Chips	10	36

boys prefer crackers & girls prefer chips

Chips \ Crackers	Boys	Girls
Crackers	32	44
Chips	30	16

girls prefer crackers & boys 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.

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.

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:

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!!

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 = 7.25, critical X^2 = 3.84

Retain or Reject H0: ???

Support for RH: ???

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 ???

Causal Interpretation?

What ***CAN*** we say from these data ???

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 = 2.25, critical X^2 = 3.84

Retain or Reject H0: ???

Support for RH: ???

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 ???

Causal Interpretation?

What ***CAN*** we say from these data ???

Yet again ...

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

	Paper	Web
Pass	21	37
Fail	23	14

X^2 obtained = 4.62, critical X^2 = 3.84

Retain or Reject H0: ???

Support for RH: ???

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 ???

Causal Interpretation?

What ***CAN*** we say from these data ???