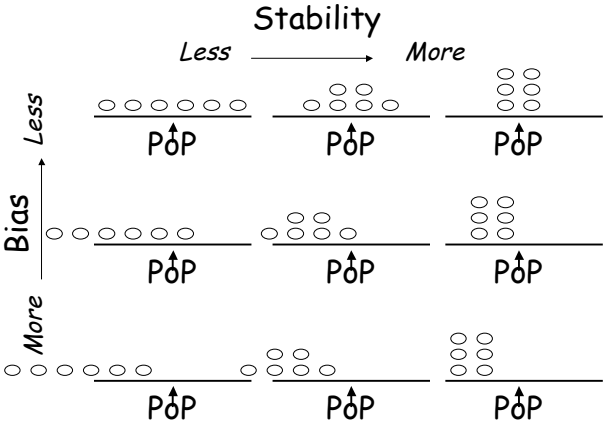
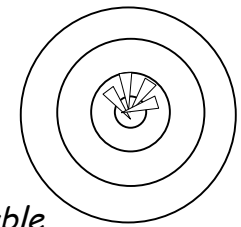
Results

from samples to population...



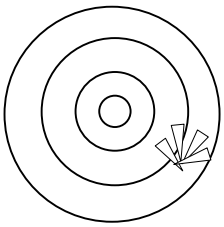
Like playing darts…

Always aim for the *center*…



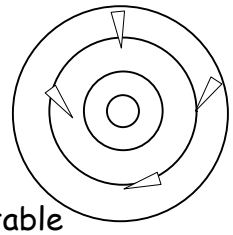
Stable

And not biased...



Stable

But… biased



Unstable

But… not biased

****** Descriptive Analysis ******

Illustrations: *Frequency Distribution*

- **Histogram**
- **Frequency Polygon**
- ***Stem-and-Leaf display****

Central tendency:

- Mean (average)
- Median (50th percentile)
- Mode

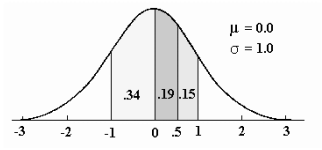
Variability:

- Range (spread)
- Variance
- Standard Deviation

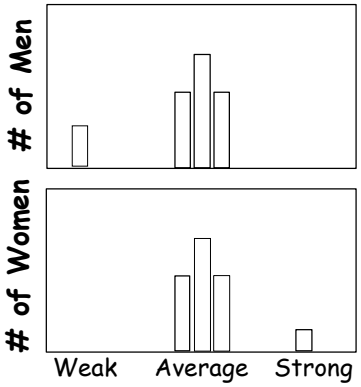
Normal Distribution

- z score

$$Z = \frac{X - \mu}{\sigma}$$



Colour vision



Colour discrimination

Conclusion: "Statistical" logic

Hypotheses

Evaluated by statistical tests

H_0 ⇨ **Null Hypothesis**

No "difference" between Gr. A and B

H_1 ⇨ **Alternate Hypothesis**

Difference between groups

- In one specific direction: Gr. A > Gr. B or Gr. A < Gr. B → *One-tailed test*
- In any direction → *Two-tailed test*

Null hypotheses

Main effects (as many as # of IV):

1. There is no difference in the DV between the levels of the IV: A

2. There is no difference in the DV between the levels of the IV: B

Null hypothesis

Interaction: There is no interaction

For IV A, level 1,

IV B: level 1 vs. level 2

↕ Similar tendency: no difference

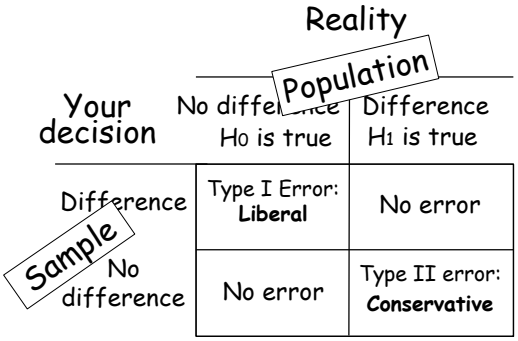
For IV A, level 2,

IV B: level 1 vs. level 2

Statistical analysis

- Null and alternate hypotheses
- Possible errors:
  type I or type II
- Sample --> Population

  Chance:
  Sampling errors
  Measurement errors



Decision	Reality: H_0 is true	Reality: H_0 is false, H_1 is true
Reject of H_0	Type I error	No error
Non Reject of H_0	No error	Type II error

Type I error: significance value ($p < 0.05$)
alpha

Type II error: beta

Probability? / chance?

Between subject design

Participants selection

Within subject design

Repeated measures:

- Statistic regression
- Maturation
- Historical factors …

Beyond statistical testing…

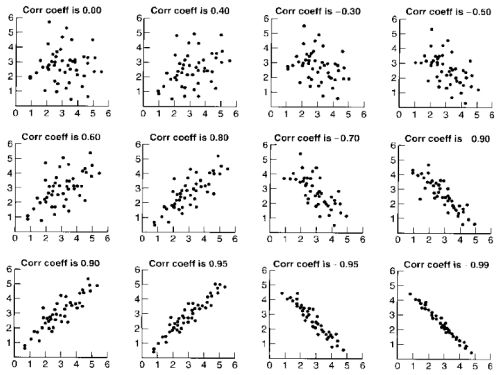
Effect size : r
- Pearson r (product-moment correlation)
- Spearman Rank correlation
- Point-Biserial correlation
- Phi coefficient

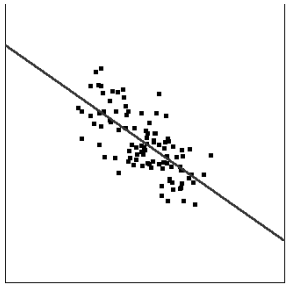
Practical significance
- BESD: Binomial Effect-Size Display

Statistical Power

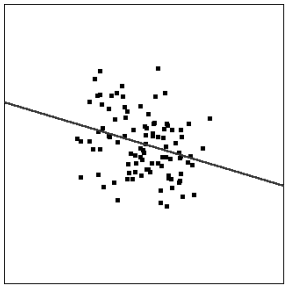
Effect size: correlation

Figure 11.2

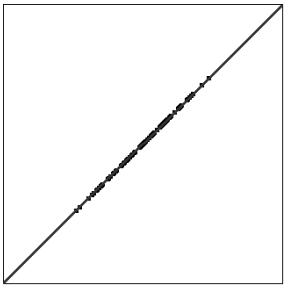




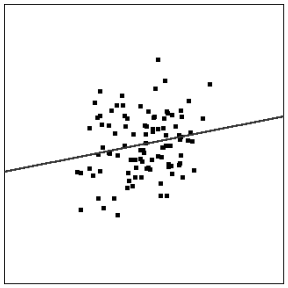
-0.7



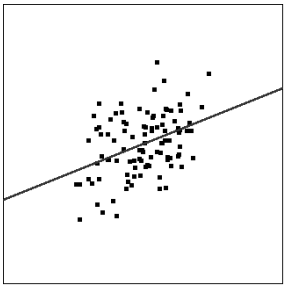
-0.3



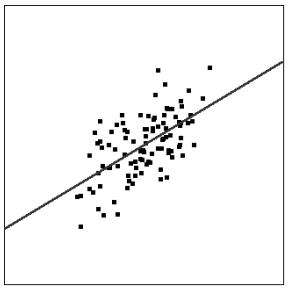
1



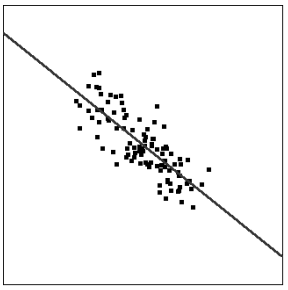
0.2



0.4



0.6



-0.8

Pearson r
(product-moment correlation)

$$r_{xy} = \Sigma Z_x Z_y / N$$

– Pearson r (product-moment correlation)

Table 11.2 Raw & Standardized Data for Pearson r correlation coefficient

Student ID and gender	Exam 1 X_1 score	Exam 1 z_1 score	Exam 2 X_2 score	Exam 2 z_2 score	Product of z_1 and z_2 scores
1 (M)	42	+1.78	90	+1.21	+2.15
2 (M)	9	−1.04	40	−1.65	+1.72
3 (F)	28	+0.58	92	+1.33	+0.77
4 (M)	11	−0.87	50	−1.08	+0.94
5 (M)	8	−1.13	49	−1.13	+1.28
6 (F)	15	−0.53	63	−0.33	+0.17
7 (M)	14	−0.62	68	−0.05	+0.03
8 (F)	25	+0.33	75	+0.35	+0.12
9 (F)	40	+1.61	89	+1.16	+1.87
10 (F)	20	−0.10	72	+0.18	−0.02
Sum (Σ)	212	0	688	0	+9.03
Mean (M)	21.2	0	68.8	0	.90
SD (σ)	11.69	1.0	17.47	1.0	

- Spearman Rank correlation

Table 11.6 Raw Data from Table 11.2 Ranked for Spearman Rho Correlation

	Exam 1		Exam 2			
Student	X_1 score	Rank	X_2 score	Rank	D	D^2
1	42	1	90	2	−1	1
2	9	9	40	10	−1	1
3	28	3	92	1	2	4
4	11	8	50	8	0	0
5	8	10	49	9	1	1
6	15	6	63	7	−1	1
7	14	7	68	6	1	1
8	25	4	75	4	0	0
9	40	2	89	3	−1	1
10	20	5	72	5	0	0
Sum (Σ)	212	55[a]	688	55[a]	0[b]	10

Useful to get rid of outliers;
No concern for absolute values

- Point-Biserial Correlation: 1 discontinuous & 1 continuous variable

Table 11.7 Raw, Dummy-Coded, and Standardized Data for Point-Biserial Correlation

	Exam 1		Student's gender		
Student ID and gender	Raw score	z score	Dummy code	z score	Product of z scores
1 (M)	42	+1.78	0	−1	−1.78
2 (M)	9	−1.04	0	−1	+1.04
3 (F)	28	+0.58	1	+1	+0.58
4 (M)	11	−0.87	0	−1	+0.87
5 (M)	8	−1.13	0	−1	+1.13
6 (F)	15	−0.53	1	+1	−0.53
7 (M)	14	−0.62	0	−1	+0.62
8 (F)	25	+0.33	1	+1	+0.33
9 (F)	40	+1.61	1	+1	+1.61
10 (F)	20	−0.10	1	+1	−0.10
Sum (Σ)	212	0	5	0	+3.77
Mean (M)	21.2	0	0.5	0	.38
SD (σ)	11.69	1.0	0.5	1.0	

- Phi coefficient: 2 discontinuous variables

Table 11.8 Dummy Coded and Standardized Data for Phi Coefficient

	Ate a burger?			Got food poisoning?			
Persons	Y 1; N 0	z score		Y 1; N 0	z score		Product of z scores
Mimi	1	+1.183		1	+1.183		1.400
Gail	0	−0.846		0	−0.846		0.716
Connie	0	−0.846		0	−0.846		0.716
Jerry	0	−0.846		0	−0.846		0.716
Greg	0	−0.846		0	−0.846		0.716
Dwight	0	−0.846		0	−0.846		0.716
Nancy	1	+1.183		1	+1.183		1.400
Richard	0	−0.846		0	−0.846		0.716
Kerry	0	−0.846		0	−0.846		0.716
Michele	1	+1.183		1	+1.183		1.400
John	1	+1.183		1	+1.183		1.400
Sheila	1	+1.183		1	+1.183		1.400
Sum (Σ)	5	0.00		5	0.00		12.012
Mean (M)	.417	0.00		.417	0.00		1.00
SD (σ)	.493	1.000		.493	1.000		.337

Table 11.9 2 × 2 Contingency Table Coded for Computation of Phi Coefficient

	Got food poisoning?		
Ate a burger?	Yes	No	Totals
No	A 0	B 7	(A + B) = 7
Yes	C 5	D 0	(C + D) = 5
Totals	(A + C) = 5	(B + D) = 7	

Statistical Power: 1- beta

—Probability of rejecting the null hypothesis when it is false

Depends on:

- the p level
- the sample size
- the effect size

Rounded Sample Sizes (Total N)

Required to Detect Effects at 0.05 Two-Tailed

	Effect size correlation (reffect)		
Power	0.10	0.40	0.70
0.20	1125	10	10
0.60	500	30	10
0.80	800	45	15

Table 12.6

Aspirin's Effect on Heart Attack

Myocardial infarction in aspirin and placebo conditions

Condition	No heart attack	Heart attack	Total
Aspirin	10 933	104	11 037
Placebo	10 845	189	11 034
Total	21 778	293	22 071

Aspirin's Effect on Heart Attack

p = 0.0000006

r_{effect} = 0.034

Practical significance = 3.4% less people have a heart attack when on aspirin

Aspirin's Effect on Heart Attack

Myocardial in… placebo conditions

100(0.5 - r/2)
r = 0.034

Condition	…eart attack	Total
Aspirin	51.7	48.3	100
Placebo	48.3	51.7	100
Total	100	100	200

Practical significance

100(0.5 + r/2)
r = 0.034

– BESD: Binomial Effect-Size Display

Statistical Power: 1- beta

—Probability of rejecting the null hypothesis when it is false

Depends on:

- the p level
- the sample size
- the effect size