Psychology 205: Research Methods in Psychology
Methods in Differential Psychology

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Outline

Two fundamentally different approaches to psychological research

- Experimental versus differential
  - Experimental approaches associated with cognitive, neurobiology, social.
  - Correlational primarily with personality/clinical/life span developmental.
- Some combine both approaches:
  - Experimental clinical/personality examines interactions of situation with individual differences.
  - Experimental developmental examines changes in response time capabilities with age.
- Should not confuse lab based data collection with experimental – experimental requires random assignment to conditions.

Differential Psychology

1. Emphasis on dispersion (variance and covariance) rather than central tendency (mean and median)
2. Studies of Ability, Interests/Values, Temperament
3. Prediction of performance in college/universities, professions, military
4. Correlations with marriage, divorce, employment, health and mortality
5. Correlations with psychopathology
    - Understanding the risk for depression in terms of cognitive processing
    - Understanding the genetic and environmental basis of schizophrenia

Data = Model + Residual

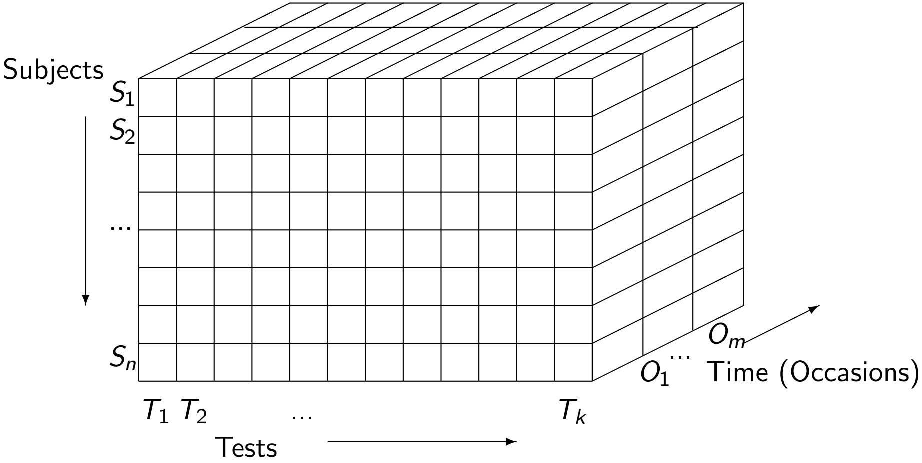
All studies have three questions:

1. What are the data?
   - Collected experimentally
   - Collected observationally
2. How do we model them?
3. How large is the residual variance?

Theory of Data + the Data Box

- Theory of data Coombs (1964)
  - Sets of Objects and of People
  - Two types of comparisons (Proximity and order)
  - Comparisons of preferences: Do you like X? is a proximity measure.
    - $|o_i - p_j| < \epsilon$ (Do you like something?)
    - $|o_i - p_j| < |o_k - p_l|$ (do you like something more than I like something else?)
  - Comparisons of order: Can you do X?
    - $o_i < p_j$ Are you better than an item?
    - $o_i < o_j$ Is this object more than that object?
- The Data Box: comparisons across time and space (Cattell, 1946, 1966b)
  - People over tests, people over time
  - Tests over people, tests over time
  - etc.

The data box: Subjects x Measures x Time



Cattell (1946, 1966b)

Cattell and the Data Box

1. One occasion
   - R: Correlate measures across persons : standard personality traits
   - Q: Correlate Persons acros measures: Personality typology
2. One Person
   - P: Correlate Measures across Occasions; Individual personality structure
   - O: Correlate Occasions across measures: Individual psychological environment
3. One Measure
   - T: Correlate Occasions across Persons: Anxiety arousing situations
   - S: Correlate Persons across Occasions: Anxious person types

Cattell (1946, 1966b,a); Revelle (2009, 2015) (Note that Cattell changed his notation from paper to paper).

Differential Psychology

1. Emphasis on variance and covariance rather than mean
2. Studies of Ability, Interests/Values, Temperament
3. Prediction of performance in college/universities, professions, military
4. Correlations with health and mortality

The basic problem is the same

1. Data = Model + Residual
2. What are the data?
3. How do we model them?

Methods of data collection

1. Self report – how do you normally behave
   traits/states/narratives
2. Ability tests - what is the best you can do
3. Behavioral observation
4. Physiology - EEG/MRI/fMRI/PET
5. Remote data – web/big EAR,websites
6. National and International Surveys
7. Animal – lesion/drug/observation

Types of designs

1. Experimental
   - lab based
   - field based
   - Quasi-experimental designs
2. Observational
   - Cross sectional
   - Longitudinal

A variety of longitudinal designs

1. Brief within subject
   - Momentary Experience Samplng (ESM)
   - Studying the dynamics of mood (Wilt, Funkhouser & Revelle, 2011; Revelle & Wilt, 2021; Beck & Jackson, 2020, Beck & Jackson)
2. Long term within subject
   - Terman and the "termites" (Terman & Baldwin, 1926; Terman & Oden, 1959; Oden, 1968)
   - Berkeley/Oakland growth studies
   - Scottish Mental Health study (Deary, Whiteman, Starr, Whalley & Fox, 2004; Deary, 2009; Deary, Pattie & Starr, 2013)
   - Seattle Longitudinal Study (Schaie, 2005)
   - Dunedin Longitudinal Study (Reuben, Caspi, Belsky, Broadbent, Harrington, Sugden, Houts, Ramrakha, Poulton & Moffitt, 2017)
   - Study of Mathematically Precocious Youth (Lubinski, Webb, Morelock & Benbow, 2001; Lubinski & Benbow, 2006; Lubinski, 2016)
   - Project Talent

Methods of Analysis

1. Issues in scaling – what do the numbers mean?
   - Do the measures have linear or just ordinal properties?
   - Are we measuring the same thing at age 11 as age 77?
   - Can we adapt prior measures for current theory?
2. The correlation coefficient and its many forms
   - Y varies as X
   - Is Y a continuous variable?
   - is X a continuous variable?
   - what is the underlying relationship?

Alternative versions of the correlation coefficient

Table: A number of correlations are Pearson r in different forms, or with particular assumptions. If $r = \frac{\sum x_i y_i}{\sqrt{\sum x_i^2 \sum y_i^2}}$, then depending upon the type of data being analyzed, a variety of correlations are found.

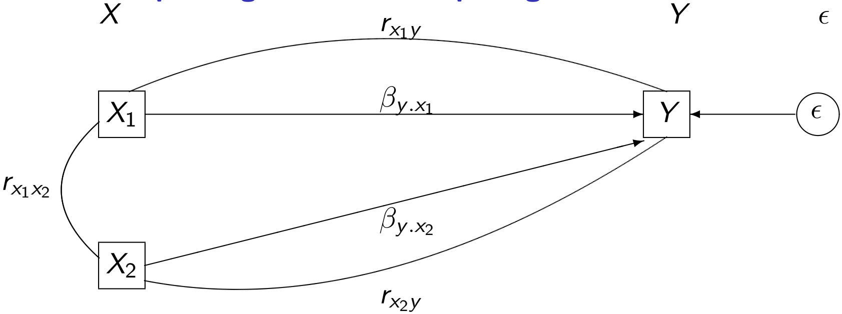
Coefficient	symbol	X	Y	Assumptions
Pearson	r	continuous	continuous	
Spearman	rho (ρ)	ranks	ranks	
Point bi-serial	r_{pb}	dichotomous	continuous	
Phi	ϕ	dichotomous	dichotomous	
Bi-serial	r_{bis}	dichotomous	continuous	normality
Tetrachoric	r_{tet}	dichotomous	dichotomous	bivariate normality
Polychoric	r_{pc}	categorical	categorical	bivariate normality

Many other statistics (F, d, b) may be expressed in terms of r

Table: Alternative Estimates of effect size. Using the correlation as a scale free estimate of effect size allows for combining experimental and correlational data in a metric that is directly interpretable as the effect of a standardized unit change in x leads to r change in standardized y.

Statistic	Estimate	r equivalent	as a function of r
Pearson correlation	$r_{xy} = \frac{C_{xy}}{\sigma_x \sigma_y}$	r_{xy}	
Regression	$b_{y.x} = \frac{Cxy}{\sigma_x^2}$	$r = b_{y.x} \frac{\sigma_y}{\sigma_x}$	$b_{y.x} = r \frac{\sigma_x}{\sigma_y}$
Cohen's d	$d = \frac{X_1 - X_2}{\sigma_x}$	$r = \frac{d}{\sqrt{d^2+4}}$	$d = \frac{2r}{\sqrt{1-r^2}}$
Hedge's g	$g = \frac{X_1 - X_2}{s_x}$	$r = \frac{g}{\sqrt{g^2+4(df/N)}}$	$g = \frac{2r\sqrt{df/N}}{\sqrt{1-r^2}}$
t - test	$t = \frac{d\sqrt{df}}{2}$	$r = \sqrt{t^2/(t^2 + df)}$	$t = \sqrt{\frac{r^2 df}{1-r^2}}$
F-test	$F = \frac{d^2 df}{4}$	$r = \sqrt{F/(F + df)}$	$F = \frac{r^2 df}{1-r^2}$
Chi Square		$r = \sqrt{\chi^2/n}$	$\chi^2 = r^2 n$
Odds ratio	$d = \frac{ln(OR)}{1.81}$	$r = \frac{ln(OR)}{1.81\sqrt{(ln(OR)/1.81)^2+4}}$	$ln(OR) = \frac{3.62r}{\sqrt{1-r^2}}$
$r_{equivalent}$	r with probability p	$r = r_{equivalent}$	

Multiple Regression: decomposing correlations



$$r_{x_1y} = \overbrace{\beta_{y.x_1}}^{direct} + \overbrace{r_{x_1x_2}\beta_{y.x_2}}^{indirect}$$

$$r_{x_2y} = \underbrace{\beta_{y.x_2}}_{direct} + \underbrace{r_{x_1x_2}\beta_{y.x_1}}_{indirect}$$

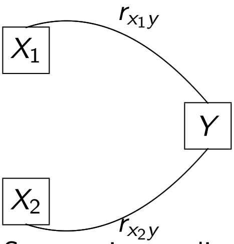
$$\beta_{y.x_1} = \frac{r_{x_1y} - r_{x_1x_2}r_{x_2y}}{1 - r^2_{x_1x_2}}$$

$$\beta_{y.x_2} = \frac{r_{x_2y} - r_{x_1x_2}r_{x_1y}}{1 - r^2_{x_1x_2}}$$

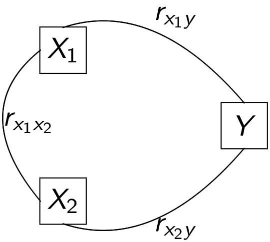
$$R^2 = r_{x_1y}\beta_{y.x_1} + r_{x_2y}\beta_{y.x_2}$$

3 special cases of regression

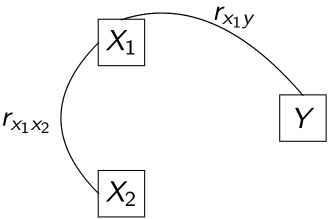
Orthogonal predictors



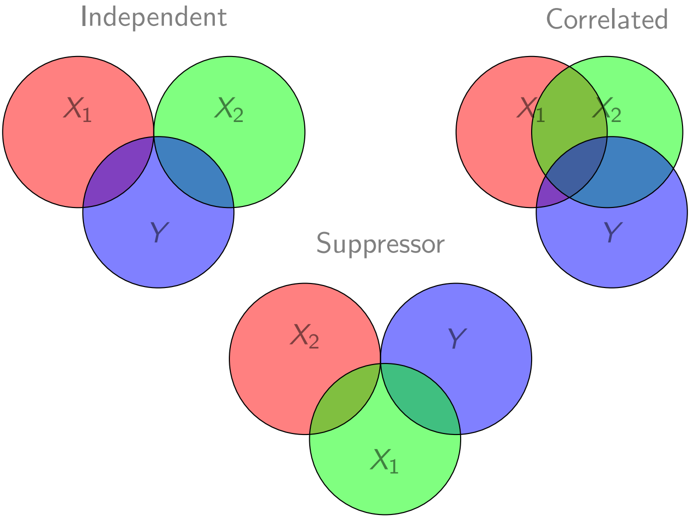
Correlated predictors



Suppressive predictors

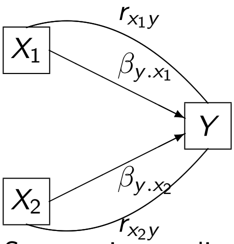


Three basic cases

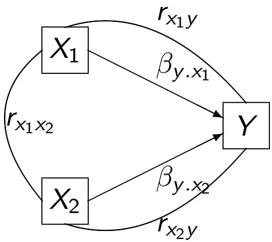


3 special cases of regression

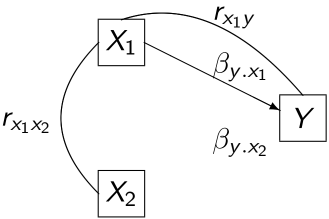
Orthogonal predictors



Correlated predictors



Suppressive predictors

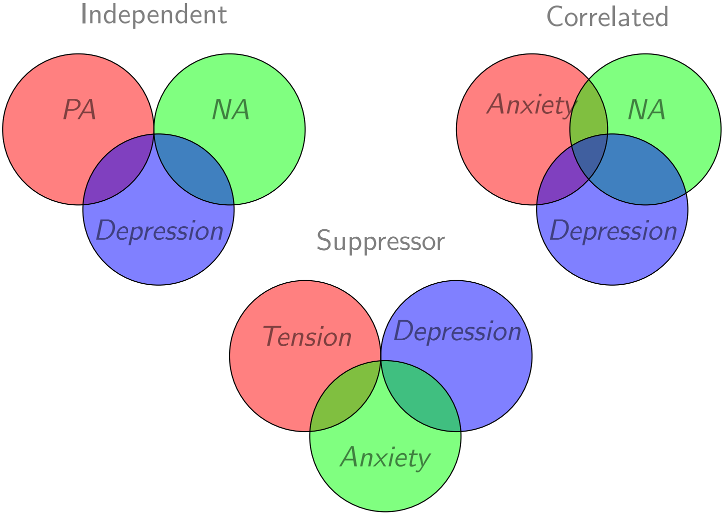


$$\beta_{y.x_1} = \frac{r_{x_1y} - r_{x_1x_2} r_{x_2y}}{1 - r^2_{x_1x_2}}$$

$$\beta_{y.x_2} = \frac{r_{x_2y} - r_{x_1x_2} r_{x_1y}}{1 - r^2_{x_1x_2}}$$

$$R^2 = r_{x_1y}\beta_{y.x_1} + r_{x_2y}\beta_{y.x_2}$$

Three basic cases: Theoretical examples



Data quality

1. Estimates of reliability reliability (Revelle & Condon, 2019)
   - parallel tests,
   - alternate form,
   - stability
   - internal consistency $\omega_h, \alpha, \omega_t$
2. Validity – does the arrow hit the target

Advanced methods

1. Factor analysis, cluster analysis, multidimensional scaling (see Revelle (prep) for a discussion of many of these concepts)
2. Structural Equation modeling Rosseel (2012)
3. Multi-level modeling of emotion (Revelle & Wilt, 2019)
4. Computer modeling (Revelle & Condon, 2015; Revelle, Elleman & Hall, 2020)
5. Machine (Statistical) learning: Old ideas in new software.

Multivariate analysis

- Many procedures use the concept of iterative fitting
- Some, such as principal components are "closed form" and can just be solved directly
- Others, such as "factor analysis" need to find solutions by successive approximations
- The issue of factor or component rotation is an iterative procedure.
- Principal Components and Factor analysis are all the result of some basic matrix equations to approximate a matrix
- Conceptually, we are just taking the square root of a correlation matrix:
- $R \approx CC'$ or $R \approx FF' + U^2$ (u^2 is a diagonal matrix
- For any given correlation matrix, R, can we find a C or an F matrix which approximates it?

Consider the following matrix

What would be its "square root"? That is to say, what simpler matrix, times itself is equal to R?

```
R
     V1   V2   V3   V4
V1 1.00 0.56 0.48 0.40
V2 0.56 1.00 0.42 0.35
V3 0.48 0.42 1.00 0.30
V4 0.40 0.35 0.30 1.00
```

Find $R \approx FF' + U^2$

A congeneric matrix is one with just one factor

R code

```
R <- sim.congeneric()
R
 f1 <- fa(R)
```

```
> R
     V1   V2   V3   V4
V1 1.00 0.56 0.48 0.40
V2 0.56 1.00 0.42 0.35
V3 0.48 0.42 1.00 0.30
V4 0.40 0.35 0.30 1.00
> f1 <- fa(R)
> f1
Factor Analysis using method =  minres
Call: fa(r = R)
Standardized loadings (pattern matrix) based upon correlation matrix
   MR1   h2   u2 com
V1 0.8 0.64 0.36   1
V2 0.7 0.49 0.51   1
V3 0.6 0.36 0.64   1
V4 0.5 0.25 0.75   1

                MR1
SS loadings    1.74
Proportion Var 0.43
```

Using multivariate statistics to simplify our data

1. Data = Model + Error
2. Approximate complex data with simpler models
3. Scale construction tales multiple items to make one or a few scales.

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