Research Methods

Major design distinctions

Qualitative Research

Literature Reviews

Measurement

Statistical analyses

Missing data and attrition

Major Design Distinctions

Independent variable – experimental manipulated variable, group comparison variable, predictor, or hypothesized cause

Dependent variable – outcome, effect

Major Design Distinctions

Experimental vs. Quasi-experimental

Cross-Sectional vs. Longitudinal

Laboratory vs. Field Study

Quantitative vs. Qualitative

Qualitative Review vs. Meta-Analysis

Major Design Distinctions: Experimental vs. Quasi-Experimental

Experimental

- Randomized between-subjects
- Within-subjects

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Major Design Distinctions: Experimental vs. Quasi-Experimental

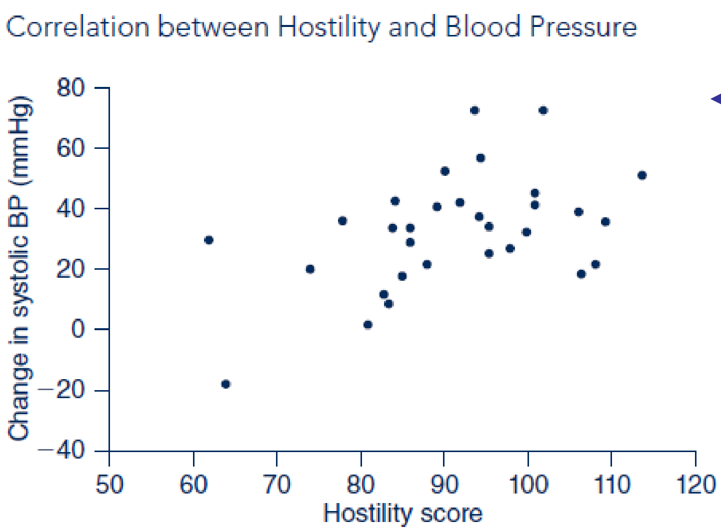
Quasi-experimental

- Passive observational (“correlational” design)
- Single-group pretest posttest design
- Non-equivalent control group design (within or without pre-test)
- Interrupted time series (multiple pretest and/or posttests)
- A-B-A-B design

Major Design Distinctions: Passive Observational ("Correlational") Design

Correlation (r)

- Shows extent of relationship between two variables
- Can be negative or positive
- Strength is indicated by how close it is to 1 (or -1).
- No ability to detect causality.



As hostility increases so does blood pressure, but we can't conclude one causes the other. There may also be a third, unmeasured variable, influence this relationship or the opposite causal direction may hold.

Source: Reprinted from Journal of Psychosomatic Research, 68(2), Brydon, L., Strike, P. C., Bhattacharyya, M. R., Whitehead, D. L., McEwan, J., Zachary, I., … Steptoe, A.. Hostility and physiological responses to laboratory stress in acute coronary syndrome patients, 109–116, Copyright (2010), with permission from Elsevier.

Major Design Distinctions: Pretest-Posttest

(X = treatment, O = observation)

Single Group

O X O

Multiple Group

posttest only:

X O
O

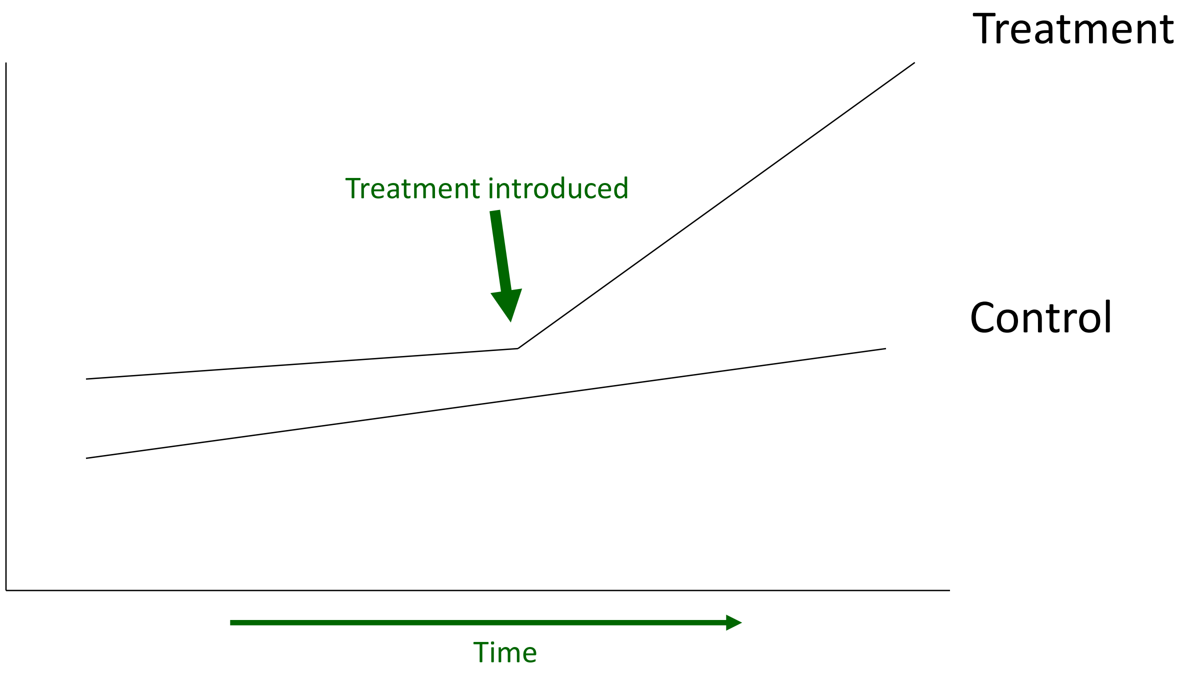
pretest-posttest:

O X O
O O

Interrupted Time-Series (Multiple group)

O O O X O O O
O O O O O O

Major Design Distinctions: Interrupted Time-Series (Multiple Group)



Major Design Distinctions: A-B-A-B Design

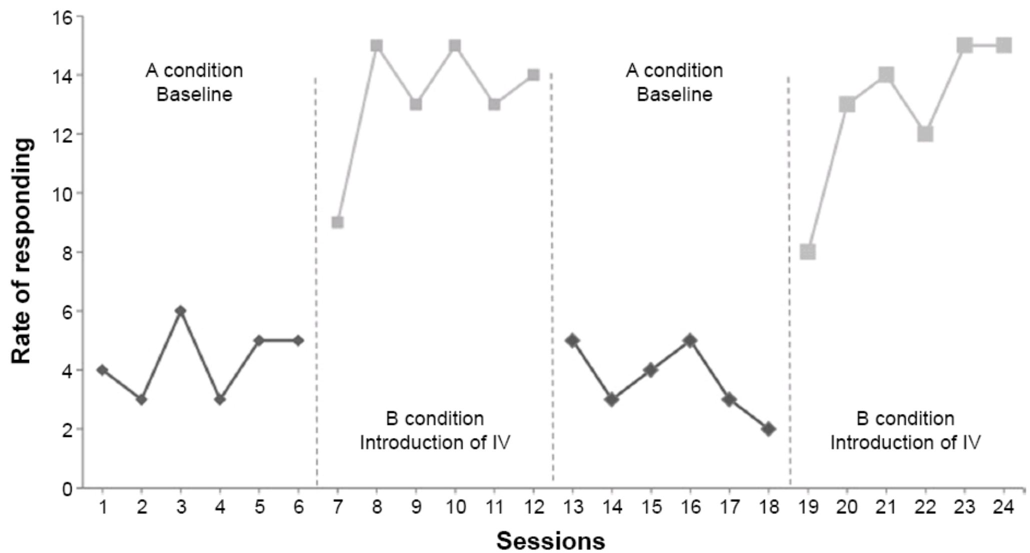


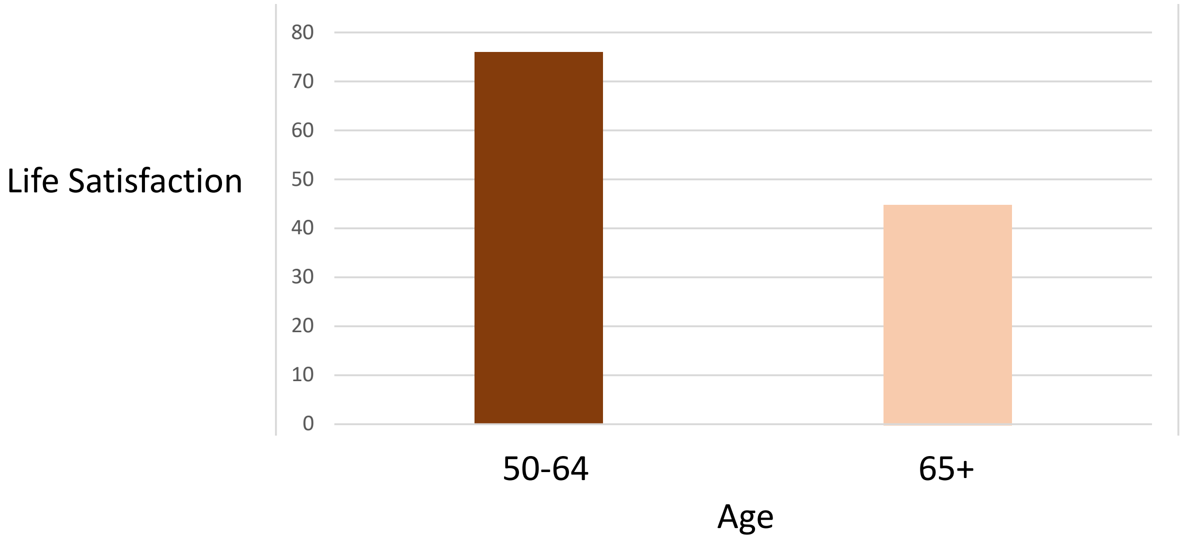
Figure 1 Hypothetical example of the withdrawal design (ABAB).
Notes: Y-axis shows number of responses per 10 minutes. The first condition is a baseline condition with low rate of responding. The second condition is the first introduction of IV where a change in the dependent variable is observed. The third condition is a reintroduction of the baseline condition where rate of responding decreases again. And the last condition is a reintroduction of the IV.
Abbreviations: IV, independent variable; A, baseline; B, introduction of IV.

Steingrimsdottir, H. S., & Arntzen, E. (2015). On the utility of within-participant research design when working with patients with neurocognitive disorders. *Clinical interventions in aging*, *10*, 1189.

Major Design Distinctions: Cross-Sectional vs. Longitudinal

Cross-sectional – measurements made at one point in time

Hypothetical example: survey of individuals with range of ages taken in one year to understand life satisfaction before and after retirement (could be age groups or a continuum of ages)



Major Design Distinctions: Cross-Sectional vs. Longitudinal

Cross-sectional

Advantages

- Less expensive and time consuming
- More practical for a wide range of ages
- Could be experimental, a strong design for ruling out confounds

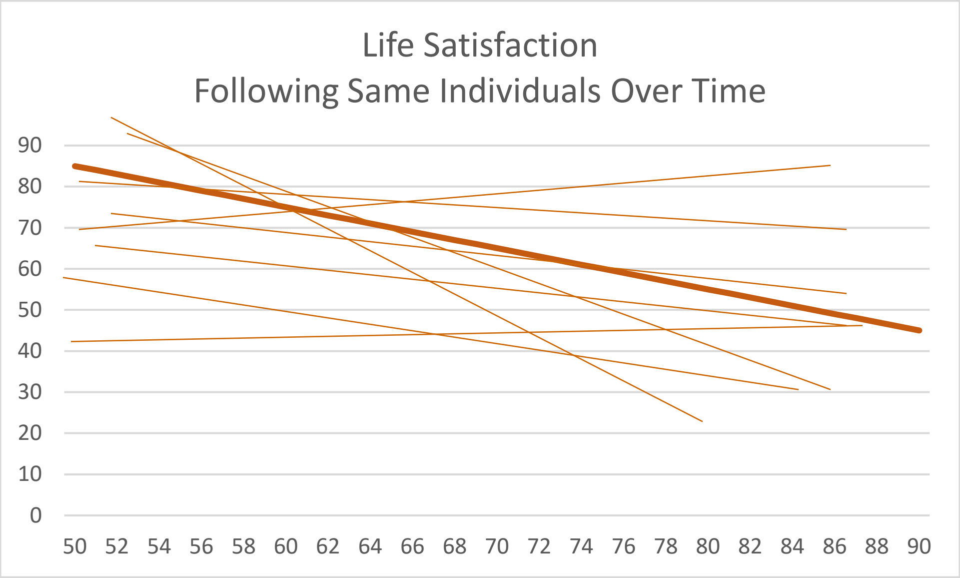
Disadvantages

- Variables other than age (or other independent variable) may be the cause of the observed difference in groups or the age-outcome relationship
- Between-person comparisons, so cannot observe developmental changes directly

Major Design Distinctions: Cross-Sectional vs. Longitudinal Design

Longitudinal – tracks each individual over time (repeated measurements)

Hypothetical example: measure life satisfaction from for every individual from age 50 to 90



Life Satisfaction

Age

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Major Design Distinctions: Cross-Sectional vs. Longitudinal Design

Longitudinal

Advantages

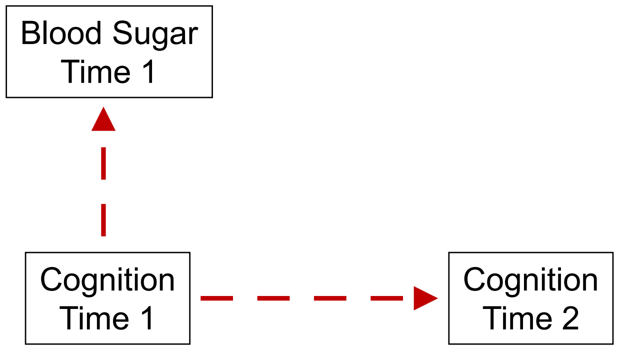
- Traces and individuals development
- Can measure and statistically remove other variables measured at each time point (e.g., social support)
- Can predict who increases or decreases at different rates (e.g., does satisfaction change depend on job status)
- Can take into account pre-existing associations to address reverse causal direction

Disadvantages

- Attrition/dropout
- Survivor effects (e.g., healthier individuals are more satisfied and also live longer which might suggest less decline)

Major Design Distinctions: Cross-Sectional vs. Longitudinal Design

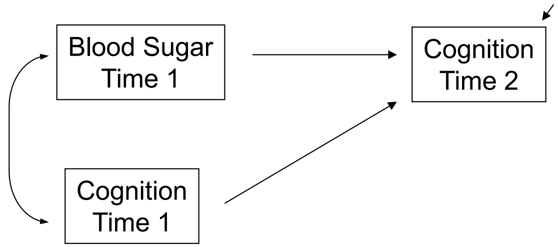
Longitudinal



Although the hypothesis may be that blood sugar/diabetes leads to cognitive decline it may be the cognitive decline impacts blood sugar through poor eating habits

Lagged Regression

- Takes into account the prior (time 1) relationship between x_1 (e.g., blood sugar) and y_1 (e.g., cognition)



Major Design Distinctions: Cross-Sectional vs. Longitudinal Design

Longitudinal studies need to have appropriate time interval that matches the theorized causal effect

Examples:

- Changing diet won't impact cancer or heart disease until years later
- Minor argument with adult child should not affect experience of life satisfaction a year later

Even if observational, can have ecological validity advantage over experiments when they cannot be conducted over long time spans

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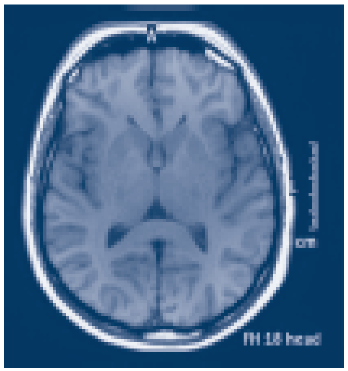
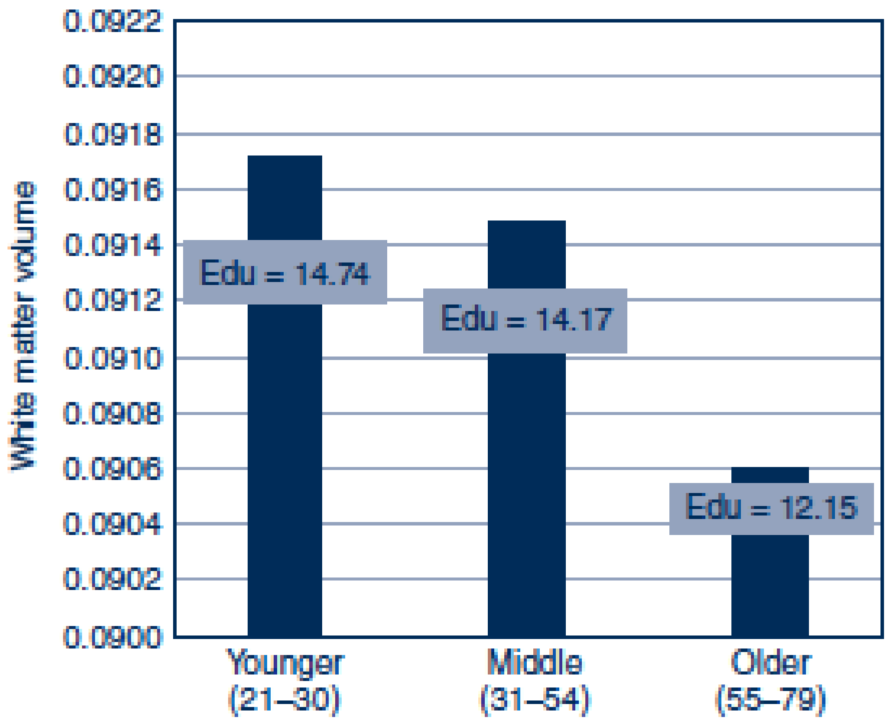
The Problem of Cohort Differences in Cross-Sectional Research



Salih Dastan/iStockphoto



Source: Reprinted from *Biological Psychiatry, 60(5)*, Brickman, A.M., Zimmerman, M. E., Paul, R. H., Grieve, S. M., Tate, D. F., Cohen, R. A., ... Gordon, E., Regional white matter and neuropsychological functioning across the adult lifespan, 444–453, Copyright (2006), with permission from Elsevier.

It appears as if there is a linear drop-off in regional white matter. However, the age groups differed significantly in years of education, suggesting possibility of cohort effects.

Major Design Distinctions:
Age, Cohort, and Time of Measurement (Period) Effects

Age, Cohort, and Time of Measurement

Term	*Definition*	*Measurement of:*
Age	• How many years (or months) the person has lived	• Change within the individual
Cohort	• Year (or period) of a person's birth	• Influences relative to history at time of birth
Time of mea-surement	• Year or period in which a person is tested	• Current influences on individuals being tested

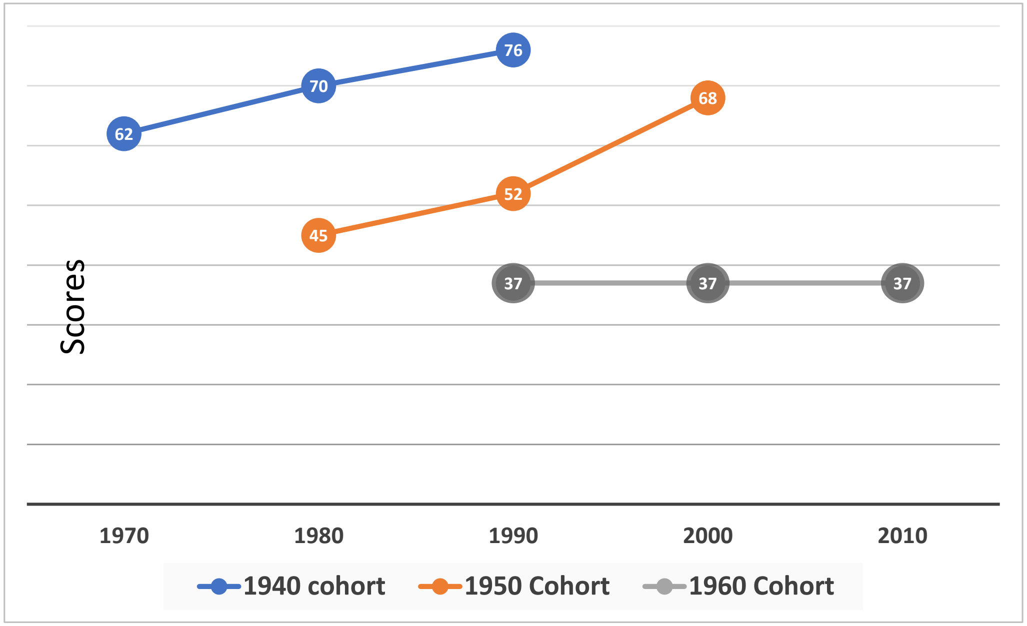
Major Design Distinctions: Age, Cohort, and Time of Measurement (Period) Effects

	Age	Time	Cohort
Time-sequential	✓	✓	
Cohort-sequential	✓		✓
Cross-sequential		✓	✓

Major Design Distinctions: Age, Cohort, and Time of Measurement (Period) Effects

Cross-sequential designs

Has some advantages of the cross-sectional and longitudinal designs



In a cross sequential design, different cohorts are compared at different times of testing. In this figure, the 1960 cohort did not change over the three times of testing. The 1950 cohort showed increases, and the 1940 cohort was higher throughout from 1970 to 1990.

Qualitative Research

Goals:

- Hypothesis generation
- Explanation of mechanisms
- Measurement development

Types:

- Case study (reports)
- Focus groups
- Ethnographic

Literature Reviews: Qualitative Review vs. Meta-Analysis

- Both review of many studies in particular area of research
  - Most common review type, can involve some subjective elements, but also can be used if fewer homogenous studies or wider range of study designs
- Meta-analysis uses statistical approach to aggregate results from many studies
  - Although often seen as more rigorous, requires sufficient number of studies with comparable measures and other study features (e.g., experiment)

Measurement

Types:

- Observation
- Self-report
- Archival

Measurement

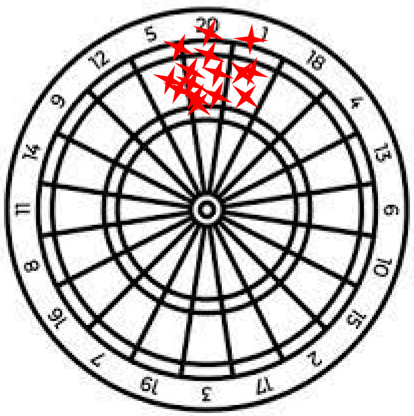
Reliability – consistent results

- Test-retest
- Internal (consistency)

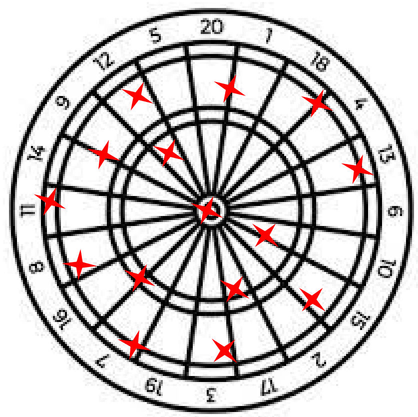
Validity

- Predictive
- Convergent/divergent
- Content

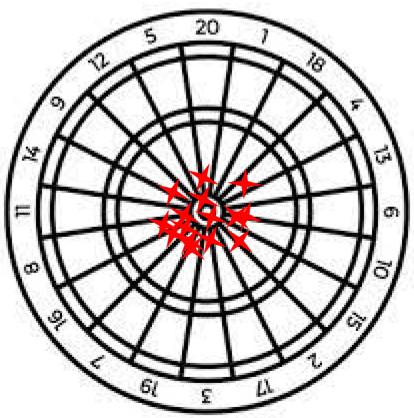
Measurement



Reliable but not valid



Valid but not reliable

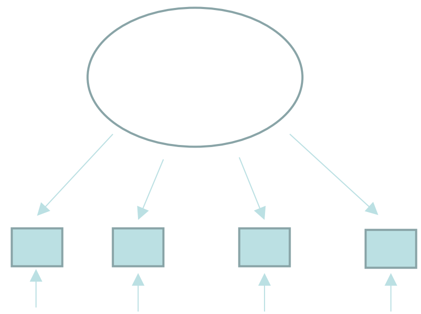


Valid and reliable

Measurement

Internal reliability

- Observed score = true score + error
- Cronbach's alpha
- Exploratory and confirmatory factor analysis
  - Latent variable



- Item Response Theory (IRT)
  - Much in common with factor analysis ideas/goals but applied mostly to yes/no or correct/incorrect responses
  - Generally applied to testing (e.g., intelligence tests, cognitive testing)

Statistical Analyses

Correlation

Regression

- Statistical control

Structural equation modeling

- Factor analysis and path analysis

Hierarchical linear models (multilevel models, mixed models, random coefficient models)

Growth curve models (for longitudinal designs)

Statistical Analyses: Correlation

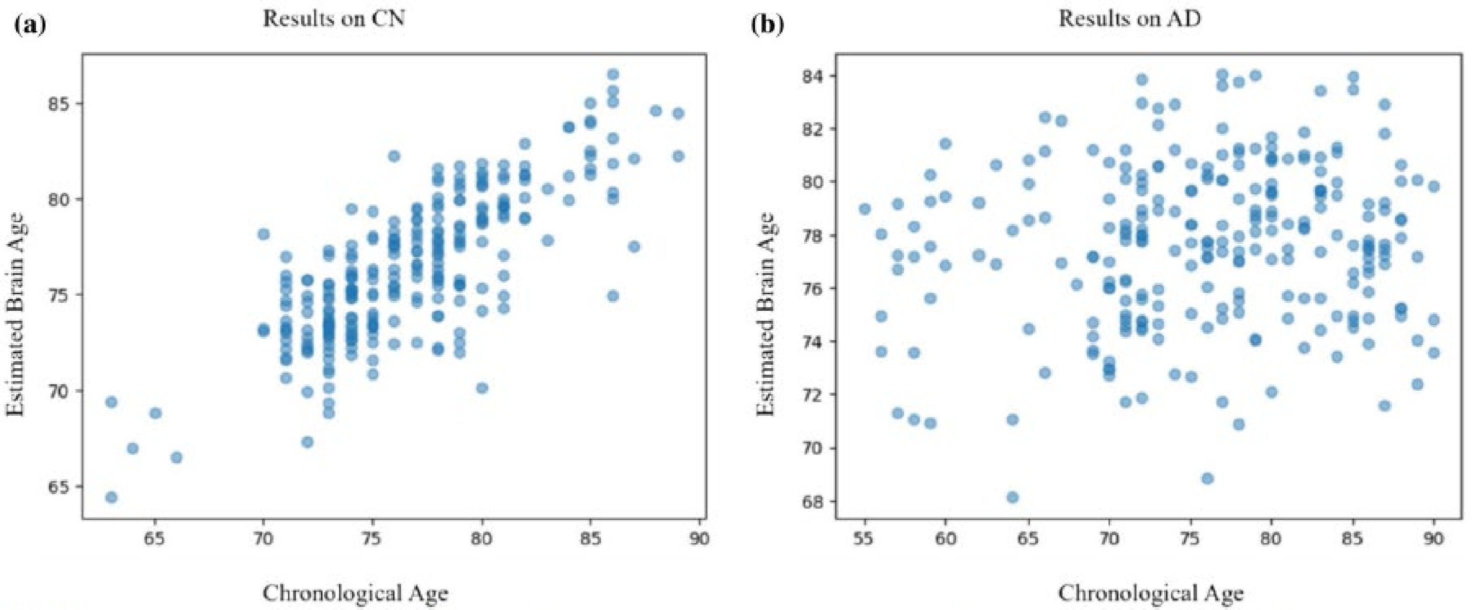


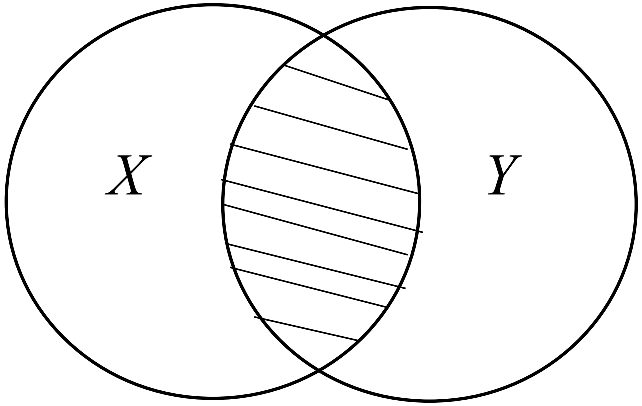
Fig. 7 the scatter plot of the chronological age and the brain age estimated using the proposed method on 500 test data of ADNI dataset. **a** the results on Cognitively 250 Normal subjects and **b** the results on 250 Alzheimer's disease patients

Aghaei, A., Ebrahimi Moghaddam, M., & Alzheimer's Disease Neuroimaging Initiative. (2024). Brain age gap estimation using attention-based resnet method for Alzheimer's disease detection. Brain Informatics, 11(1), 16.

Statistical Analyses: Correlation

Squaring correlation gives the percentage of shared variance between the two variables, r^2

Can be represented by a Venn diagram.



Statistical Analyses: Correlation

Correlations are on a standard metric

Possible range from -1.0 to +1.0

Positive value indicates higher values of Y when higher values of X observed

- Example: SES and educational tests

Negative correlation indicates lower values of Y when higher values of X observed

- Example: driver age and risk of car accident

Statistical Analyses: Regression

The equation for a line, $mx + b$, is used to summarize the trend of the points

In the equation for a line, m is the slope, which you should remember as "rise over run"—the amount that Y increases as X is incremented by one point

b is the intercept, or the point on the y-axis where the line intersects when X is equal to 0

Statistical Analyses: Regression

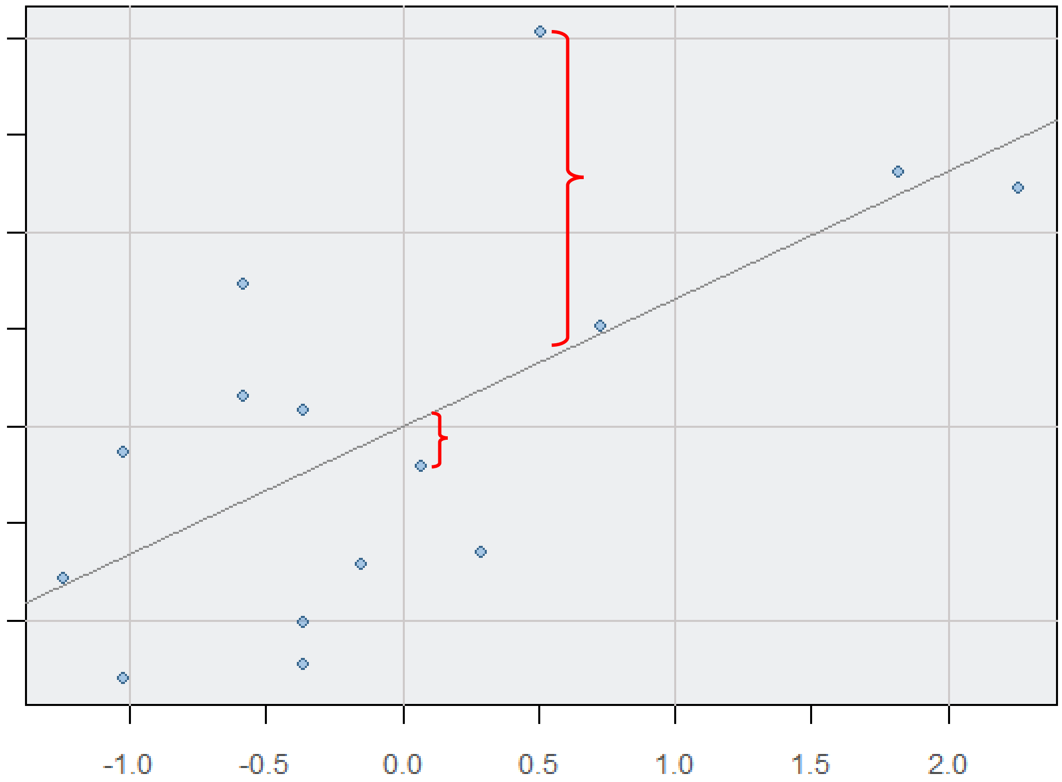
The statistical equation then adds a term that accounts for the error of prediction—the distance of a point from the line, known as the residual

$$Y = a + b(X) + r$$

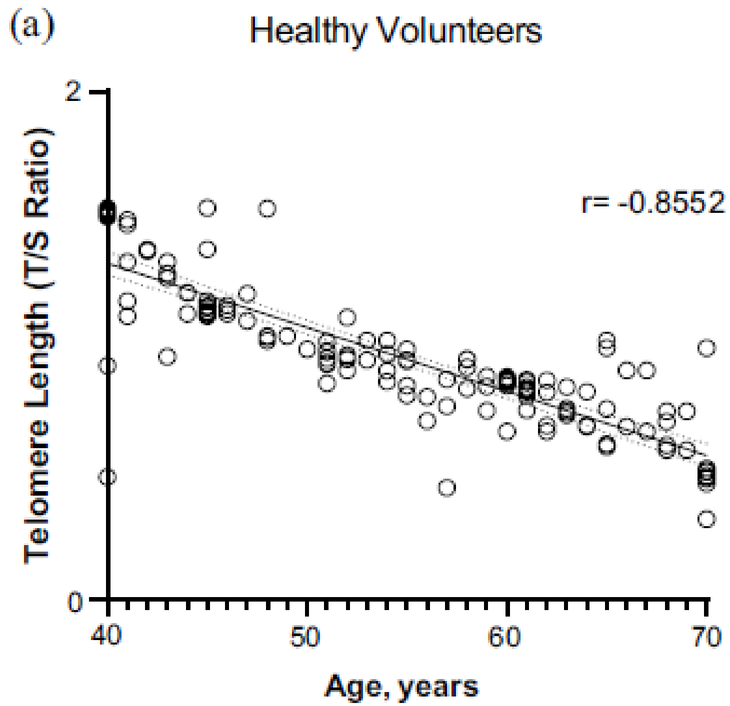
The actual or observed score, Y, is equal to the equation for the line plus some error, r (sometimes this is *e*, instead)

Statistical Analyses: Regression

But as we can see in the scatterplot, the actual points are not always perfectly predicted



Statistical Analyses: Regression

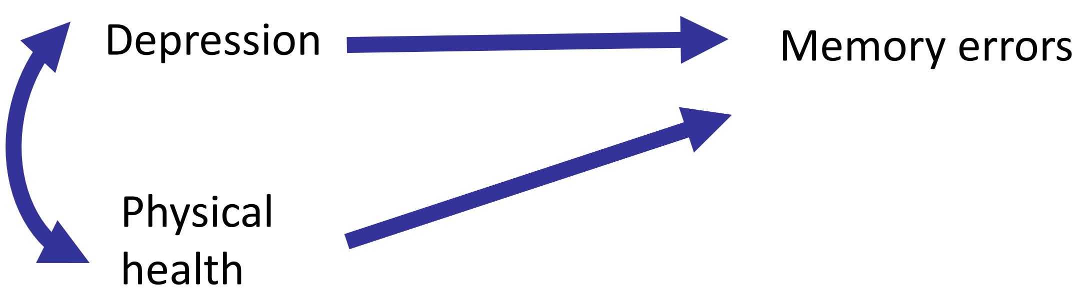


Devrajani, T., Abid, S., Shaikh, H., Shaikh, I., Devrajani, D. B., Memon, S. M., ... & Syed, B. M. (2023). Relationship between aging and control of metabolic syndrome with telomere shortening: a cross-sectional study. Scientific Reports, 13(1), 17878.

Statistical Analyses: Regression

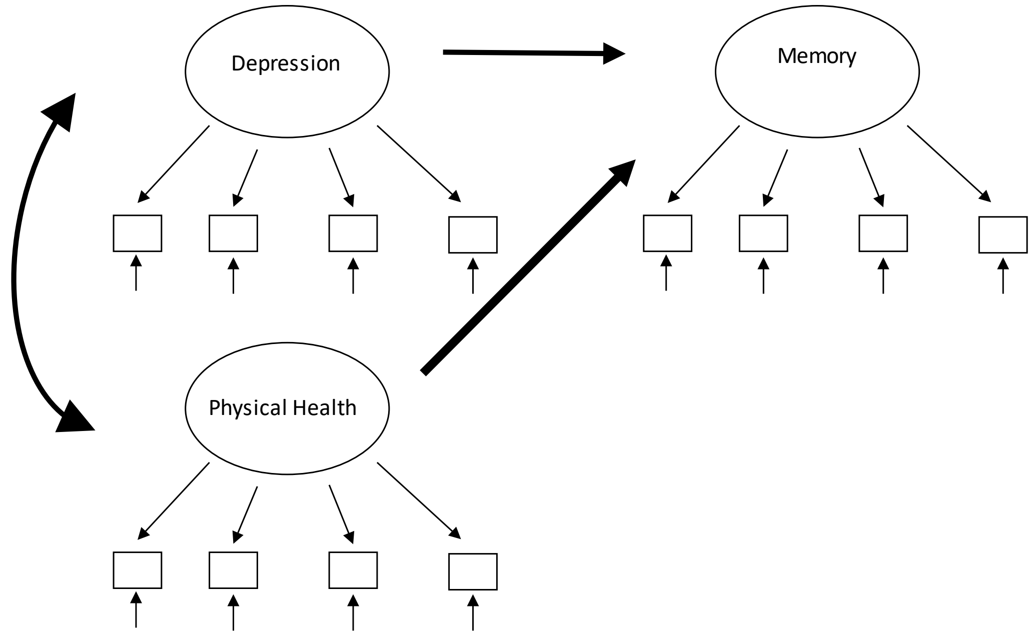
Multiple regression involves more than one predictor

- Adds to amount of variance accounted for
- But also uses statistical control to take into account third variables that may explain a relationship



Statistical Analyses: Structural Equation Modeling

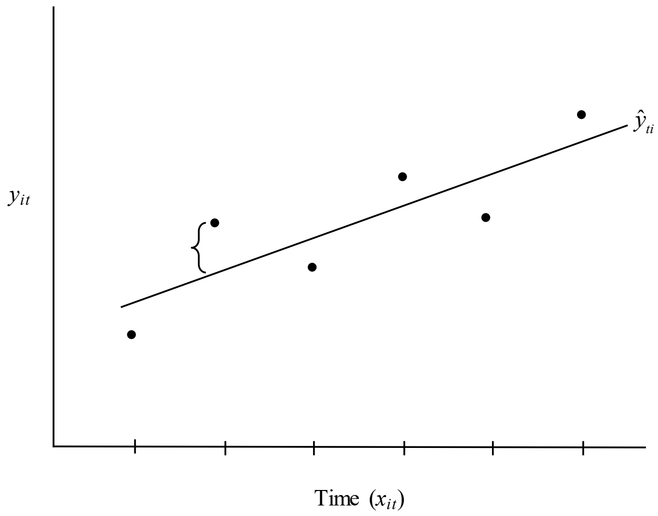
Combines factor analysis and regression to account for measurement error



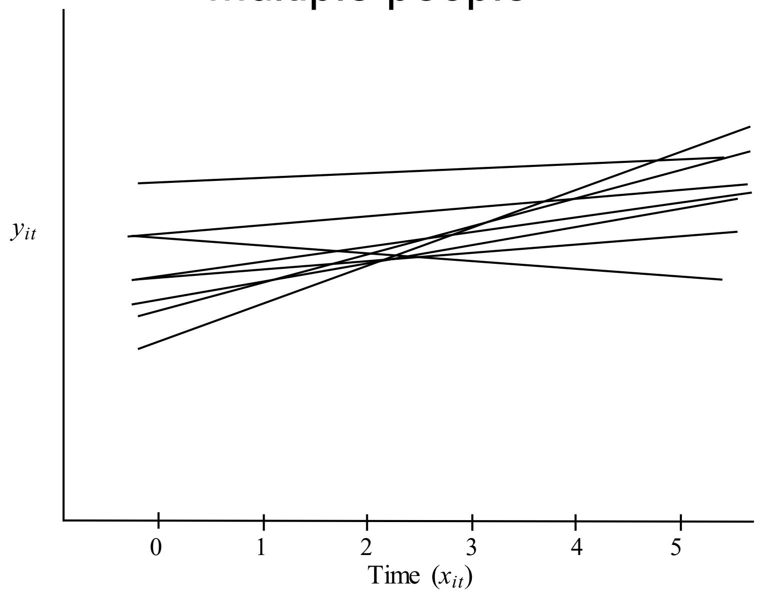
Statistical Analyses: Growth Curve Models

Regression but with a time variable (e.g., age, time point) as a predictor to model change over time

Single person

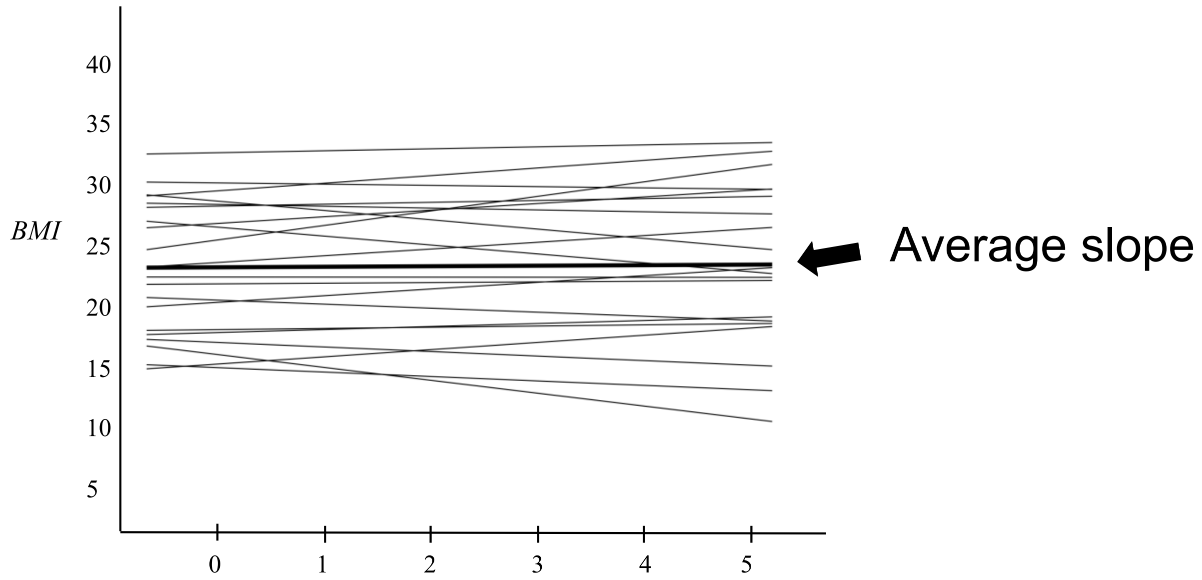


Multiple people



Statistical Analyses: Growth Curve Models

Figure 7.5. Sample of 20 predicted growth curves for change in BMI over 12 years.



Missing Data and Attrition

- Best to prevent missing data in data collection
- Can be addressed with analyses if reason is not related to the variable of interest (“missing at random assumption”)
- Best to use analysis to explore possible reasons for missing data and try to understand how missing data may affect results and conclusions

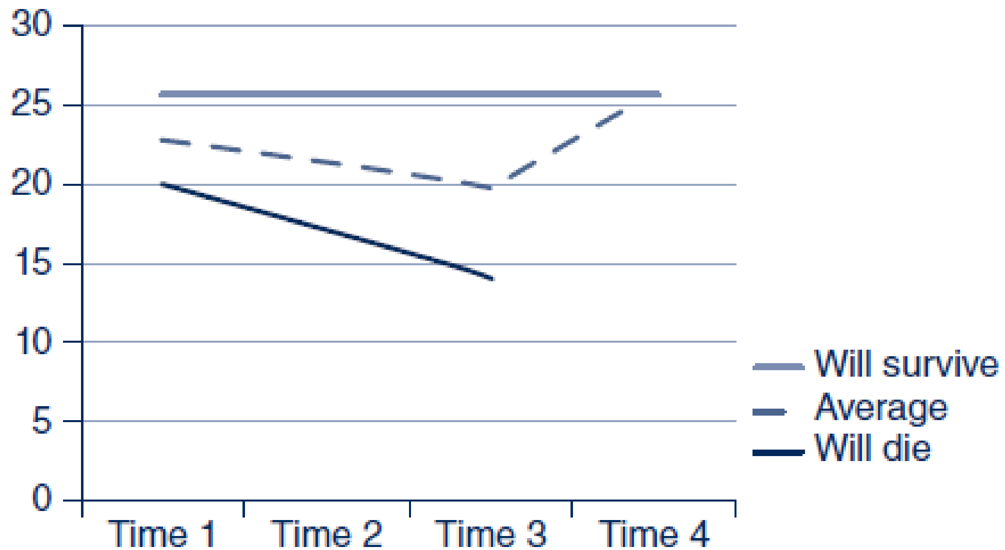
Missing Data and Attrition

Attrition special form of missing data

- Study dropout: loss of cases due to health, refusals, death
- Key is still whether those missing are different from those not missing
- Have more information than cross-sectional studies because of baseline measurements

Missing Data and Attrition

The Problem of Selective Attrition in Longitudinal Studies



Data in a longitudinal study are distorted by those who die. Here, the average appears to increase between Times 3 and 4 even though the survivors never changed.