Instructor’s Guide to Using Research Methods and Statistics Concept Maps

Alexis Grosofsky
Beloit College

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The maps in this resource (the first nine) represent the concepts that are typically covered in Research Methods and Statistics courses in psychology. The final two (previously published by OTRP) represent the computational material typically taught in psychology departments in their Statistics courses.

These maps can be handed out at the end of a section to provide students with a summary of the material covered and to use as a review/study guide when preparing for tests covering that material. Alternatively, these maps could be handed out at the beginning of a section to provide students with a “road map” about what material will be covered and how it relates to other material in the course.

Regardless of when instructors hand this out, these maps should help students organize the material in the course and see the bigger picture of how the concepts they are learning interrelate. Novice instructors could use these concept maps to help ensure that relevant topics are covered in their courses.

The maps span nine pages based on reviewer feedback to avoid overwhelming students with material as would have happened if there were only three maps (one each for concepts in descriptive statistics, inferential statistics, and research methods).

The PDFs have hyperlinks (noted in the key) tying related maps together. Instructors need not distribute the maps with functioning hyperlinks, however. In fact, if an instructor desired, she or he could give students only the main concept and subtopics and having students fill in the remainder (not unlike giving students an outline in PowerPoint® for note taking during class).
Descriptive Statistics

A branch of statistics for organizing, summarizing, and presenting information. It starts with raw data (unorganized) and can be presented with variables that can take on different values (discrete or continuous).

- **Variables**
  - can take on different values
  - can be discrete or continuous
  - IV (possible) manipulated by experimenter
  - control
  - var
  - held constant
  - DV (measured by experimenter)

- **Population**
  - subset of sample
  - parameter (numerical characteristic)
  - statistic (point estimate of the corresponding parameter value)

- **Sampling**
  - assignment to groups
  - random (if not, confounded)
  - random, stratified random, convenience

- **Scales of Measurement**
  - nominal (categories)
  - ordinal (previous + magnitude info)
  - interval (previous + equal units)
  - ratio (previous + true zero)

issues to consider:
- valid?
- does it measure what it claims?
- reliable?
- does it give the same result each time?

related to precision
related to accuracy

- **Parameter**
- **Statistic**

- **Population**
- **Sample**

- **Bias**
  - biased (not representative)
  - unbiased (representative)

- **Variables**
  - manipulated by experimenter
  - held constant

- **IV**
- **DV**

- **Nominal**
- **Ordinal**
- **Interval**
- **Ratio**

- **Scales of Measurement**

- **Reliability**
- **Validity**

- **Sampling**

- **Random**
- **Stratified Random**
- **Convenience**

- **Random**
- **Stratified Random**
- **Convenience**

- **With or without replacement**

- **See Research Methods concept map**

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**Key**

- main concept
- subtopic
- secondary subtopic
- note/explanation
- procedural note

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created by Alexis Grosofsky, Ph.D.
Psychology Department
Beloit College
2012
Descriptive Statistics

central tendency
(location)

variability
(spread)

single numbers
give info about
can be converted into
transformed scores
can allow direct comparisons from different distributions
percentile rank
e.g., deciles (10 even parts) IQR = 1st & 3rd quartiles
z score (i.e., standard score)
z distribution mean = 0, std dev = 1
mode
most frequently occurring score
median
use with skewed distributions middle score i.e., 50th percentile
mean (μ, x̄, or M)
uses numerical value of all scores, so outliers have large effect
sum of deviations from mean = 0
squared deviations from mean smaller than from any other #
range
uses only highest and lowest scores
variance
reported in squared units
std deviation (σ, s or SD)
sqrt of variance (reported in original units)
central tendency + variability into lose 1 degree of freedom w/ sample corrected by N-1 in denominator
decide which to use by knowing scale of measurement
scales of measurement
statistics decision aid

Key

main concept

subtopic

secondary subtopic

note/explanation

procedural note

hyperlink

created by Alexis Grosofsky, Ph.D.
Psychology Department
Beloit College
2012
Descriptive Statistics

- **Tables**
  - Reg freq distribution
  - Cumulative freq dist
  - Relative (percentage) freq dist
  - Cumulative percentage freq dist
  - Grouped freq distribution
  - 5-number display
  - Same data

- **Graphs**
  - Box & whiskers plot
  - Same data
  - Can provide info about
  - Shape of distribution
  - cannon differ in
  - Means + std deviation or std error
  - "Outcome"
  - Mean-on-spoke
  - T-on-bar
  - Frequency polygon
  - Relative (%age) freq polygon
  - Cf polygon
  - Stem and leaf
  - Hybrid (table & graph features)

- **General rules**
  - Label axes meaningfully
  - Y axis = ⅔ size of X
  - Use dashes before color
  - Strive for visual clarity

- **Bar graph**
  - Qualitative, discrete data

- **Histogram**
  - Continuous data

- **Line graph**

- **Alphabetical mnemonic**:
  - H (horizontal)
  - V (vertical)
  - Similarly...

- **Gaussian (i.e., normal)**
  - If “normal”...
  - Mod = unimodal
  - Skew = symmetrical (neither pos nor neg)
  - Kurtosis = mesokurtic (bell-shaped)

- **Lepto-, meso-, or platykurtic**

- **Uni-, bi-, or trimodal**

- **Mode = unimodal**
  - Skew = symmetrical (neither pos nor neg)
  - Kurtosis = mesokurtic (bell-shaped)

- **Meaningful labeling**
  - Created by Alexis Grosofsky, Ph.D.
  - Psychology Department
  - Beloit College
  - 2012
Inferential Statistics is a branch of statistics for drawing conclusions about populations from samples thereof. It uses the goal of achieving a good representation of the population, which leads to statistical approaches that assess the likelihood of events occurring just by chance, often expressed as proportions ranging from 0 (never) to 1 (absolutely certain). With more observations, results become closer to what is expected in the long run, on the average. The central limit theorem (CLT) states that the sampling distribution of a statistic will approach normality regardless of the population's shape, provided the sample size is sufficiently large (typically n ≥ 30). Therefore, classical/frequentist (which uses theoretical probabilities) and Bayesian (which uses prior/subjective probabilities) statistical approaches can be utilized. The sampling distribution of a statistic, such as the mean, is characterized by SEM (standard error of the mean), which is the standard deviation of individual observations divided by the square root of the sample size: SEM = σ/√N. SEM properties mean centered on μ, with larger n leading to less variability. Probability distributions can be subject to errors, such as the gambler’s fallacy and conjunction fallacy.
Inferential Statistics

two main categories of tests

parametric

null (H₀)

alternative (H₁)

i.e., distribution free

use when:

• assumptions of

parametric test violated

advantage:

less power

dominant approach

non parametric

null hypothesis testing (NHST)

actual Q answered = given the H₀ is true, what’s the prob of these (or more extreme) data? P(E | H) (deductive approach: from pop to sample)

common misperception: significance is about the likelihood that the H₀ is true given these data P(H | E) (inductive approach: from sample to pop)

retain or reject H₀ if rejected

possible outcomes

significance

statistical

i.e., practical

is result important? meaningful?

substantive

i.e., practical

is result important? meaningful?

if statistically significant

if not statistically significant

does not mean finding is:

• large

• important

• in expected direction

results written in APA style

power affected by

determine sample size prior to research so you don’t

• spend time/money with little likelihood of rejecting H₀

• abandon good research because power is too low to reject a false H₀

sample size (larger = more)

effect size (larger = more)

alpha (.05 > .01); tails (1 > 2)

decision about H₀

retain

Type I error

p = α

Type II error

p = β

correct

p = 1 - α

correct

p = 1 - β

aka power

H₀ is actually

true

false

n too small

error variance too large

problems with IV choice/manipulation
Research Methods in Psychological Science

American Psychological Association (APA) style
- recipe for reporting research; all research follows a strict code of ethics
  - sections include
    - abstract
    - introduction
    - method
    - results
    - discussion
    - references
    - figures / tables
  - weaves tale; starts general, ends specific
  - analysis of data (descriptive before inferential)
  - all research referred to in text
  - 120-150 word summary
  - provides all info necessary to replicate
  - interprets results, implications, limitations, future directions noted
  - supporting materials not duplicated in text

ethics
- for humans
  - IRB
    - Institutional Review Board
    - evaluates such things as
      - informed consent
      - right to withdraw
      - debriefing
      - confidentiality
  - for animals
    - ACUC
      - Institutional Animal Care & Use Committee
      - food & water
      - housing
      - humane treatment
      - disposal methods

--- Key ---
- main concept
- subtopic
- secondary subtopic
- note/explanation
- procedural note
- hyperlink
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causation

changes in IV result in changes in DV

must establish time order
Cause before effect

rationale
logical reason for IV/DV link

rule out alternate explanations

observed change in DV caused by IV, not something else

correlation

only indicates a relationship between variables

be alert to possibility of lurking / 3rd variables, possible illusory relationship

observation

good for generating hypotheses

be concerned about "file-drawer" problem

can search for patterns in each via meta-analysis

statistical method for combining results of different studies

types include:
- case study
- archival research
- surveys/interviews

observed change in IV result in changes in DV

changes in IV result in changes in DV

must establish time order
Cause before effect

rationale
logical reason for IV/DV link

rule out alternate explanations

observed change in DV caused by IV, not something else

Research Methods in Psychological Science

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Psychology Department
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Research Methods in Psychological Science

Ways of knowing
- Tenacity / intuition
  - It's always been that way
- Authority
  - Expert / person with power says it's so
- A priori method / rationalism
  - Use logic
- Experience
  - Use prior knowledge from similar situations / events

Hypotheses
- Testable predictions about behavior

Operational definitions

Science
- Knowledge gained through systematic observation & experimentation
- Psychology uses this one
  - Characteristics
    - Empirical
    - Falsifiable
    - Self-correcting
    - Parsimonious
    - Cumulative
    - Replicable
    - Peer-reviewed
    - Concerned with theory

Versus pseudoscience
- Some characteristics
  - Not open to criticism
  - Relies on testimony / anecdote
  - Uses scientific sounding pseudo-jargon
  - Shifts burden of proof to others
  - Doesn't rule out alternative explanations

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are your findings repeatable?

**general research concerns**
- do you have enough participants? (power)
- do you have the “right” participants?
- have you asked the “right” question(s)?
- have you made the “right” comparison(s)?

**measurement error**
- systematic
- random

**bias**
- subject
- experimenter
- help control with
  - single- or double-blind procedure
  - expectancy effects

**validity**
- are you measuring what you claim?
  - internal
  - deals with causality
  - threats involve
    - history
    - statistical regression
    - selection
    - mortality / attrition
  - construct
  - deals with generalizing to higher-order constructs
  - threats involve
    - confounds

**reliability**
- are your findings repeatable?
  - test-retest
  - split-half
  - inter-rater
  - external
  - deals with generalizing across persons, settings, times
  - threats involve
    - effects of testing
      - non-representative samples
    - interaction of selection and treatment
    - interaction of setting and treatment
    - interaction of history and treatment

**research methods in psychological science**
- general research concerns
- measurement error
- bias
- validity
- reliability
- general research concerns
- measurement error
- bias
- validity
- reliability

**key**
- main concept
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*created by Alexis Grosofsky, Ph.D. Psychology Department Beloit College 2012*
## Decision Aid: Descriptive Statistics

### Selection

<table>
<thead>
<tr>
<th>Type of Description</th>
<th>Scale of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal</td>
</tr>
<tr>
<td>central tendency</td>
<td>mode</td>
</tr>
<tr>
<td>variability</td>
<td>not applicable</td>
</tr>
<tr>
<td>relationship</td>
<td>Cramer’s V (for two dichotomous variables*) or tetrachoric correlation (if variables are not truly dichotomous**)</td>
</tr>
</tbody>
</table>

* dichotomous variable: only two categories exist (e.g., male-female, yes-no, pet owner-not owner)
** not truly dichotomous: actually on a continuum, but combined into only two categories (e.g., anxiety: high-low)

### Display

<table>
<thead>
<tr>
<th>Scale of Measurement</th>
<th>Type of Display</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Table</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal or Ordinal</td>
<td>simple freq. distribution</td>
</tr>
<tr>
<td></td>
<td>cumulative freq. distribution</td>
</tr>
<tr>
<td></td>
<td>grouped freq. distribution (simple or cumulative)</td>
</tr>
<tr>
<td>Interval or Ratio</td>
<td>simple freq. distribution percentage (i.e., relative) freq. dist.</td>
</tr>
<tr>
<td></td>
<td>cumulative freq. distribution</td>
</tr>
<tr>
<td></td>
<td>grouped freq. distribution (simple or cumulative)</td>
</tr>
<tr>
<td></td>
<td>5-number summary</td>
</tr>
<tr>
<td></td>
<td>stem and leaf plot (hybrid table/graph)</td>
</tr>
<tr>
<td></td>
<td>freq. bar graph (discrete data)</td>
</tr>
<tr>
<td></td>
<td>freq. histogram (continuous data)</td>
</tr>
<tr>
<td></td>
<td>freq. polygon (all varieties) (continuous data)</td>
</tr>
<tr>
<td></td>
<td>bar graph (with variability/error information)</td>
</tr>
<tr>
<td></td>
<td>mean dot (with variability/error information)</td>
</tr>
</tbody>
</table>