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

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Supported by a 2011 Instructional Resource Award

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).

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Concept Map: Descriptive Statistics

branch of statistics for organizing, summarizing, presenting information

starts with

raw data (unorganized)

can be presented with

variables

can take on different values

can be

discrete or continuous

IV ← possible — control var

manipulated by experimenter

held constant

DV

measured by experimenter

population — subset of → sample

can be

biased (not representative)

unbiased (representative)

parameter

numerical characteristic

statistic

is a

point estimate of the corresponding parameter value

assignment to groups → random

if not, confounded

obtained by

sampling

random

with or without replacement

stratified random

convenience

issues to consider: is measure

reliable?

does it give the same result each time?

valid?

does it measure what it claims?

related to

precision

related to

accuracy

see Research Methods concept map

scales of measurement

nominal

categories

ordinal

previous + magnitude info

interval

previous + equal units

ratio

previous + true zero

treated the same

- - - - - - - Key - - - - - - -

main concept

subtopic

secondary subtopic

note/explanation

procedural note

hyperlink

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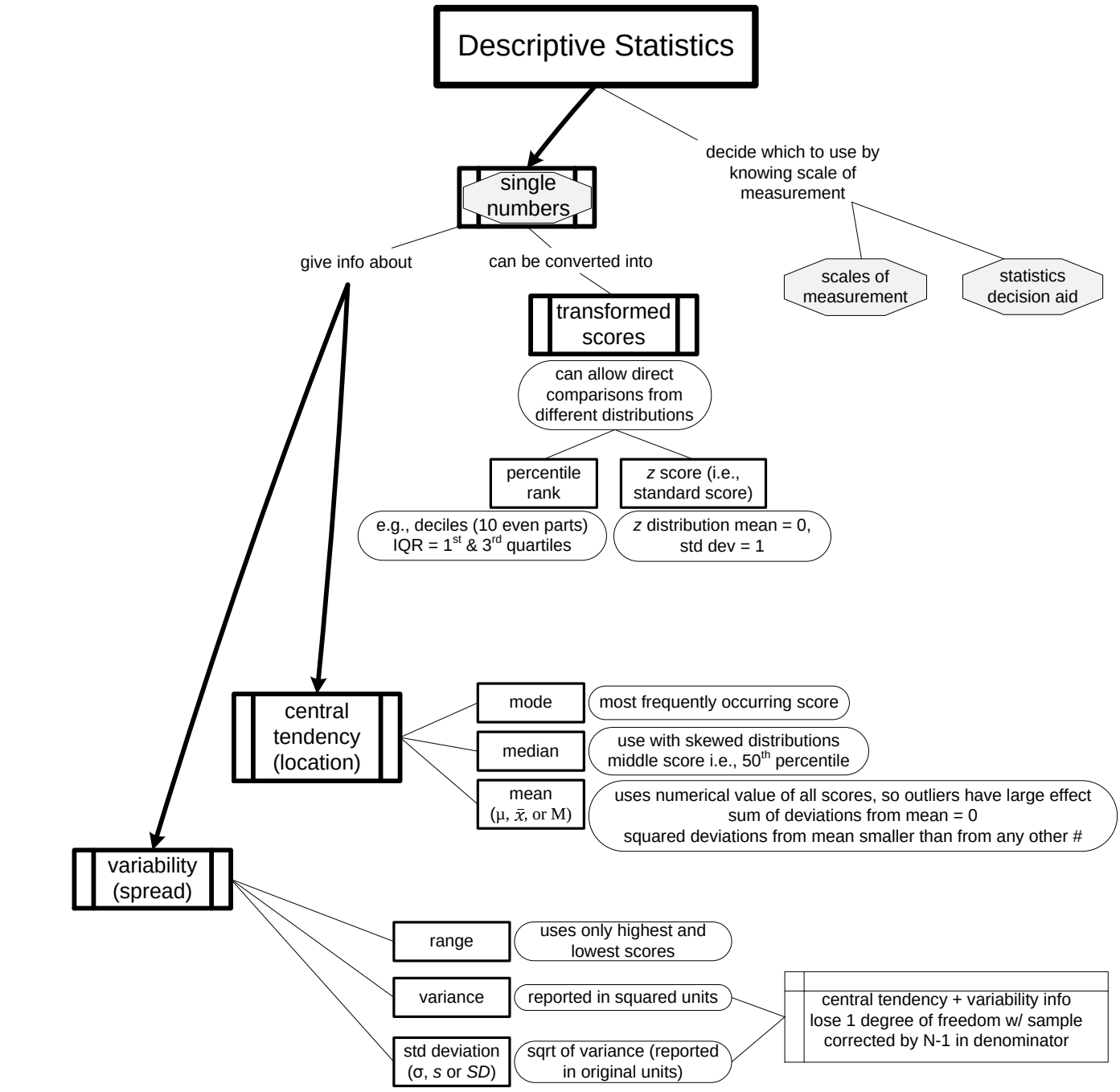
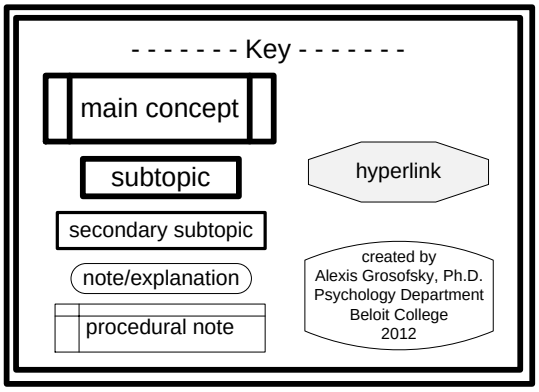

Descriptive Statistics
single numbers
decide which to use by knowing scale of measurement
scales of measurement
statistics decision aid
give info about
can be converted into
transformed scores
can allow direct comparisons from different distributions
percentile rank
z score (i.e., standard score)
e.g., deciles (10 even parts)
IQR = 1st & 3rd quartiles
z distribution mean = 0,
std dev = 1
central tendency (location)
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 #
variability (spread)
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 info
lose 1 degree of freedom w/ sample
corrected by N-1 in denominator


- - - - - - - Key - - - - - - -
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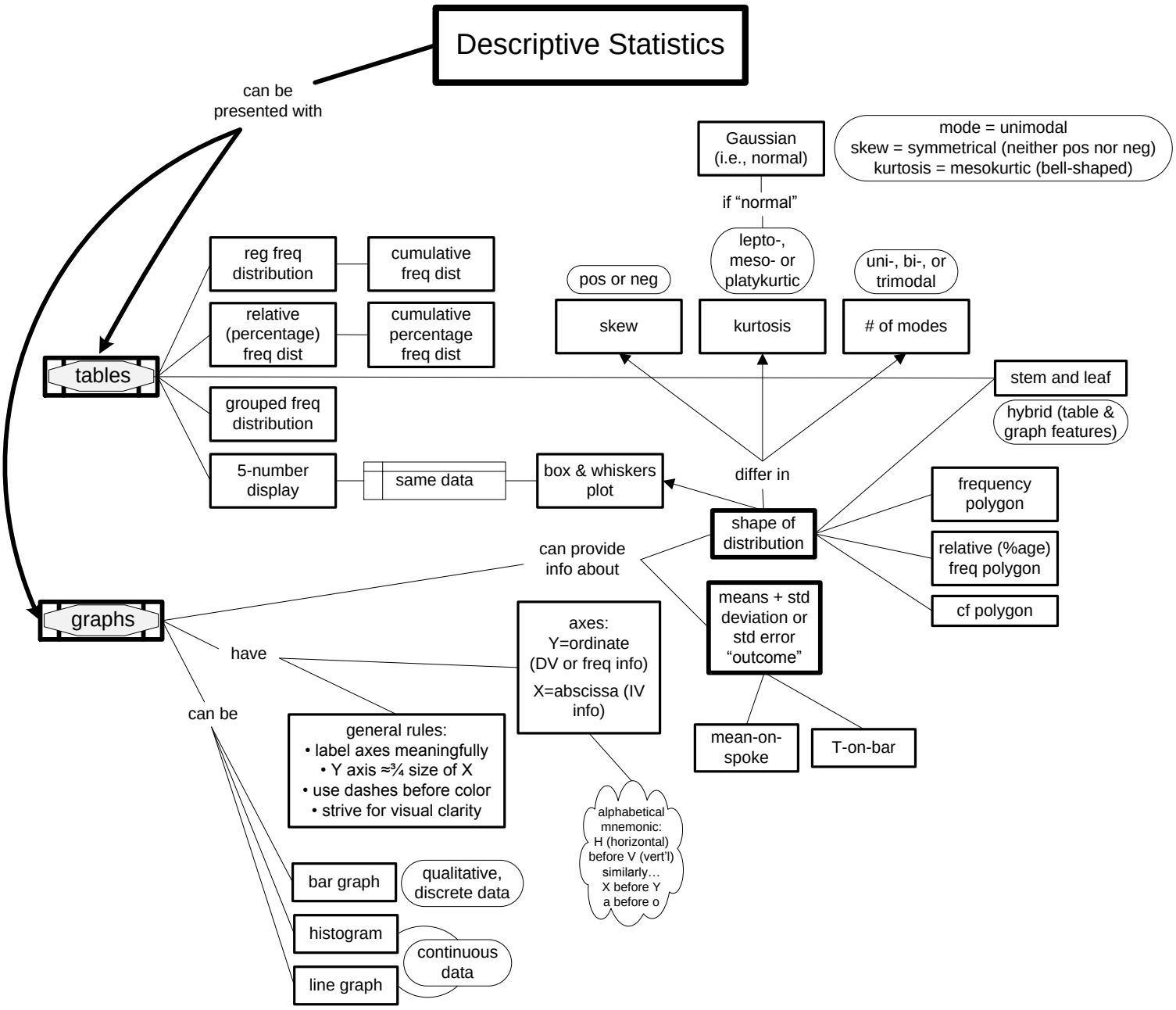
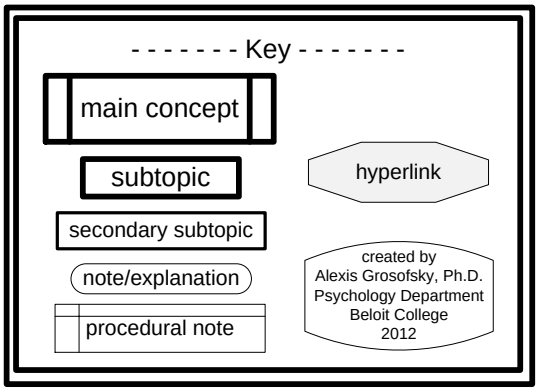

Descriptive Statistics
can be presented with
tables
graphs
reg freq distribution
cumulative freq dist
relative (percentage) freq dist
cumulative percentage freq dist
grouped freq distribution
5-number display
same data
box & whiskers plot
stem and leaf
hybrid (table & graph features)
Gaussian (i.e., normal)
mode = unimodal
skew = symmetrical (neither pos nor neg)
kurtosis = mesokurtic (bell-shaped)
if "normal"
pos or neg
skew
lepto-, meso- or platykurtic
kurtosis
uni-, bi-, or trimodal
# of modes
differ in
shape of distribution
frequency polygon
relative (%age) freq polygon
cf polygon
means + std deviation or std error "outcome"
mean-on-spoke
T-on-bar
can provide info about
have
can be
axes:
Y=ordinate (DV or freq info)
X=abscissa (IV info)
alphabetical mnemonic:
H (horizontal) before V (vert'l)
similarly…
X before Y
a before o
general rules:
• label axes meaningfully
• Y axis ≈¾ size of X
• use dashes before color
• strive for visual clarity
bar graph
qualitative, discrete data
histogram
continuous data
line graph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Concept Map: Inferential Statistics

branch of statistics for drawing conclusions about populations from samples thereof

uses

yield raw data

samples

goal = good representation of population

see descriptive decision aid

fundamental concepts

lead to

sampling distributions

distribution of a statistic (vs individual observations)
std deviation = std error of statistic (e.g., std error of the mean: SEM)

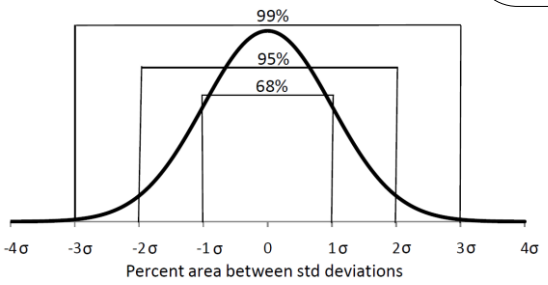
SEM properties

mean centered on μ
lgr n → less variability

$$SEM = \sigma_{\bar{x}} = \frac{\sigma}{\sqrt{N}}$$

central limit theorem (CLT)

the larger the sample, the more a sampling distribution will approach normality regardless of shape of population it's drawn from
(requires n approx. 30)
thus, can use parametric statistics (based on normal curve)



probability

likelihood of event occurring just by chance
often expressed as a proportion (0=*never* to 1=*absolutely certain*)
more observations = closer to expected
("in the long run, on the average")

human reasoning

subject to errors, e.g.,
gambler's fallacy
conjunction fallacy

statistical approaches

classical/ frequentist (uses theoretical probabilities)

Bayesian (uses prior / subjective probabilities)

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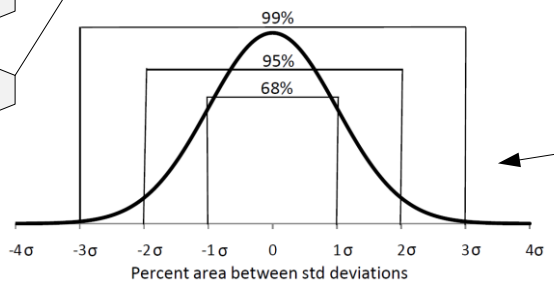
Inferential Statistics

two main categories of tests

decide which to use by knowing scale of measurement

- scales of measurement
- inferential decision tree



parametric

assumptions:
- interval or ratio data
- normal distribution
- homogeneity of variance
- random selection

advantage:
fairly robust to violations

non parametric

i.e., distribution free
use when:
- assumptions of parametric test violated

disadvantage:
less power

see inferential decision tree

have

hypotheses

dominant approach

null hypothesis significance testing (NHST)

actual Q answered = given the H_0 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 H_0 is true given these data P(H | E)
(inductive approach: from sample to pop)

- **null (H_0)**: there will be no effect ($\mu_1=\mu_2$)
- **alternative (H_1)**: there will be an effect ($\mu_1\neq\mu_2$)

expected direction of results

- nondirectional i.e., 2-tailed
- directional i.e., 1-tailed

retain or reject H_0

possible outcomes

decision about H_0	H_0 is actually true	H_0 is actually false
retain	correct p=1-α	Type II error p=β
reject	Type I error p=α	correct p=1-β aka power

power affected by

- sample size (larger = more)
- effect size (larger = more)
- alpha (.05 > .01); tails (1 > 2)

determine sample size prior to research so you don't
- spend time/money with little likelihood of rejecting H_0
- abandon good research because power is too low to reject a false H_0

if rejected

significance

- **statistical**: based solely on probability
- **substantive**: i.e., practical is result important? meaningful?

independent of one another

if statistically significant

does not mean finding is:
- large
- important
- in expected direction

if not statistically significant

does not mean H_0=T
could mean:
- n too small
- error variance too large
- problems with IV choice/manipulation

results written in APA style

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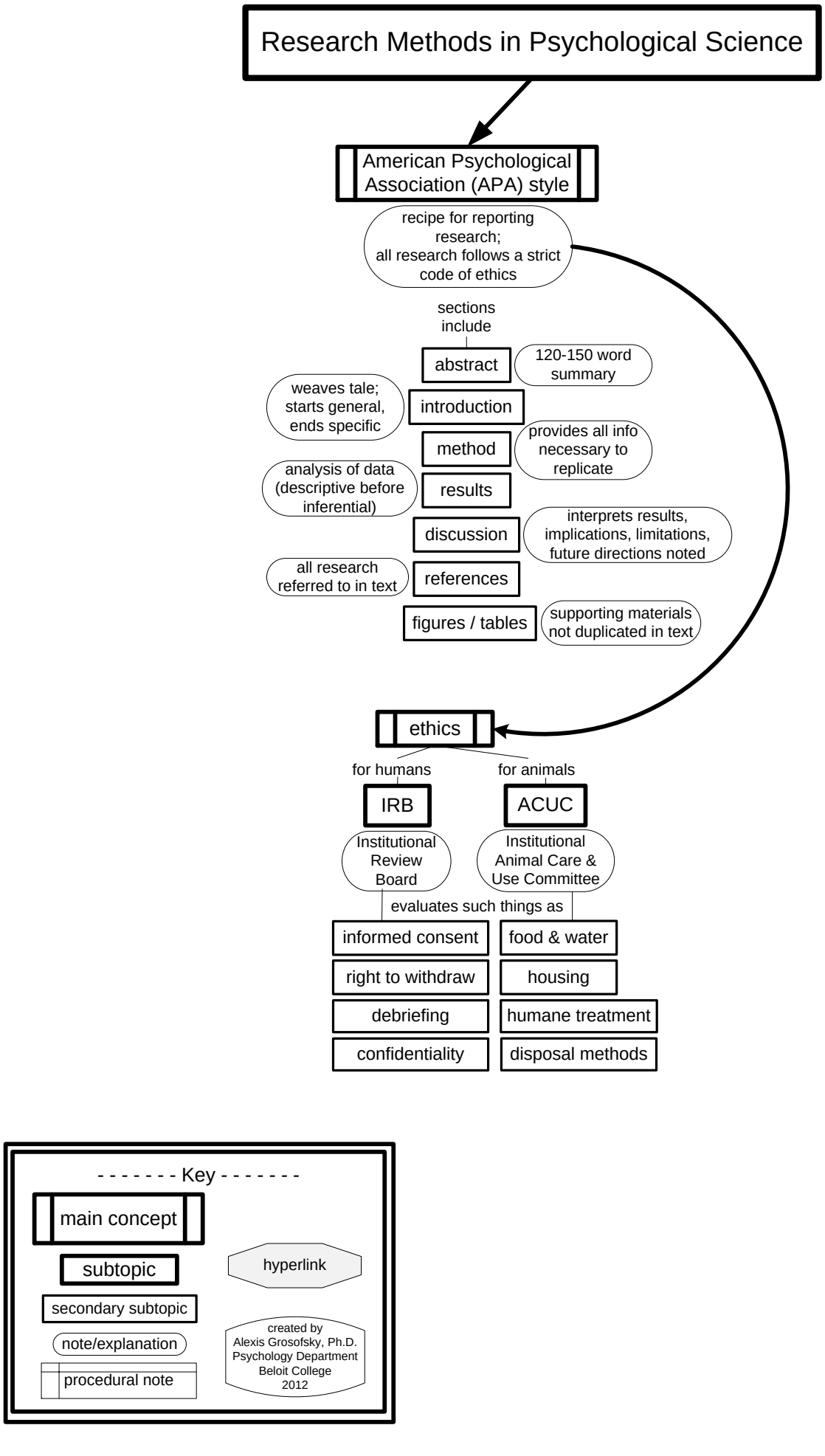
Research Methods in Psychological Science
American Psychological Association (APA) style
recipe for reporting research; all research follows a strict code of ethics
sections include
abstract
120-150 word summary
introduction
weaves tale; starts general, ends specific
method
provides all info necessary to replicate
results
analysis of data (descriptive before inferential)
discussion
interprets results, implications, limitations, future directions noted
references
all research referred to in text
figures / tables
supporting materials not duplicated in text
ethics
for humans
for animals
IRB
ACUC
Institutional Review Board
Institutional Animal Care & Use Committee
evaluates such things as
informed consent
right to withdraw
debriefing
confidentiality
food & water
housing
humane treatment
disposal methods
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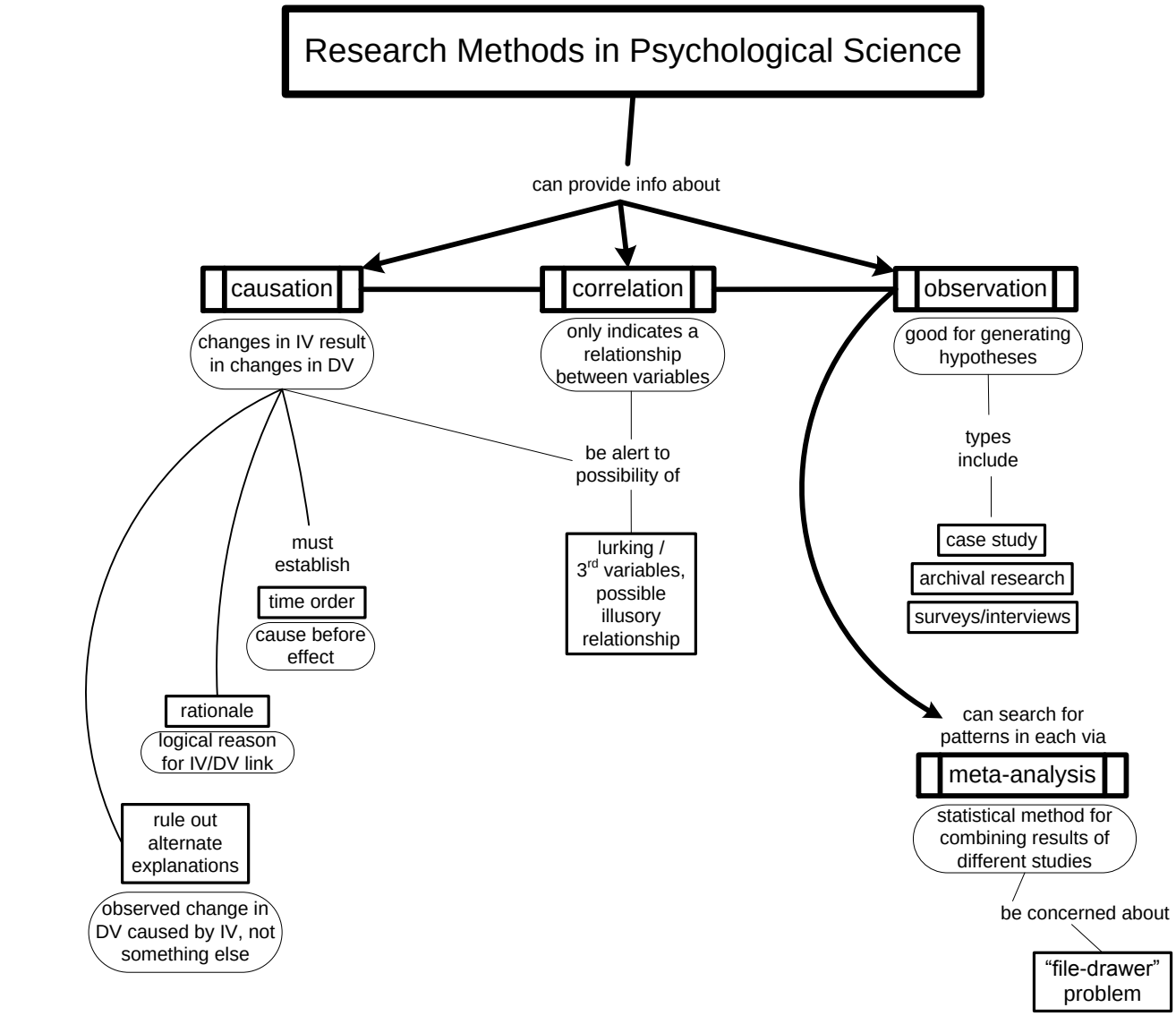
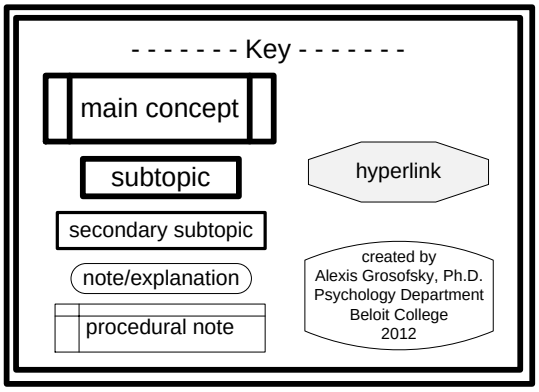

Research Methods in Psychological Science
can provide info about
causation
correlation
observation
changes in IV result in changes in DV
only indicates a relationship between variables
good for generating hypotheses
be alert to possibility of
types include
must establish
time order
cause before effect
lurking / 3rd variables, possible illusory relationship
case study
archival research
surveys/interviews
rationale
logical reason for IV/DV link
can search for patterns in each via
meta-analysis
statistical method for combining results of different studies
rule out alternate explanations
observed change in DV caused by IV, not something else
be concerned about
"file-drawer" problem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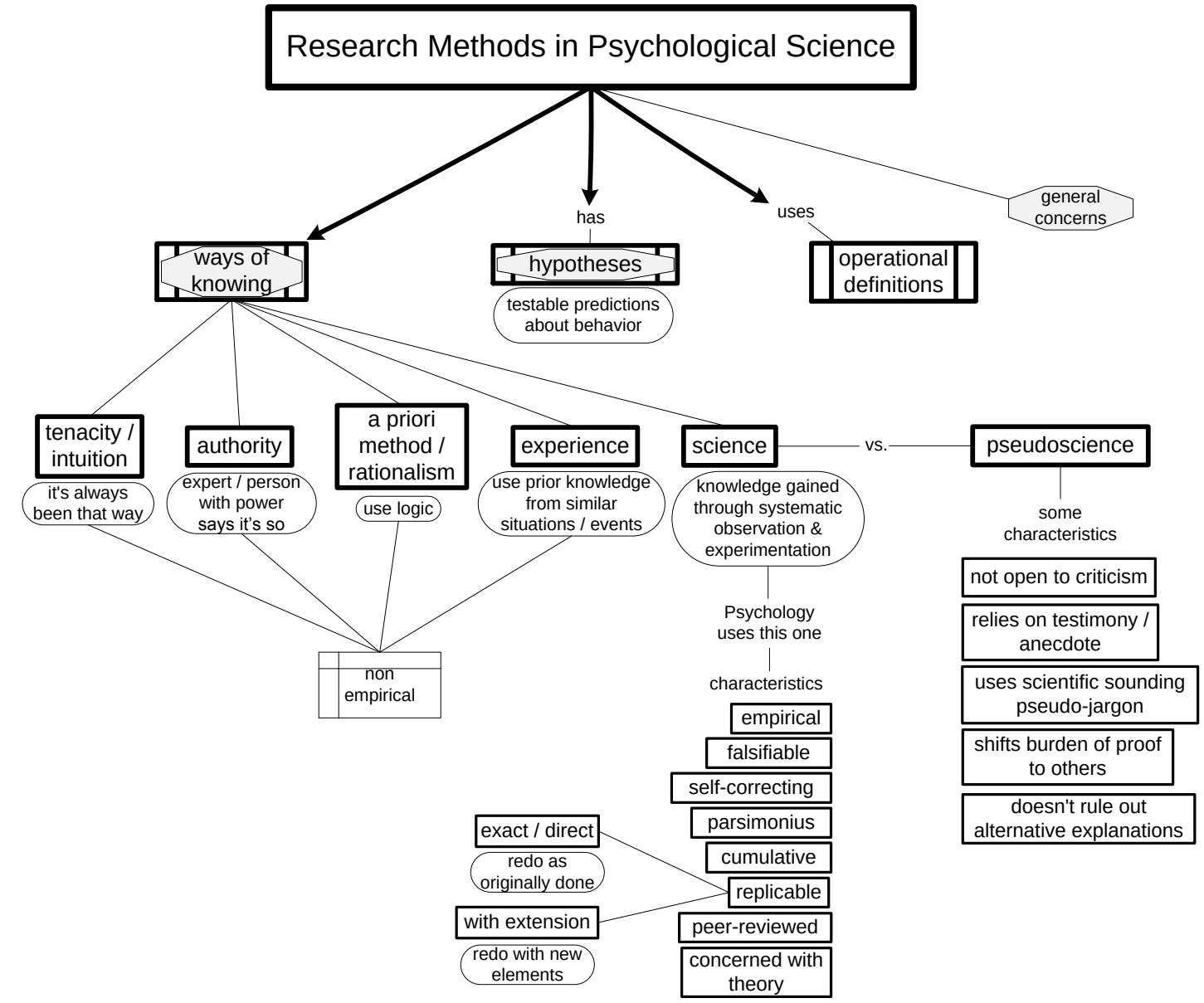
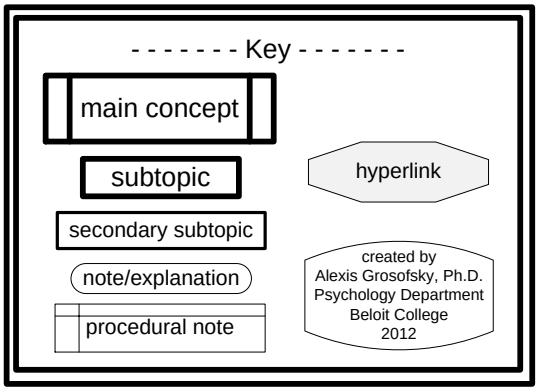

Research Methods in Psychological Science
has
uses
general concerns
ways of knowing
hypotheses
testable predictions about behavior
operational definitions
tenacity / intuition
it's always been that way
authority
expert / person with power says it's so
a priori method / rationalism
use logic
experience
use prior knowledge from similar situations / events
science
vs.
pseudoscience
knowledge gained through systematic observation & experimentation
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
non empirical
Psychology uses this one
characteristics
empirical
falsifiable
self-correcting
parsimonius
cumulative
replicable
peer-reviewed
concerned with theory
exact / direct
redo as originally done
with extension
redo with new elements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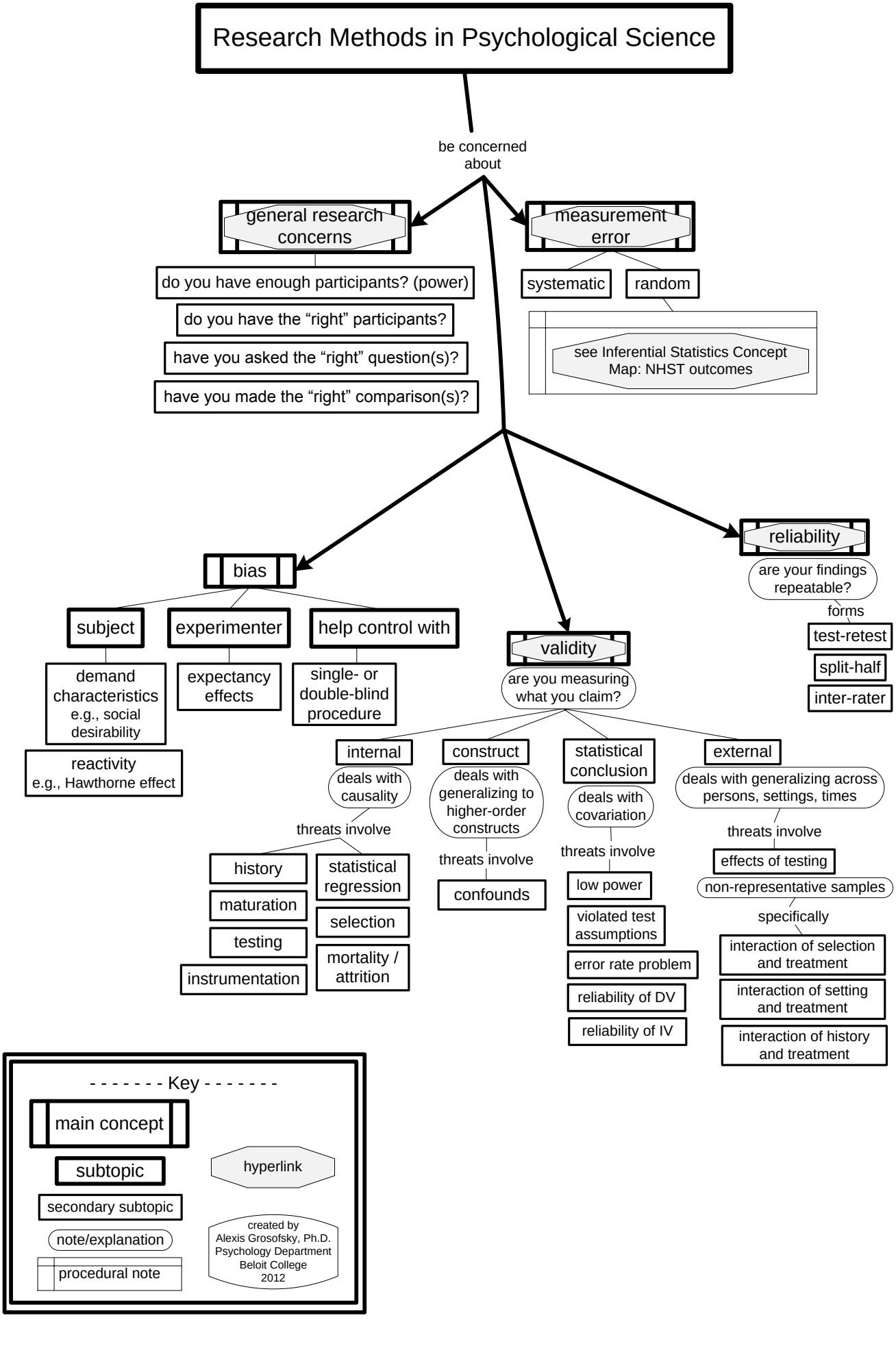
Research Methods in Psychological Science
be concerned about
general research concerns
do you have enough participants? (power)
do you have the "right" participants?
have you asked the "right" question(s)?
have you made the "right" comparison(s)?
measurement error
systematic
random
see Inferential Statistics Concept Map: NHST outcomes
bias
subject
demand characteristics e.g., social desirability
reactivity e.g., Hawthorne effect
experimenter
expectancy effects
help control with
single- or double-blind procedure
validity
are you measuring what you claim?
internal
deals with causality
threats involve
history
maturation
testing
instrumentation
statistical regression
selection
mortality / attrition
construct
deals with generalizing to higher-order constructs
threats involve
confounds
statistical conclusion
deals with covariation
threats involve
low power
violated test assumptions
error rate problem
reliability of DV
reliability of IV
external
deals with generalizing across persons, settings, times
threats involve
effects of testing
non-representative samples
specifically
interaction of selection and treatment
interaction of setting and treatment
interaction of history and treatment
reliability
are your findings repeatable?
forms
test-retest
split-half
inter-rater
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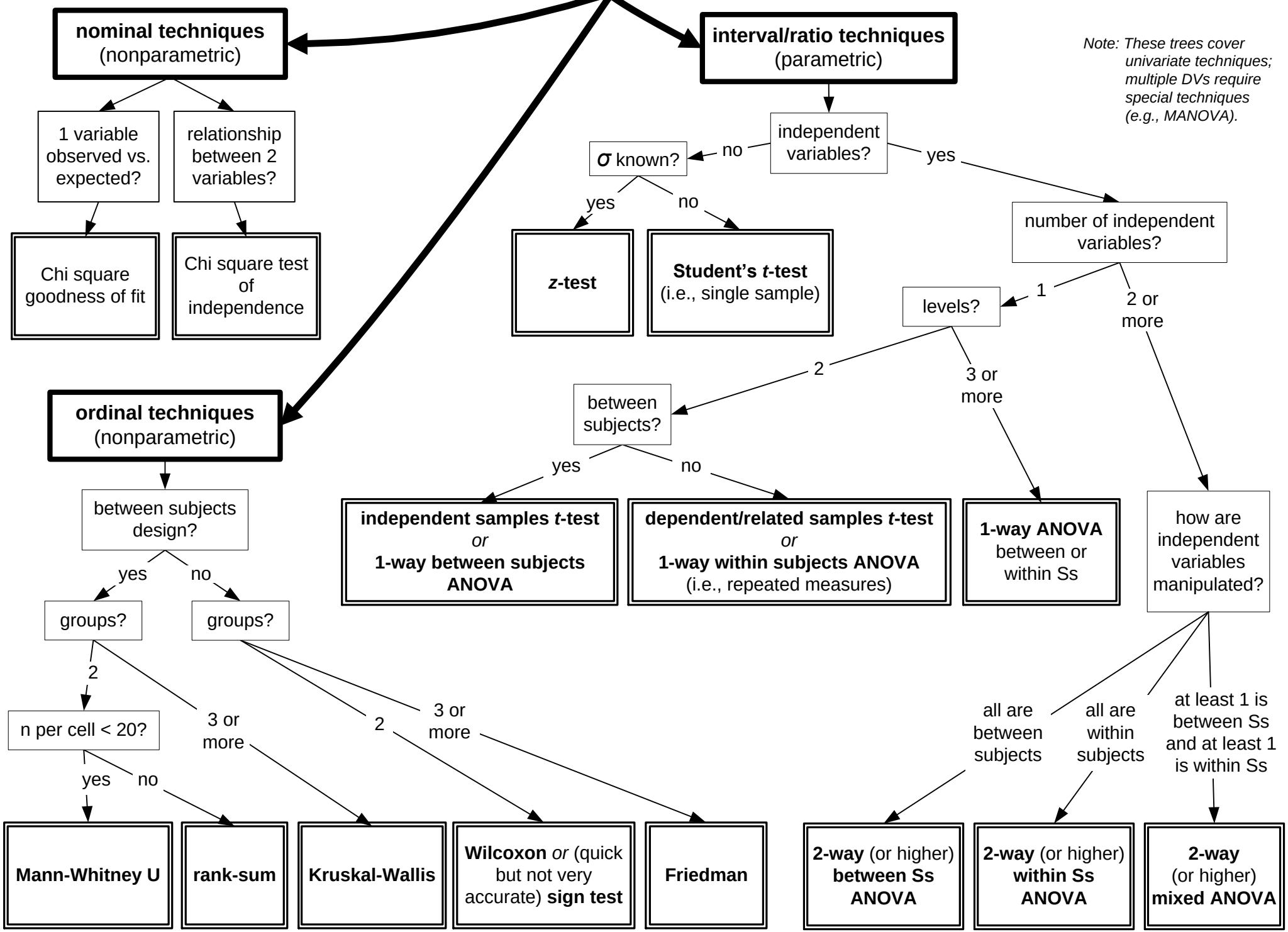
Decision Tree: Inferential Statistics

Note: These trees cover univariate techniques; multiple DVs require special techniques (e.g., MANOVA).



Decision Aid: Descriptive Statistics

Selection

Type of Description	Scale of Measurement		
	Nominal	Ordinal	Interval/Ratio
central tendency	**mode**	**mode, median**	**mode, median, mean**
variability	not applicable	**range, semi-interquartile range**	**range, semi-interquartile range, standard deviation, variance**
relationship	**Cramer's V** (for two dichotomous variables*) or **tetrachoric correlation** (if variables are not truly dichotomous**)	**Spearman rank order correlation**	**Pearson product-moment correlation**

relationship between nominal (categorical/ dichotomous) and interval/ ratio variables	**point-biserial correlation** or (if variables are not truly dichotomus**) **biserial correlation**

*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

Scale of Measurement	Type of Display			
	Table	Graph		
		Shape	Outcome	Relationship
Nominal or Ordinal	simple freq. distribution cumulative freq. distribution grouped freq. distribution (simple or cumulative)	pie chart frequency bar graph	bar graph	scatterplot
Interval or Ratio	simple freq. distribution percentage (i.e., relative) freq. dist. cumulative freq. distribution grouped freq. distribution (simple or cumulative) 5-number summary stem and leaf plot (hybrid table/graph)	pie chart box & whiskers (i.e., boxplot) freq. bar graph (discrete data) freq. histogram (continuous data) freq. polygon (all varieties) (continuous data)	bar graph (with variability/error information) mean dot (with variability/error information)	

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