Single-Factor Experimental Designs

Chapter 8

Experimental Control

- manipulation of one or more IVs
- measured DV(s)
- everything else held constant

Causality and Confounds

What are the three criteria that must be met in order to make a causal inference?

- covariation of X and Y
- temporal order
- absence of plausible alternative explanations

What is a confounding variable?

- a factor that covaries with the IV
- cannot tell whether the IV or the confound affects the DV

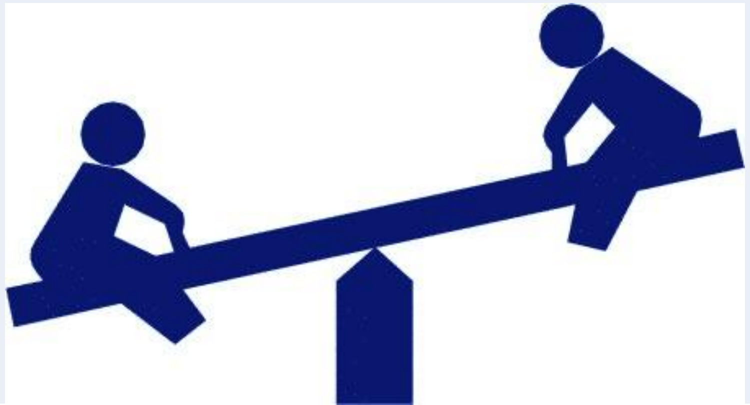
Confounding Variables

- many environmental factors can be held constant
- those environmental factors that cannot be held constant (e.g., time of day) can be balanced across different experimental conditions

Confounding Variables

- confounds dealing with participant characteristics (e.g., personality, age) are further addressed through experimental design

- one major distinction to attend to is whether a **between-subjects design** or a **within-subjects design** is used

Research Design	Description	Confounds minimized through…
Between-subjects	Different participants in each condition	Random assignment
Within-subjects	Participants encounter all levels of experiment	Counterbalancing 

Manipulating an IV

- Quantitative vs. Qualitative Manipulation
  - Quantitative Manipulations
    - variations in amount of independent variable
      - e.g., 0 mg, 10 mg, 20 mg, or 50 mg of a drug
  - Qualitative Manipulations
    - variations in type of independent variable
      - e.g., exposed to rock, jazz, new-age, or classical music

Between-Subject Designs

- subjects serve in just one of the possible experimental groups

Advantages
- subjects are naïve to the experimental hypothesis
- no carryover effects
- used where exposure to multiple levels of the IV may be impossible or ethically and practically difficult

Disadvantages
- require large number of subjects
- between-subject differences contribute to “noise” reducing efficiency
- creating equivalent groups

Within-Subjects (Repeated Measures) Designs

- subjects serve in all experimental conditions

Advantages

- require fewer subjects
- more sensitive/powerful
- don’t have to worry about non-equivalent groups

Within-Subjects (Repeated Measures) Designs

Disadvantages

- increased risk of contamination
- possible order/sequence effects
  - progressive effects
    - produce changes in participants’ responses due to their cumulative participation in the experiment
  - carryover effects
    - occur when participants’ responses in one condition are affected by the prior condition

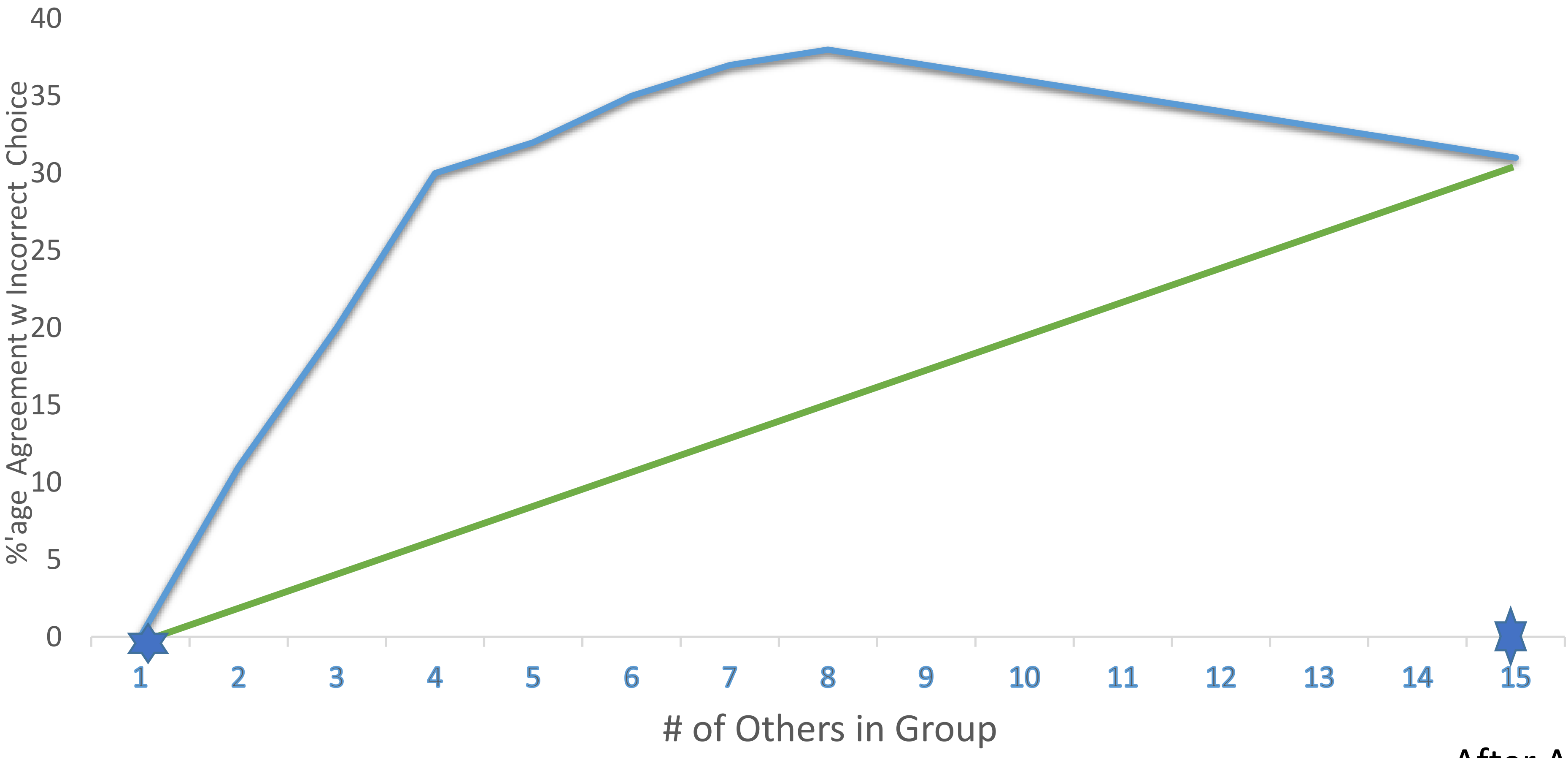
Single-Factor Designs: Number of Levels

Experimental and Control Conditions

- participants in an **experimental condition** are exposed to a "treatment"
- participants in a **control condition** do not receive the treatment

Single-Factor Designs: Number of Levels

Evaluating Non-Linear Effects



After Asch, 1955

Varieties of Between-Subjects Designs

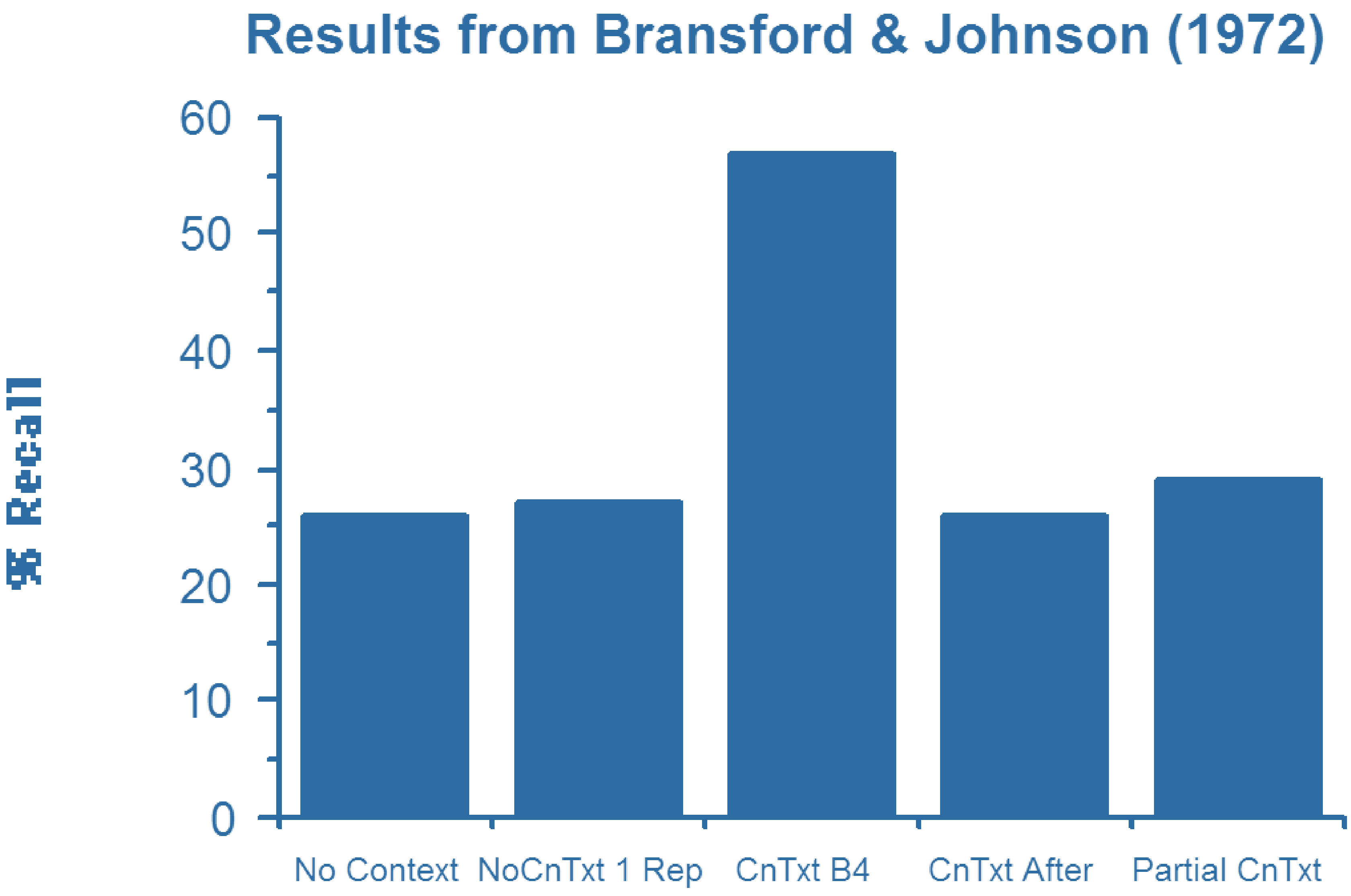
Independent Groups

- Blakemore & Cooper (1970)

Multilevel Independent Groups

Bransford and Johnson (1972)

- five conditions:
    a) No Context (0 Repetition)
    b) No Context (1 Repetition)
    c) Context Before
    d) Context After
    e) Partial Context Before


Results from Bransford & Johnson (1972)
% Recall
60
50
40
30
20
10
0
No Context
NoCnTxt 1 Rep
CnTxt B4
CnTxt After
Partial CnTxt

Varieties of Between-Subjects Designs

Matched Groups

- identify a relevant characteristic (a matching variable) and randomly assign participants to conditions based on their standing (e.g., high, average, low) on this characteristic

- possible confounds may be used as matching variables

Varieties of Between-Subjects Designs

Matched Groups

- Fletcher & Atkinson (1972)

Varieties of Between-Subjects Designs

Nonequivalent Groups/Natural-Groups/Quasi-Experiments

- different groups of participants based on naturally occurring attributes called **subject variables**
  - e.g., age, classroom, gender

- subject variables often referred to as *quasi*-independent variables

  - e.g., Knepper, Obrzut, & Copeland (1983)

Varieties of Between-Subjects Designs

Block randomization

- run through random order of blocks (rounds of conditions) until desired sample size reached
- ensures equal number of subjects in each of the groups

Block
1
S1:Cond 3
S2:Cond 1
S3:Cond 4
S4:Cond 2

Varieties of Between-Subjects Designs

Block randomization

- run through random order of blocks (rounds of conditions) until desired sample size reached
- ensures equal number of subjects in each of the groups
-

Block			
1	2	3	4
S1:Cond 3	S5:Cond 3	S9:Cond 2	S13:Cond 1
S2:Cond 1	S6:Cond 4	S10:Cond 1	S14:Cond 4
S3:Cond 4	S7:Cond 2	S11:Cond 3	S15:Cond 2
S4:Cond 2	S8:Cond 1	S12:Cond 4	S16:Cond 3

Concept Clarification

- ***What is the difference between random sampling and random assignment?***

Random Sampling vs. Random Assignment

Table 8.3 Difference Between Random Sampling and Random Assignment

	Random Sampling	Random Assignment (in experiments)
Description	Each member of a population has an equal probability of being selected into a sample chosen to participate in a study.	People who have agreed to participate in a study are assigned to the various conditions of the study on a random basis. Each participant has an equal probability of being assigned to any particular condition.
Example	From a population of 240 million adults in a nation, a random sample of 1,000 people is selected and asked to participate in a survey.	After a college student signs up for an experiment (e.g., to receive extra course credit or meet a course requirement), random assignment is used to determine whether that student will participate in an experimental or control condition.
Goal	To select a sample of people whose characteristics (e.g., age, ethnicity, gender, annual income) are representative of the broader population from which those people have been drawn.	To take the sample of people you happen to get and place them into the conditions of the experiment in an unbiased way. Thus, prior to exposure to the independent variable, we assume that the groups of participants in the various conditions are equivalent to one another overall

Varieties of Within-Subjects Designs

Single-Factor Design – Two Levels

Lee & Aronson (1974)

Within-Subjects (Repeated Measures), Multilevel Designs

Kosslyn, Ball, and Reiser, (1978)

Within-Subjects Designs

Counterbalancing Goals

1. Every condition of the IV appears equally often in each position
2. Every condition appears equally often before and after every other condition
3. Every condition appears with equal frequency before and after every other condition *within each pair of positions in the overall sequence*

Within-Subjects Designs

All Possible Orders

- aka *complete counterbalancing*
- determine all possible sequences (*k*!) of IV conditions, and assign equal number of participants to each sequence
  - e.g., if k=4 levels of IV the 4! = 4X3X2X1=24 sequences
- all possible confounding is counterbalanced
- requires a large number of participants to satisfy all counterbalancing goals

Within-Subjects Designs

Latin Square

- design wherein matrix structured so that each condition appears only once in each column and each row

Participant	Trial 1	Trial 2	Trial 3	Trial 4
Bria	Pepsi	Shasta	Coke	RC
Tamara	Shasta	RC	Pepsi	Coke
Josh	RC	Coke	Shasta	Pepsi
Erin	Coke	Pepsi	RC	Shasta

Within-Subjects Designs

Latin Square

- accomplishes goals of all-possible-orders design *except* Goal 3
  - Every condition appears with equal frequency before and after every other condition *within each pair of positions in the overall sequence*
- if IV has odd number of conditions, cannot construct a single matrix that accomplishes Goal 2

Within-Subjects Designs

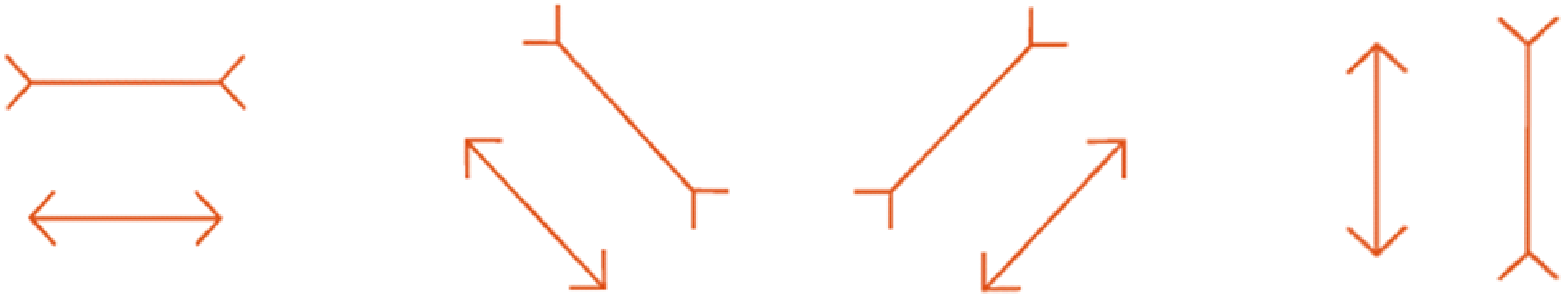
Random-Selected-Orders

- subset of orders is randomly selected from the set of all possible orders
- each order administered to one participant
- not recommended if using small number of participants

Within-Subjects Designs

Participants Exposed To Each Condition More Than Once

Research Example



A: Horizontal   B: 45° Right   C: 45° Right   D: Horizontal

Within-Subjects Designs

Participants Exposed To Each Condition More Than Once

Reverse-Counterbalancing

- aka ABBA-counterbalancing design
- participants first receive random order of all conditions
- participants then receive conditions once more in reverse order aka ABBA-counterbalancing design

Subj #1	A-B-C-D	D-C-B-A	A-B-C-D	D-C-B-A	A-B-C-D	D-C-B-A
Subj #2	D-C-B-A	A-B-D-C	D-C-B-A	A-B-C-D	D-C-B-A	A-B-C-D

- potential for non-linear order effect

Within-Subjects Designs

Participants Exposed To Each Condition More Than Once

Block-Randomization-Design

- participants encounter all conditions within a block and are exposed to multiple blocks
- each block contains a newly randomized order of conditions

Subj #1	A-D-C-B	C-B-D-A	C-D-B-A	A-D-B-C	D-C-A-B	B-C-B-A
Subj #2	C-B-A-D	D-C-B-A	C-D-B-A	D-C-B-A	A-D-B-B	B-C-A-D

Analysis of Single-Factor Designs

descriptive statistics

- e.g., means and standard deviations for each condition

Analysis of Single-Factor Designs

inferential statistics – *parametric procedures*

- if k=2 conditions and *DV at interval or ratio level*
- *between-subjects or non-equivalent groups design*
  - *independent groups t-test*
- *within-subjects and matched-groups designs*
  - *paired t-test*

http://vassarstats.net/tu.html

Analysis of Single-Factor Designs

inferential statistics – *non-parametric procedures*

- if k=2 conditions and *DV at ordinal level*
- *between-subjects or non-equivalent groups design*
  - *Mann-Whitney U Test*
- *within-subjects and matched-groups designs*
  - *Wilcoxon signed rank test*
- if k=2 conditions and *DV at nominal level*
  - *use chi-square test for equivalent proportions*

Analysis of Single-Factor Designs

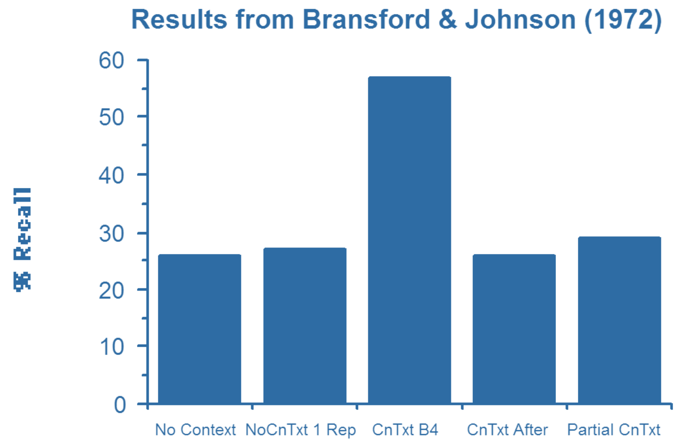
- if k>2 conditions and DV at interval or ratio level
- *between-subjects and non-equivalent designs*
    - *between-groups ANOVA*
    - *controls for inflation of Type-I Error*
    - *e.g., Bransford & Johnson, 1972*

ANOVA

	SS	df	MS	F	Sig
Between Groups	145.6	4	36.4	7.725	<.001
Within Groups	212.0	45	4.7		
Total	357.6	49			

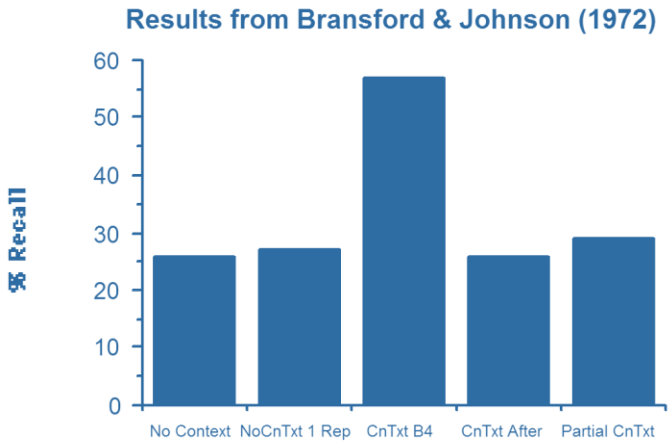
Means

condition	recall
No Context - 0 Rep	3.6
No Context - 1 Rep	3.8
Context Before	8.0
Context After	3.6
Partial Context Before	4.0



Analysis of Single-Factor Designs

- *between-groups ANOVA*
- *if F-test significant use Post-Hoc Tests to isolated where differences exist*
    - *e.g., Student Newman-Keuls*
    - *just one of many*



Student-Newman-Keuls[a]

condition	N	Subset for alpha = .050	
		A	B
1	10	3.6	
4	10	3.6	
2	10	3.8	
5	10	4.0	
3	10		8.0

Analysis of Single-Factor Designs

- if k>2 conditions and DV at interval or ratio level
- *within-subjects and matched designs*
    - *repeated-measures ANOVA*

- if k>2 conditions and DV at ordinal level
- *between-subjects and non-equivalent designs*
    - *Kruskal-Wallis Test*
    - *within-subjects and matched designs*
    - *Friedman Test*

- if k>2 conditions and *DV at nominal level*
    - *use chi-square test for independent groups*