PSY 250

Chapter 9: Within Designs

Within Subjects Design

- Within subjects factorial design
- Repeated measures design
- Dependent Groups
- Participants participate in all treatment conditions (not necessarily in same order)
- One IV (factor) manipulated within a group
- Ultimate in equivalent groups design

Advantages of Within Subjects Designs

- Conserve participants
  - E.g. 3 treatments with 30 participants
  - For between subjects design would need 90 participants
- Increased control
  - Individual differences
    - Confound
    - Increased variance

Advantages of Within Subjects Designs cont.

- When indiv. diffs. are consistent across treatments, can measure them and separate effects from the rest of the variance
- Treatment effects easier to see when indiv. diffs. removed
- So within design more powerful than between design

Student	Class A	Class B
John	78	88
Mary	62	74
Peter	60	69
Paul	80	93
Average	70	81

Rationale of ANOVA

- Variability in your data can be divided into two sources:
  - Between-groups variability (BG)
    - represents the variability caused by the independent variable
    - Differences between the levels of the IV
    - E.g. between Class A and Class B
    - Think of it as Between-conditions variability

Rationale of ANOVA cont.

- Within-groups variability (Error variability) or (WG)
  - Variability due to factors such as individual differences, errors in measurement, and extraneous variation
  - Any variation not due to the IV

Rationale of ANOVA cont.

- We want BG > WG
- This means there are more differences caused by our manipulation of the IV than there are just random differences (WG or error variability)

Rationale of ANOVA

- In general terms:

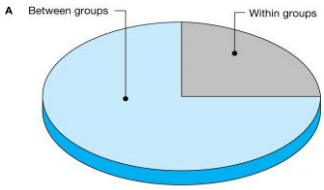
$$\text{statistic} = \frac{\text{between-groups variability}}{\text{error variability}}$$

- The general formula used is:

$$F = \frac{\text{variability due to IV} + \text{error variability}}{\text{error variability}}$$

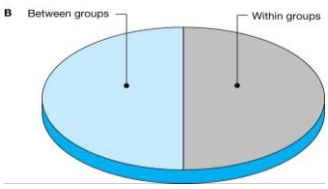
Rationale for ANOVA

- If your IV has a strong treatment effect and creates much more variability than all the error variability, we should find the numerator of this equation as considerably larger than the denominator.
- The result would be a large *F* ratio. See Figure A.



Rationale for ANOVA

- The reverse is also true, if the IV has no effect, there would be no variability due to the IV, meaning we would add 0 for the factor in the in equation.
- Thus, the *F* ratio would be close to one because the error variability between groups should approximately equal the error variability within the groups. See Figure B.
- The *F* ratio is conceptualized (and computed) with the following formula:



$$F = \frac{\text{between-groups variability}}{\text{within-groups variability}}$$

Disadvantages of Within Subjects Designs

- Time demand
- Participant Attrition
  - Volunteer Bias
- Environmental Factors

Disadvantages of Within Subjects Designs

- Time Related Factors
  - History
  - Maturation
  - Instrumentation
  - Regression
  - Testing

Disadvantages of Within Subjects Designs cont.

- Testing/Order effects
  - Carry-over
    - Related to specific treatment
    - E.g. lingering drug effects, study technique
  - Progressive error
    - Dependent on general experience
    - E.g. practice, fatigue, comfort

Solutions to Time-Related Threats

- Reducing time between treatments
  - But can increase risk of carry-over etc.
- Switch to between design
- Counterbalancing
  - Matching treatments with respect to time

Counterbalancing

- Treatments given in different orders
- Balances but hides order effects
- NOTE: does NOT make it a between design
  - Groups balanced on order but NOT on IV itself

Group 1	Treatment A	Treatment B
Group 2	Treatment B	Treatment A

Counterbalancing

- To control for sequencing effects
  - Order effects
    - IV – rate of presentation of nonsense syllables
    - DV – verbal learning
    - Learn slow, moderate then fast list – speed confounded with order
  - Carry-over effects
    - Performance in condition partially dependent on preceding conditions
    - IV – monetary reward
    - Dime may be more rewarding when preceded by nickel vs. quarter

Intrasubject (within subject) Counterbalancing

- The ABBA Technique
- Administer treatment conditions to each participant in more than one order
- Coke pepsi pepsi coke
- Based on assumption that order effects are linear
- If not linear – use each treatment condition in every possible position in sequence
  - Also use BAAB pepsi coke coke pepsi
  - Half participants assigned to each sequence

Intragroup Counterbalancing

- Less time-consuming
- Groups of participants rather than individuals counterbalanced
- Different groups take each of sequences (fewer than all possible sequences)

Counterbalancing

TABLE 5-3 WITHIN-GROUP COUNTERBALANCING FOR THE TWO-COLA CHALLENGE WHEN SIX PARTICIPANTS ARE TESTED

	TASTING 1	TASTING 2
Participant 1	A	B
Participant 2	A	B
Participant 3	A	B
Participant 4	B	A
Participant 5	B	A
Participant 6	B	A

Counterbalancing

TABLE 5-4 WITHIN-GROUP COUNTERBALANCING FOR THE THREE-COLA CHALLENGE WHEN SIX PARTICIPANTS ARE TESTED

	TASTING SESSION		
	1	2	3
Participant 1	A	B	C
Participant 2	A	C	B
Participant 3	B	A	C
Participant 4	B	C	A
Participant 5	C	A	B
Participant 6	C	B	A

Complete Counterbalancing

- All possible treatment sequences are presented.
- You can calculate the number of sequences by using the formula *n!* (*n* factorial).
- With n = 6, *n!* = 720!
  - 6 X 5 X 4 X 3 X 2 X 1
- Might require too many participants

Incomplete/Partial Counterbalancing

- Only a portion of all possible sequences are presented
- Must have equal number of each treatment in each temporal position
- With 4 treatments need 4 sequences:

ABCD
BCDA
CDAB
DABC

Latin Square Matrix

A	B	C	D
B	C	D	A
C	D	A	B
D	A	B	C

Incomplete Counterbalancing

- Three basic requirements:
  - Each treatment must be presented to each participant an equal number of times.
  - Each treatment must occur an equal number of times at each testing or practice session.
  - Each treatment must precede and follow each of the other treatments an equal number of times.

Balanced Latin Square Matrix

A	B	D	C
B	C	A	D
C	D	B	A
D	A	C	B

Counterbalancing

- Sequence or Order Effects
  - Sequence or order effects are produced by the participant's being exposed to the sequential presentation of the treatments.
    - The sequence or order effect depends on *where* in the sequential presentation of treatments the participant's performance is evaluated, *not* which treatment is experienced.

Counterbalancing

TABLE S-7 EXAMPLE OF SEQUENCE OR ORDER EFFECTS IN A COUNTERBALANCED EXPERIMENT

The performance increase shown in parentheses below each sequence indicates the effect of testing reaction time to red (R), green (G), and flashing white (FW) lights on an instrument panel at that particular point in the sequence. Thus, second and third testings result in increases of 4 and 3, respectively, regardless of the experimental task.

	ORDER OF TASK PRESENTATION		
	R	G	FW
Performance Increase →	(0	4	3)
	R	FW	G
	(0	4	3)
	G	R	FW
	(0	4	3)
	G	FW	R
	(0	4	3)
	FW	R	G
	(0	4	3)
	FW	G	R
	(0	4	3)

Counterbalancing

TABLE 5-8 EXAMPLE OF CARRYOVER EFFECTS IN A COUNTERBALANCED EXPERIMENT

Carryover effects occur when a specific preceding treatment influences the performance in a subsequent treatment. In this example, experiencing Treatment G prior to Treatment R results in a decrease of 2 (i.e., −2), whereas experiencing Treatment R prior to Treatment G results in an increase of 2 (i.e., +2). Experiencing Treatment G prior to FW or Treatment FW prior to G does not produce a unique effect. However, experiencing Treatment R prior to FW results in an increase of 3, whereas experiencing Treatment FW prior to R results in a decrease of 3.

	SEQUENCE OF TREATMENTS		
	G	R	FW
Effect on Performance →	(0	−2	+3)
	G	FW	R
	(0	0	−3)
	R	G	FW
	(0	+2	0)
	R	FW	G
	(0	+3	0)
	FW	G	R
	(0	0	−2)
	FW	R	G
	(0	−3	+2)

- Carryover Effects
  - The effects of one treatment persist or carry over and influence responses to the next treatment.

Counterbalancing

TABLE 5-9 EXAMPLE OF DIFFERENTIAL CARRYOVER IN A COUNTERBALANCED EXPERIMENT

Differential carryover occurs when performance depends on which specific sequence occurs. In the following example, experiencing Treatment A prior to Treatment B results in an increase of 6 (i.e., +6), whereas all other sequences result in an increase of 2 (i.e., +2).

	SEQUENCE OF TREATMENTS		
	A (1 M&M)	B (3 M&M'S)	C (5 M&M'S)
Effect on Performance →	(0	+6	+2)
	A	C	B
	(0	+2	+2)
	B	A	C
	(0	+2	+2)
	B	C	A
	(0	+2	+2)
	C	A	B
	(0	+2	+6)
	C	B	A
	(0	+2	+2)

Differential Carryover

- The response to one treatment depends on *which* treatment was administered previously.

Two Treatment Designs

- Easy to conduct
- Easy to interpret

Multiple Treatment Designs

- More likely to reveal functional relationship between IV and DV
- But same probs as with between designs
- Also increased risk of attrition, fatigue etc.