Lecture 7-9: Complex Designs

- INTRODUCTION
  A. Multiple Experimental Designs

- Remember the task testing the impact of Nike vs. other Shoes on athletic performance.
- There were two possible experimental designs
- **1. Between-subjects design:** A design in which participants contribute a score to only *one level of the IV*.
  - Nike or other shoes are randomly assigned to different samples of athletes

II. WITHIN-SUBJECTS DESIGN
A. Defined

- **2. Within-subjects Design**: A design in which participants contributes a score to *each level of the IV*.
  - The same participants receives each level of the IV.
  - Nike and other shoes are worn by the same sample of athletes.

II. WITHIN-SUBJECTS DESIGN
B. Why Use Within Subjects Designs?

- **1. Problems with random groups**
  - One problem with RG designs is insuring that participants are initially equal in all (potentially confounding) variables.
    - To insure equality use the same subjects.
- **2. Small Sample Size**
  - Depending on the number of levels of the IV, we may need many times the number of subjects to run the study as a between subjects design
  - Within subjects design requires fewer participants.

II. WITHIN-SUBJECTS DESIGN
B. Why Use?

- **3. Necessity.**
  - Some analyses require the study of changes in participants' performance over time (e.g., longitudinal designs, studies of learning) .
    - Also psycho-physical studies require that participants contribute scores to a variety of different conditions.
- **4. Elegance**
  - It is most impressive to show the influence of an IV by demonstrating that the same participant's performance is profoundly altered.

II. WITHIN-SUBJECTS DESIGN
C. Major Problem

- Say we have a within subject design with an IV that has two levels (e.g. $IV_{1,}$ IV_2) and we find the following

	IV_1	IV_2
DV	10	25

- Can we conclude that the performance is significantly affected by the IV?
  - Would it matter if the DV is…
    - correct performance on a math test
    - RT on a speed task?

II. WITHIN-SUBJECTS DESIGN
C. Major Problem

- **1. Practice/Fatigue Effect.**
- There is a problem resulting from a confound between the IV levels and their ordinal position in the sequence of task presentation.
  - This confound may cause practice or fatigue effects or both.
    - Increase in RT may reflect fatigue (just getting tired or bored).
    - Increase in correct math test performance may reflect practice (increasing performance on similar tasks over time).

II. WITHIN-SUBJECTS DESIGN
C. Major Problem

- **2. Problem of Transfer**
- Performance in one level of the IV may influence performance on the other level
  - Say we have two different orders for presenting the two levels of the IV.

Order	IV_1	IV_2
$IV_1 \rightarrow IV_2$	.13	.13
$IV_2 \rightarrow IV_1$	.00	.40

We can find order effects on performance, which is a problem, but also the basis for important findings.

II. WITHIN-SUBJECTS DESIGN
C. Major Problem

- Practice/Fatigue effects and transfer are problems which are the result of **carry-over.**
- Carryover suggests that levels of the IV are not independent of each other.
  - Carryover (i.e., lack of independence) can not be solved.
  - To some it means you should never use within-subject designs
  - **<u>While not solvable, it is manageable.</u>**

II. WITHIN-SUBJECTS DESIGN
D. Solutions

- **1. Counterbalancing**: Treatments are presented in different orders, so that carryover is distributed equally across each order.
- **1a: <u>Complete Counterbalancing</u>:** Identifies every possible ordering of treatments and then assigns each order to <u>at least</u> one subject.
  - IV level (k) and ordinal position is unconfounded only by computing all **possible orders (k! 3! = 3 x 2 x 1 = 6)** and giving all orders to each participant or one order to each of k! groups of participants.

II. WITHIN-SUBJECTS DESIGN
D. Solutions

- Each of the 6 possible orders of a 3-level IV can be given to the same subject over six trials

  Ss: A B C/ A C B/ B A C/ B C A/ C A B/ C B A
- Each of the 6 possible orders of a 3-level IV can be given to the different groups of participants.

G1 ABC	G4 BCA
G2. ACB	G5 CAB
G3 BAC	G6 CBA
- But 4! = 24, 5!=120

II. WITHIN-SUBJECTS DESIGN
D. Solutions

- **1b: Partial counterbalancing:** Participants receive a subset of all possible orders.
  - i. AB/BA counterbalancing design
    - One order and its opposite (e.g., ABC/CBA)
  - ii. Randomly Selected orders
    - A subset of orders with the proviso that each treatment appears equally often in each position
  - iii. Latin Square
    - Economic counterbalancing:
      - Treatments = orders

II. WITHIN-SUBJECTS DESIGN

D. Solutions

- **2. Minimizing carryover**
  - Training to asymptote: Lots of practice, so that practice effect would me minimized
  - Time out period: A period of rest (or adaptation) so that fatigue is not a problem.
- **3. Making order an IV**
  - Treat order as IV to assess the extent of carryover.
  - **Differential Carryover effect** is a problem to counterbalancing because it is assumed that different orders will have similar carryover effects.

II. WITHIN-SUBJECTS DESIGN

E. Types of Within Subjects Designs

- **1. Single-Factor Two-Level**

IV	1
	2

- **2. Single Factor Multiple-Level**

	1
IV	2
	3

- **3. Multi-Factor Factorial Design**

		IV_1	IV_2
Order	$IV_1 \rightarrow IV_2$		
	$IV_2 \rightarrow IV_1$		

II. WITHIN-SUBJECTS DESIGN

F. Statistical Issues

- **1. t-tests for correlated samples**
  - Null hypothesis for between-subjects design
    - $IV_1 = IV_2$
  - Null hypothesis for within-subjects design
    - $IV_1 - IV_2 = 0$
- **2. Repeated measures ANOVA**
  - F Ratio = SS between groups /SS within groups
  - In within-subjects variable, it's the same F ratio, but subjects are treated as a factor in the analysis and are subtracted from SS within-groups.

II. WITHIN-SUBJECTS DESIGN

G. Identifying designs and hypotheses

- Gleaning information from graphs.
  - This goes to the most central aspect of class: identifying connections between verbal, statistical, and graphical representations of ideas.
  - Spend some time learning how to do translations on these relatively easy tasks.

II. WITHIN-SUBJECTS DESIGN
G. Identifying designs and hypotheses

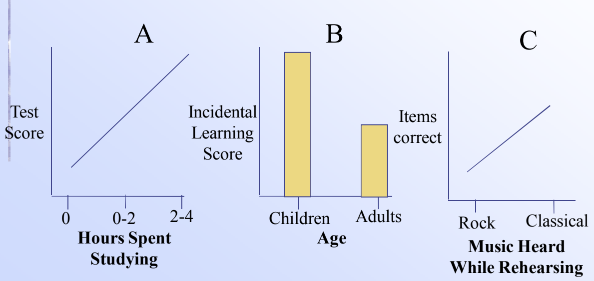
- Draw and clearly label a graph that accurately represents the variables and their relationship described in each statement below (note: the IV in on the x axis and the DV is on the y axis).
  - Women have higher scores on tests of depression than do men.
  - Seniors have a higher GPA than do freshmen.
  - More adolescents than children reason at a formal operational stage level.

II. WITHIN-SUBJECTS DESIGN
G. Identifying designs and hypotheses

- For each graph:
  - Identify the IV (specifying it as a true or a subject IV) and the DV.
  - Judge whether the study could have been an experimental design.
  - Judge whether the design was a between-subject (BS), within-subjects (WS), or potentially either (PE).

II. WITHIN-SUBJECTS DESIGN
G. Identifying designs and hypotheses

- For each of the following graphs, describe the relations depicted in words.



II. WITHIN-SUBJECTS DESIGN
G. Identifying designs and hypotheses

- For each graph:
  - Identify the IV, specifying it as a true or a subject IV.
  - Identify the dependent variable.
  - Judge whether the study could have been an experimental design.
  - Judge whether the design was a between-subject (BS), within-subjects (WS), or potentially either (PE).

III. FACTORIAL AND COMBINED DESIGNS
A. Why Use Multivariable Designs?

- 1. Resolving Contradictions
  - Why researchers may disagree!
    - Researchers A and B disagree whether a treatment is effective with children. But, children of different ages may respond differently to different treatments: Age (2) by Treatment (2).
- 2. Greater Sensitivity
  - Interactions between IVs.
    - Multiple variables simultaneously studied is more sensitive measure of a phenomenon than separate studies of individual variables.

III. FACTORIAL AND COMBINED DESIGNS
A. Factorial Designs Defined

- **1. Factorial Design: Separate group for each unique combination of independent variable levels.**
  - One thing we can study is whether Psychological Literacy is affected by both Major Status and Class Level.
    - Class Level (Intro, Advanced) and Major Status (Major/Minor vs. Neither)
  - This is called 2 by 2 factorial design
    - Participants contributed scores to each of 4 pairings of level of each IV (Status and Level)

III. FACTORIAL AND COMBINED DESIGNS
A. Defined

- Between subjects study: Participants assigned to one of 4 groups, which are the result of pairing two IVs each with two levels.
  - Neither Students in Intro Class
  - Major/Minor in Intro Class
  - Neither Students in Advanced Class
  - Major/Minor in Advanced Class
- So a 2 x 2 design means that there are two IVs each with 2 levels so there are 4 (2 x 2) cells.

III. FACTORIAL AND COMBINED DESIGNS
A. Defined

- How many IVs and parings between IVs (cells)?

	IVs (# of numbers)	Cells (x of the numbers)
2 x 2	2	4
2 x 2 x 2	?	?
2 x 3	?	?
2 x 4	?	?
2 x 2 x 3	?	?
2 x 2 x 2 x 6	?	?

III. FACTORIAL AND COMBINED DESIGNS

A. Factorial Repeated Measures Defined

Factorial repeated measures design: Each subject is exposed to every combination of levels of each IV.

- Say every student completed PAS in both conditions at the beginning and end of the semester
  - Perspective (Self and Prof)
  - Time (Beginning vs. End of semester)
- Study of the effect of Condition and Time on PAS which would explore the effects of the class on viewing psychology as a science.

III. FACTORIAL AND COMBINED DESIGNS

A. Combined or Mixed Design Defined

- **2. Combined or Mixed Design (split plot design)** : Multiple IV which combine between- and within-subjects variables.
  - Perspective (2) Within or Repeated Measures
  - Level (2) Between
  - Status (2) Between
- This is A 2 x 2 x 2 Combined design.
  - Predicted a Perspective by Status interaction effect as majors and minors are more likely to think like their profs.

III. FACTORIAL AND COMBINED DESIGNS

A. Nested Design Defined

- **Nested Design**: Also combines multiple independent variables (could be used as a combined design too)
  - But the paring of IV levels is <u>partial</u> rather than <u>complete</u> (e.g. factorial)
  - Anagram Task (2) and Classroom (3), with Classroom nested in Anagram Task
    - Easy: tac (cat); Hard: diwnow (window)

Easy Condition			Hard Condition		
Class1	Class2	Class3	Class4	Class5	Class6

III. FACTORIAL AND COMBINED DESIGNS

C. Sources of Influence

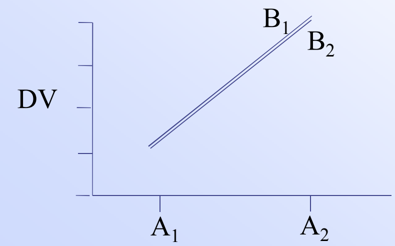
- With multiple IVs studied in a single design, there are ***<u>multiple sources of influence on the DV</u>***
  - **Main Effects**: Influence of individual IVs on the DV in a multivariable design.
    - Number of Main effects = the number of IVs.
  - **Interaction Effects**: Influence of one variable depends on another
    - Number of Interaction effects = number of combinations (pairs, triplets, etc) of IVs

III. FACTORIAL AND COMBINED DESIGNS
C. Sources of Influence

- In a 2 (A) x 2 (B) design:
  - 2 Main Effects (A; B)
  - 1 Interaction Effect (AxB)
- In a 2 (A) x 3 (B) design:
  - 2 Main Effects (A; B)
  - 1 Interaction Effect (AxB)
- In a 2 (A) x 2 (B) x 2 (C) design:
  - 3 Main Effects (A; B; C)
  - 4 Interaction Effects (AxB; BxC; AxC; AxBxC)

III. FACTORIAL AND COMBINED DESIGNS
C. Sources of Influence

- The following is a 2(A) by 2(B) factorial design.
- Assess whether there is a main of IVs A or B and whether there is an interaction effect.



	B_1	B_2	
A_1	2	2	2
A_2	5	5	5
	3.5	3.5	

III. FACTORIAL AND COMBINED DESIGNS
C. Sources of Influence

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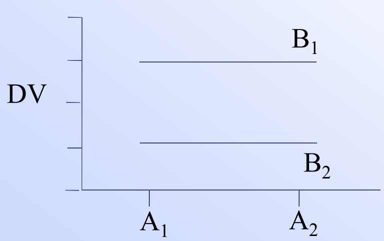

	B_1	B_2	
A_1	4	2	3
A_2	4	2	3
	4	2	

III. FACTORIAL AND COMBINED DESIGNS
C. Sources of Influence

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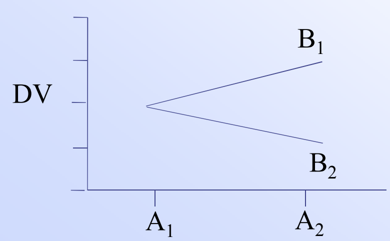

	B_1	B_2	
A_1	3	3	3
A_2	4	2	3
	3.5	2.5	

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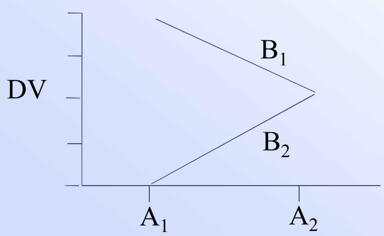

	B_1	B_2	
A_1	5	1	3
A_2	3	3	3
	4	2	

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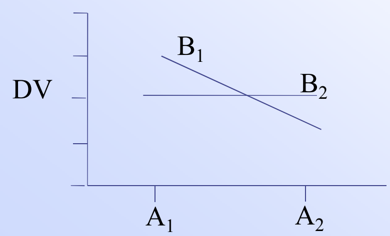

	B_1	B_2	
A_1	4	3	3.5
A_2	2	3	2.5
	3	3	

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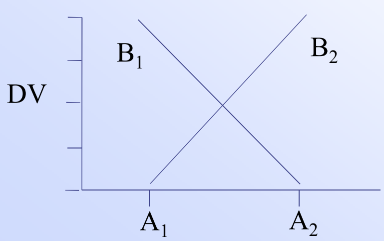

	B_1	B_2	
A_1	5	0	2.5
A_2	0	5	2.5
	2.5	2.5	