Experimental Designs

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Experiments

- Creation of *meaningful* comparisons
  - *Deliberate manipulation of independent variables*
  - *Take advantage of "natural" manipulations to create comparisons*
    - *Ex post facto studies*
    - *Quasi-experimental manipulations*
  - *Control of extraneous variables*
    - *Random assignment of subjects to groups*
    - *Maintain at a constant value*
    - *Counterbalancing*

Sources of Variability in Data

- Systematic Variability
  - *Variability attributed to the effects of manipulations of an independent variable*
  - *Treatment Variability*
- Error Variability
  - *Variability attributed to the effects of extraneous variables*
    - *Individual differences (subject variability)*
    - *Error variability of measures used (when reliability of a measure is less than 1.00)*

Error Variability

- Ideally, error variability is distributed randomly across conditions in an experiment
  - *Error variability is evaluated & controlled within the statistical analysis of the data*
- Confounded Variables
  - *Extraneous variables that are correlated with manipulations of an independent variable*
  - *Problem: Confounds confuse variation due to treatments with variation due to these extraneous variables*
  - *This variability cannot be reliably isolated using statistical procedures*

Between-Subjects Designs

- Two-group versus parametric (multi-group) designs
- Problem of non-equivalent groups
- Matched-groups Designs
  - *Matched pairs (precision matching)*
  - *Matched groups (frequency distribution matching)*

Matching

- Costs associated with matching
  - *Time and expense related to finding matching subjects*
  - *Loss of potential subjects (unable to match)*
  - *Loss of generalizability of results*
  - *Problems created by attrition after matching*
  - *Loss of degrees of freedom in the statistical analysis*
- Advantages associated with matching
  - *Control of extraneous subject variables*
  - *Potential for increased sensitivity to the effects of manipulated variables (when matching variables are related to the dependent measure)*

Within-Subjects Designs

- "Ultimate" Match – each subject is matched with itself
- Each subject participates in every condition in the design
- Individual differences (subjects) are now treated as an additional factor in the statistical analysis ***(Repeated Measures Designs)***

Advantages of Within-Subjects Designs

- Efficient in the recruitment and use of subjects
- Good control of individual differences as an extraneous variable
- Statistical advantage
  - *Potential for increased sensitivity to effects of treatment*
  - *Individual differences are no longer part of error variance, but are identified as variance attributed to the Subjects variable*

Disadvantages of Within-Subjects Designs

- Time required for subject participation
- Subject attrition
  - *Loss of data (e.g., from equipment failures) in one condition will require discarding all data for that subject*
- Carryover effects
  - *Practice*
  - *Fatigue*
  - *Habituation or sensitization to manipulations*
  - *Adaptation*
  - *Contrast effects*
  - *Irreversible changes*

Minimizing Carryover Effects

- Allow subject behavior to stabilize before exposure to any data collection conditions
  - *Create room for adaptation or habituation to occur*
- Practice trials
  - *Give enough practice before data collection begins to familiarize with task and procedures*
- Create breaks to offset effects of boredom or fatigue
- Counterbalance presentation of conditions

Counterbalancing

- Complete counterbalancing
  - *All possible orders of conditions used*
- Partial counterbalancing
  - *Block Randomization*
  - *Latin Square Design*
  - *Randomization (requires many sequences)*

Block Randomization

- Each subject completes all four conditions
- 4*n* subjects required for the design
- Controls effects of order in the sequence
  - *Practice, boredom, etc.*
- Does *not* control the effects of unique effects of one condition on the following condition

Subject	Order of Conditions			
1	A	C	B	D
2	C	B	D	A
3	B	D	A	C
4	D	A	C	B

Latin Square Design

- Each subject completes all four conditions & 4*n* subjects required for the design
- Controls effects of order in the sequence
- Controls the unique effects of context or contrast created by experimental conditions

Subject	Order of Conditions			
1	A	B	D	C
2	B	C	A	D
3	C	D	B	A
4	D	A	C	B

Choice of Design

- Within-Subjects Designs
  - *Large individual differences: Subject variables are correlated with performance on the dependent measure*
  - *Economic use of subjects*
  - *Interest in practice or order effects as manipulations requires use of a within-subjects design*
- Matched Groups Designs
  - *Need to control individual differences but carryover effects are a serious concern*
- Between-Subjects Designs
  - *Participation in conditions requires extensive time*
  - *Concern over carryover effects*

Factorial Designs

- Two or more independent variables
- Test Hypothesis about Main Effect of each IV separately (as occurs in single factor designs)
- Test Hypothesis about Interaction Effects

Single Factor Experiment: Noise Intensity	
Soft	Loud
Group 1	Group 2

Two Factor Experiment		
	Noise Intensity	
Predictability	Soft	Loud
Predictable	Grp 1	Grp 2
Unpredictable	Grp 3	Grp 4

Three Hypotheses Tested in a Two Factor Experiment

- What is the effect of Noise Intensity?
  - *Main Effect of Noise*
- What is the effect of Noise Predictability?
  - *Main Effect of Predictability*
- Interaction of Noise and Predicability
  - *Interaction Effect*
  - *Cell Means*

Two Factor Experiment			
	Noise Intensity		
Predictability	Soft	Loud	
Predictable	Grp 1	Grp 2	X
Unpredictable	Grp 3	Grp 4	X
	X	X	

Notation for Factorial Designs

- Identifying the number of factors in the design
- Identifying the number of levels for each factor in the design
  - *2 x 2 design*
  - *3 x 3 design*
  - *2 x 3 design*
- All designs are expected to be fully crossed

	Factor A	
Factor B	A1	A2
B1	A1B1	A2B1
B2	A1B2	A2B2

	Factor A		
Factor B	A1	A2	A3
B1	A1B1	A2B1	A3B1
B2	A1B2	A2B2	A3B2
B3	A1B3	A2B3	A3B3

Factorial Designs

- Between Subjects
  - *n x n design requires n x n independent groups*
- Within Subjects (Repeated Measures)
  - *n x n design requires each subject to do n x n tasks*
- Mixed Designs
  - *One or more factors manipulated within-subjects*
  - *Other factors manipulated between subjects*

Higher Order Designs

- Three or more Factors
- Test one main effect for each factor
- Test all possible combinations of two-way interactions
- Test all possible combinations of higher-order interactions (three-way, four-way, etc.)
- Problem in interpretation of higher-order interactions