Topic #5

EXPERIMENTAL RESEARCH DESIGNS

As a strict technical definition, an experiment is a study or research design in which we MANIPULATE variables.

This also implies that experimental designs are characterized by RANDOM ASSIGNMENT to groups, treatments, and/or conditions.

That is, the researcher has high levels of **control** over the WHO, WHAT, WHEN, WHERE and HOW of the study.

MANIPULATION and RANDOM ASSIGNMENT are the defining characteristics of experimental designs.

RANDOM SAMPLING AND RANDOM ASSIGNMENT

- Ideally, **all** research designs and studies should use random sampling.
- In addition, **experimental research designs** call for random assignment to groups.
- The use of random sampling and random assignment gives the strongest case for causal inferences and generalizability.

1. **Random Sampling—**the process of choosing a "representative" sample from an entire population such that every member of the population has an equal and independent chance of being selected into the sample.
    - Probabilistic sampling.
2. **Random Assignment (Randomization)—**a control technique that equates groups of participants by ensuring every member (of the sample) an equal chance of being assigned to any group.
    - Controls for **both** known and unknown effects and threats.
    - Randomization is of concern in experimental research where there is some manipulation or treatment imposed.
    - As a systematic procedure for avoiding bias in assignment to conditions or groups, if we can avoid said bias, then we can assert that any differences between groups (conditions) prior to the introduction of the IV are due solely to chance.

- The principal concern is whether differences between groups AFTER the introduction of the IV are due solely to chance fluctuations or to the effect of the IV plus chance fluctuations.

EXAMPLES OF SOME EXPERIMENTAL RESEARCH DESIGNS

1. *Control experiment with control group and experimental group*

	PRETEST	**TREATMENT**	**POSTTEST**
GROUP I	YES	YES	YES
GROUP II	YES	NO	YES

2. *Control experiment with no control group*

	PRETEST	**TREATMENT**	**POSTTEST**
GROUP I	YES	A_1	YES
GROUP II	YES	A_2	YES

3. *Control experiment with control condition within-subjects*

ALL PARTICIPANTS	**PRETEST**	**TREATMENT**	**POSTTEST**
CONDITION I	YES	YES	YES
CONDITION II	YES	NO	YES

4. *Solomon Four-Group design*

- Generally accepted as the best design, but requires a large number of participants.

	PRETEST	TREATMENT	POSTTEST
GROUP I	YES	YES	YES
GROUP II	NO	YES	YES
GROUP III	YES	NO	YES
GROUP IV	NO	NO	YES

- Some possible comparisons

  (a) effect of treatment (Group I and Group II) vs. No treatment (Group III and Group IV)

  (b) effect of pretest (Group I and Group III) vs. No pretest (Group II and Group IV)

  (c) effect of pretest on treatment (Group I vs. Group II)

Why pretest?

1. Equivalence of groups
2. Baseline
3. Effects of testing or practice effects

What does one do if there are pretest/baseline differences?

1. Difference scores [generally considered to be a very poor methodological approach]
2. Analysis of covariance (ANCOVA)
3. Partial/semi-partial correlations
4. Regression (hierarchical)

EXAMPLES OF SOME RESEARCH DESIGNS TO AVOID

1. *One-group posttest only design*

	TREATMENT	POSTTEST
GROUP I	YES	YES

2. *One-group pretest-posttest design*

	PRETEST	TREATMENT	POSTTEST
GROUP I	YES	YES	YES

3. *Posttest only design with nonequivalent control groups*

	ALLOCATION TO GROUPS	TREATMENT	POSTTEST
GROUP I	NONEQUIVALENT NATURALLY OCCURRING GROUPS	YES [A_1]	YES
GROUP II		NO [A_2]	YES

- Nonequivalent control group of participants that is not randomly selected from the same population as the experimental group

WITHIN-SUBJECTS, BETWEEN-SUBJECTS, AND MIXED FACTORIAL DESIGNS

1. **Within-subjects design**—a research design in which each participant experiences every condition of the experiment or study.

   A. *Advantages*

      1. do not need as many participants
      2. equivalence is certain

   B. *Disadvantages*

      1. effects of repeated testing
      2. dependability of treatment effects
      3. irreversibility of treatment effects

2. **Between-subjects design**—a research design in which each participant experiences only one of the conditions in the experiment or study.

   A. *Advantages*

      1. effects of testing are minimized

   B. *Disadvantages*

      1. equivalency is less assured
      2. greater number of participants needed

3. **Mixed factorial design**—a research design that combines/uses between- and within-subject variables in the same design.

SUMMARY OF KEY CONCEPTS—EXPERIMENTAL DESIGNS

1. **Control**

   - Any means used to rule out possible threats to a piece of research
   - Techniques used to eliminate or hold constant the effects of extraneous variables

2. **Control Group**

   - Participants in a control condition
   - Participants not exposed to the experimental manipulation

3. **Experimental Group**

   - Participants in an experimental condition

4. **Control Condition**

   - A condition used to determine the value of the dependent variable without the experimental manipulation. Data from the control condition provide a baseline or standard to compare behavior under changing levels of the independent variable.

5. **Experimental Condition**

   - Treatment condition in which participants are exposed to a non-zero value of the independent variable; a set of antecedent conditions created by the experimenter to test the impact of various levels of the independent variable.

6. **Within-subjects Design**

   - Research design in which each participant serves in each treatment condition.

7. **Between-subjects Design**

   - Research design in which different participants take part in each condition of the experiment or study.

8. **Mixed Factorial Design**

   - Research design that has both within- and between-subject variables.

9. **Pretest**

   - Why?
   - What do we do about preexisting differences?

10. **Manipulation**

    - Defining characteristic of experimental designs

11. **Manipulation check**

12. Distinction between **study** and **experiment**

CAUSAL INFERENCES

- An advantage that experimental designs have over other research designs is that they permit us to make causal inferences.

- Causation implies the ability to make statements about the absence or presence of cause-effect relationships.

- A causal inference is a much stronger statement than a simply and association between variables.

- While there are several *methods*—some of which are discussed in the text—to experimentally identify causality, in conjunction with manipulation (and use of random assignment), there are three additional *conditions* that must be met to infer cause.

  (a) **Contiguity**—between the presumed cause and effect.
  (b) **Temporal precedence**—the cause has to precede the effect in time.
  (c) **Constant conjunction**—the cause has to be present whenever the effect is obtained.

- The ability to make causal inferences is dependent on how well or the extent to which alternative causes or explanations are ruled out.

- Cause—is a necessary and sufficient condition.

- An event that only causes an effect sometimes is NOT a cause.

- The assessment of causation technically demands the use of manipulation.

- Caveats to determining causality:

  (a) Concerning cause-effect relationships, it cannot be said that they are true. We can only say that they have **NOT** been falsified.

  (b) The use of correlational methods to infer casual relationships should be avoided.

  (c) Although one might find that $r \neq 0$ or that the regression equation is significant, this does **NOT** prove or indicate a causal relationship (i.e., that X *caused* Y to change]. At best we can only say that there is a relationship between X and Y.

  Thus, from the perspective of a methodological purist, one cannot make causal inferences on the basis of correlational data or designs.

Summary of Causation

With the scientific method, a number of conditions must be met to make **strong** causal claims (weaker conclusions of causality can be made when less than all these conditions are present).

- The cause X must precede the consequence Y in time. Thus, X is manipulated (or measured) and then Y is measured. [temporal precedence and constant conjunction]

- Statistical covariation between X and Y must be present. [constant conjunction and contiguity] This covariation must be statistically **significant**, and thus unlikely to be due to random chance fluctuation alone. Stated differently, random chance should be ruled out as a plausible alternative cause of the observed covariation between X and Y.

- Alternative causes of Y must be controlled, either via random assignment to groups (perhaps with a preceding matching procedure for the most plausible alternative cause) or via statistical controls.

FACTORIAL DESIGNS, ANALYSIS OF VARIANCE (ANOVA), MAIN EFFECTS, AND INTERACTIONS

1. **Analysis of Variance (ANOVA)—**is a statistical procedure used to simultaneously compare two or more means; it is used to study the joint effect of two or more IVs.

    - The ANOVA is based on the *F*-statistic and can be thought of as an extension of the *t*- test.

        - $t^2 = F$
        - *t*-test = 2 means
        - ANOVA = 2 or more means

    - One-factor or simple ANOVA—employs only one IV. We might use two or more levels of the variable but there is only ONE IV.

EXAMPLE OF (SIMPLE) ANOVA SUMMARY TABLE

SOURCE	**df**	**SS**	**MS**	***F***
Factor A	a-1	SS_a	SS_a/df_a	MS_a/MS_e
Error	$df_{tot}-df_a$	SS_e	SS_e/df_e	
Total	N-1			

where a = number of levels

- The assumption is that:

    individual's score = base level + treatment effect + effects of error

    where treatment effect = Factor A (or IV_A)

- The above design is also referred to or described as a one-factor (experimental) design, primarily because only one IV is manipulated.

- "Factor" is merely another term for "IV".

2. **Factorial Design—**a design in which 2 or more variables or factors are employed in such a way that all of the possible combinations of selected values of each variable are used.

   - Examples of factorial designs

     2×2 factorial design
     - IV_A = 2 levels
     - IV_B = 2 levels

     2×2×2 factorial design
     - IV_A = 2 levels
     - IV_B = 2 levels
     - IV_C = 2 levels

     2×3 factorial design
     - IV_A = 2 levels
     - IV_B = 3 levels

   - An issue that arises when we use factorial designs is that of main effects and interactions.

3. **Main Effect—**the effect of one IV averaged over all levels of the other IV.

   - That is, the effect of IV_A independent of IV_B or holding IV_B constant; can also be described as the mean of A_1 and A_2 across levels of B.

   - A main effect is really no different from a *t*-test for differences between means (assuming there are only 2 means).

4. **Interaction—**when the effect of one IV depends on the level of the other IV.

   - Two or more variables are said to interact when they act on each other.

   - Thus, an interaction of IVs is their joint effect on the DV, which cannot be predicted simply by knowing the main effect of each IV separately.

   - Main effects are qualified by interactions (interpreted within the context of interactions). Specifically, we do **not** interpret main effects when interactions are significant.

   - The occurrence of an interaction is analyzed by comparing differences among cell means rather than among main effect means.

   - Graphical plots are commonly used to illustrate the results of the ANOVA test. We plot graphs to aid us in interpreting the ANOVA results *after* we have run the test.

- It has been alleged that SUV A has a very high propensity to rollover and thus is patently unsafe. The manufacturer of SUV A argues that the problem is not with its vehicle but instead the tires that are mounted on the vehicle, specifically, TIRE A.

  - How would one determine whether the problem is with the tires or the vehicle?

  - An experimental design investigating this issue would be a basic 2×2 factorial design.

    - IV_A = 2 types of SUVs (SUV A and SUV B)
    - IV_B = 2 types of tires (Tire A and Tire B)

		SUV	
		SUV A	SUV B
TIRES	Tire A		
	Tire B		

    - How many conditions?

    - Within-subjects, between-subjects, or mixed factorial design?

    - Depending on whether the problem is with SUV A or Tire A, what will the data look like?

    - Main effects or an interaction?

    - Plot the data.

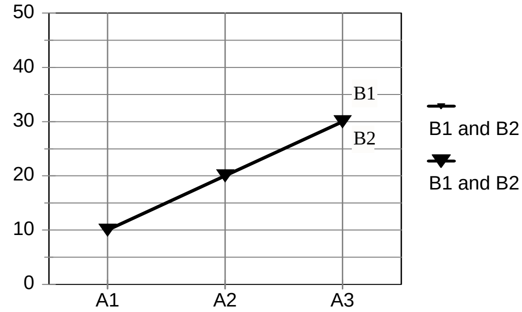
    - What would an interaction look like?

    - How would you interpret a SUV A/Tire A interaction?

Hypothetical Data Illustrating Different Kinds of Main and Interaction Effects

1. A is significant; B and the interaction are not significant.

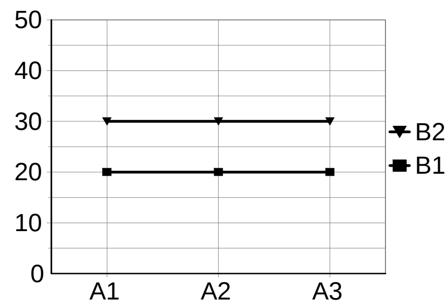
	A1	A2	A3	Mean
B1	10	20	30	20
B2	10	20	30	20
Mean	10	20	30	



A main effect significant (a)

2. B is significant; A and the interaction are not significant.

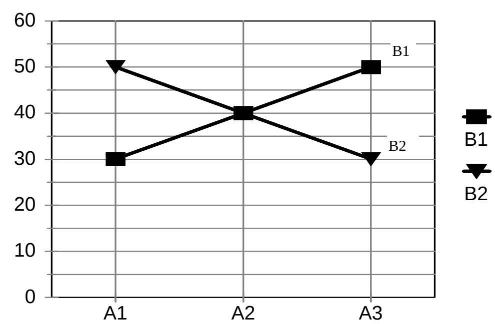
	A1	A2	A3	Mean
B1	20	20	20	20
B2	30	30	30	30
Mean	25	25	25	



B main effect significant (b)

3. Interaction is significant; A and B are not significant.

	A1	A2	A3	Mean
B1	30	40	50	40
B2	50	40	30	40
Mean	40	40	40	

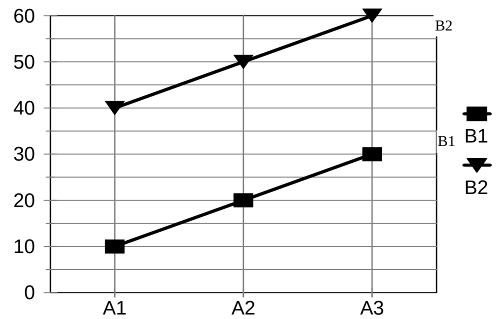


Interaction effect significant (c)

Hypothetical Data Illustrating Different Kinds of Main and Interaction Effects (continued)

4. A and B are significant; the interaction is not significant.

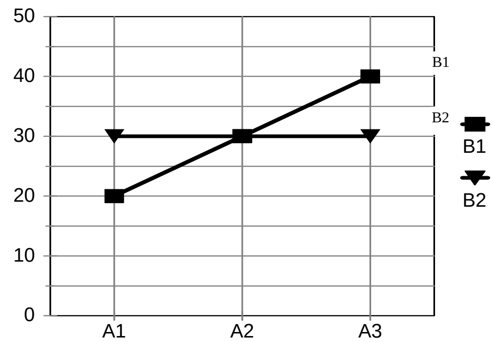
	A1	A2	A3	Mean
B1	10	20	30	20
B2	40	50	60	50
Mean	25	35	45	



A and B main effect significant (d)

5. A and the interaction are significant; B is not significant.

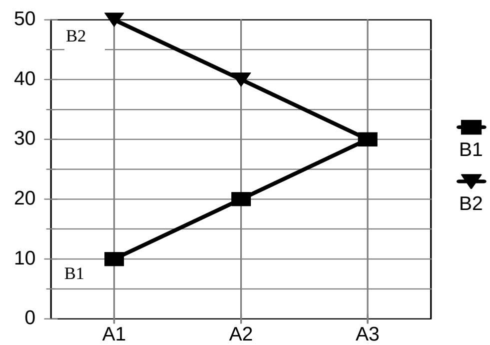
	A1	A2	A3	Mean
B1	20	30	40	30
B2	30	30	30	30
Mean	25	30	35	



A main effect and interaction significant (e)

6. B and the interaction are significant; A is not significant.

	A1	A2	A3	Mean
B1	10	20	30	20
B2	50	40	30	40
Mean	30	30	30	

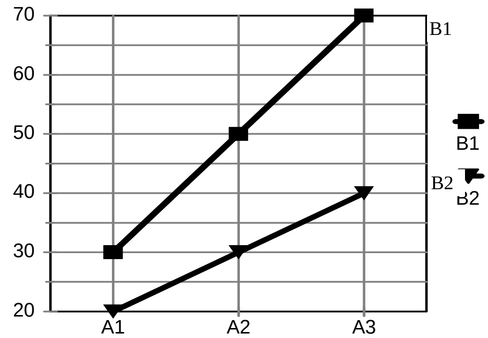


B main effect and interaction significant (f)

Hypothetical Data Illustrating Different Kinds of Main and Interaction Effects (continued)

7. A, B, and the interaction are significant.

	A1	A2	A3	Mean
B1	30	50	70	50
B2	20	30	40	30
Mean	25	40	55	



A and B main effect and interaction significant (g)

RESEARCH SETTING

- Psychological research usually takes place in one of two settings—lab or field.

- The major distinction between lab and field has to do with the "naturalness" or "artificiality" of the setting.

  - Field research typically employs a real-life setting.

- Another important concept associated with naturalness and artificiality is that of control.

  - Lab settings tend to permit higher degrees of control than field settings.

1. **Lab Experiment**

   A. *Advantages*:

   1. Is the strongest method for inferring causality. Permits the elimination of, or control for other explanations of observed behavior.

   2. Measurement of behavior is very precise.

   3. Precision of control makes them relatively easier to replicate.

   B. *Disadvantages*:

   1. There is a lack of realism—that is, the degree of similarity between experimental conditions and the natural environment is limited.

   2. Some phenomena do not lend themselves to study in the lab.

   3. Some variables may have a weaker impact in the lab than they do in the natural environment.

2. **Field Experiment**

A. *Advantages*:

1. Very realistic.
2. Results are highly generalizable.
3. Suggestions of causal inference are possible.
4. Broader research issues dealing with complex behavior in real-life contexts can be addressed.

B. *Disadvantages*:

1. Precision and exactness of control is relatively weaker.
2. Individuals or groups may refuse to participate.
3. Often cannot gain access to "natural" (business, organization, home or other) environment.