True Experiments:

Multifactorial Designs

Factorial Designs

- Also called Multifactorial Designs
- Two or more independent variables that are qualitatively different
  - Each has two or more levels
  - Can be within- or between-subjects
  - Can be manipulated or measured IVs
- Efficient design
- Good for understanding complex phenomena

Factorial Designs

- Each IV is a factor in the design
- Described in terms of
  - number of IVs
  - number of levels of each IV
  - E.g., 2 X 2 X 3 has:
    - 3 IVs
    - 2 with 2 levels and 1 with 3 levels
    - results in 12 conditions

Notation cont.

- A “2 x 2 factorial” (read “2-by-2”) is a design with two independent variables, each with two levels.
- A “3 x 3 factorial” has two independent variables, each with three levels.
- A “2 x 2 x 4 factorial” has three independent variables, two with two levels, and one with four levels.

Example

Exhibit 7.1 Independent Variables (*IV*) of Mood Induction and Cognitive Tests, Each With Two Levels		
	Cognitive Exercises (IV)	
Mood Induction *(IV)*	Verbal *(Level)*	Visual *(Level)*
Happy *(Level)*	Verbal word associations	Visual attention
Sad *(Level)*	Verbal word associations	Visual attention

Source: Adapted from Rowe et al., 2007.

Main Effects

- The unique and independent effects of each independent variable on the dependent variable
- the effects of one variable "collapsing across" the levels of another variable
  - Row means = the averages across levels of one independent variable
  - Column means = the averages across levels of the other independent variable

Main Effects

-13, main effect of dress style

Sex

		Males	Females	
Dress Style	Sloppy	82	62	72
	Casual	79	59	69
	Dressy	69	49	59
		76.7	56.7	

-3

-10

-20, main effect of Sex

Interactions

- When the effects of one level of the independent variable *depend on* the particular level of the other independent variable
- For example, if the effect of variable A is different under one level of variable B than it is under another level of variable B, an interaction is present.
- A significant interaction should be interpreted before the main effects

Extra Mean Differences Between Cells

		Sex		
		Males	Females	
Dress Style	Sloppy	69 (-7)	62	72
	Casual	79 (-20)	59	69
	Dressy	82 (-33) (+13)	49 (-13)	59
		76.7	56.7	

A Complex Within-Subjects Experiment

- Adams and Kleck (2003)
  - Two independent variables:
    - gaze direction (direct / indirect),
    - facial muscle contraction (anger / fear)
  - Within-subjects design
  - Participants made anger / fear judgments of faces and reaction time was recorded (DV)

Adams and Kleck (2003) Results

Table 7.1 Mean Response Times in Milliseconds to Correctly Labeled Anger and Fear Expressions, as a Function of Gaze Direction

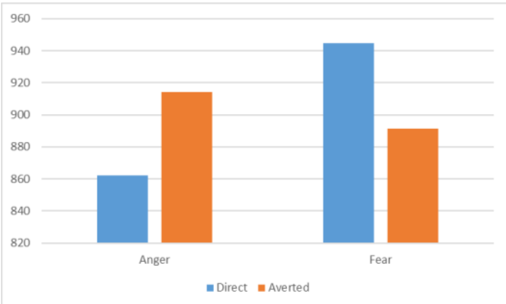
	Direction of Eye Gaze (A) (Independent variable A)		
			Row Means (Main Effect of Emotional Expression)
Type of Emotional Expression (B) (Independent variable B)	Direct (A1)	Averted (A2)	
Anger (B1)	862.3 *A1B1*	914.1 *A2B1*	888.2
Fear (B2)	944.5 *A1B2*	891.2 *A2B2*	917.9
Column Means (Main Effect of Gaze Direction)	903.4	902.7	

Source: Adapted from Adams & Kleck, 2003.

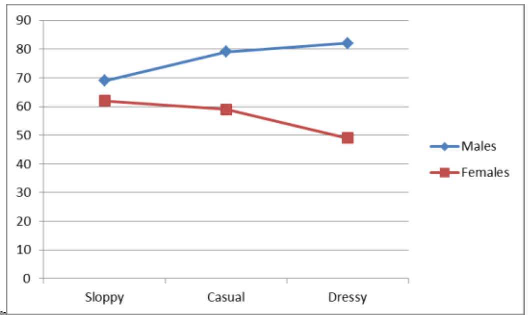
Understanding Interactions

- A good way to understand interactions is to graph them.
  - By graphing your DV on the *y* axis and one IV on the *x* axis, you can depict your other IV as lines on the graph.
- When you have a significant interaction, you will notice that the lines of the graph cross or converge.
  - This pattern is a visual indication that the effects of one IV change as the second IV is varied.
- Non-significant interactions typically show lines that are close to parallel.

Adams and Kleck (2003) Results

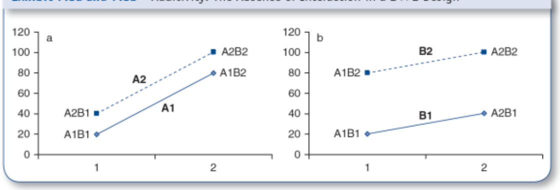


Less obvious pattern



Additivity: No Interaction

Exhibit 7.8a and 7.8b Additivity: The Absence of Interaction in a 2 × 2 Design

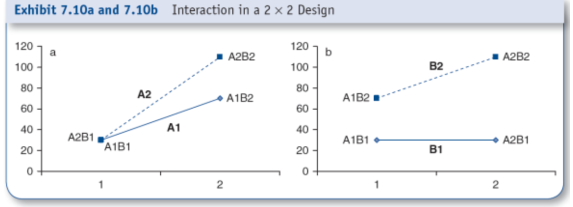


Source: Adapted from Elmes et al., 2006.

Antagonistic Interaction

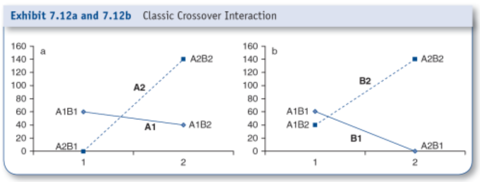
- Antagonistic interaction
  - Independent variables show opposite effects

Exhibit 7.10a and 7.10b Interaction in a 2 × 2 Design

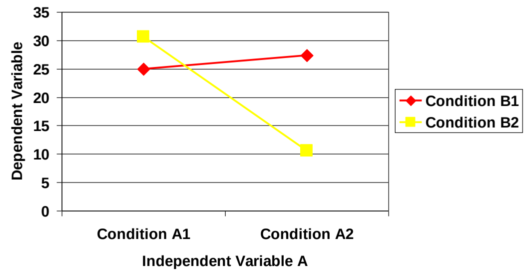


Crossover Interaction

- Lines cross over one another
  - Effects of one IV are reversed at different levels of another IV



Graph of an Interaction

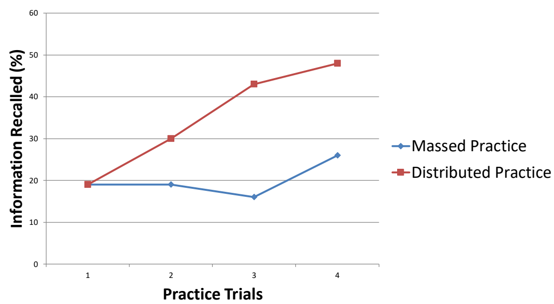


Variable A had no significant effect on participants in Condition B1 but caused a decline from A1 to A2 for those in Condition B2.

Results of 2 (Type of Practice) X 4 (Number of trials) Design

- Underwood (1970) used a factorial design to study children's recall for information
- Had two IVs:
  - timing of practice sessions (2 levels)
    - distributed over time
    - massed
  - number of practice trials (4 levels)

Results of Underwood's Study



Source: Underwood, 1970

Results

- The main effect for type of practice indicated that distributed practice was better than mass practice
- The main effect for number of practice trials indicated that recall improved over the four trials
- The interaction indicated that improvement was markedly better for the distributed practice trials
- Note that effect across number of trials is non-linear

A Complex Between-Subjects 2x3 Experiment

- Baumeister, Twenge, & Nuss (2002)
  - Can feelings of social isolation influence our cognitive abilities?
  - Manipulated participants' "future forecast" (alone, rich relationships, accident-prone)
  - Also manipulated the point at which the participant was told the forecast was bogus (after test/recall, before test/encoding)

Baumeister et al. (2002) Study Design

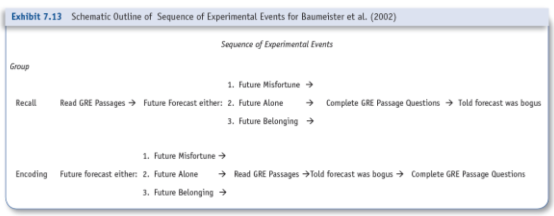


Exhibit 7.13 Schematic Outline of Sequence of Experimental Events for Baumeister et al. (2002)

Results: Baumeister et al. (2002)

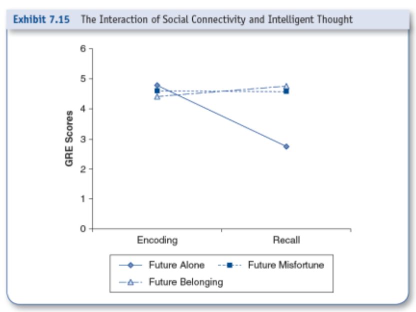


Exhibit 7.15 The Interaction of Social Connectivity and Intelligent Thought

Source: Adapted from Baumeister, Twenge, & Nuss, 2002.

Mixed Design

- Factorial designs can involve different subjects participating in each cell of the matrix (Between Subjects), the same subjects participating in each cell of the matrix (Within Subjects) or a combination where one (or more) factor(s) is manipulated between subjects and another factor(s) is manipulated within subjects (Mixed Design)
- Factors can be experimental or nonexperimental (Combined Design)

Mixed Factorial Design

- Mixed design
  - One between participant factor and one within participant factor
  - Sex = between
  - Drug = within
  - 2 X 2 mixed design

	Manipulated conditions	
Sex	**Drug**	**Placebo**
Women	A	B
Men	C	D

Mixed/Combined Design Example

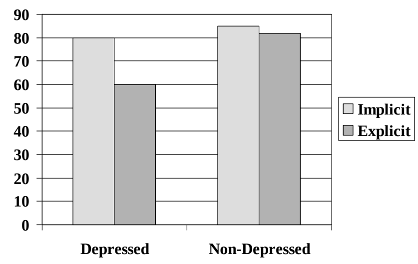
Within Subjects
Experimental

Between Subjects

Non-Experimental

	Explicit Memory Test	Implicit Memory Test
Depressed	60	80
Non-Depressed	82	85

Mixed Design Example cont.



Uses of Combined (or Expericorr) Designs

- Determine whether effects of the independent variable generalize only to participants with particular characteristics
- Examine how personal characteristics relate to behavior under different experimental conditions
- Reduce error variance by accounting for individual differences among participants

Classifying Participants into Groups in Mixed Expericorr Designs

- **Median-split procedure** – participants who score below the median on the participant variable are classified as *low,* and participants scoring above the median are classified as *high*

- **Extreme groups procedure** – use only participants who score very high or low on the participant variable (such as lowest and highest 25%)

Classifying Participants

- Splitting participants on a continuous variable with a median split or extreme groups procedure may bias the results by missing effects that are actually present or obtaining effects that are statistical artifacts.

- Instead of splitting participants into groups, researchers often use multiple regression analyses that allow them to keep the participant variable continuous.

Cautions in Interpreting Results from Expericorr Designs

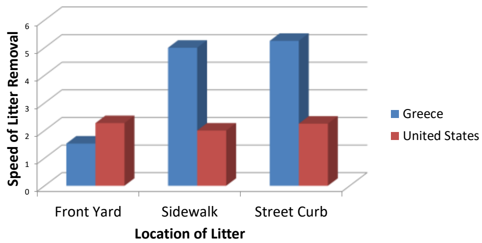
- If the manipulated independent variable affects the dependent variable, we can conclude that the independent variable *caused* this effect.
- However, because participant variables are measured rather than manipulated, we cannot infer causation.
- If a participant variable is involved in an interaction, we say that it *moderates* participants' reactions to the independent variable (rather than causes them).

Cross-Cultural Study of Speed of Litter Removal

- 2 X 3 design
- Country was a measured variable with 2 levels (US and Greece)
- Location of litter was manipulated with 3 levels: Litter was left
  - in front yards
  - on sidewalk
  - on street curb

Cross-Cultural Study of Speed of Litter Removal

(lower numbers = faster removal)



Source: Worchel & Lossis, 1982

Cross-Cultural Study of Speed of Litter Removal

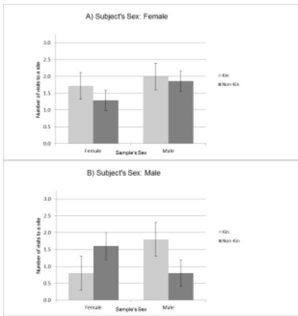
Post-hoc tests showed:

- main effect for location: Not significant
- main effect for country: Litter removed faster in US
- interaction:
  - speed of removal did not differ by country when litter was in front yard
  - removal was faster in US than in Greece when litter was on sidewalk or street curb

Higher-Order Designs

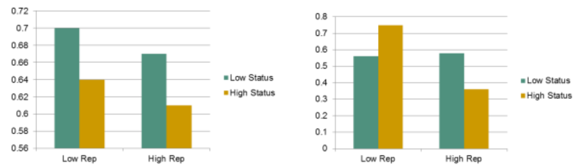
- Three-way designs examine:
  - the main effects of three independent variables
  - three two-way interactions – the A X B interaction (ignoring C), the A X C interaction (ignoring B), the B X C interaction (ignoring A).
  - The three-way interaction of A X B X C
- Fairly easy to interpret 3-way interactions
  - E.g. A X B Pattern differs for C1 and C2
- But very difficult to interpret 4-way interactions and beyond

Three Factor Designs



Three way interaction between subject sex, sample sex and kinship

Three Factor Designs



India U.S.

3 Way interaction of reputation, status and sample (country)

Uses for Factorial Designs

Test hypotheses about moderator variables

- Recall that moderator variables change the effect of an IV
- Effect of IV is different under different conditions of the moderator variable
- Effect of moderator takes the form of an interaction
  - In litter removal example, country (US or Greece) moderated the effect of litter location (front yard, sidewalk, or curb) on removal speed
  - In other words, effect of location on removal speed depended on whether location was US or Greece

Uses for Factorial Designs

- Detecting order effects
- Controlling extraneous variance by blocking
  - Participants are grouped according to an extraneous variable and that variable is added as a factor in the design
- Reducing variance between groups
  - Include factor contributing to increased variance within groups (e.g. age) such that groups are now divided into the levels of this factor (young vs. older)
  - Doesn't limit external validity like restricting range or holding constant does