## Multifactorial design

- Up until now, we have looked at statistical designs where there was only one factor
  - Factor:
- When there were 2 levels, we could use a t-test; more than 2, an ANOVA; but there was only 1 dimensior, or way in which the levels differed.
  - Level:
- Multifactorial design:

## Factors and Levels

- A factor is
- A level is
- 2x2x2 design =
- 3x2x4 design =

- No limit on the number of factors or levels
- But for each additional factor, you get more and more complicated interactions . . .

## Example multifactorial study

- Do children speak differently to an infant than to an adult?
- Factor 1: who the child was speaking to.
- Factor 2: whether the child had siblings.
- Main effect of listener
  - Ignores factor 2 - just looks at whether kids in general spoke differently to infants than to adults.
- Main effect of sibling
  - Ignores factor 1 - just looks at whether kids with sibs talk differently overall than kids without.
- Interaction of these two factors interact.

## Could have had more levels…

- Do children speak differently to an infant than to a young adult than to an older adult?
- Factor 1: still is who the child was speaking to
  - There's just 3 levels now
- Factor 2: whether the child had siblings.
- Main effect of listener
  - Ignores factor 2 - just looks at whether kids in general spoke differently to infants than to young adults than to older adults
- Main effect of sibling
  - Ignores factor 1 - just looks at whether kids with sibs talk differently overall than kids without.
- Interaction of these two factors interact.

## Interactions

- When the effect of one factor depends on the other factor.
- Ex: You want to examine whether kids speak differently to infants than to adults
  - You find that it matters whether they have younger siblings or not
    - kids with younger siblings speak differently to adults than to infants, but kids without younger siblings do not
  - The effect of listener changes depending on the value of the other factor (having younger sibs or not)

## Main effects vs. Interactions

- Main effects -

- Interactions -

## Examples of Interactions

- Medicine:
  - Drug 1 is a good, safe medicine.
  - Drug 2 is a good, safe medicine.
  - Prescribing both at the same time leads to bad things.
- Personalities:
  - John is a friendly guy who likes most people.
  - Mary may be a friendly person who most people like.
  - John and Mary can't stand one another.

## Another example

- A researcher is interested in the English skills of overseas students coming to the US for graduate school.
- She gives a multiple choice vocabulary test to 40 incoming students, and subdivides them into even groups based on gender and on region of origin (Europe, South America, Southeast Asia, North Africa )

Example taken in a modified form from Woods, Fletcher & Hughes (1986) *Statistics in Language Studies*. Cambridge, Cambridge Univ. Press, chapter 12

## Language example data

Geographical Location

| Gender | Eu. | S Am. | N Af. | Asia | Total |
|---|---|---|---|---|---|
| male | 99 | 127 | 116 | 105 | 447 |
| female | 151 | 92 | 115 | 108 | 466 |
| TOTAL | 250 | 219 | 231 | 213 | 913 |

Example taken from Woods, Fletcher & Hughes (1986) *Statistics in Language Studies.* Cambridge, Cambridge Univ. Press, chapter 12 - page 203

## Language example, questions

- Main effects:
  - Do males differ from females?
  - Do people coming from one region differ from those of another region?
- Interactions:
  - Does the extent of any gender difference differ depending on the geographical location?

Example taken from Woods, Fletcher & Hughes (1986) *Statistics in Language Studies.* Cambridge, Cambridge Univ. Press, chapter 12 - page 203

## Interactions

- As you get more and more factors, the interactions become more and more complicated
- Eventually interactions can become almost impossible to interpret.
- So most experiments stop at 2 or 3 IVs.

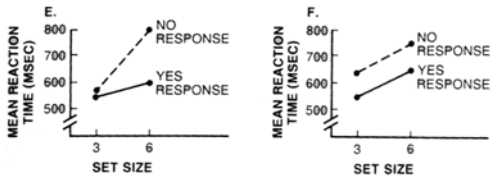
## If we add another factor to earlier study

- Add in gender of talker:
- 2x2x2 design examining who is being spoken to (adult vs. child), gender of the speaker (m vs. f), and whether the speaker has siblings (have vs. not)
  - Main effect of listener
  - Main effect of gender
  - Main effect of sibling
  - Two-way interaction between listener & gender
  - Two-way interaction between listener & sibling
  - Two-way interaction between gender & sibling
  - Three-way interaction between listener, gender & sibling

# If we add a 4th factor

- 2x2x2x2 design examining who is being spoken to, gender of the listener, gender of the speaker, and siblings (have vs. not)
  - 4 main effects of listener, listener's gender, talker's gender & sibling
  - 6 two-way interactions
    - listener & talker's gender
    - listener & listener's gender
    - listener & sibling
    - talker's gender & listener's gender
    - talker's gender & sibling
    - listener's gender & sibling
  - 4 three-way interactions
    - listener, talker's gender & sibling
    - listener, talker's gender & listener's gender
    - listener, listeners' gender & sibling
    - listener's gender, talker's gender & sibling
  - Four-way interaction between all four

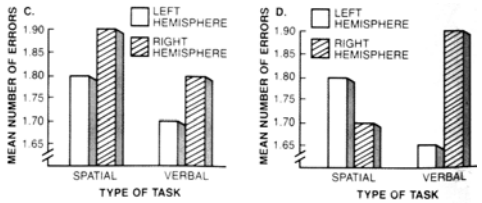
# Interactions, cont.




Mean reaction time as a function of set size and response type.

Source: J. J. Shaughnessy & E. B. Zechmeister, *Research methods in psychology*, 2nd ed,

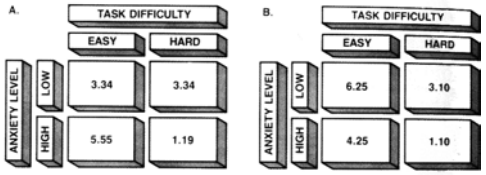
# Interactions, cont.




Mean number of errors as a function of type of task and brain hemisphere tested.

Source: J. J. Shaughnessy & E. B. Zechmeister, *Research methods in psychology*, 2nd ed,

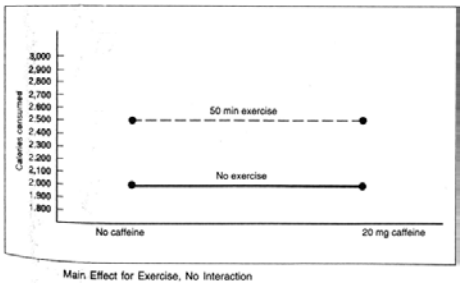
# Interactions, cont.




Mean number of correct responses as a function of task difficulty and anxiety level

Source: J. J. Shaughnessy & E. B. Zechmeister, *Research methods in psychology*, 2nd ed,

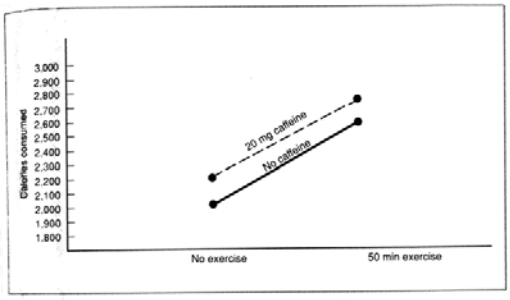
# One main effect, no interaction




Main Effect for Exercise, No Interaction

Source: M. Mitchell & J. Jolley, *Research design explained*, 2nd ed.

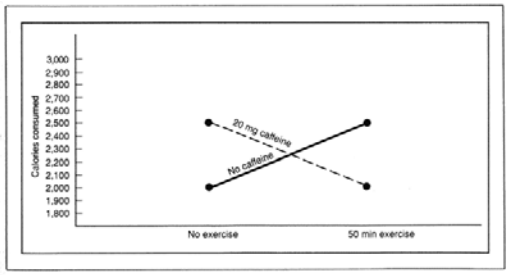
# Two main effects, no interaction




Main Effects for Caffeine and Exercise, No Interaction

Source: M. Mitchell & J. Jolley, *Research design explained*, 2nd ed.

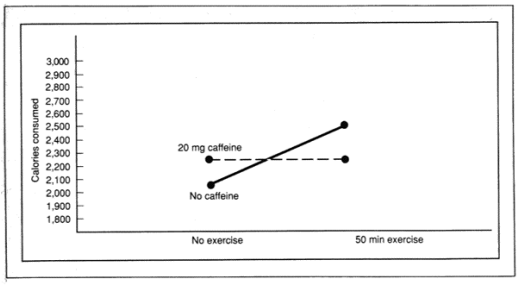
## Interaction, no main effect




No Main Effects for Caffeine or Exercise with an Interaction

Source: M. Mitchell & J. Jolley, *Research design explained*, 2nd ed.

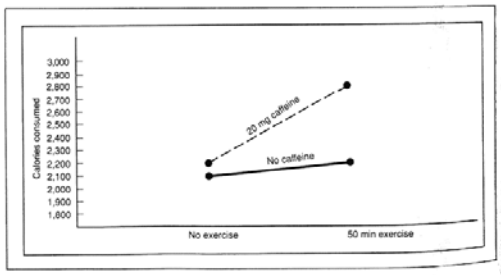
## One main effect + interaction




Main Effect for Exercise only and an Interaction

Source: M. Mitchell & J. Jolley, *Research design explained*, 2nd ed.

## Two main effects + interaction




Main Effects for Caffeine and Exercise with an Interaction

Source: M. Mitchell & J. Jolley, *Research design explained*, 2nd ed.

## Advantages of factorial design

- Allow you to test multiple factors (IVs) at same time
- Allow you to see how different factors interact
- Presence of interactions may mask main effects in non-factorial design

## ANOVA

- Used whenever there is more than 1 IV
- Looks for is differences in the amount of variability between groups vs. within groups.
- Examines both the main effects (each of the IVs) and how these IVs interact with one another (if the effect of one IV is different at different levels of another IV)

## ANOVA cont.

- Can do ANOVAs for
  - Repeated measures (within subjects)
  - Independent measures (between subjects)
  - Mixed designs (some of each)
- Ex: A speech perception task:
  - different types of noise (white vs pink)
  - different amounts of noise (0 dB SNR, -5 dB SNR, -10 dB SNR)
  - gender
  - 2x3x2 ANOVA, with two factors within-subjects (type and amount) and one factor between-subjects

## ANOVA cont.

- A significant effect will only tell you that there is some difference that is unlikely to be due to chance.
- It does not mean that ALL of the differences are real.
- To determine which ones differ, you need to do follow-up (post hoc) tests.
  - Newman-Keuls post-hoc tests
  - Sheffe post-hoc tests
  - Tukey post-hoc tests
  - T-tests???

## Test scores -- 10 pts = signif.

| | Normal hearing | Hearing impaired | |
|---|---|---|---|
| Quiet | 80 | 60 | 70 |
| Noise | 70 | 50 | 60 |
| | 75 | 55 | |

## Test scores -- 10 pts = signif.

| | Group 1 | Group 2 | |
|---|---|---|---|
| Condition 1 | 80 | 60 | 70 |
| Condition 2 | 50 | 80 | 65 |
| | 65 | 70 | |

## Test scores -- 10 pts = signif.

| | Group 1 | Group 2 | |
|---|---|---|---|
| Condition 1 | 60 | 80 | 70 |
| Condition 2 | 60 | 50 | 55 |
| | 60 | 65 | |

## Test scores -- 10 pts = signif.

| | Level 1 | Level 2 | Level 3 | |
|---|---|---|---|---|
| Condition 1 | 60 | 80 | 70 | 70 |
| Condition 2 | 70 | 50 | 90 | 70 |
| | 65 | 65 | 80 | |