FOUNDATIONS OF STATISTICAL DECISION MAKING

Comparing Multiple Groups

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OUTLINE

Outline

- Statistical variables
- Multiple group comparisons (ANOVA)

Recap

- Descriptive vs. inferential statistics
- The normal distribution
- Comparing groups
- Statistical/practical significance

Resources

- Slides, data, and handouts available at:

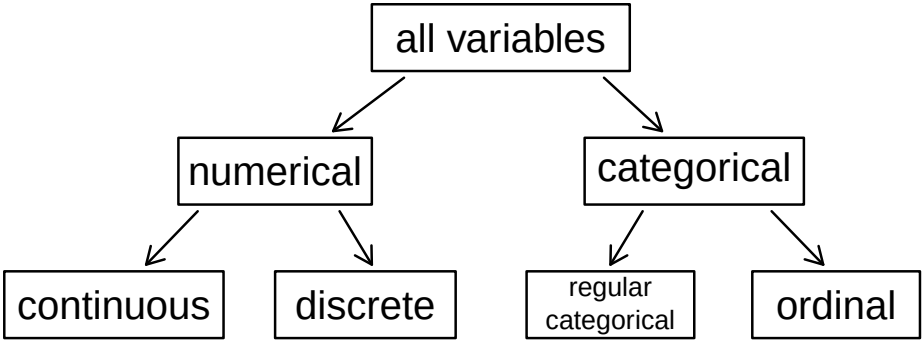
bit.ly/umhb_dpt

STATISTICAL VARIABLES

Statistical Variables

- Measureable, observable values or characteristics
- Vary across observations, measures
- Provide the basis for hypothesis test selection
- For example:
  - Is Y numerical?
  - Is X numerical or categorical?

Statistical Variables



EXAMPLE

Attitudes Toward Exercise Intensity

- Imagine we design an experiment to test attitudes toward different levels of exercise intensity between high- and low-fit participants

ID	Intensity	Fitness	Attitude
26	Low Intensity	High Fitness	21
10	High Intensity	High Fitness	33
14	High Intensity	Low Fitness	12
8	High Intensity	High Fitness	37
17	High Intensity	Low Fitness	12
3	High Intensity	High Fitness	46
⋮	⋮	⋮	⋮

Attitudes Toward Exercise Intensity

- Independent variables (factors):
    1. Exercise intensity (high, low)
    2. Fitness level (high, low)
- Dependent variable (outcome):
    1. Attitude score (0-50)

Attitudes Toward Exercise Intensity

- The current study can be thought of as a 2×2 factorial design
- 2 IVs with 2 levels each = 4 cells
- To analyze experimental data like these, we use an *F*-test
- Analysis of variance (ANOVA)

Attitudes Toward Exercise Intensity

- The current study can be thought of as a 2×2 factorial design
- 2 IVs with 2 levels each = 4 cells
- To analyze experimental data like these, we use an *F*-test
- Analysis of variance (ANOVA)

	High Fitness	Low Fitness
High Intensity	$n = 10$	$n = 10$
Low Intensity	$n = 10$	$n = 10$

ANOVA

ANOVA

- Multiple group comparisons (2+)
- All factors are categorical
- Mean comparison between- or within-groups
- Two types of effects are produced
    1. Main effects
    2. Interaction effects

MAIN EFFECTS

Main Effects

- Represent mean comparison of the levels of each factor, ignoring others
- An effect suggests a mean difference between levels of a single factor, holding all others constant

Attitudes Toward Exercise Intensity

- Factors (IVs)
    1. Exercise intensity
    2. Fitness level

	High Fitness	Low Fitness
High Intensity	$M_1 = 36.30$	$M_2 = 11.60$
Low Intensity	$M_3 = 20.70$	$M_4 = 29.50$

Main Effects::Exercise Intensity

1. **Exercise intensity:**
   - How do participants in the high intensity condition compare to participants in the low intensity condition, when participants' fitness level is ignored?

$$H_0 = \frac{M_1 + M_2}{2} = \frac{M_3 + M_4}{2}$$

$$H_1 = \frac{M_1 + M_2}{2} \neq \frac{M_3 + M_4}{2}$$

Main Effects::Exercise Intensity

1. **Exercise intensity:**
   - How do participants in the high intensity condition compare to participants in the low intensity condition, when participants' fitness level is ignored?

	High Fitness	Low Fitness		
High Intensity	M_1 = 36.30	M_2 = 11.60	=	**23.95**
Low Intensity	M_3 = 20.70	M_4 = 29.50	=	**25.10**

Main Effects::Exercise Intensity

1. **Exercise intensity:**
   - The typical person in a *high* intensity exercise condition has an attitude-toward-fitness score of 23.95.
   - The typical person in a *low* intensity exercise condition has an attitude-toward-fitness score of 25.10.

	High Fitness	Low Fitness		
High Intensity	M_1 = 36.30	M_2 = 11.60	=	**23.95**
Low Intensity	M_3 = 20.70	M_4 = 29.50	=	**25.10**

Main Effects::Fitness Level

2. **Fitness level:**
   - How do highly fit participants compare to low fit participants, when exercise intensity is ignored?

$$H_0 = \frac{M_1 + M_3}{2} = \frac{M_2 + M_4}{2}$$

$$H_1 = \frac{M_1 + M_3}{2} \neq \frac{M_2 + M_4}{2}$$

Main Effects::Fitness Level

2. **Fitness level:**
   - How do highly fit participants compare to low fit participants, when exercise intensity is ignored?

	High Fitness	Low Fitness
High Intensity	M_1 = 36.30	M_2 = 11.60
Low Intensity	M_3 = 20.70	M_4 = 29.50
	= **28.50**	= **20.55**

Main Effects::Fitness Level

2. **Fitness level:**
   - The typical *highly fit* person has an attitude-toward-fitness score of 28.50.
   - The typical *low fit* person has an attitude-toward-fitness score of 20.55.

	High Fitness	Low Fitness
High Intensity	M_1 = 36.30	M_2 = 11.60
Low Intensity	M_3 = 20.70	M_4 = 29.50
	= **28.50**	= **20.55**

INTERACTION EFFECTS

Interaction Effects

- Represent the combination, or interaction, of different levels of each IV on the DV
- Occur when the pattern of means across one level of an IV differ from the pattern across another level

Attitudes Toward Exercise Intensity

- Factors (IVs)
    1. Exercise intensity
    2. Fitness level
- Dependent variable (DV)
    1. Attitude toward fitness score

	High Fitness	Low Fitness
High Intensity	36.30	11.60
Low Intensity	20.70	29.50

Interaction Effects

1. Exercise Intensity $\times$ Fitness Level
    - Does exercise intensity influence attitudes toward working out among people categorized as either high or low fit?

No interaction effect: $M_1 - M_2 = M_3 - M_4$

Interaction effect: $M_1 - M_2 \neq M_3 - M_4$

Attitudes Toward Exercise Intensity

- Let's test our hypotheses using a factorial ANOVA

$$F = \frac{MS_{BG}}{MS_{WG}}$$

Results

Table 1: Two-Way Analysis of Variance Results

	df	*SS*	*MS*	*F*	*p*	ω^2
Intensity	1	13.22	13.22	0.56	0.46	0.00
Fitness	1	632.02	632.02	26.80	$<.01$	0.14
Intensity $\times$ Fitness	1	2805.63	2805.63	118.95	$<.01$	0.64
Total	36	849.10	23.59			

Results::Main Effects

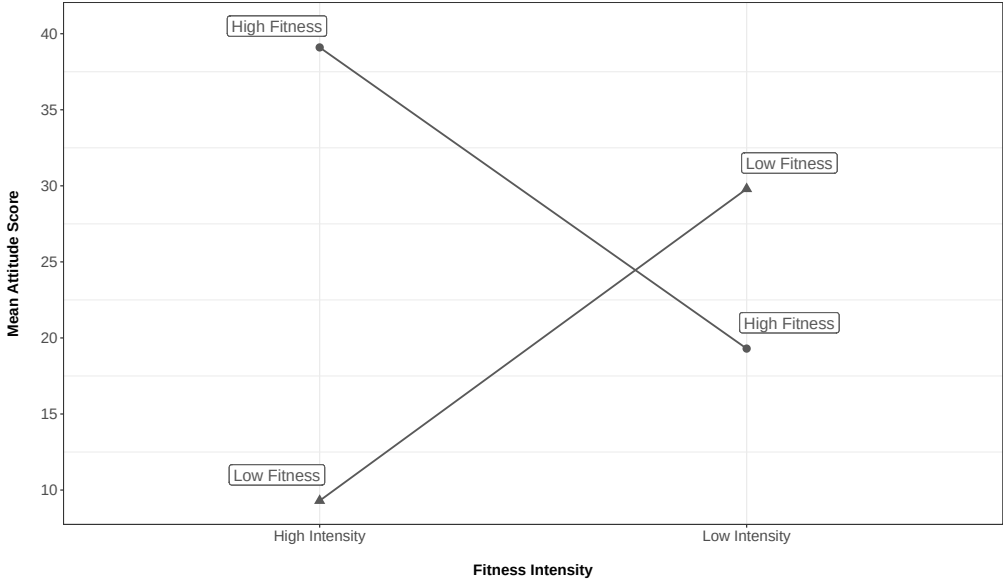
- No main effect for exercise intensity was observed, $F(1, 36) = 0.56$, $p > .05$
  - Attitude-toward-fitness scores did not differ between participants in either the high- or low-intensity exercise conditions
- A main effect for participant fitness level was observed, $F(1, 36) = 26.79$, $p < .01$, $\omega^2 = .14$
  - People who are highly fit demonstrate higher attitude-toward-fitness scores, on average, comared to people who are considered low fit

Results::Interaction Effects

- A significant Intensity $\times$ Fitness level interaction effect was observed, $F(1, 36) = 118.95, p < .01, \omega^2 = .64$
  - High fitness::High intensity **>** High fitness::Low intensity
  - Low fitness::High intensity **<** Low fitness::Low intensity

	High Fitness	Low Fitness
High Intensity	$M_1 = 36.30$	$M_2 = 11.60$
Low Intensity	$M_3 = 20.70$	$M_4 = 29.50$

Results::Interaction Effects



Results::Effect Sizes

- Intensity: N/A
- Fitness: ω^2 = .14
  - Participant fitness level explains approximately .14 $\longrightarrow$ 14% of the variability in attitude-toward-fitness scores
- Intensity $\times$ Fitness: ω^2 = .64
  - The Intensity $\times$ Fitness interaction explains approximately .64 $\longrightarrow$ 64% of the variability in attitude-toward-fitness scores

RECAP

Recap

- All variables are either numerical or categorical
- ANOVA allows for multiple group comparisons
- Main effects represent differences between levels of a single variable, ignoring others
- Interaction effects occur when the pattern of means across one level of an IV differ from the pattern across another level

Next Time

- Foundations of relationships and prediction
  - Correlating variables
  - Predicting outcomes (Regression)