Between-Participants Designs

PSYC204: Experimental Research Methods

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Week 2

Learning Objectives

- Introduction to between-participants designs:
  - characteristics
  - advantages & disadvantages
- Confounding variables:
  - sources of confounding
  - equivalent groups
  - limiting confounding
- Individual differences and variability:
  - differences between treatments and variance within treatments
  - minimising variance within treatments
- Other threats:
  - differential attrition
  - communication between groups

Between-Participants Designs

Between-Participants Designs

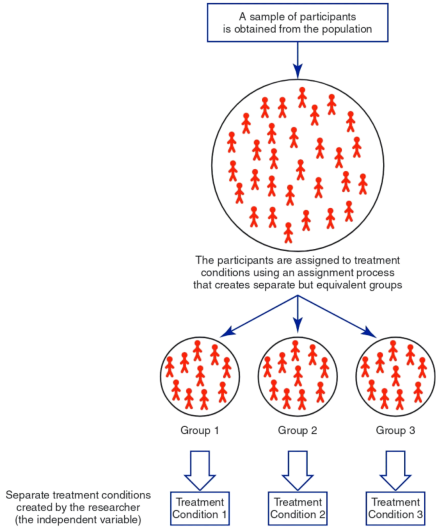
- There are two basic research designs used to obtain groups of scores that are compared in an experiment:
    1. In a **within-participants design**, the different groups of scores are obtained from the same group of participants
    2. In a **between-participants design**, each group of scores is obtained from a different group of participants

Today:

- Focus on between-participants designs
- Next week: Within-participants designs

Characteristics of Between-Participant Designs

- A between-participants design uses **independent scores**
- It allows only one score for each participant
- If there are 30 scores each in treatments A, B, and C, then the experiment employed 30 participants in each treatment (90 participants)
- A different group of participants is used for each level of the independent variable
- Each participant receives one level of the independent variable



Advantages of Between-Participants Designs

- The main advantage of between-participants designs is independent scores:
  - yields a relatively clean measurement that is uncontaminated by other treatment factors
- A between-participants design is also immune to:
  - practice or experience gained in other treatments
  - fatigue or boredom from participating in multiple treatments
  - contrast effects resulting from comparing one treatment to another
- A between-participants design is always an option

Disadvantages of Between-Participants Design

- One disadvantage of between-participants designs is they require a relatively large number of participants
- The main disadvantage of such designs is **individual differences:**
  - personal characteristics (e.g., gender, age, IQ, personality) that vary across participants
  - such individual differences are extraneous variables that are not features of the research design
- The problem with individual differences is two-fold:
  1. they can become confounding variables
  2. they can produce high variability in scores, which can mask an effect of the independent variable manipulation

Confounding Variables

Sources of Confounding

- In a between-participants design, one must ensure different groups are as similar as possible, except for the independent variable used to differentiate groups
- Any extraneous variable that systematically differentiates groups is a confounding variable
- There are two major sources of confounding in a between-participants design:
    1. confounding from individual differences
    2. confounding from environmental variables
- A researcher must try to create groups that are equivalent to avoid these sources of confounding

Confounding Variables: Equivalent Groups

- We can control for confounding by individual differences and environmental variables by creating equivalent groups
- This means the separate groups must be:
    1. *Created equally*. The process used to obtain participants should be as similar as possible
    2. *Treated equally*. Except for the independent variable manipulation, groups should be treated identically
    3. *Composed of equivalent individuals*. The characteristics of the participants in any one group should be as similar as possible to those of participants in every other group

Limiting Confounding by Individual Differences

- The three primary techniques for limiting confounding by individual differences are:
    1. Random Assignment (Randomisation)
    2. Matching Groups (Matched Assignment)
    3. Holding Variables Constant or Restricting Range of Variability
- These methods were discussed in our Week 1 Lecture

Limiting Confounding by Individual Differences

- Random assignment is the most popular method for creating equivalent groups:
  - we use **restricted random assignment**; the restriction is that groups must be equal in size
  - controls for many variables without having to address each individual variable
  - with small samples, chance may not produce equivalent groups
- When a few variables can be identified whose control is crucial, these can be controlled by matching or holding constant:
  - matching requires pretesting to measure variables being controlled
  - holding a variable constant guarantees a variable cannot confound the research but limits external validity

Individual Differences and Variability

Individual Differences and Variability

- In addition to becoming confounding variables, individual differences can produce high variability in the scores in a study
- This can obscure any treatment effects that may exist
- For example, suppose you conduct an experiment examining the effect of working memory training on working memory performance
  - an experimental group receives the training, whereas a no-treatment control group does not
  - you then measures performance on a “novel” working memory test (min = 0; max = 66)
- You observe a mean difference of 10 points between the two groups

Individual Differences and Variability

- In some situations a 10-point difference is large, but in other circumstances it is small
- The absolute size of the difference must be considered in relation to the **variance** of the scores
- **Variance** is a statistical value that measures the size of the differences from one score to another:
  - if scores all have similar values, variance is small
  - if there are big differences between scores, variance is large

The following demonstration shows:

- how individual differences influence variance
- how high variance can obscure treatment effects

Hypothetical Scores on a Working Memory Measure for Two Simulated Populations

Table: In population A, the individual differences are small. In population B, the individual differences are large.

Population A					Population B				
42	39	41	39	39	32	48	28	24	20
41	40	41	41	40	24	32	56	60	44
40	38	38	40	40	44	20	40	52	40
42	39	40	41	40	44	36	36	48	60
40	42	40	38	39	36	56	56	52	28
38	41	40	39	38	56	32	60	24	28
38	42	41	42	39	36	52	48	40	20
41	38	42	39	40	48	28	20	60	40
40	39	41	40	40	40	44	32	24	48
41	40	40	42	39	40	32	36	44	52

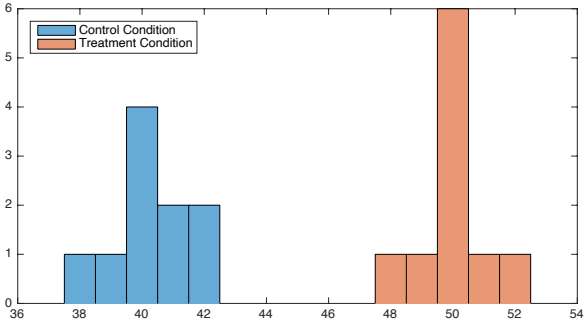
Population A: $\overline{X}$ = 40.00, s^2 = 1.25, σ = 1.55, range = 4
Population B: $\overline{X}$ = 40.20, s^2 = 140.78, σ = 11.86, range = 40

Individual Differences and Variability

- Let's run a simulation study, first with population A, then with population B
    1. We select a random sample of 20 scores from the population and randomly divide the sample into two groups, with 10 in each group
    2. One group is assigned to the control condition that has no effect on their scores. The second group is assigned to a treatment (working memory training) that increases each participant's score by 10 points.

Simulation 1: Population A (Small Individual Differences)

Control Condition	Treatment Condition
41	50
40	50
42	49
40	50
39	50
40	48
42	50
41	51
38	52
40	50
$\overline{X}$ = 40.3	50
s^2 = 1.56	1.10
σ = 1.25	1.05



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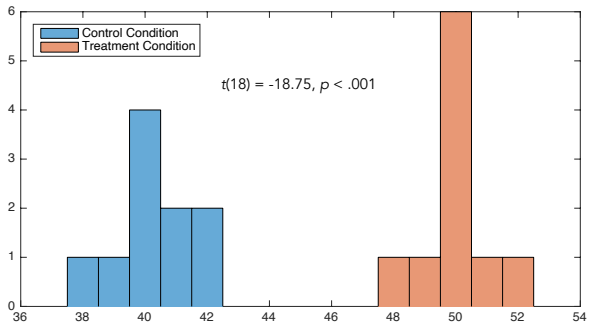
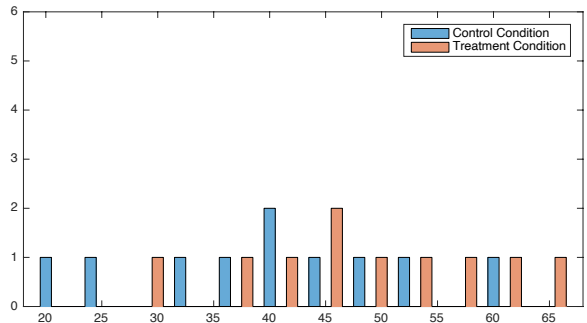


Simulation 2: Population B (Large Individual Differences)

	Control Condition	Treatment Condition
	40	46
	36	58
	52	66
	44	38
	48	62
	40	46
	60	30
	24	42
	32	50
	20	54
$\overline{X}$ =	39.6	49.2
s^2 =	151.04	123.65
σ =	12.29	11.12



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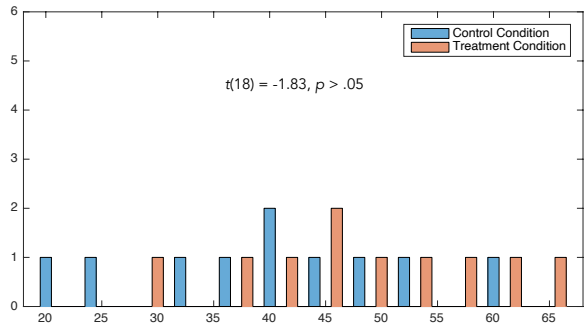

Individual Differences and Variability

- You can think of variance within each group as similar to interference to a cell phone or radio signal
  - when there is a lot of interference, it is difficult to get a clear signal
- Similarly when an experiment has a lot of variance, it is difficult to see a real treatment effect
- In between-participants experiments, much of the variance is cause by individual differences
- Whenever there are large differences between individuals, there is large variance

Differences Between Treatments and Variance Within Treatments

- In general, the goal of a between-participants experiment is to establish the existence of a treatment effect
- Accordingly, big differences *between* treatments are good because they provide evidence of differential treatment effects
- On the other hand, big differences *within* treatments are bad because they can obscure patterns in the data
- Notice we are distinguishing differences *between treatments* and variance *within treatments*
- We generally try to *increase* the differences *between treatments* and *decrease* the variance *within treatments*

Differences Between Treatments and Variance Within Treatments

Table: Examples of differences between treatments and variance within treatments.

	Large between group differences, no within-group variance			*No between group differences, high within-group variance*			*Moderate between group differences, moderate within-group variance*		
	Group A	Group B	Group C	Group A	Group B	Group C	Group A	Group B	Group C
	10	20	30	10	15	5	10	10	20
	10	20	30	25	20	25	10	20	20
	10	20	30	30	30	25	10	20	30
	10	20	30	35	40	45	20	20	30
	10	20	30	50	45	50	20	30	30
Mean	10	20	30	30	30	30	14	20	26
S^2	0	0	0	14.6	12.8	18.0	5.5	7.1	5.5

Differences Between Treatments and Variance Within Treatments

- We can *increase* differences between treatments by using strong manipulations
- Suppose we want to know if smokers exposed to a fear appeal are more likely to quit smoking than smokers not exposed to a fear appeal
- To increase the likelihood of observing a large difference between treatments, we should create an appeal that induces high (versus low or moderate) levels of fear
- How, then, do we *decrease* the variance within treatments?

Minimizing Variance Within Treatments

- There are at least three strategies for minimising variance within treatments:
    1. Standardise Procedures and Treatment Setting
    2. Limit Individual Differences
    3. Sample Size

Standardise Procedures and Treatment Setting

- Variability within each group can be minimised by using standardised testing procedures that ensure all participants within a group are treated exactly the same
- Although existing individual differences are not reduced, care is taken not to increase them
- Thus, researchers should avoid making any changes in the treatment setting or procedures used from one individual to another
- Whenever two individuals are treated differently, there is a chance differences between their scores will be increased, increasing variance within the group

Limit Individual Differences

- Holding a variable constant (or restricting its range) can help limit confounding from individual differences
- This method also reduces the variance within a group of participants
- For example, suppose it is known that age is related to the participants scores (e.g., older adults tend to have higher scores than younger adults)
- A mixed group of younger and older adults will have higher variance than a group of only younger adults
- By holding age constant (e.g., older only), age differences are eliminated and variance within the group is reduced

Limit Individual Differences

- Similarly, restricting a participant variable to a narrow range of values creates a more homogenous group, reducing the variability in scores
- For example, if participants within a group are limited to those between the ages of 18 and 20, then age differences make a very small contribution to the variance of scores
- In general, any attempt to minimise differences between participants within a group tends to reduce variance within the group

Sample Size

- Sample size does not directly affect individual differences or variance
- However, some of the negative effects of high variance can be overcome in the statistical analysis by use of a very large sample
- This technique is limited as the influence of sample size occurs in relation to the *square root* of the sample size
- To reduce the effects of high variance by a factor of 4, for example, the sample size must be increased by a factor of $4^2 = 16$ (a sample of 20 would need to be increased to 320!)
- This means it takes a dramatic increase in sample size to have a real effect

Summary and Recommendations

- The best methods for minimising high variance are to standardise treatments and minimise individual differences
- Both methods eliminate factors that can cause differences between scores and reduce variance within treatments
- Minimising individual differences by holding a variable constant or restricting its range has two advantages:
    1. it helps create equivalent groups, reducing the threat of confounding variables
    2. it helps reduce variance within groups, making treatment effects easier to see
- However, limiting individual differences has the disadvantage of limiting external validity

Other Threats

Other Threats to Internal Validity

- Earlier, we discussed two major threats to the internal validity of between-participants experiments:
    1. Confounding due to individual differences
    2. Confounding from environmental variables
- We now consider two additional potential confounds specific to between-participants designs:
    3. Differential Attrition
    4. Communication between Groups

Differential Attrition

- *Attrition* refers to when participants withdraw from a study before it is completed
- **Differential attrition** refers to differences in the rates of attrition from one group to the next
- If the rate of attrition is comparable across groups, then this is not a problem
- However, if the attrition rate varies markedly between groups, this can become a threat to internal validity
  - groups are created initially to be equivalent
  - if large numbers withdraw from one group, it may no longer be similar to the others

Differential Attrition

- For example, a researcher tests the effectiveness of a diet program
- Two groups of participants are created with comparable characteristics (weight, gender, dieting history)
  - the treatment group receives the diet program during a 10-week period
  - the no-treatment control group receives no diet program during this period
- At the end of the 10-weeks, weights of the two groups are compared
- Since the study runs for 10 weeks, some attrition may be expected

Differential Attrition

- Suppose none of the participants withdraw from the control group
- But, several of the less motivated participants drop out of the treatment group
- If the mean weight of the treatment group is lower than the control group
  - it could be the diet program is genuinely effective, or ...
  - ... that participants in the treatment group simply have higher levels of motivation
- Differential attrition has introduced a confounding variable, clouding interpretation of the results

Communication Between Groups

- If participants in one treatment condition are allowed to talk with participants in another condition, various problems can arise …

Communication Between Groups

1. **Diffusion** is the spread of the treatment from the experimental group to the control group, which tends to reduce the difference between the two conditions
2. **Compensatory equalisation** is when one group having learned about the treatment being received by another group demands the same treatment
3. **Compensatory rivalry** is when participants in an untreated group learn about the special treatment received by another group and compensate by working extra hard
4. **Resentful demoralisation** is when participants in an untreated group learn about the special treatment received by another group and become less productive and motivated

Communication Between Groups

- In each case, internal validity is threatened because the observed differences (or lack thereof) between groups can be explained by factors other than effects of the treatment
- Keeping different groups separate as much as possible is the best remedy to these threats from communication
- In practice, this is easier said than done

Key Terms and Definitions

- **Between-participants design:** an experimental design in which there are separate, independent groups of individuals for each treatment condition. As a result, the data for a between-participants design contain only one score for each participant. To qualify as an experiment, the design must satisfy all other requirements of the experimental research strategy, such as manipulation of an independent variable and control of extraneous variables.
- **Independent measures design:** a between-participants design is also known as an independent measures or independent groups design because researchers compare unrelated measurements taken from separate groups.
- **Individual differences:** personal characteristics that differ from one participant to another (e.g., intelligence, learning, personality, speed of processing, working memory etc).
- **Restricted random assignment:** a form of random assignment where the group assignment is limited to ensure pre-determined characteristics (such as equal size) for the separate groups.

In Next Week's Lecture

- Within-participants designs

That’s All Folks!