Experimental Research Strategy

PSYC204: Experimental Research Methods

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Week 1

Learning Objectives

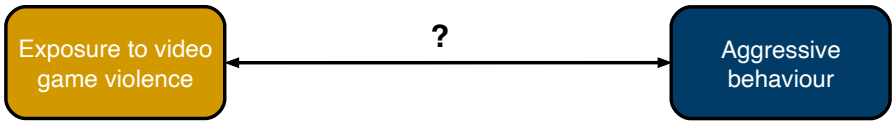
- Problems with correlation:
  - directionality problem
  - third-variable problem
- Experimental research strategy:
  - manipulation
  - control
- Controlling extraneous and confounding variables:
  - holding constant, matching, and randomisation
- Control conditions:
  - no-treatment control conditions
  - placebo control conditions
- Manipulation checks

Problems With Correlation

Correlational Research Strategy

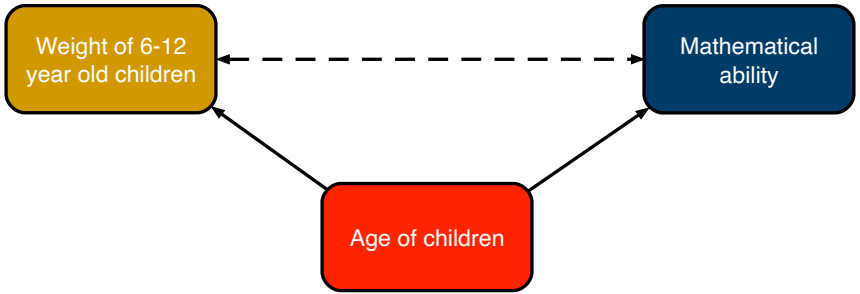
- Measure two or more variables as they exist naturally
- Determine if a relationship exists between variables and describe the nature of that relationship
- **Problem:** correlation does not imply causation, for two reasons
    1. directionality problem
    2. third-variable problem

Directionality Problem



- This is a specific example of a more general problem known as the directionality problem
- Two variables, x and y, can be related because x causes y or because y causes x
- In correlational research, it is impossible to determine the direction of causality between two related variables

Third-Variable Problem



- This is a specific example of another general problem—the third-variable problem
- If two variables, x and y, are related, it does not mean one causes the other
- Changes in an unintended variable, z, may be causing a coincidental relationship between variables by independently changing x and y

Experimental Research Strategy

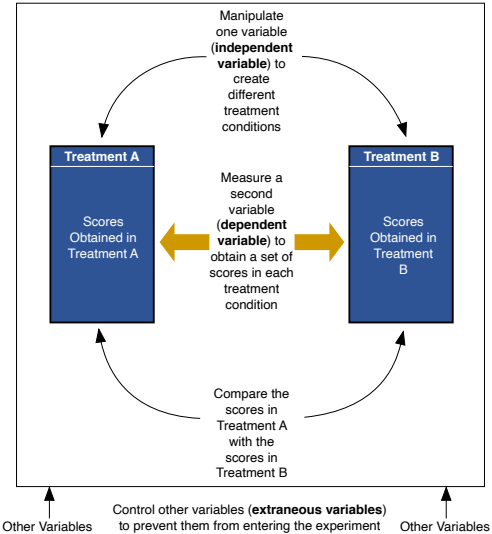
Experimental Research Strategy

- The goal of the experimental research strategy is to establish a cause-and-effect relationship between two variables
- We want to know that any relationship between the two variables is not merely coincidental
- To do this, an experiment must show that changes in one variable are accompanied by changes in another variable
- An experiment contains four basic elements

Components of an Experimental Research Study

1. Manipulation★. An **independent variable** is manipulated by changing its value to create two or more **treatment conditions** (**levels** of the independent variable)
2. Measurement. A **dependent variable** is measured to obtain a set of scores in each treatment condition
3. Comparison. The scores in each treatment condition are compared with one another
4. Control★. Other variables—known as **extraneous variables**—are controlled to ensure they do not influence the two variables being examined

★ = unique to experimental research strategy



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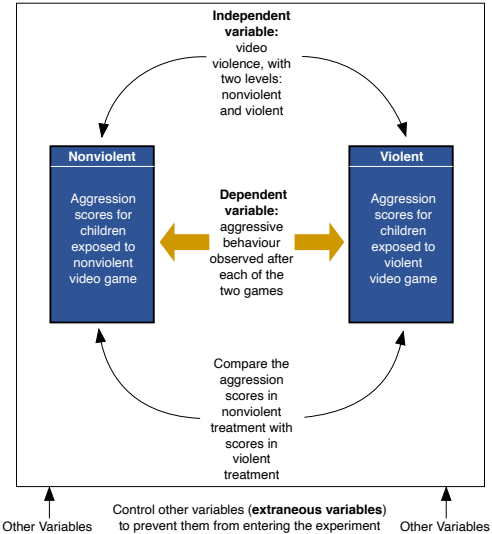
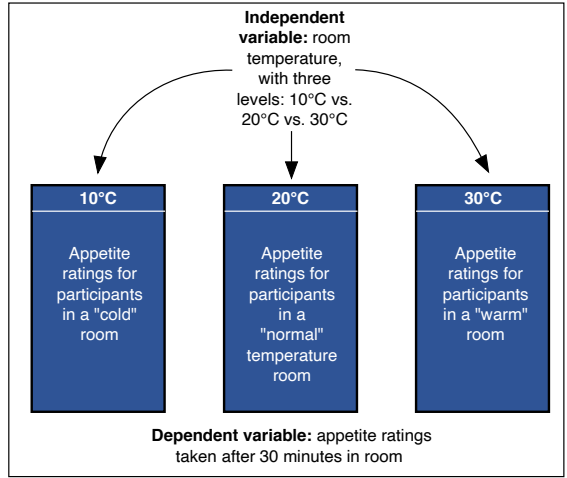


Cause-and-Effect Relationships

- To demonstrate a cause-and-effect relationship, two things must be satisfied:
    1. **It must be shown that the "cause" precedes the "effect".** To accomplish this, a researcher first manipulates the independent variable before observing the dependent variable to see if it changes also (**Manipulation)**
    2. To establish one specific variable is responsible for changes in another variable, **an experiment must rule out the possibility the changes are caused by an extraneous variable** (**Control**)

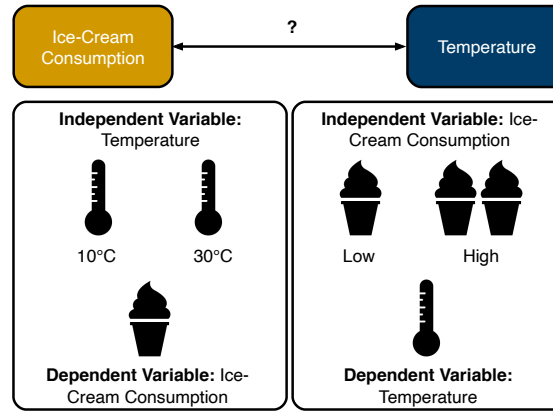
Manipulation

- **Manipulation** is achieved by deciding which values of the independent variable you want to examine before creating treatment conditions corresponding to those values
- For example, a researcher might examine the effect of room temperature (independent variable) on appetite (dependent variable)
- The researcher tests participants in three different treatment conditions where room temperature is either 10°C (“cold”), 20°C (“normal”), or 30°C (“warm”)
- Appetite ratings are taken after participants have spent 30 minutes in the room



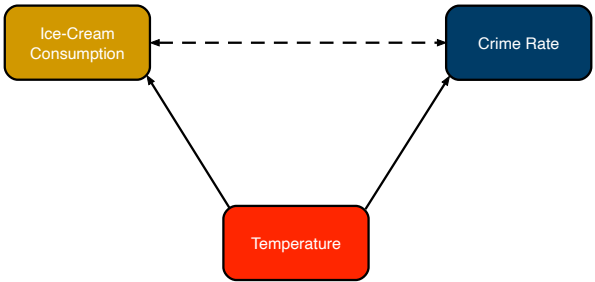
Manipulation and the Directionality Problem

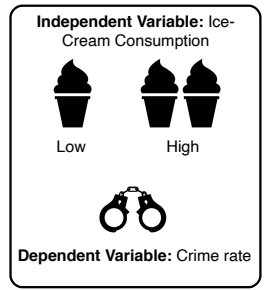
- Manipulation allows the researcher to determine the *direction* of a relationship between variables
- One technique is to manipulate one of the variables (cause it to increase or decrease) and watch the second variable to see if it is affected
- Whenever there is a relationship between two variables, manipulation can be used to determine which variable is *cause* and which is *effect*

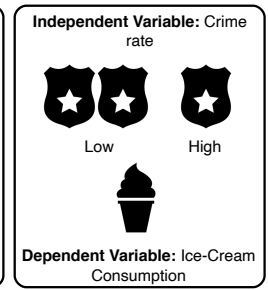


Manipulation and the Third-Variable Problem

- Manipulation overcomes the third-variable problem by establishing whether there is a cause-and-effect relationship between two variables







Control

- The second defining feature of experiments is **control** of other variables
- Specifically, variables other than the independent and dependent variables
- To accurately determine the relationship between two variables, one must ensure that relationship is not contaminated by other variables

Key Terms and Definitions

- **Experimental research strategy:** establishes the existence of a cause-and-effect relationship between two variables by manipulating an independent variable while a dependent variable is measured and extraneous variables are controlled.
- **Independent variable:** the variable manipulated by the researcher. It consists of two or more treatment conditions which participants are exposed to.
- **Treatment condition:** a situation characterised by one specific value of the independent variable.
- **Levels:** the different values of the independent variable selected to create and define the treatment conditions (e.g., a manipulation of room temperature might have three levels: 10°C, 20°C, or 30°C.)
- **Dependent variable:** the variable measured for changes to assess the effect of the independent variable.
- **Extraneous variables:** all variables other than the independent and dependent variables.

Extraneous Variables

Extraneous and Confounding Variables

- The focus in an experiment is on the relationship between the independent and dependent variables
- However, there are many other extraneous variables that exist within any experiment:
  - participant variables (e.g., age, IQ, personality)
  - situational variables (e.g., temperature, lighting, noise)
  - experimenter variables (e.g., physical appearance & demeanour)
- Any of these extraneous variables has the potential to become a **confounding variable**:
  - a third variable that is allowed to change systematically along with the two variables being studied

Extraneous and Confounding Variables

- A confounding variable has two characteristics:
  1. An extraneous variable becomes a confounding variable only if it influences the dependent variable
     - something unrelated to the dependent variable is not a threat
  2. A confounding variable must vary systematically with the independent variable
     - a variable that changes randomly, with no relation to the independent variable is not a threat

Extraneous and Confounding Variables

- The first step in controlling extraneous variables is to identify those variables most likely to influence the dependent variable
  - based on commonsense, logical reasoning, and past experience controlling extraneous variables
- For example, suppose you are measuring working memory performance
  - IQ, executive functioning, age, and variation in the test setting or testing times could all influence performance
- The variables identified in this step are ones that may require special attention to ensure control
  - other variables are not ignored but are instead handled more casually (this will become clear later)

Methods for Controlling Extraneous Variables

- There are three methods for controlling extraneous variables
- **Active control methods:**
    1. Holding constant
    2. Matching
- **Passive control methods:**
    3 Randomisation

Holding a Variable Constant

- An extraneous variable can be eliminated by **holding** it **constant**
- We can standardise the testing situation and procedures to hold these constant
  - e.g., by testing participants in the same room, at the same time of day, by the same experimenter
- We can hold participant variables constant
  - e.g., by only selecting 10-year-old children to participate in an experiment, age is held constant
- Since these variables are the same for each observation, they do not vary across different treatments and can't become confounding variables

Holding a Variable Constant

- Often it is not possible to hold a variable completely constant
  - e.g., it would not be possible to require all participants to be 21 years old and have an IQ of 110
- Instead, researchers often restrict a variable to a limited range instead of holding it completely constant
  - e.g., a researcher may require participants to be between 18 and 21 years of age with an IQ between 100 and 110
- Although age and IQ are not perfectly constant here, the restricted range should ensure participants in one treatment do not differ appreciably from those in another treatment

Holding a Variable Constant

- Holding a variable constant eliminates its potential to become a confounding variable, improving the **internal validity** of the experiment
- However, it can limit the **external validity** of the experiment
- For example, conclusions about the capacity limit of working memory based on experiments with 18–21 year olds may not generalise to older adults
- Memory abilities decline over the life span, so we may reasonably expect older adults to have a lower working memory capacity than younger adults

Matching Values across Treatment Conditions

- Control over extraneous variables can also be achieved by **matching** the levels of the variable across treatments
- For example, we could assign 20 younger participants (under age 25) and 10 older participants (25 or older) to each treatment
- A more common form of matching is to ensure the average value of a variable is the same (or nearly the same) for all treatments
- For example, participants could be assigned so the average age is the same across treatments
- In this case, age is balanced across treatments and, therefore, cannot be a confounding variable

Matching Values across Treatment Conditions

- Controlling a variable by matching or holding constant can be time-consuming and effortful
- Matching requires a measurement of a participant's score on all variables (e.g., age, executive functioning, IQ) on which they will be matched before the experiment commences
- Although it is possible to control a few variables by matching or holding constant, the demands of these methods render them impractical or impossible to control all extraneous variables
- Active control by matching or holding constant is only recommended for a small number of extraneous variables considered serious threats to an experiment

Randomisation

- It is impossible to think of every extraneous variable that may intrude into an experiment, let alone control for it
- The standard solution to this is **randomisation**
  - randomly assign people to different groups, and then give each group a different treatment (i.e., a different value of the independent variable)
- Randomisation seeks to disrupt any systematic relation between extraneous variables and the independent variable
- This prevents extraneous variables from becoming confounding variables

Randomisation

- Randomisation requires an unpredictable and unbiased procedure
- The procedure used must be a random process—all different possible outcomes are equally likely
- Examples of random processes include
  - tossing a fair coin
  - rolling a fair dice
  - shaking a collection of balls in a bag before pulling one out without looking
- Experimental software (e.g., PsychoPy) contain random number generators that can deal with random assignment of participants to treatments

Randomisation

- Randomisation is a powerful tool for controlling many extraneous variables
- But, it does not guarantee extraneous variables are controlled—it uses chance to control variables
  - in the long run, with large numbers (i.e., a large sample), a random process guarantees a balanced result
  - in the short run, with small numbers (i.e., a small sample), there is a chance randomisation will not work
- Variables with high potential for influencing results should therefore be actively controlled
- Others can be randomised with the understanding they will probably be controlled by chance

Comparing Methods of Control

Table: A confounding variable (column 1) and three methods to prevent confounding (columns 2–4)

IQ Confounded		IQ Held Constant		IQ Matched		IQ Randomised	
Treatment		Treatment		Treatment		Treatment	
I	II	I	II	I	II	I	II
High	High	Low	Low	High	High	High	Low
High	High	Low	Low	High	High	Low	High
Low	High	Low	Low	High	High	Low	Low
Low	High	Low	Low	High	High	High	Low
Low	High	Low	Low	Low	Low	Low	High
Low	High	Low	Low	Low	Low	High	High
Low	High	Low	Low	Low	Low	High	Low
Low	High	Low	Low	Low	Low	Low	Low
Low	High	Low	Low	Low	Low	High	High
Low	High	Low	Low	Low	Low	Low	High

Advantages and Disadvantages of Control Methods

- Active control methods:
  - holding constant and matching provide precise control of a few extraneous variables deemed real threats for confounding ✓
  - both procedures can be time-consuming and effortful ✗
  - holding a variable constant can limit generalisability (external validity) ✗
- Passive control methods:
  - randomisation has the advantage of controlling a large number of variables simultaneously ✓
  - it is not guaranteed to be successful ✗

Key Terms and Definitions

- **Internal validity:** the extent to which you can be confident that a cause-and-effect relationship established in a study cannot be explained by other factors.
- **External validity:** the extent to which you can generalise the findings of a study to other situations, people, settings, and measures.
- **Confounding variable:** a third variable that is allowed to change systemically along with the independent and dependent variables.
- **Holding constant:** holding a variable constant by fixing its value or restricting its range for all observations.
- **Matching:** matching the levels of a variable across treatments by, for example, ensuring the average value is the same for all treatments.
- **Randomisation:** the use of a random process to help avoid a systematic relationship between two variables.

Control Conditions

Control Conditions

- Typically, an experiment compares observations across different treatment conditions
- However, sometimes a researcher wishes to evaluate only one treatment rather than compare a different set of treatments
- The solution here is to compare the treatment condition with a baseline “no treatment” condition
- The treatment condition is called the **experimental condition**, and the non-treatment condition is called the **control condition**

In practice:

- Even in experiments with multiple treatments, it is often helpful to include a control condition

Control Conditions

- There are two types of control condition:
    1. No-treatment control conditions
    2. Placebo control conditions

No-Treatment Control Conditions

- A **no-treatment control condition** is one in which participants do not receive any experimental treatment
- The purpose is to provide a baseline against which the treatment condition, or conditions, can be compared
- To determine the effectiveness of a new working memory training procedure, for example, the experimental group receives the training and the control group does not
- To determine the effectiveness of a drug, for example, the experimental group receives the drug and the control group receives nothing

Placebo Control Conditions

- A **placebo** is a fake or innocuous medication, a fake medical treatment such as a sugar pill or water injection
- It has no medical effect, but produces a positive or helpful effect simply because an individual expects or believes it will happen
- The **placebo effect** is thought to be psychosomatic
  - the mind (psyche), rather than the placebo itself, has an effect on the body (somatic)
- That an individual thinks a medication is effective can be sufficient to cause a response to the medication

Placebo Control Conditions

- The placebo effect generalises to other situations
- Common examples in behavioural research include:
  - use of inactive drugs (when people are expecting psychotropic drugs)
  - nonalcoholic beverages (when people are expecting alcohol)
  - nonspecific psychotherapy (therapy with the therapeutic components omitted)

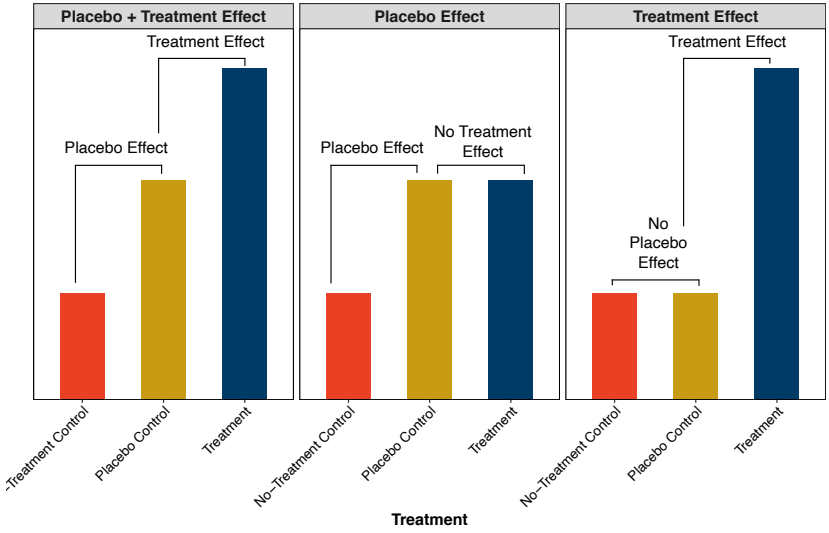
Placebo effect implications:

• A significant difference between treatment and no-treatment control could be a genuine effect of the treatment, or simply a placebo effect

Placebo Control Conditions

- To separate placebo effects from “real” treatment effects, researchers include one or more **placebo control conditions**
- The placebo control is a treatment condition in which participants receive a placebo instead of the treatment
  - comparison of the placebo control condition with the treatment condition reveals how much treatment effect exists beyond the placebo effect
- It is also common to include a third, no treatment control condition
  - comparison of the placebo control with the no-treatment control reveals the magnitude of the placebo effect

Placebo Control Conditions



Manipulation Checks

Manipulation Checks

- Sometimes, when we conduct an experiment we want to know:
  - the direct effect of the independent variable manipulation, and/or
  - how participants perceived and interpreted the manipulation
- When these questions are important, we can include a **manipulation check** as part of an experiment
- A manipulation check directly measures whether the independent variable had the intended effect on the participant

Manipulation Check

- A manipulation check is often an explicit measure of the independent variable
- Suppose we want to examine the effects of anxiety on cognitive performance
- Our experiment manipulates people's state levels of anxiety (i.e., anxiety is the independent variable)
  - experimental group receives an anxiety-induction treatment
  - no-treatment control group receives no treatment
- We could include a state anxiety measure to check the manipulation had the desired effect
  - if so, state anxiety levels should be higher in the experimental than in the control group

Manipulation Check

- A second way to check a manipulation is to embed specific questions about the manipulation in an exit questionnaire
- If the room lighting was adjusted during the experiment as part of the manipulation, you could ask:
  - “Did you notice any changes in the lights during the experiment?”
- If participants received “praise” or “criticism” from the the experimenter as part of the manipulation, you could ask:
  - “How did the researcher respond when you failed to complete the first task?”
- The intent of the manipulation-check questions is to determine whether participants perceived the manipulation and/or how they interpreted it

Manipulation Check

- Although a manipulation check can be used in any study, it is particularly important in three situations:
    1. *Participant Manipulations*. Especially attempts to manipulate a participant's emotional state using emotion-induction procedures (e.g., anxiety, mood, frustration)
    2. *Subtle Manipulations*. When the variable being manipulated is not particularly salient and may go undetected by participants
    3. *Placebo Controls*. Effectiveness of a placebo depends on its credibility, which can be assessed through a simple manipulation check

Key Terms and Definitions

- **Experimental condition:** the condition in which the treatment is administered.
- **Control condition:** the condition in which the treatment is not administered.
- **No-treatment control condition:** a condition in which the participants do not receive the treatment being evaluated.
- **Placebo effect:** a positive response by a participant to an inert medication that has no real effect on the body. The placebo effect occurs simply because the individual thinks the medication is effective.
- **Placebo control condition:** a condition in which participants receive a placebo instead of the actual treatment.
- **Manipulation check:** an additional measure to assess how participants perceived and interpreted the manipulation and/or assess the direct effects of the manipulation.

Next Week’s Lab

- Brief intro to module and Short Report CWA
- Organise into groups
- Multiple choice and open-ended questions on lecture content
- See you there!

That’s All Folks!