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Research methodologies I

Research Methodologies and Scientific Communication

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Empirical research

Content

- Target of empirical research
- Deduction versus induction
- Quality criteria
- Characteristics and variables
- Components of empirical research

Empirical research

Target of empirical research

Empirical research

The main objective of empirical investigation is to gain insight "**why**" and under "**what**" conditions certain events occur and whether there is causality between these events.

Empirical investigations are carried out to systematically **describe**, **understand** and **explain** events.

This is the basis for the derivation of **theories**, which in turn are prerequisites for making predictions as well as interventions and changes.

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Theories are **general assumptions** about the world.

Theories include the best possible description and explanation based on **empirical research** or everyday observations.

In order to test a theory it has to be verified or falsified.

Empirical research

If a theory describes specific events precisely, it’s possible to predict what will happen under certain conditions.

Hypothesis (assumptions) are made which will happen under certain conditions. It is empirically investigated whether the hypothesis is likely or not.

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Characteristics of hypothesis:

- They must relate to real facts that are empirically verifiable
- They are universal statements
- They must be falsified through experience
- They have to be formulated precisely
- They must be theory-driven

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Example of hypothesis:

Water levels affect the amount of lice suffered by rainbow trout

Rainbow trout suffer more lice in low water conditions because there is less oxygen in the water

The rate of corn plant growth does not depend on the duration of light.

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Deductive versus inductive reasoning

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Deductive reasoning

- Deductive reasoning is a basic form of valid reasoning. Deductive reasoning, starts out with a **general statement**, or hypothesis, and examines the possibilities to **reach** a **specific**, logical **conclusion**.
- It is used to **test hypotheses** and **theories**.
- In deductive inference, a theory is held and based on a prediction of its consequences is made.
- In deductive reasoning you go from the general — the theory — to the specific — the observations.

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Deductive reasoning

- For example, if a = b and b = c, then a = c. Let's flesh that out with added examples:
  - All men are mortal. (First premise). Socrates is a man. (Second premise). Therefore, Socrates is mortal. (Conclusion)
  - All numbers ending in 0 or 5 are divisible by 5. The number 35 ends with a 5, so it must be divisible by 5.
  - It's dangerous to drive on icy streets. The streets are icy now, so it would be dangerous to drive.
  - Red meat has iron in it and beef is red meat. Therefore, beef has iron in it.

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Inductive reasoning

- Inductive reasoning is the opposite of deductive reasoning.
- Inductive reasoning makes broad generalizations from specific observations. Basically, there is data, then conclusions are drawn from the data.
- In inductive inference, you go from the specific to the general

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Inductive reasoning

Examples:

- *Premise:* Every day so far, the sun has risen in the East and set in the West.
- *Conclusion:* The sun will probably continue to rise in the East and set in the West.

- *Premise:* Every time I use the can opener, my cat comes running into the kitchen.
- *Conclusion:* The cat probably thinks I am opening a can of tuna or wet food.

- *Premise:* Ben has visited four places today, and Sam has gone to those places soon after.
- *Conclusion:* Sam is probably following Ben.

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- **Quality criteria**

- Objectivity
- Reliability
- Validity

Empirical research

- **Quality criteria**

- When we talk about tests and assessments, we often talk about objectivity, reliability, and validity. Exactly what are we talking about when we throw these words around? Are these all different ways of saying the same thing?
- The three terms are interrelated but they each describe something different. It is easiest to picture the three terms as rings on a target.

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Quality criteria - Objectivity

Objectivity is the broadest and thus is the outermost ring on the target. A test that is objective measures without reference to outside influences. For example, an objective test of personality will return the same answers regardless of whether the person completing the test uses a pen or pencil. Irrelevant, unrelated factors do not influence the test results if a test is objective.

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Quality criteria - Reliability

The middle ring on the target is reliability. Before reliability can be considered, a test or assessment must first be objective. Objectivity is essential but not sufficient to ensure reliability. There are different types of reliability, but at its simplest, reliability is repeatability. A reliable measure is one that returns the same result each and every time.

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Quality criteria - Validity

Validity is at the center of the target. A test must be both objective and reliable before its validity can be considered. Validity is the extent to which the test measures what it claims to measure. Unless items (questions) on a test are shown to be related to what is being assessed, the test cannot be valid. Validity also requires that a test fully assesses every aspect of a domain (or topic) it claims to assess. A driving test that only measures knowledge of traffic laws is not a valid measure of driving ability since the written test alone does not adequately assess all skills required to be a successful driver. That same test, however, can be a valid measure of knowledge of traffic laws since validity relies in part on how the domain is defined.

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Characteristics and Variables

Characteristics

- Characteristic is the property that can be assigned to an object or a person,
  - e.g. sex, body size, eye-color

Variables

- A variable is any characteristics, number, or quantity that can be measured or counted (usually marked by capital letters in Latin).
  - Example: characteristic: sex,

    variable: x1 = male or x2 = female

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Variables

- Dependent variables / Independent variables
- Moderator variables / Mediator variables

Alternative ways of classification

- Manifest variables / Latent variables
- Discrete variables / Continuous variables

Empirical research

Variables

Dependent and independent variables

- A **dependent** variable is the variable being tested in a scientific experiment.
- The dependent variable is 'dependent' on the **independent** variable. If the **independent** variable is changed, the change in the dependent variable is observed and recorded.
- The **dependent** variable is the one being **measured**.

Empirical research

Variables

Dependent and independent variables

Example:

If you're studying the rate of growth of plants using different fertilizers, can you identify the variables?

Dependent variable: rate of growth;

Independent variable: type of fertilizer

You are interested in learning which kind of chicken produces the largest eggs. The size of the eggs depends on the breed of chicken.

Dependent variable: egg size

Independent variable: breed

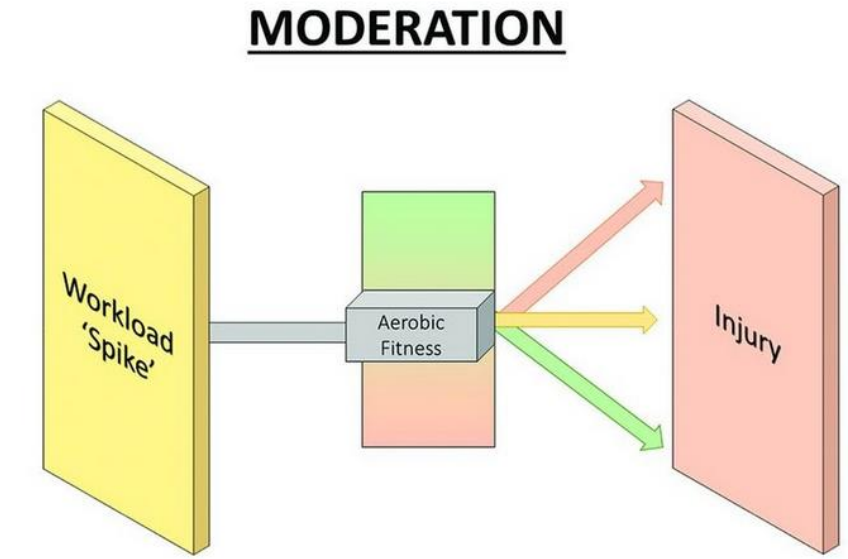
Empirical research

Variables

Moderator variables

A moderator variable, is a third variable that affects the strength of the relationship between a dependent and independent variable.

In correlation, a moderator is a third variable that affects the correlation of two variables.



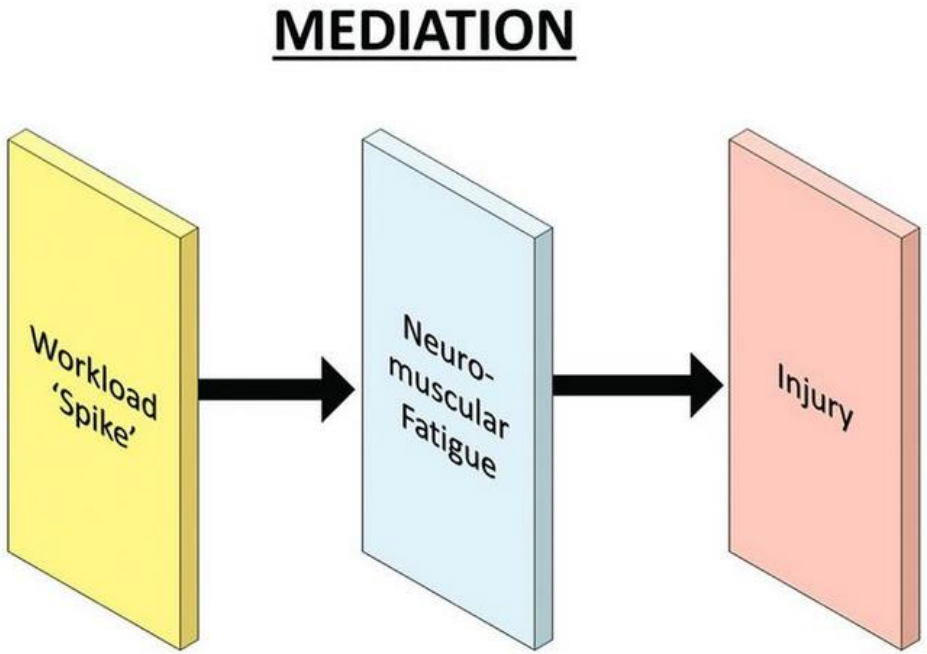
Source: Why do workload spikes cause injuries, and which athletes are at higher risk? Mediators and moderators in workload--injury investigations
Assessed: 3.4.2019

Empirical research

Variables

Mediator variables

In general, a given variable may be said to function as a mediat to the extent that it accounts for the relation between the predictor and the criterion. Mediators explain how external physical events take on internal psychological significance. Whereas moderator variables specify when certain effects will hold, mediators speak to how or why such effects occur.



Source: Why do workload spikes cause injuries, and which athletes are at higher risk? Mediators and moderators in workload--injury investigations
Assessed: 3.4.2019

Empirical research

Variables *(an alternative way to classify variables)*

manifest variables

- Directly observable
  - e.g. price of a product, sex,...

Latent variables

- Not directly observable,
- not directly observed but are rather inferred from other variables that are observed (directly measured).
  - e.g. Evaluation of a green area in terms of quality of life

Empirical research

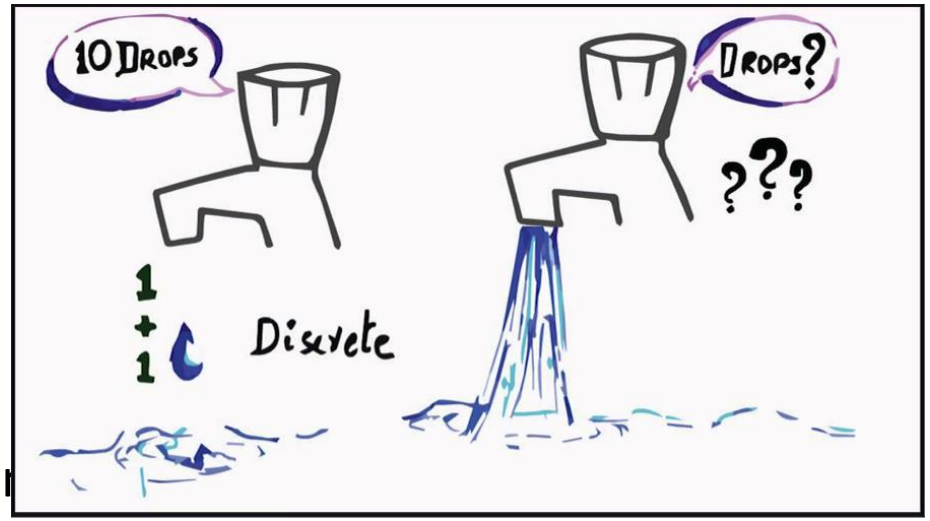
Variables *(another alternative way to classify variables)*

Discrete versus continuous variables

A discrete variable is a variable that can only take on a certain number of values. In other words, they don't have an infinite number of values.

e.g.: 1-2- 3- 4 - 5 - 6 -7

A continuous variable can take on an infinite number of possibilities, for instance time (although it may be measured in certain intervals like every 10 seconds)



Source: blog unbiased research (15/07/19)

Empirical research

Scale of measurement

Measurement scales are used to categorize and/or quantify variables. Four scales of measurement that are commonly used in statistical analysis:

- Nominal scale
- Ordinal scale
- Interval scale
- ratio scale

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Nominal scale

- The nominal scale of measurement only satisfies the **identity property of measurement**. Values assigned to variables represent a descriptive category, but have no inherent numerical value with respect to magnitude.
- **Gender** is an example of a variable that is measured on a **nominal scale**. Individuals may be classified as "**male**" or "**female**", but neither value represents more or less "gender" than the other. Religion and political affiliation are other examples of variables that are normally measured on a nominal scale.

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Ordinal scale

- The ordinal scale has the property of both **identity** and **magnitude**. Each value on the ordinal scale has a unique meaning, and it has an ordered relationship to every other value on the scale.
- An example of an ordinal scale in action would be the **results of a sports competition**, e.g. Marathon run. We know the rank order of runners who finished the competition. The winner of the first prize finished ahead of the winner of the second prize and the winner of the second prize finished ahead of the winner of the third prize. However, we cannot tell from this ordinal scale whether it was a close race or whether the winner won by a kilometer.

Source: pixabay.com (assessed July, 17, 2019)

Empirical research

Interval scale

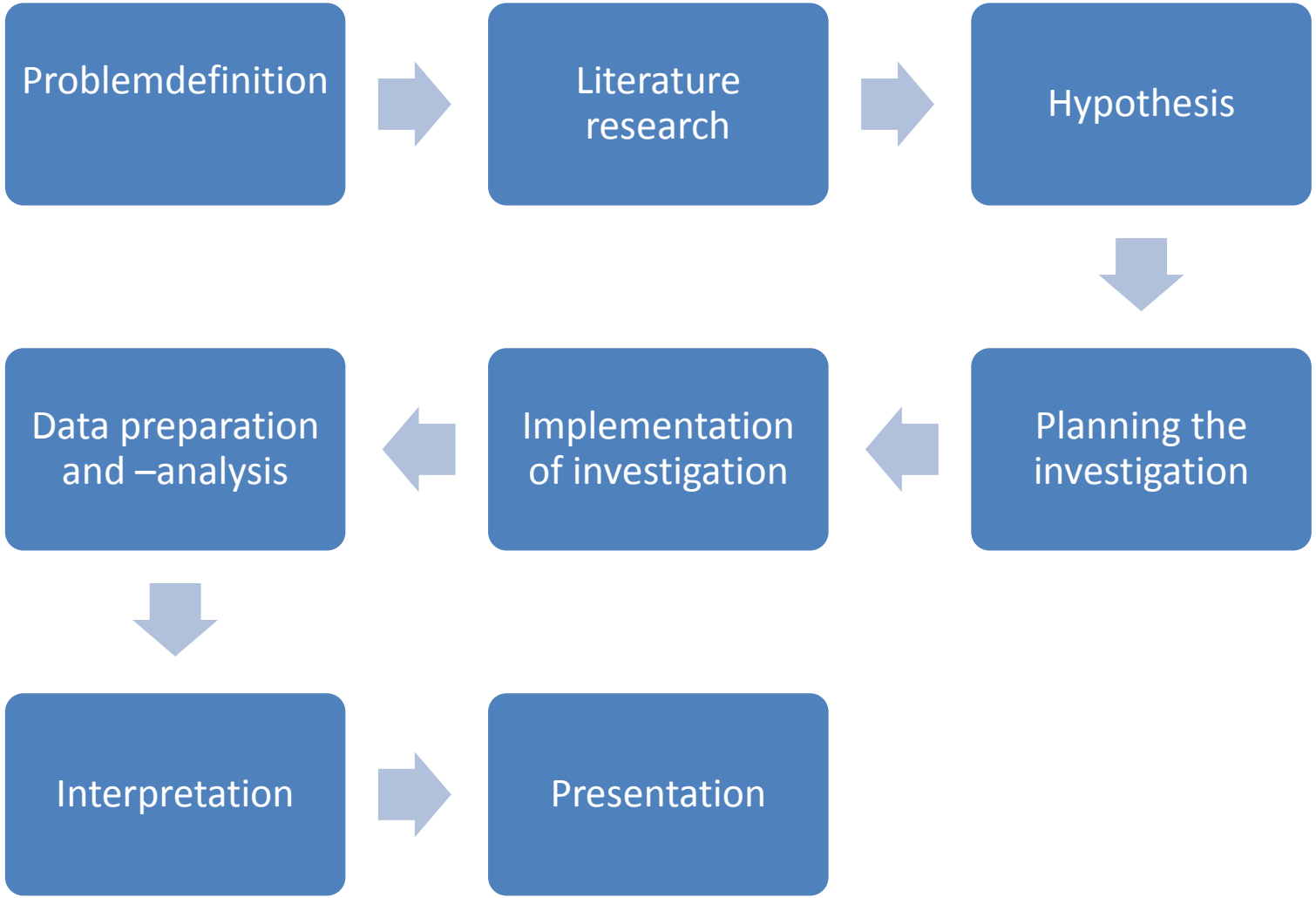
- The interval scale of measurement has the properties of **identity**, **magnitude**, and **equal intervals**.
- A perfect example of an interval scale is the **Fahrenheit scale** to **measure temperature**. The scale is made up of equal temperature units, so that the difference between 40 and 50 degrees Fahrenheit is equal to the difference between 50 and 60 degrees Fahrenheit.
- With an interval scale, you know not only whether different values are bigger or smaller, you also know *how much* bigger or smaller they are. For example, suppose it is 60 degrees Fahrenheit on Monday and 70 degrees on Tuesday. You know not only that it was hotter on Tuesday, you also know that it was 10 degrees hotter.

Empirical research

Ratio scale

- The ratio scale of measurement satisfies all four of the properties of measurement: **identity**, **magnitude**, **equal intervals**, and a **minimum value of zero**.
- The **weight of an object** would be an example of a ratio scale. Each value on the weight scale has a unique meaning, weights can be rank ordered, units along the weight scale are equal to one another, and the scale has a minimum value of zero.
- Weight scales have a minimum value of zero because objects at rest can be weightless, but they cannot have negative weight.

Planning an empirical investigation



Planning an empirical investigation

- Good examination planning is crucial for the validity of the results of an empirical study.
- Planning is extremely important.
- It depends on the planning
  - that the data is not faulty,
  - that the statistical evaluation is adequate and
  - that the results are clearly interpretable.

Planning an empirical investigation

- Planning of the population and the sample
- Choice of research approach
- Determination of place of investigation
- Variable selection, survey methodology and operationalization

Planning an empirical investigation

Planning of the population and the sample

- A population data set contains all members of a specified group (the entire list of possible data values). ...

- A sample data set contains a part, or a subset, of a population. The size of a sample is always less than the size of the population from which it is taken. Sample data sets should be similar to the population in terms of as many features as possible and should be representative.

Planning an empirical investigation

- **Forms of sample data sets**

- Unrestricted random sample
- Stratified sample
- Lump random sample
- Multilevel sample
- Quota sample

Empirical concepts

Choice of research approach

Cross-sectional studies

- A cross-sectional study looks at people who differ on one key characteristic at one specific point in time. The data is collected at the same time from people who are similar in other characteristics but different in a key factor of interest such as age, income levels, or geographic location. Participants are usually separated into groups known as cohorts. For example, researchers might create cohorts of participants who are in their 20s, 30s, and 40s.

Empirical concepts

Choice of research approach

Cross-sectional studies

- Cross-sectional studies are observational in nature and are known as descriptive research.
- This type of research can be used to describe characteristics that exist in a community, but not to determine cause-and-effect relationships between different variables. This method is often used to make inferences about possible relationships or to gather preliminary data to support further research and experimentation.

Empirical concepts

Choice of research approach

Cross-sectional studies - summary

- The study takes place at a single point in time
- It does not involve manipulating variables
- It allows researchers to look at numerous characteristics at once (age, income, gender, etc.)
- It's often used to look at the prevailing characteristics in a given population
- It can provide information about what is happening in a current population

Empirical concepts

Choice of research approach

Longitudinal studies

- Longitudinal research is a type of correlational research that involves looking at variables over an extended period of time. This type of study can take place over a period of weeks, months, or even years. In some cases, longitudinal studies can last several decades.
- A longitudinal study can be used to discover relationships between variables that are not related to various background variables. This observational research technique involves studying the same group of individuals over an extended period.

Empirical concepts

Choice of research approach

Longitudinal studies - summary

- They are observational in nature
- They are a type of correlational research
- Longitudinal research is often contrasted with cross-sectional research
- Longitudinal research involves collecting data over an extended period, often years or even decades
- Cross-sectional research involves collecting data at a single point in time

Empirical concepts

Choice of research approach

Longitudinal studies – different types

- **Panel Study**: Involves sampling a cross-section of individuals.
- **Cohort Study**: Involves selecting a group based on a specific event such as birth, geographic location or historical experience.
- **Retrospective Study**: Involves looking to the past by looking at historical information such as medical records.

Empirical concepts

Determination of place of investigation

Field studies / laboratory studies

- **Field experiments** are carried out in the real world, away from a laboratory. The advantage of this type of experiment is that it is very practical. Field experiments also allow experiments to take place, with no confounding variables being introduced. Field experiments are often used to study participant's behaviour when they have no idea they are being watched. This allows the experimenter to gather true data.
- Field experiments have no control group and there are often many variables that are not wanted.

Empirical concepts

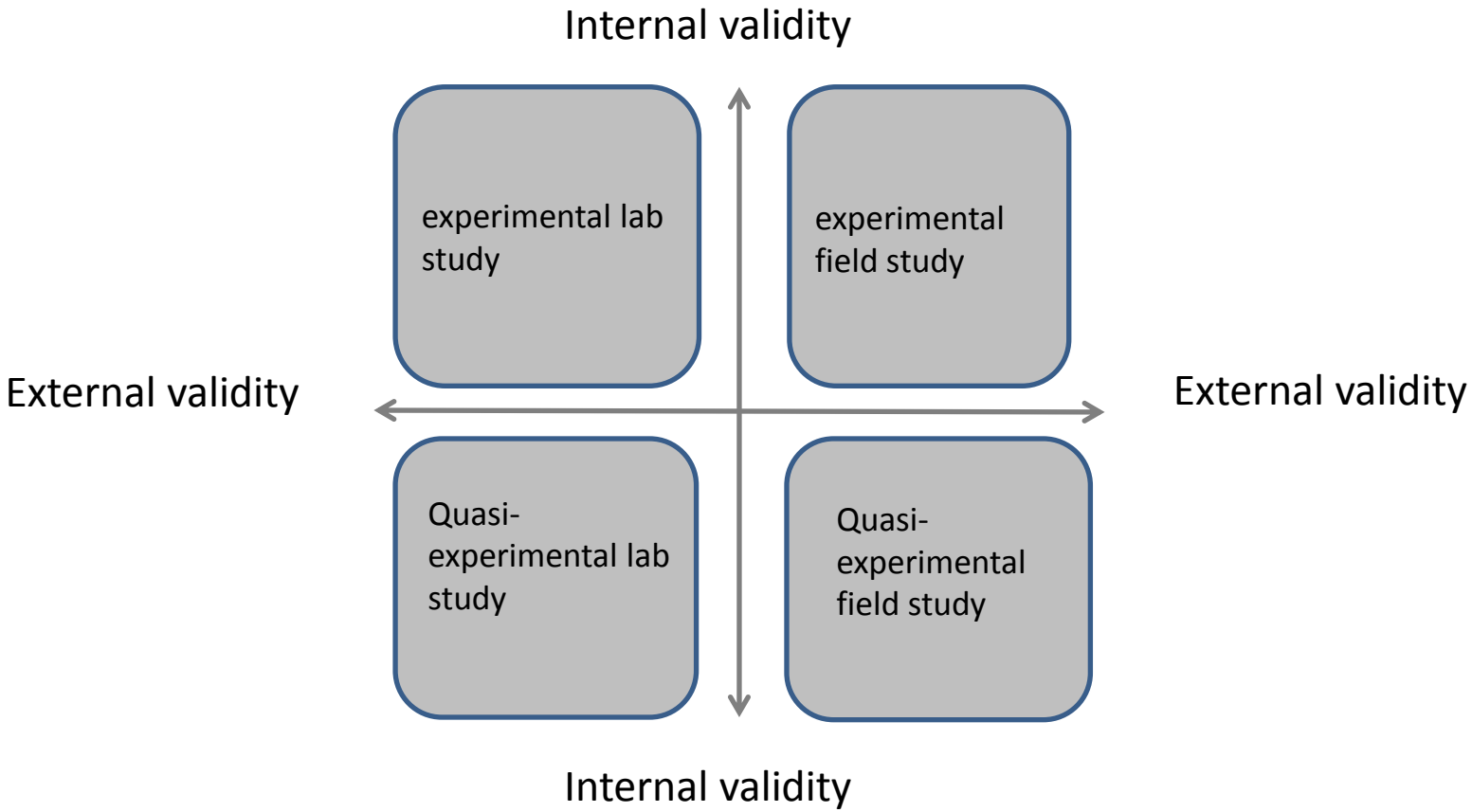
Determination of place of investigation

Field studies / laboratory studies

- **Laboratory experiments** are also known as **true experiments**. Lab experiments are preferred as the environment and variables can be controlled, however this may lead to a lack of external validity. This refers to ability to generalize a set of results from a small study to the real world. Laboratory experiments manipulate the independent variable, and this manipulation indicates a cause and effect relationship.

Empirical concepts

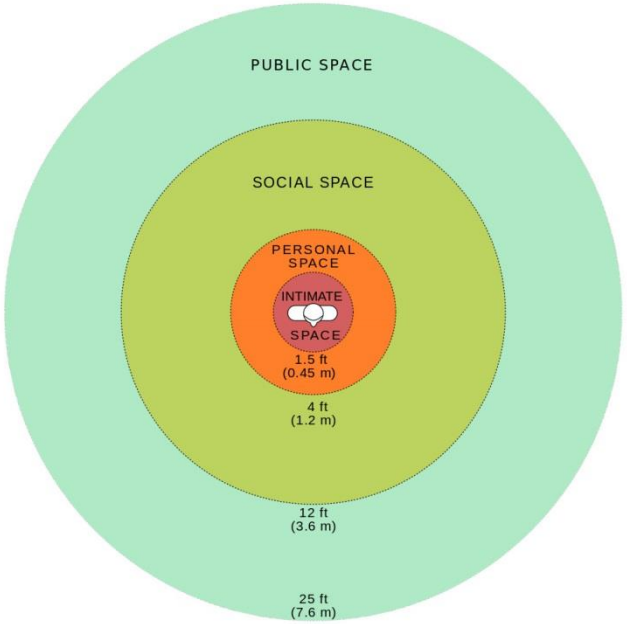
- **Determination of place of investigation**



Empirical concepts

Variable selection, survey methodology and operationalization

- At the beginning you have to ask yourself the question which variables you need for the examination and how to operationalize them.
- In research design, especially in psychology, social sciences, life sciences and physics, operationalization is a process of defining the measurement of a phenomenon that is not directly measurable, though its existence is inferred by other phenomena.
- Operationalization thus defines a fuzzy concept so as to make it clearly distinguishable, measurable, and understandable by empirical observation.
- In a broader sense, it defines the extension of a concept



Source: wikipedia (4.4.19)

Empirical concepts

- **Variable selection, survey methodology and operationalization**

- Data derived by qualitative survey methods can be evaluated both qualitatively and quantitatively.
- Qualitative data collection methods (overview):
  - Observation
  - Interview
  - Focus groups

- Quantitative data collection methods (overview):
  - counting
  - judging
  - Testing
  - Interview / survey