Cognitive (Neuro) Psychology

II. Experiments in Psychology

Marianne Maertens

Technische Universität Berlin

July 2016

Overview

- Psychology as a scientific discipline
- Variables
- Hypotheses
- Components of an experiment
- Practical steps in an experiment

Overview

Common sense psychology ...

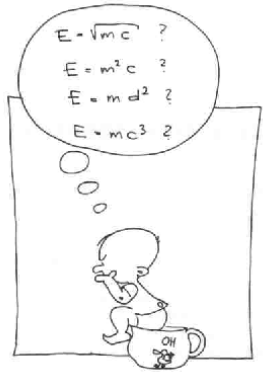
contains a number of statements which are not being tested with respect to their validity:

- birds of a feather flock together
- actions speak louder than words
- can’t judge a book by its cover
- ...
- German products are usually high quality ... (VW)
- German trains are on time ...

Common sense psychology

- objects fall down if you release the grip
- birds fly, foxes don't

...



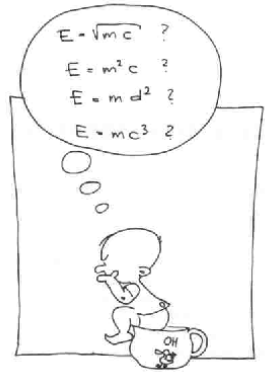
Common sense psychology

- objects fall down if you release the grip
- birds fly, foxes don't

  ...

→ basic understanding of concepts in physics, biology, psychology, etc. ... without studying them

- folk-physics, psychology, biology, ...



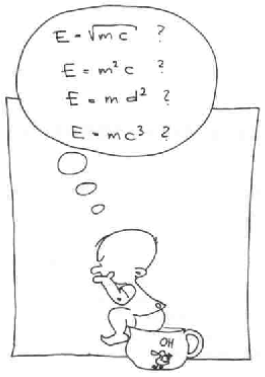
Common sense psychology

- objects fall down if you release the grip
- birds fly, foxes don't

  ...

→ basic understanding of concepts in physics, biology, psychology, etc. ... without studying them

- folk-physics, psychology, biology, ...



Common sense is ...

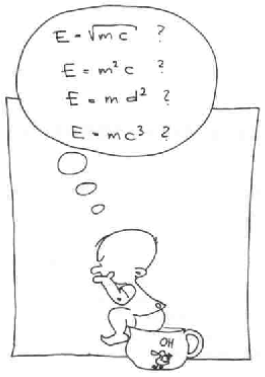
Common sense psychology

- objects fall down if you release the grip
- birds fly, foxes don't

  ...

→ basic understanding of concepts in physics, biology, psychology, etc. ... without studying them

- folk-physics, psychology, biology, ...



Common sense is ...

- mix of true and false beliefs
- prejudices and stereotypes
- full of contradictions

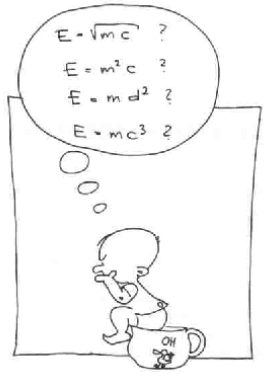
Common sense psychology

- objects fall down if you release the grip
- birds fly, foxes don't

  ...

→ basic understanding of concepts in physics, biology, psychology, etc. ... without studying them

- folk-physics, psychology, biology, ...



Common sense is ...

- mix of true and false beliefs
- prejudices and stereotypes
- full of contradictions

! common sense wisdom does not undergo critical testing with scientific methods

Why don’t we notice the inadequacy of folk wisdom?

1. Even behavior based on false presumptions, might still lead to desired consequences out of pure luck.

Why don’t we notice the inadequacy of folk wisdom?

1. Even behavior based on false presumptions, might still lead to desired consequences out of pure luck.

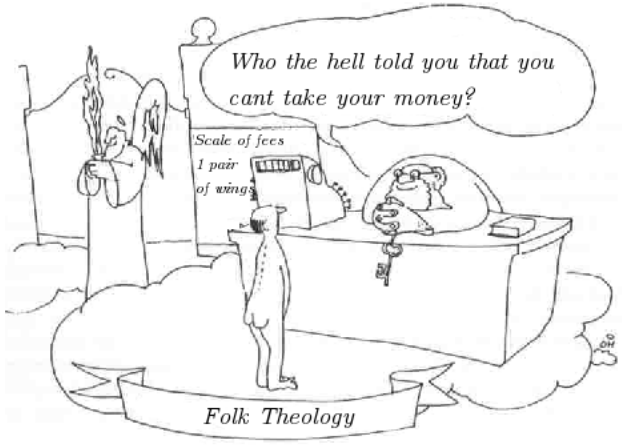
2. Folk wisdom might influence our behavior so that we act in a certain way and this causes the desired outcome.

Why don’t we notice the inadequacy of folk wisdom?

1. Even behavior based on false presumptions, might still lead to desired consequences out of pure luck.

2. Folk wisdom might influence our behavior so that we act in a certain way and this causes the desired outcome.

3. The way we interpret and remember events is influenced by our expectations. We selectively attend to evidence in favour of our beliefs.



Why don’t we notice the inadequacy of folk wisdom?

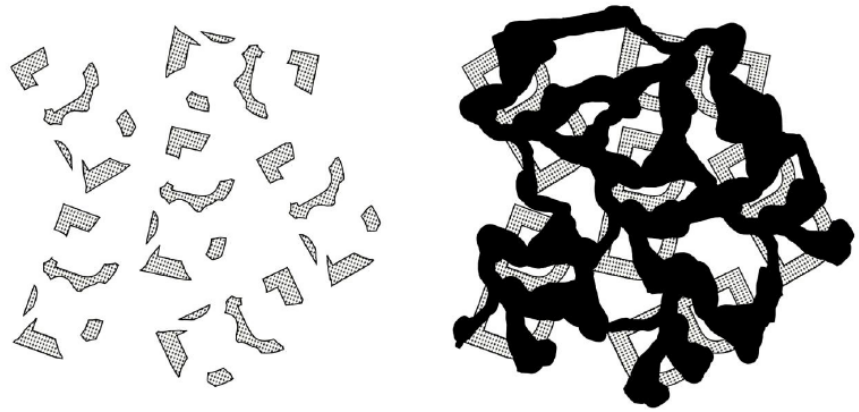
1. Even behavior based on false presumptions, might still lead to desired consequences out of pure luck.

2. Folk wisdom might influence our behavior so that we act in a certain way and this causes the desired outcome.

3. The way we interpret and remember events is influenced by our expectations. We selectively attend to evidence in favour of our beliefs.

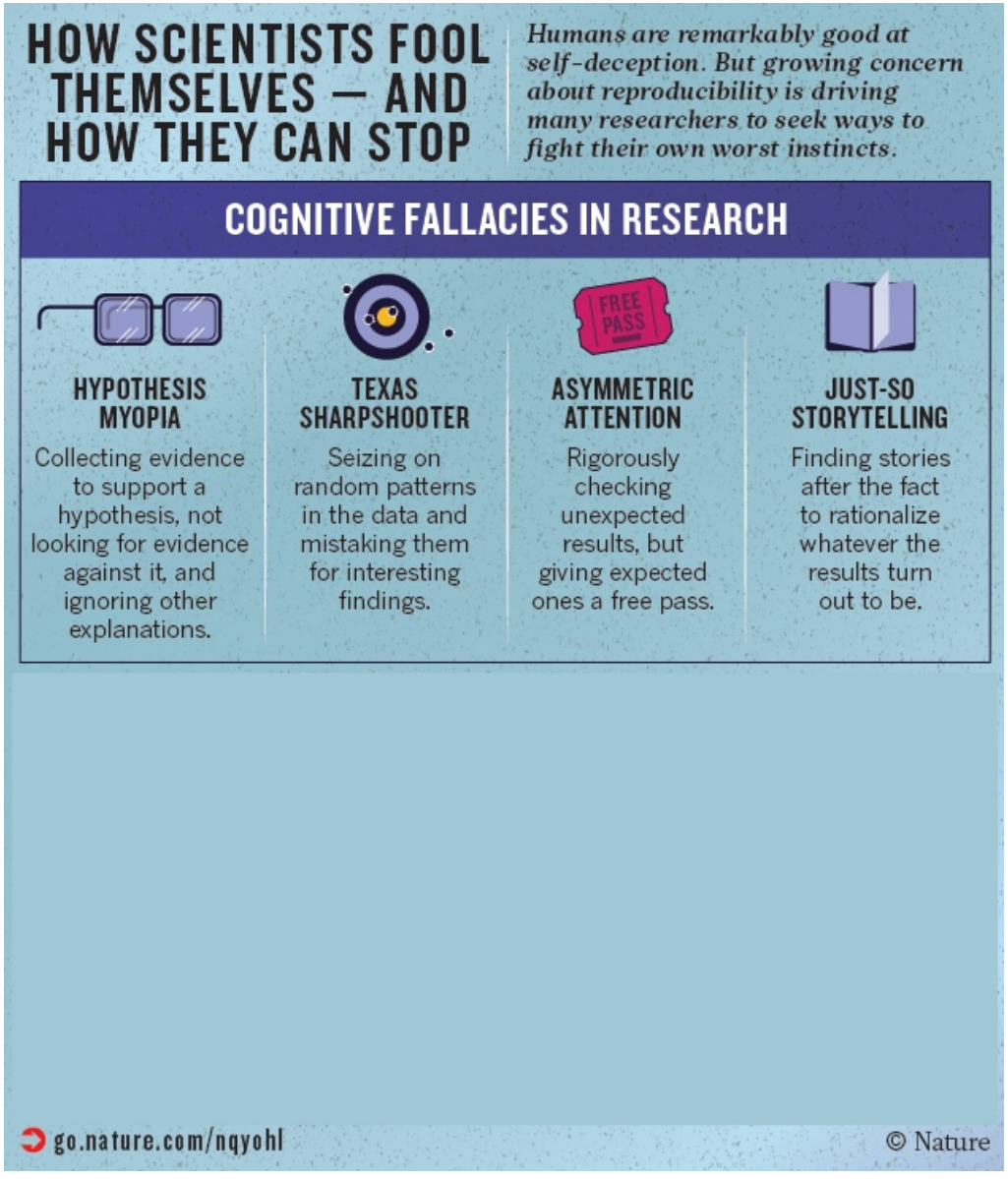
4. The knowledge content of folk psychology is used to explain events **post-hoc**. Plausibility of the explanation is more important than accuracy.

Perceptual vs cognitive biases

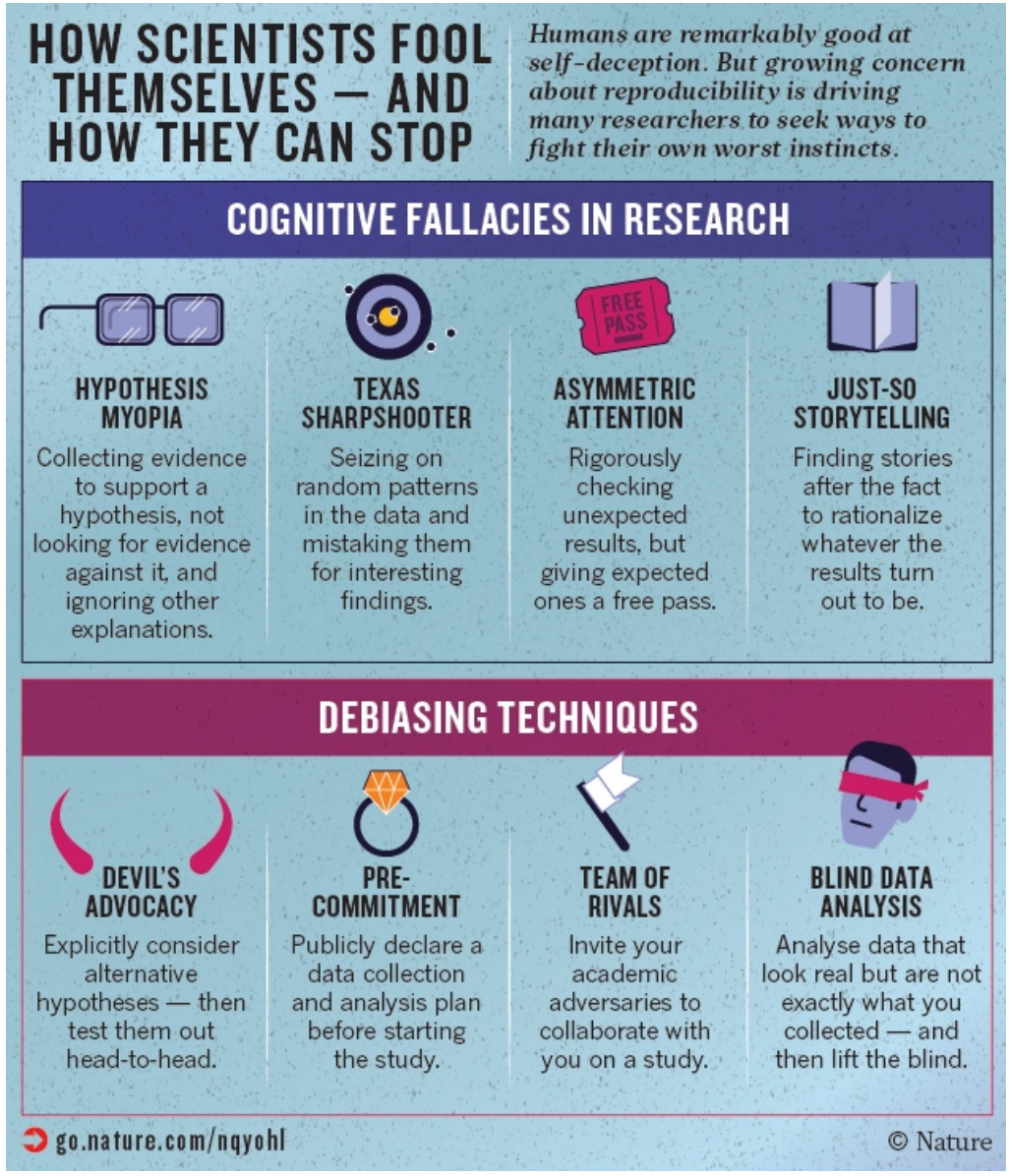


Perceptual vs cognitive biases

Cognitive biases in science



Cognitive biases in science



The scientific method

- How to distinguish science from non-science?

  The demarcation problem
- When is one theory better than another?

The scientific method

- How to distinguish science from non-science?

  The demarcation problem
- When is one theory better than another?

Philosophy of science - 3 main schools of thought

1. militant positivism: program to find definition that puts every theory in its proper place
2. scepticism, cultural relativism: demarcation problem is unsolvable, because there is no demarcation line, no progress but changing fashions
3. elitist authoritarianism: there is a demarcation line, but there are no demarcation criteria, belief in a wise judge (great scientist)

The scientific method

Mertonian norms of science (R. Merton, 1910-2003)

Communalism: common ownership of scientific ideas

Universalism: claims to truth are evaluated in terms of universal or impersonal criteria

Desinterestedness: scientists are rewarded for acting in ways that outardly appear to be selfless

Organized scepticism: all ideas must be tested and are subject to rigorous, structured community scrutiny

NATURE | NEWS FEATURE

How scientists fool themselves – and how they can stop

Humans are remarkably good at self-deception. But growing concern about reproducibility is driving many researchers to seek ways to fight their own worst instincts.

Regina Nuzzo

07 October 2015

Illustration by Dale Edwin Murray

The scientific method

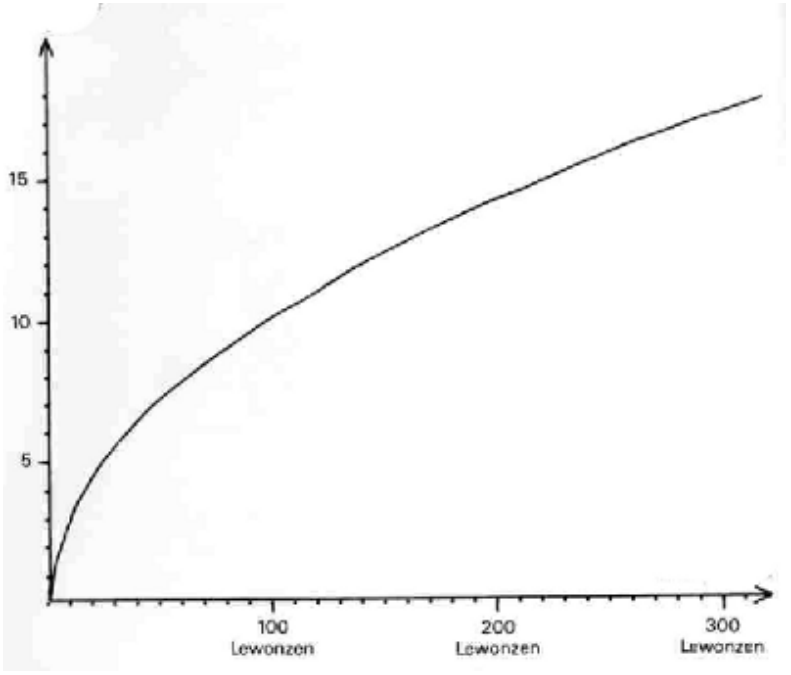
“As a researcher, I’m not trying to produce misleading results, but I do have a stake in the outcome.” And that gives the mind excellent motivation to find what it is primed to find. (Nuzzo, 2015)

Overview

Goals of scientific research

Accumulation of knowledge

Investigation of lawful relations



Variables

- concept to describe characteristic attributes of human beings, animals, objects, systems etc...

Variables

- concept to describe characteristic attributes of human beings, animals, objects, systems etc...

- take at least 2 different values, but only one at a time, e.g. fear of spiders - yes or no; emotions: joy, sadness, fear, shame, curiosity; intelligence: 70, ...145
- varying levels of abstraction: age vs. political attitudes
- more or less directly observable: soup intake vs. intelligence

$\rightarrow$ **operationalization**

How to select variables?

Write down all the variables that would allow a complete description of yourself in the current situation!

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

Social relations: son/daughter, mother/father, personally acquainted with, friend of, contemporary of, neighbour of, boss of, ...

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

Social relations: son/daughter, mother/father, personally acquainted with, friend of, contemporary of, neighbour of, boss of, ...

Personality attributes: neurotic, cooperative, curious, ...

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

Social relations: son/daughter, mother/father, personally acquainted with, friend of, contemporary of, neighbour of, boss of, ...

Personality attributes: neurotic, cooperative, curious, ...

Goals/desires/preferences: artistic, work-related, study-related, personality-wise, ...

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

Social relations: son/daughter, mother/father, personally acquainted with, friend of, contemporary of, neighbour of, boss of, ...

Personality attributes: neurotic, cooperative, curious, ...

Goals/desires/preferences: artistic, work-related, study-related, personality-wise, ...

Physiological Variables: blood pressure, heart rate, size of liver, ...

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

Social relations: son/daughter, mother/father, personally acquainted with, friend of, contemporary of, neighbour of, boss of, ...

Personality attributes: neurotic, cooperative, curious, ...

Goals/desires/preferences: artistic, work-related, study-related, personality-wise, ...

Physiological Variables: blood pressure, heart rate, size of liver, ...

Individual history: childhood memories, family situation, ...

How to select variables

Appearance: shoe size, hair colour, form of nostrils, ...

Social relations: son/daughter, mother/father, personally acquainted with, friend of, contemporary of, neighbour of, boss of, ...

Personality attributes: neurotic, cooperative, curious, ...

Goals/desires/preferences: artistic, work-related, study-related, personality-wise, ...

Physiological Variables: blood pressure, heart rate, size of liver, ...

Individual history: childhood memories, family situation, ...

Knowledge: German grammar, memory of locations, soccer results, cooking skills, ...

Variable selection

theoretical account influences variables under study

Variable selection

theoretical account influences variables under study

Example: Theoretical accounts of depression

- Hippocrates - black bile
- middle ages - obsessed by the devil

Variable selection

theoretical account influences variables under study

Example: Theoretical accounts of depression

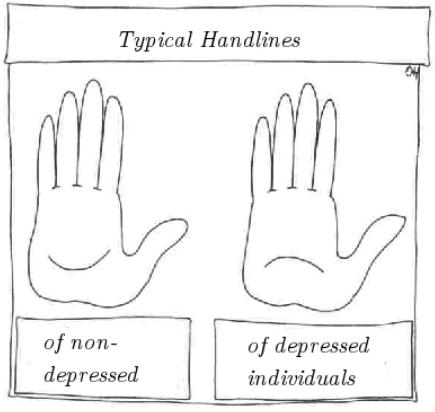
- Hippocrates - black bile
- middle ages - obsessed by the devil
- characteristic hand lines (Höping, 1689)

Variable selection

theoretical account influences variables under study

Example: Theoretical accounts of depression

- Hippocrates - black bile
- middle ages - obsessed by the devil
- characteristic hand lines (Höping, 1689)
- psychoanalysis - early childhood experiences



Variable selection

theoretical account influences variables under study

Example: Theoretical accounts of depression

- Hippocrates - black bile
- middle ages - obsessed by the devil
- characteristic hand lines (Höping, 1689)
- psychoanalysis - early childhood experiences
- cognitive theory - thinking patterns (Beck)

Variable selection

theoretical account influences variables under study

Example: Theoretical accounts of depression

- Hippocrates - black bile
- middle ages - obsessed by the devil
- characteristic hand lines (Höping, 1689)
- psychoanalysis - early childhood experiences
- cognitive theory - thinking patterns (Beck)
- theory of learned helplessness (Seligman)

Variable selection

theoretical account influences variables under study

Example: Theoretical accounts of depression

- Hippocrates - black bile
- middle ages - obsessed by the devil
- characteristic hand lines (Höping, 1689)
- psychoanalysis - early childhood experiences
- cognitive theory - thinking patterns (Beck)
- theory of learned helplessness (Seligman)
- neurotransmitter imbalance

Important part of psychological research is:

- to identify variables that are crucial for answering a certain question
- to assign observable variables to theoretically interesting variables

Overview

Scientific research starts with questions

- Is intelligence inherited?
- Is therapy x more effective than therapy y to cure disorder Z?
- What are the factors that influence whether a person is attracted to another or not?
- Under which conditions do humans behave aggressively?
- At what age do kids have an understanding or the concept of 'probability'?
- How do people in their 30ies think about death?

What is a hypothesis?

What is a hypothesis?

- A hypothesis is a presumed answer to a question.

What is a hypothesis?

- A hypothesis is a presumed answer to a question.
- To test whether or not a hypothesis applies it needs to be exposed to scientific testing.

What is a hypothesis?

- A hypothesis is a presumed answer to a question.
- To test whether or not a hypothesis applies it needs to be exposed to scientific testing.
- The basic idea of empirical testing is the derivation of a prediction from the hypothesis and its test under realistic conditions.

What is a hypothesis?

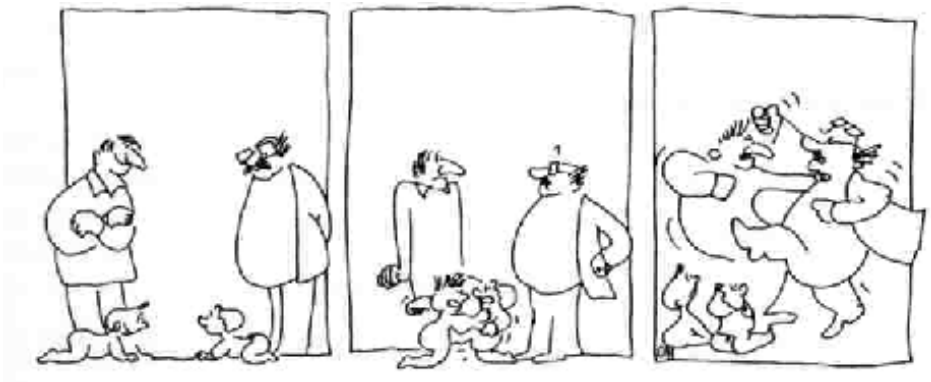
- A hypothesis is a presumed answer to a question.
- To test whether or not a hypothesis applies it needs to be exposed to scientific testing.
- The basic idea of empirical testing is the derivation of a prediction from the hypothesis and its test under realistic conditions.

! empirical hypotheses allow predictions about and comparison with reality

Example:

If aggressive behavior is learned by imitation,

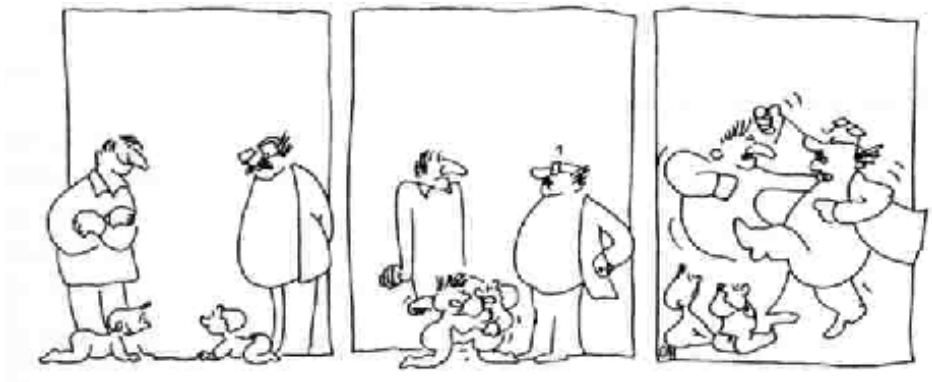
then the observation of an aggressive model should increase the probability that a person will act aggressively herself (Model learning, learning by imitation).



Example:

If aggressive behavior is learned by imitation,

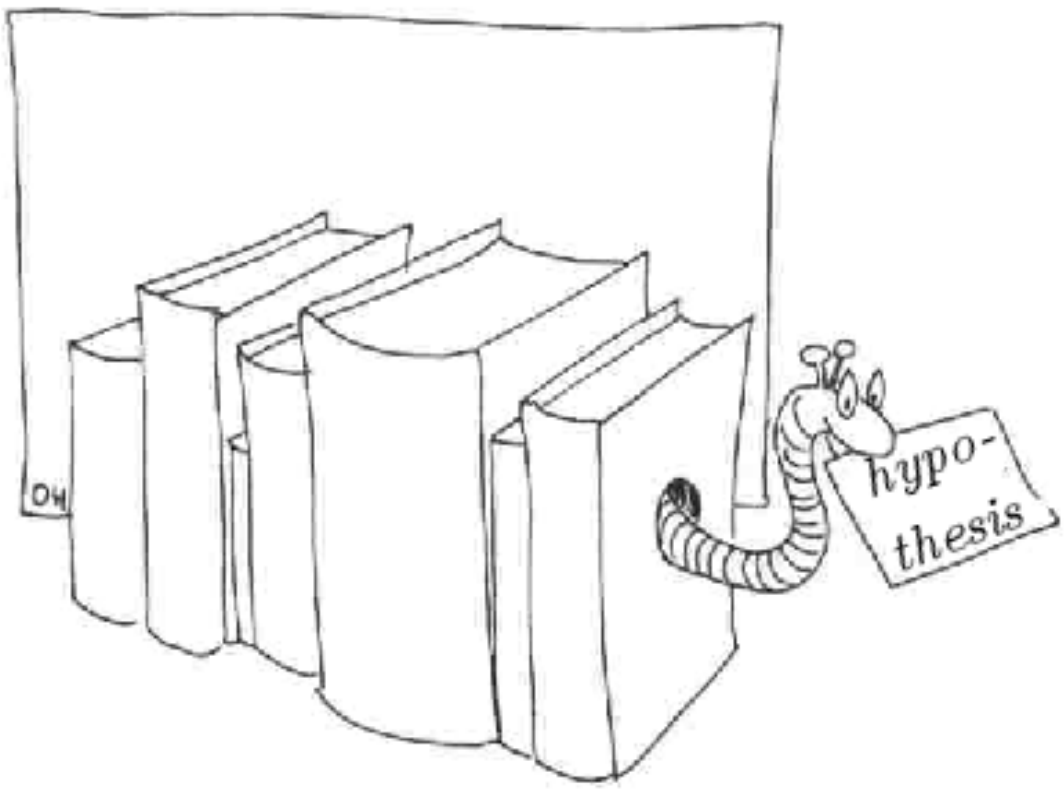
then the observation of an aggressive model should increase the probability that a person will act aggressively herself (Model learning, learning by imitation).



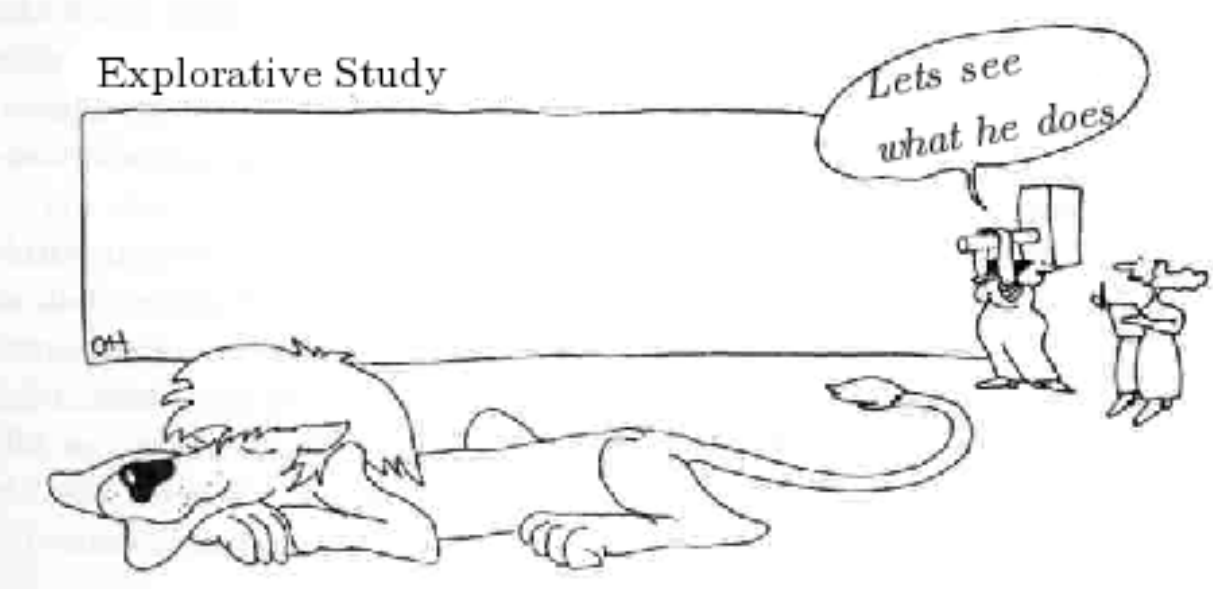
Empirical hypothesis

- Guests in a restaurant who observe an aggressive model are more likely to react aggressively in response to a cold soup than guests who do not observe an aggressive model.

Formation of hypotheses



Formation of hypotheses



Testing of hypotheses

- I am deeply convinced, that ...
- reference to authorities
- 'proof' by example

! prone to cognitive biases

Testing of hypotheses

- I am deeply convinced, that ...
- reference to authorities
- 'proof' by example

! prone to cognitive biases

- The power of examples can be explained by the observation, that the subjective probability for an event is influenced by the ease of which we can find examples for it in our memory

= availability heuristic (Tversky & Kahneman, 1973)

Preconditions for hypothesis testing

1. consistency

Preconditions for hypothesis testing

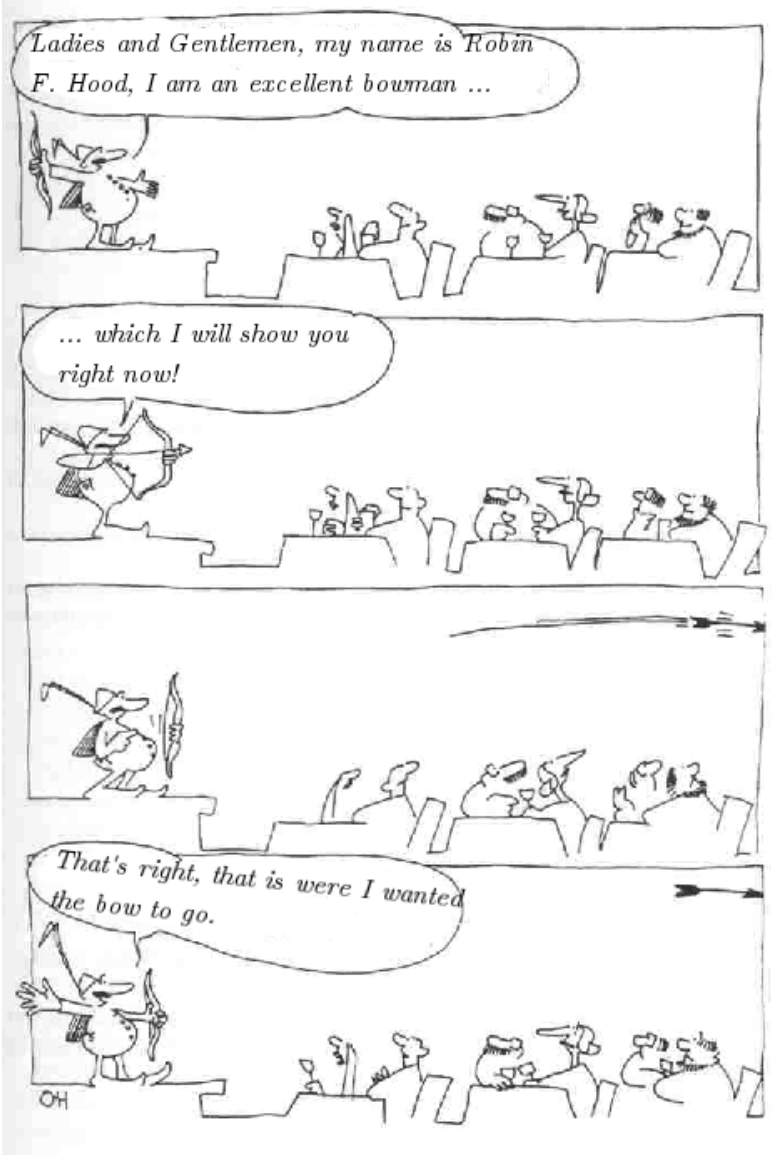
1. consistency
2. falsifiability

Preconditions for hypothesis testing

1. consistency
2. falsifiability
3. operationalizability

Preconditions for hypothesis testing

1. consistency
2. falsifiability
3. operationalizability
4. generation **before** the test



Overview

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
    - independent variable

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments
   - number of IV: one-way, two-way, ...

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments
   - number of IV: one-way, two-way, ...
   - number of DV: univariate, multivariate, ...

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments
   - number of IV: one-way, two-way, ...
   - number of DV: univariate, multivariate, ...
   - assignment of subjects: between, within, mixed designs

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments
   - number of IV: one-way, two-way, ...
   - number of DV: univariate, multivariate, ...
   - assignment of subjects: between, within, mixed designs
   - laboratory or field studies

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments
   - number of IV: one-way, two-way, ...
   - number of DV: univariate, multivariate, ...
   - assignment of subjects: between, within, mixed designs
   - laboratory or field studies
   - longitudinal or cross-sectional

Experimental ingredients

1. experimental vs. non-experimental research (observation/correlational)
2. types of variables
   - independent variable
   - dependent variable
   - confounding variables
   - moderating variables
3. experimenter vs. subjects/participants/observers
4. control of confounds
   - constant value
   - random variation
5. classification of experiments
   - number of IV: one-way, two-way, ...
   - number of DV: univariate, multivariate, ...
   - assignment of subjects: between, within, mixed designs
   - laboratory or field studies
   - longitudinal or cross-sectional
   - ...

Research Question

- unanswered question: *What are the causes for aggressive behavior?*
- ... studying the literature ...

$\Rightarrow$ Does an aggressive exemplar (role model) influence aggressive behavior?

Hypotheses

If a person *A* observes the aggressive behavior of person *B* in a certain situation, **then** this increases the probability that also person *A* will act aggressively in that situation.

IV: observation or non-observation of aggressive model

DV: aggressive behavior of person A

Operationalization

Write down indicators of aggressive behavior!

Operationalization

- loudness of voice
- adrenaline level
- heart rate
- verbal statements
- body posture
- interpersonal distance
- physical attacks
- report

Goodness of operationalization

- background knowledge helps
- a theoretical context helps even more
- critical discussion is minimum
- different ways to operationalize one and the same variable/concepts usually indicates necessity to redefine the concept - lack of construct validity
- the more abstract the construct of interest the more challenging the operationalization e.g. consciousness

Measurement

- assign numbers to measurement items (e.g. to be measured individuals, objects, events) such that characteristic empirical relations between the measurement items are represented by the corresponding numerical relations in the numbers
- resulting numbers are called scale values

Measurement

- assign numbers to measurement items (e.g. to be measured individuals, objects, events) such that characteristic empirical relations between the measurement items are represented by the corresponding numerical relations in the numbers
- resulting numbers are called scale values

$\Rightarrow$ Why cant we just describe the variation verbally?

Measurement

- assign numbers to measurement items (e.g. to be measured individuals, objects, events) such that characteristic empirical relations between the measurement items are represented by the corresponding numerical relations in the numbers
- resulting numbers are called scale values

$\Rightarrow$ Why cant we just describe the variation verbally?

- assignment of the right scale: nominal, ordinal, interval, ratio, absolute
- validity and reliability, ...

Experimental design

- logical structure of the experiment
- e.g. 1 independent variable with 2 levels

Experimental design

- logical structure of the experiment
- e.g. 1 independent variable with 2 levels

	time 1	**time 2**
group 1	IV - level 1	DV
group 2	IV - level 2	DV

Experimental design

- logical structure of the experiment
- e.g. 1 independent variable with 2 levels

	time 1	**time 2**
group 1	IV - level 1	DV
group 2	IV - level 2	DV

	time 1	**time 2**
group 1	aggressive model	loudness of voice
group 2	neutral model	loudness of voice

Experimental design

- logical structure of the experiment
- e.g. 1 independent variable with 2 levels

	time 1	**time 2**
group 1	IV - level 1	DV
group 2	IV - level 2	DV

	time 1 pre-test	**time 2**	**time 3** post-test
group 1	DV	IV - level 1	DV
group 2	DV	IV - level 2	DV

Experimental design

- logical structure of the experiment
- e.g. 1 independent variable with 2 levels

	time 1	**time 2**
group 1	IV - level 1	DV
group 2	IV - level 2	DV

	time 1 pre-test	**time 2**	**time 3** post-test
group 1	DV	IV - level 1	DV
group 2	DV	IV - level 2	DV

	t1	**t2**	**t3**	**t3**
1 group	IV - level 1	DV	IV - level 2	DV

Control of confounding variables

Factors of the participants:

- e.g. gender, age, intelligence,...

$\Rightarrow$ **Matching** (variable needs to be known and measurable, small groups)

- e.g. intelligence, motivation, mood, ...

$\Rightarrow$ **Randomization**

Control of confounding variables

Factors of the participants:

- e.g. gender, age, intelligence,...

$\Rightarrow$ **Matching** (variable needs to be known and measurable, small groups)

- e.g. intelligence, motivation, mood, ...

$\Rightarrow$ **Randomization**

Factors of the experimental setup:

- Noise, experimenter effects, ...

$\Rightarrow$ **Elimination**

- time of the day, number of sessions per week, ...

$\Rightarrow$ **Constancy**

$\Rightarrow$ **Random variation**

$\Rightarrow$ **Control group**

Control of confounding variables

... in the example:

- degree of identification with the model
- aggressive tendencies
- behavior of the experimenter
- time of the day, weather, differently pleasant rooms, ...

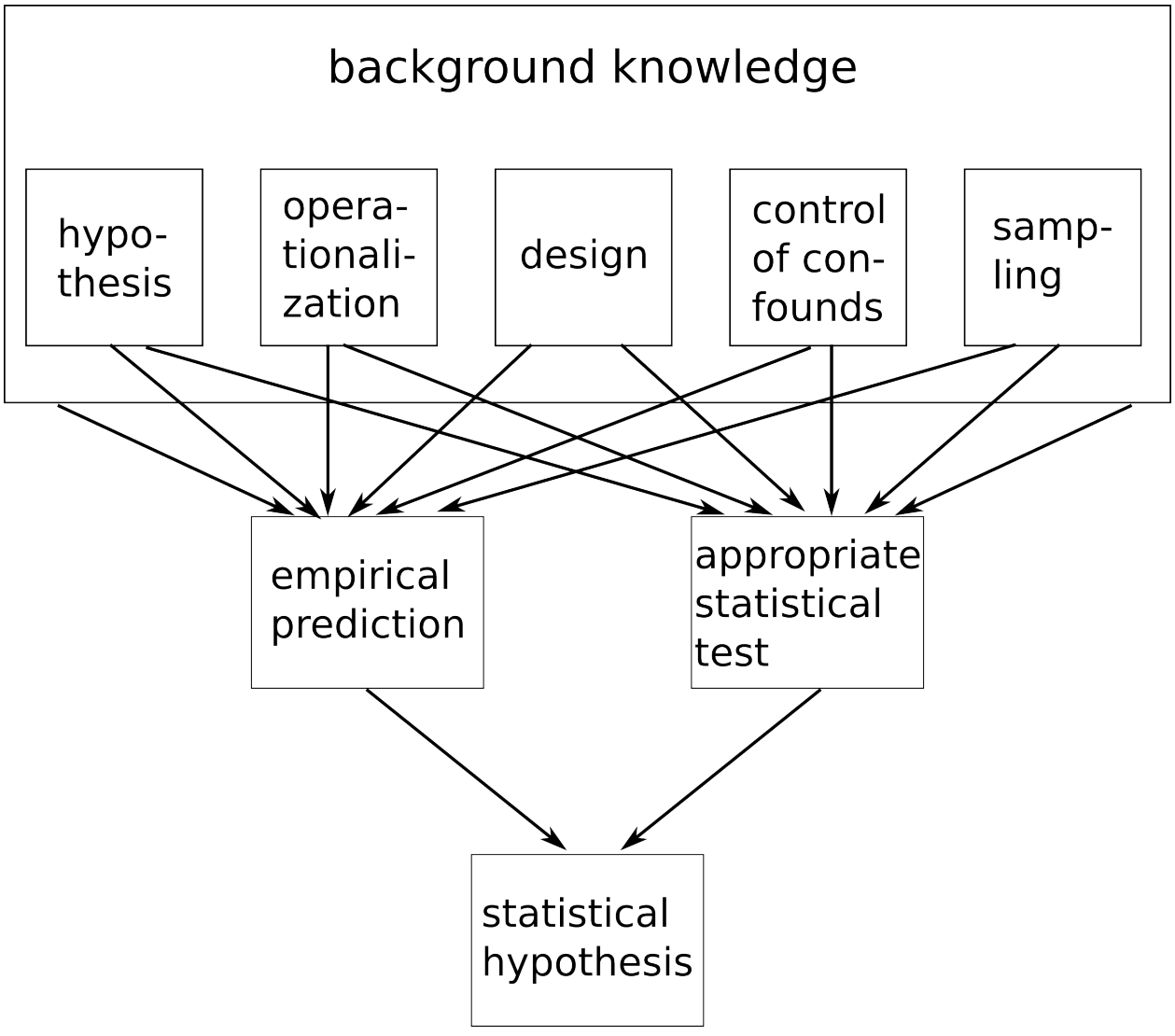
constant value

- videotaping the model
- written instructions
- identical rooms

random variation

- random assignment of observers to groups (sampling)

Summary


background knowledge
hypo-
thesis
opera-
tionali-
zation
design
control
of con-
founds
samp-
ling
empirical
prediction
appropriate
statistical
test
statistical
hypothesis

Reference

This lecture is based on the following book:
Oswald Huber (2009). Das psychologische Experiment: Eine Einführung. Bern: Huber.