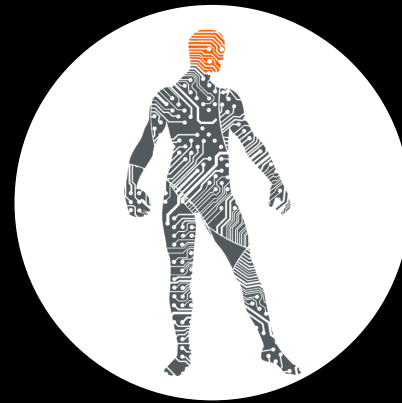




https://t.me/+s2K_1hh1Ffc0YjVk



Research Methods in Engineering Psychology

B.Sc. Engineering Psychology
Prof. Dr. Robin Welsch

Have you come across psychological research methods?

Please indicate on the scale below, to which degree you agree/disagree with the positions

Robin is a great teacher

Agree

Disagree

x



**What are do you expect to
learn in this course?**

Learning goals

- Develop skills in conducting and evaluating psychological research
- Learn about research methods and ethical considerations in engineering psychology
- Understand study design and measurement techniques
- Evaluate empirical research
- Learn how to set up and manage a study and record your work
- see advanced methods in action

You will **NOT** learn: Qualitative methods, Test construction, Diagnostics(e.g., IQ), Complex sampling protocols.

Why is this important?

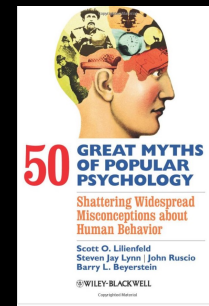
Opposites attract

Learn to be skeptic about folk psychology

- Folk psychology says opposite attract
 - 77% of undergraduates agreed that opposites attract in relationships
- Psychological Science shows that
 - Similarity in personality traits predicts attraction and relationship maintenance

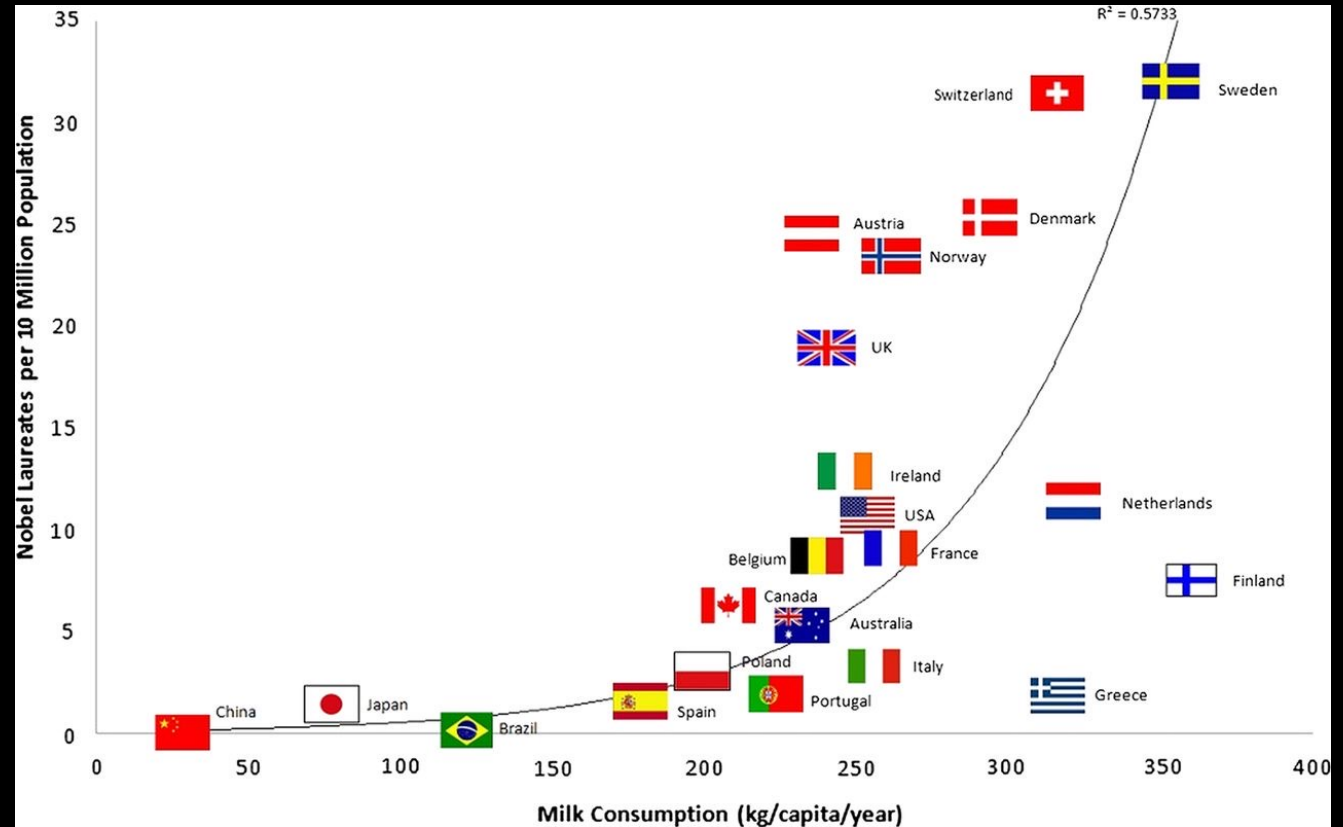
McCutcheon, L. E. (1991). A new test of misconceptions about psychology. *Psychological Reports*, 68(2), 647-653.

Lewak, R. W., Wakefield Jr, J. A., & Briggs, P. F. (1985). Intelligence and personality in mate choice and marital satisfaction. *Personality and Individual Differences*, 6(4), 471-477.



Milk consumption and Nobel prizes

Identify confounding variables!

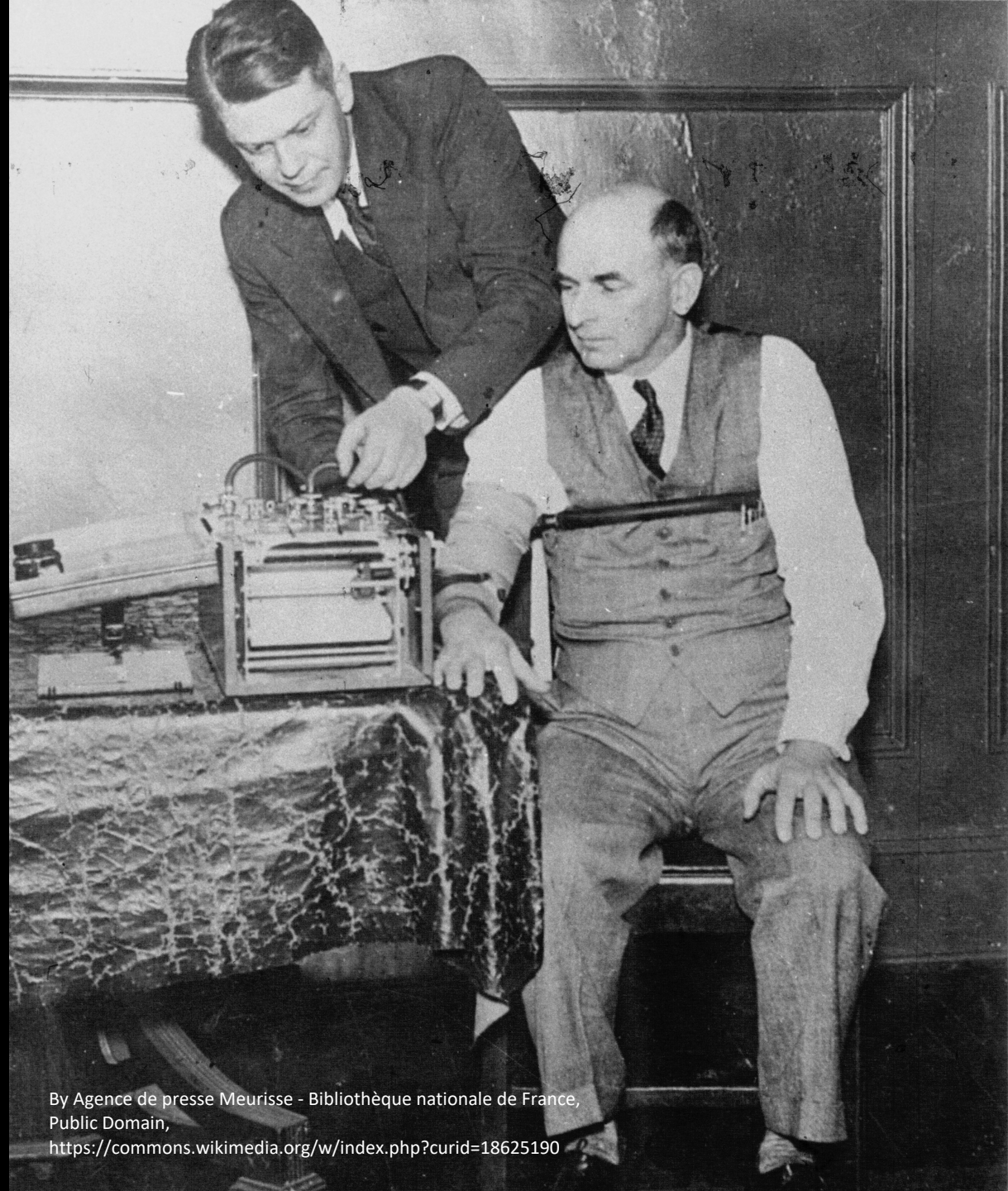


Linthwaite, S., & Fuller, G. N. (2013). Milk, chocolate and Nobel prizes. *Practical neurology*, 13(1), 63-63.

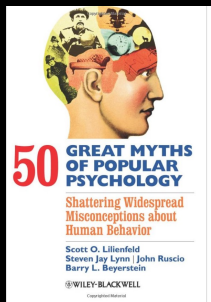
Lie detector

Identify issues with measurement!

- Was supposed to measure when someone is lying
- Measures only psychophysiological correlates of arousal



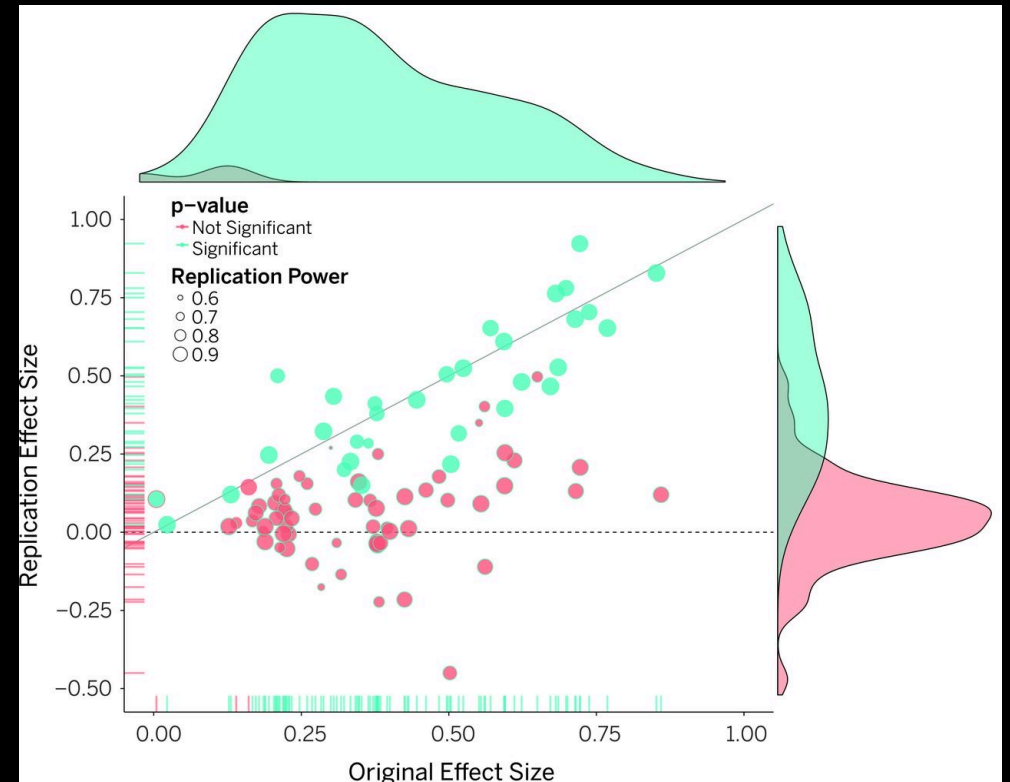
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Public Domain,
<https://commons.wikimedia.org/w/index.php?curid=18625190>



Documentation

Learn to record and report your research methods and make robust inferences!

- Documentation and publication is integral to science
- Replicability and systematic work is fundamental to the scientific method
- In a study from 2015 only about 68% of effects in psychological studies could be replicated
- Misreporting and questionable research practices further undermine the scientific record → You can learn here to do better!



Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, 349(6251), aac4716.

Research methods are important to

- Critically examine theories
- Use the right measurements
- Engage in good research practices
- Make research reproducible

Organisation of the course

- Format with mandatory elements and self-study elements
- Research Study
- Schedule



Format

Lecture

High level introduction to psychology methods applied in engineering contexts

Study

Apply your knowledge to testing real participants alongside experienced researchers

Self-Assesment

Questions to test your knowledge

Not-graded
optional

Poster

Learn best-practices in research presentation

Graded as Group work
(Individual grading possible)

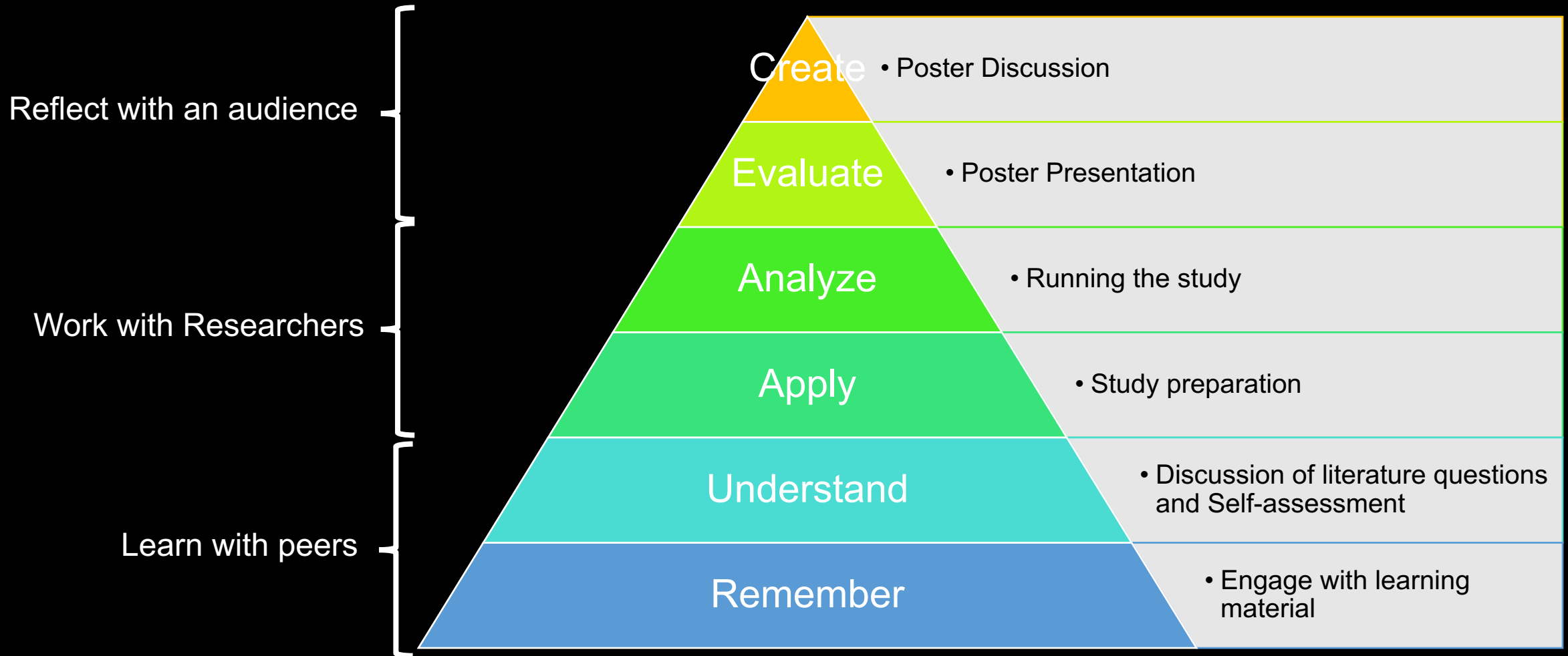
Book

Re-read important details yourself

Hand in 1 question (from previous or coming lecture) before the lecture to receive 10 extra points (all or nothing)

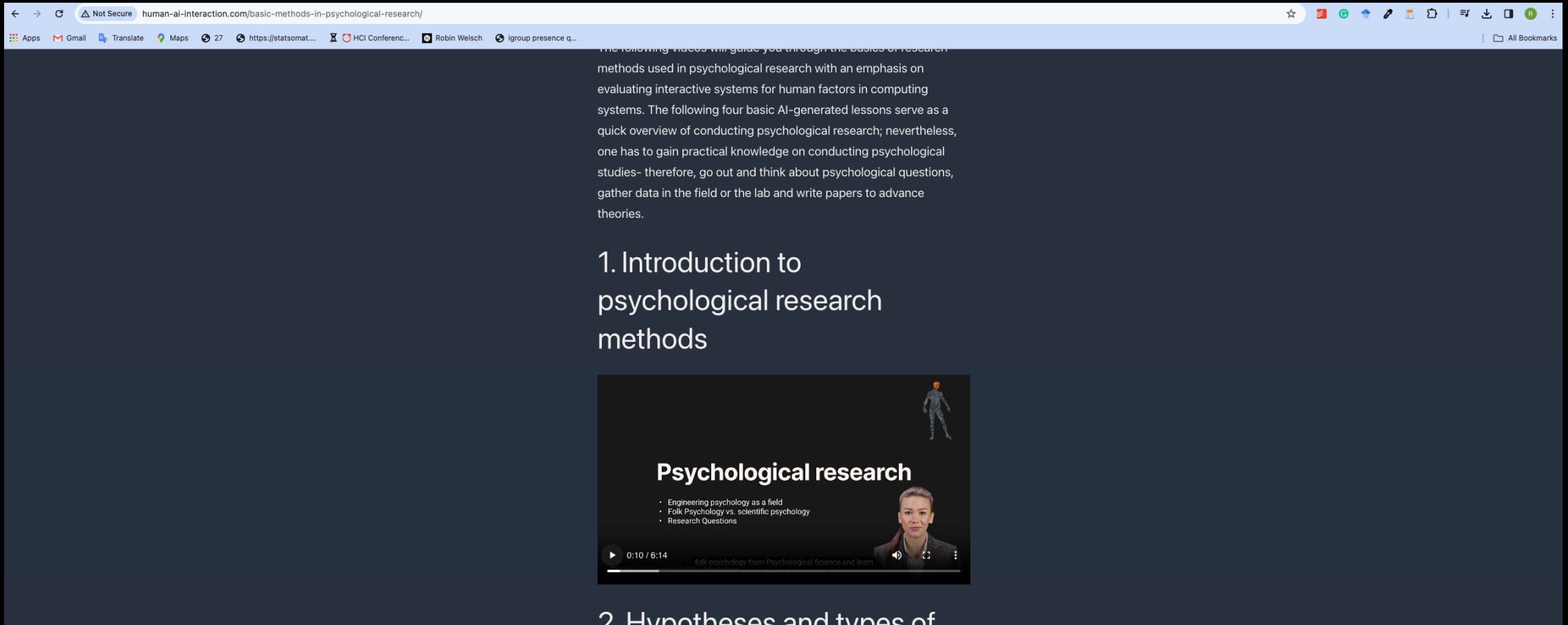
Teaching concept

Following Bloom's Taxonomy



Short summary videos

Human-AI-interaction.com (now in English; soon in Finnish and Swedish)



The following videos will guide you through the basics of research methods used in psychological research with an emphasis on evaluating interactive systems for human factors in computing systems. The following four basic AI-generated lessons serve as a quick overview of conducting psychological research; nevertheless, one has to gain practical knowledge on conducting psychological studies- therefore, go out and think about psychological questions, gather data in the field or the lab and write papers to advance theories.

1. Introduction to psychological research methods

Psychological research

- Engineering psychology as a field
- Folk Psychology vs. scientific psychology
- Research Questions

0:10 / 6:14 folk psychology from Psychological Science and learn

2. Hypotheses and types of

Self-assessment

Lecture X

1. How is data obtained in folk psychology and scientific psychology?
2. How is inductive reasoning applied in folk psychology?
3. Come up with a scientific hypothesis on one of the following topics and state the type of hypothesis
 - Smartphone-use and mental health
 - Shooter games and violence
 - Old-adults and novel technologies
4. What is the difference between falsification and Bayesianism in hypothesis testing?


EXAMPLE

Poster Presentation

Will be the main driver of your grade

Examples can be found in MyCourses

We will have a session about preparing and presenting a poster



Interpersonal distance in field-theoretical terms

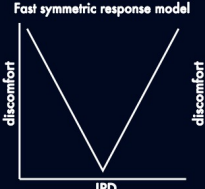
JOHANNES GUTENBERG UNIVERSITÄT MAINZ
Robin Welsch, Christoph von Castell and Heiko Hecht
Johannes Gutenberg-Universität Mainz, Department of Psychology, Section Experimental Psychology

Motivation

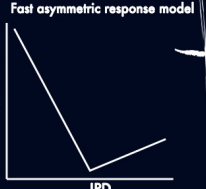
Psychological fields are constructed through individually scaled vectors of approach and avoidance that link the person to the environment (Lewin, 1939). In this vein, Hayduk (1978) defines Personal space (PS) as the area around the individual into which intrusion causes discomfort and arousal. Thus, we conceived four different response models that predict the relationship between interpersonal distance (IPD) and discomfort.

Competing models of IPD and discomfort:

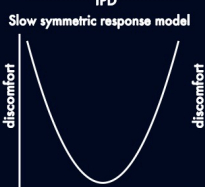
Fast symmetric response model



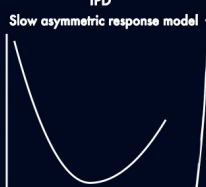
Fast asymmetric response model



Slow symmetric response model



Slow asymmetric response model



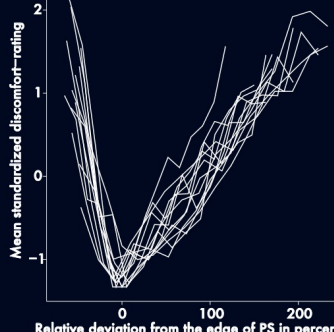
Method

- N = 24, 6♂ (M_{age} = 21.66, SD_{age} = 6.92)
- placed at 15 interpersonal distances from 40cm to 250cm in steps of 15 cm to a female confederate
- verbal rating of discomfort: -100 (maximum discomfort, too close) to +100 (maximum discomfort, too far)
- manual rating of discomfort: tilt of a joystick
- 3 repetitions of all 15 distances in three blocks: verbal active rating, verbal passive rating, manual passive rating
- PSsize estimated by stop-distance task
- 2 female confederates

Results

PSsize in stop-distance task: M = 88.31 cm, SD = 17.39 cm
Shortest distance without discomfort: M = 88.33 cm, SD = 16.08 cm; r(22) = .64

Four linear mixed models:
Discomfort ~ IPD-PSsize + Block (AIC = 2279.2)
Discomfort ~ IPD-PSsizeⁱⁿ + extrusion + Block (AIC = 1881.6)
Discomfort ~ (IPD-PSsize)² + in + extrusion + Block (AIC = 2032.0)
Discomfort ~ (IPD-PSsize)/PSsizeⁱⁿ + extrusion + Block (AIC = 1834.7)



Discussion


- Intrusion of PS elicits a rapid and immediate increase in discomfort
- IPDs exceeding the limits of PS cause a moderate increase in discomfort
- Consistent with field-theory (Lewin, 1939), the function of IPD and discomfort is scaled individually on the size of PS
- The tolerance previously observed in other studies (Thompson et al., 1979), may merely be an artifact of aggregation across subjects that has resulted in a U-shaped function of IPD and discomfort.
- We cannot rule out a tolerance for violations of PS smaller than 15 cm

Conclusion

The data favor the fast asymmetric response model

Hayduk, L. A. (1978). Personal space: An evaluative and orienting overview. *Psychological Bulletin*, 1985(1), 117-134.
Hayduk, L. A. (1981). The permeability of personal-space. *Canadian Journal of Behavioural Science-Revue Canadienne Des Sciences Du Comportement*, 13(3), 274-287. doi:10.1037/a0081182
Thompson, D. E., Aiello, J. R., & Epstein, Y. M. (1979). Interpersonal distance preferences. *Journal of Nonverbal Behavior*, 4(2), 113-118. doi:10.1007/BF01004355
Lewin, K. (1939). Field theory and experiments in social psychology: Concepts and methods. *American Journal of Sociology*, 44(6), 868-896. doi:10.1086/218177

Contact: welsch@uni-mainz.de



WHY PSYCHOPATHS DO NOT STAND BACK: UNDERSTANDING PERSONAL SPACE VIOLATIONS

JOHANNES GUTENBERG UNIVERSITÄT MAINZ
Robin Welsch, Christoph von Castell, Heiko Hecht
Johannes Gutenberg-Universität Mainz, Department of Psychology, Section Experimental Psychology

Motivation

- Clinical reports: Psychopathic individuals are prone to invade the personal space of others (Quayle, 2006; Rime, Bouvy, Leborgne, & Rouillon, 1978)
- Experimental findings: psychopathic lack of empathy, coldheartedness is associated with diminished preferred interpersonal distance (IPD; Viera & Marsh, 2004)

It is still unclear why psychopathic individuals might prefer shorter IPD. Therefore, we investigated whether psychopathy effects on IPD are modulated by facial expression and egocentric vs. exocentric views.

Method

Sample

- N = 40, 16♂ (M_{age} = 23.80, SD_{age} = 4.92)
- Psychopathy as a dimensional trait: via Psychopathic Personality Inventory-Revised-40 (Eisenbarth, Lilienfeld, & Yearkon, 2016; M = 85.87, SD = 11.51)
- sample split on the median psychopathy-score: high and low psychopathy-group

EX.P.1: Egocentric IPD-Effects of Emotion

Procedure and design

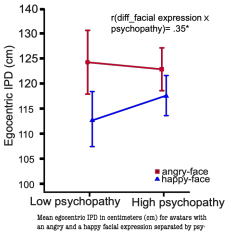
- Instructed to approach the avatar until a comfortable distance for conversation was reached (asking a stranger for directions)
- Initial distance: 2.5 m or 2.2 m
- 4 avatars (2♂, 2♀) × 2 initial distances (2.2 m, 2.5 m) × 2 facial expression (happy, angry) × 3 repetitions = 48 trials

rMANOVA

- Within: gender of avatar, facial expression, initial position
- Between: psychopathy-group
- DV: egocentric IPD

Results:

- psychopathy n.s.
- facial expression*



facial expression x psychopathy*

initial distance*

initial distance x gender of avatar*

(effects of initial distance was more pronounced for female avatars)

EX.P.2: Exocentric IPD

Procedure and design

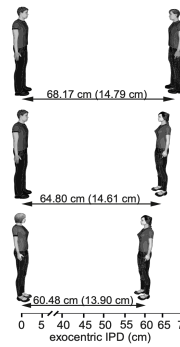
- Variation from Exp. 1: each two avatars were presented in the frontoparallel plane
- Instructed to move one avatar via joystick towards the other avatar until comfortable distance for conversation between the two avatars was reached (asking a stranger for directions)
- Initial distance: 2.5 m
- 12 pairs (2 male pairs, 2 female pairs, 8 mixed pairs) × 2 movement (left to right, right to left) × 2 repetitions = 48 trials

rMANOVA:

- Within: pair
- Between: psychopathy-group
- DV: exocentric IPD

Results:

- psychopathy n.s.
- pair*
- (all pairwise comparisons)



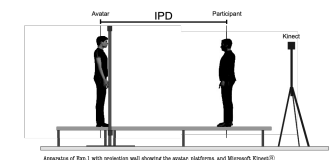
All other effects n.s.

Egocentric vs. exocentric IPD

Mean exocentric IPD (M = 64.48 cm, SD = 22.57 cm) was significantly smaller than mean egocentric IPD (M = 119.28 cm, SD = 22.57 cm). However, both distances were strongly associated, r(38) = .73.

Apperatus

- Large rear-projection screen (2.60 m width, 1.95 m height)
- 3D virtual environment resembling the surrounding laboratory
- Participant's position was tracked via Microsoft Kinect®
- stereoscopic projection was dynamically adjusted to the participant's position



Apperatus of Exp. 1 with projection wall covering the avatars, platform, and Microsoft Kinect®

Conclusion:

Psychopathy is not associated with a general compression of personal space but rather compromises the regulation of IPD in response to facial expression.

Acknowledgments:

We are grateful to Agnes Mischak for creating the virtual environment.

References:

Eisenbarth, S., Lilienfeld, D. O., & Yearkon, T. (2016). Using a genetic algorithm to adaptively personalize the Psychopathic Personality Inventory-Revised (PPI-R). *Psychological Assessment*, 27, 194-202. <https://doi.org/10.1037/psa0000038>

Quayle, J. (2006). Interviewing a psychopathic suspect. *Journal of Investigative Psychology and Offender Profiling*, 6, 19-20. <https://doi.org/10.1080/10439860500090858>

Viera, B., Bouvy, S., Leborgne, S., & Rouillon, F. (1978). Psychopathy and social behavior in an interpersonal situation. *Journal of Abnormal Psychology*, 87, 656.

Viera, B., & Marsh, A. A. (2004). Does threat or cues to the psychopathy level modulate the regulation of interpersonal distance. *Personality & Individual Differences*, 36(7), 1007-1016. <https://doi.org/10.1016/j.paid.2003.09.007>

Evaluation Criteria – Poster

- **Correctness (1-20)**
- **APA Guidelines (1-20)**
- **Presentation (1-20)**
- **Replicability (1-20)**
- **Completeness (1-10)**
- **Visualization (1-10)**

Illustrative cutoffs:

Grade 5: 91 and above

Grade 4: 81-90 points

Grade 3: 71-80 points

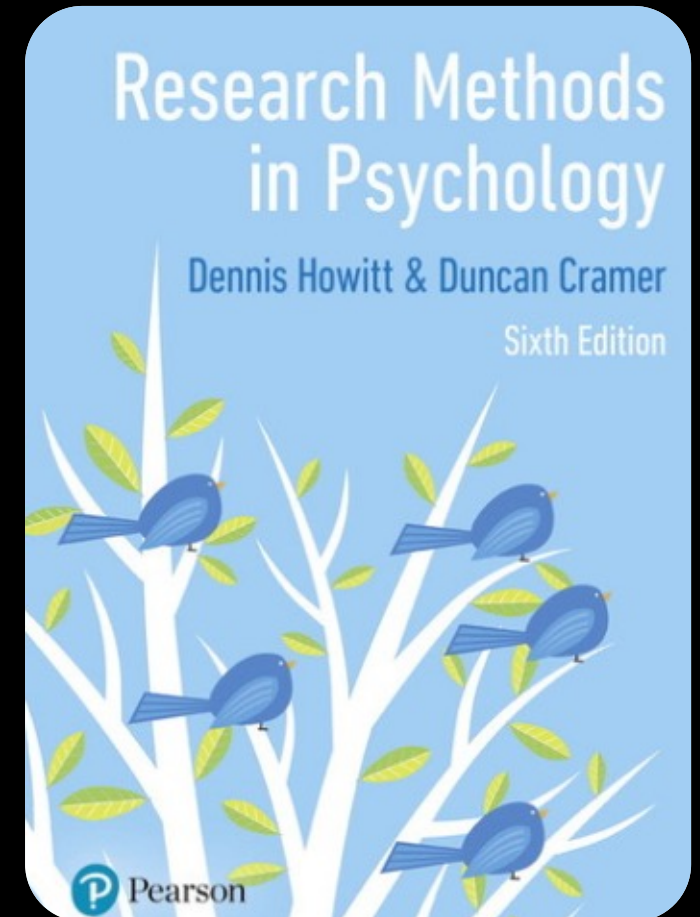
Grade 2: 61-70 points

Grade 1: 51-60 points

Note: These are subject to change and will be calibrated depending on the overall course.

Book

- Is your first resource if something is unclear
- Gives guidance on how to write research up
- Before each lecture send one question to me about the reading material to get 10 extra points.



Timeline

Day	Date	Time	Room	Activity	Meeting Study Coordinator	Classroom
Wed	10.01.24 (week 02)	14:15 - 16:00	R030/A133 T5	Lecture 1		x
Wed	17.01.24 (week 03)	14:15 - 16:00	R030/A133 T5	Lecture 2		x
Wed	24.01.24 (week 04)	14:15 - 16:00	R030/A133 T5	Lecture 3		x
Wed	31.01.24 (week 05)	14:15 - 16:00	R030/A133 T5	Lecture 4	X	x
Wed	07.02.24 (week 06)	14:15 - 16:00	R030/A133 T5	Tutorial 1		x
Wed	14.02.24 (week 07)	14:15 - 16:00	R030/A133 T5	Tutorial 2	X	x
Tue	27.02.24 (week 09)	10:15 - 12:00	R030/C206 T3	Tutorial 3/Testing	X	maybe
Tue	05.03.24 (week 10)	10:15 - 12:00	R030/C206 T3	Testing		
Tue	12.03.24 (week 11)	10:15 - 12:00	R030/C206 T3	Testing		
Tue	19.03.24 (week 12)	10:15 - 12:00	R030/C206 T3	Testing / Poster Design		
Tue	26.03.24 (week 13)	10:15 - 12:00	R030/C206 T3	Data analysis / Poster design	X	
Tue	09.04.24 (week 15)	10:15 - 12:00	R030/C206 T3	Poster presentation		x

Lecture preparation

Before

- Read chapter(s)

After

- Watch short-video
- Maybe: Re-read chapter(s)
- Maybe: Look at slides again
- Complete Self-assessment
- Derive questions and hand them in

Project preparation in Groups

Testing in March

Before

- Meet with your study coordinator
- Read literature
- Prepare materials
- Prepare call for participants
- Walk study coordinator through the study
- Get the OK signal to run your study
- Coordinate testing
- Send call for participants out

After

- Analyze the data
- Prepare the poster & presentation
- Rehearse with your coordinator
- Present your study

Questions?

Group A

Brade Elias (100843390, elias.brade@aalto.fi, SCI Perustieteiden korkeakoulu)

Heikkilä Elisa (101516231, elisa.a.heikkila@aalto.fi, SCI Perustieteiden korkeakoulu)

Hetemaa Anniina (101830072, anniina.hetemaa@aalto.fi, SCI Perustieteiden korkeakoulu)

Laine Mette (101789042, mette.laine@aalto.fi, SCI Perustieteiden korkeakoulu)

Parvinen Meri (101497185, meri.parvinen@aalto.fi, SCI Perustieteiden korkeakoulu)

Tuloisela Tapio (1032488, tapio.tuloisela@aalto.fi, SCI Perustieteiden korkeakoulu)

Group B

Student

Hyttinen Onni (101677714, onni.hyttinen@aalto.fi, SCI Perustieteiden korkeakoulu)

Kemppinen Artturi (101769198, artturi.kemppinen@aalto.fi, SCI Perustieteiden korkeakoulu)

Lindberg Henna (101552318, henna.lindberg@aalto.fi, SCI Perustieteiden korkeakoulu)

Rautama Otso (820730, otso.rautama@aalto.fi, SCI Perustieteiden korkeakoulu)

Uthardt Jacob (100598823, jacob.uthardt@aalto.fi, SCI Perustieteiden korkeakoulu)

Group C

Kalsta Otto (101795311, otto.kalsta@aalto.fi, SCI Perustieteiden korkeakoulu)
Katajisto Iida (100553224, iida.katajisto@aalto.fi, SCI Perustieteiden korkeakoulu)
Koponen Sofi (101788030, sofi.koponen@aalto.fi, SCI Perustieteiden korkeakoulu)
Pellinen Veeti (101712271, veeti.pellinen@aalto.fi, SCI Perustieteiden korkeakoulu)
Virtanen Noora (100889396, noora.virtanen@aalto.fi, SCI Perustieteiden korkeakoulu)
Välimäki Inka (101735960, inka.valimaki@aalto.fi, SCI Perustieteiden korkeakoulu)

Group D

Student

Hänninen Iivari (101769952, iivari.hanninen@aalto.fi, SCI Perustieteiden korkeakoulu)

Lamberg Pinja (101495543, pinja.lamberg@aalto.fi, SCI Perustieteiden korkeakoulu)

Läärä Urho (100828412, urho.laara@aalto.fi, SCI Perustieteiden korkeakoulu)

Paananen Elena (101538620, elena.paananen@aalto.fi, SCI Perustieteiden korkeakoulu)

Salmela Arno (100880515, arno.salmela@aalto.fi, SCI Perustieteiden korkeakoulu)

Group E

Student

Backman Nicole (101734372, nicole.backman@aalto.fi, SCI Perustieteiden korkeakoulu)

Erho Tiina (100802195, tiina.erho@aalto.fi, SCI Perustieteiden korkeakoulu)

Karppinen Anni (101699462, anni.e.karppinen@aalto.fi, SCI Perustieteiden korkeakoulu)

Stenberg Amanda (101753285, amanda.stenberg@aalto.fi, SCI Perustieteiden korkeakoulu)

Vähäpesola Erika (101714347, erika.vahapesola@aalto.fi, SCI Perustieteiden korkeakoulu)

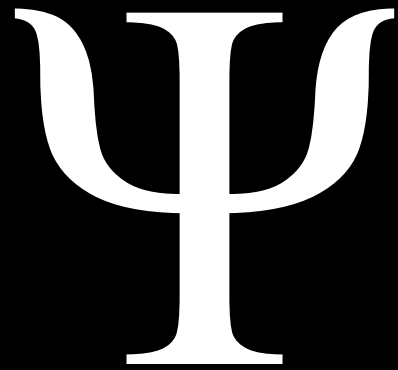
Psychological research

- Differentiate
 - Folk psychology from Psychological Science
- The problem of causality and alternative explanations
- Types of research





Psychology as a science



Scientific psychology investigates human experience, behavior and cognition.

What motivates people to play?

Why do we need a personal space?

How do people estimate distance?

How do we remember things?

Do opposites attract?

Does exposure to violence cause aggressive behavior?

Can people have multiple personalities?

What motivates people to play videogames?

How do we remember pincodes?

Why do we need a personal space in social VR?

How do people estimate distance when driving?

Does exposure to violent video games cause aggressive behavior?

Do opposites match better in dating apps?

Can people maintain multiple videogame characters?

**How do we formulate a
research question?**

Scientific curiosity

leads to research questions

- Variables: characteristics or conditions that change or have different values for different individuals
- Research question: a statement that describes or explains a relationship between or among variables
 - often begins with: How? Why? What? Which?
 - is interesting to others
 - can be answered with research
 - are open-ended

Checklist for Developing a Research Question

- Is it an open-ended question?
- Is it appropriate in scope? Focused and narrow enough for your project or paper?
- Does it suggest factors that can be measured?
- Is it relevant to my audience?
- Is answering the question manageable, and can I find and access enough documents, statistics, or persons to provide information to develop and support my ideas?
- Is the topic of interest to me?

Good and Bad Research Questions

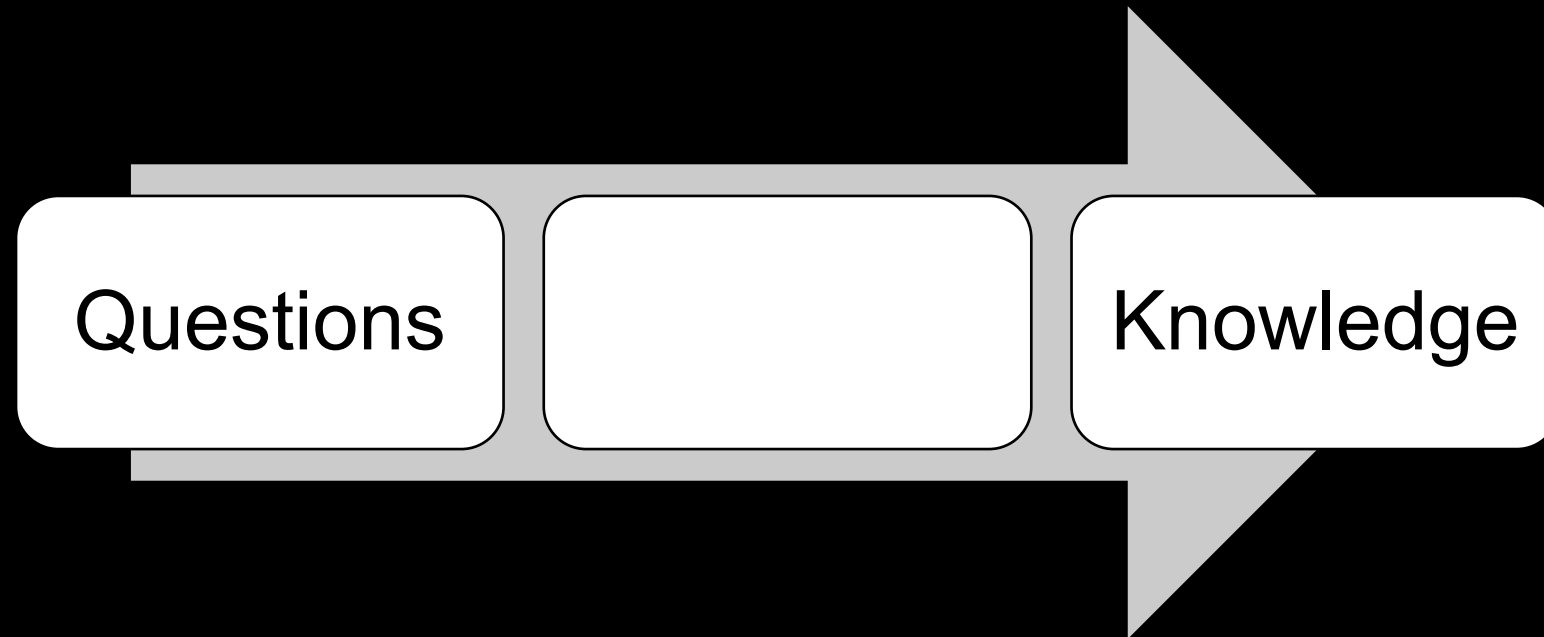
- **Example 1: Questions Should Have Complex Answers**
 - **Bad:** Does owning a pet improve quality of life for older people?
 - **Good:** In what ways does owning a pet improve quality of life for older people?
- **Example 2: Good Research Questions Need Focus**
 - **Bad:** Does medication help alleviate attention deficit hyperactivity disorder (ADHD) symptoms? And do kids need more exercise?
 - **Good:** How effective are the various types of medication in treating elementary students with ADHD?
- **Example 3: Questions Should Be Specific**
 - **Bad:** How do artificial sweeteners affect people?
 - **Good:** How does aspartame affect post-menopausal women who suffer from migraines?

How can we answer research questions?

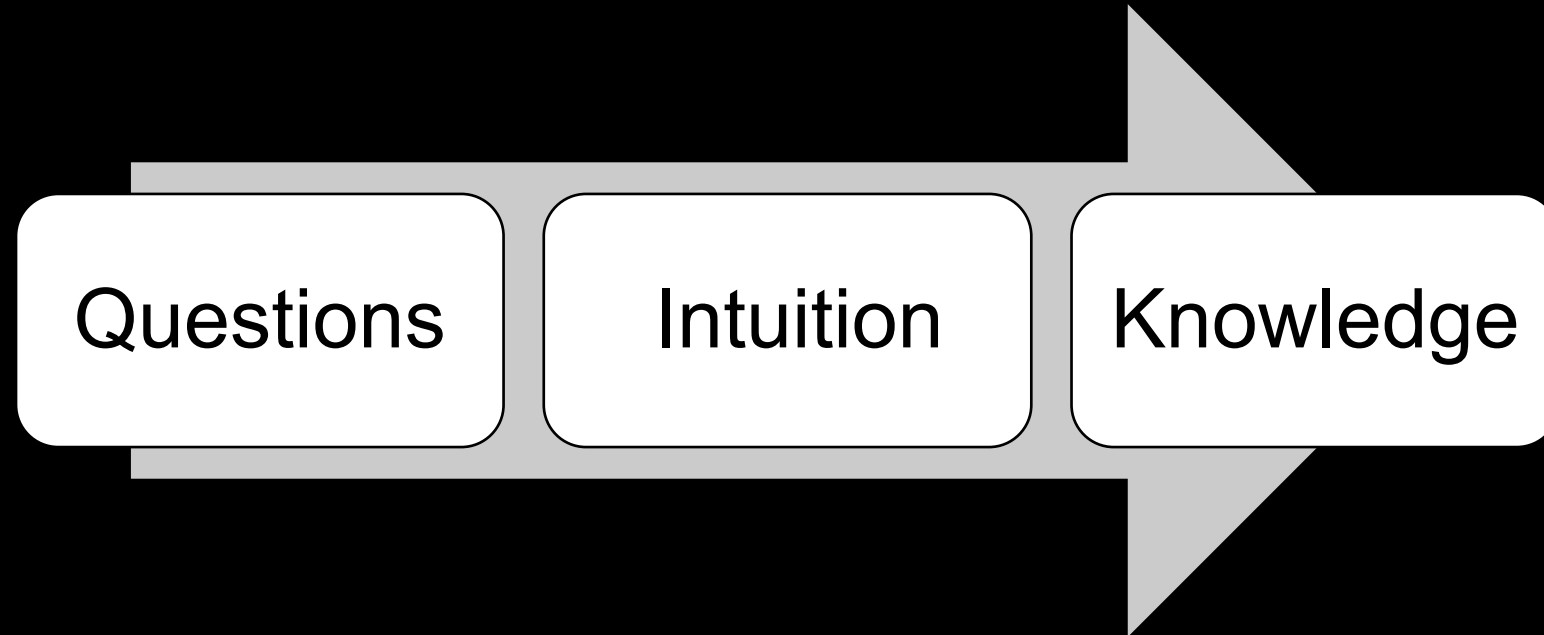


Why does exposure to violent video games cause aggressive behavior?

Psychological Science as problem solving



Psychology as problem solving



Folk Psychology

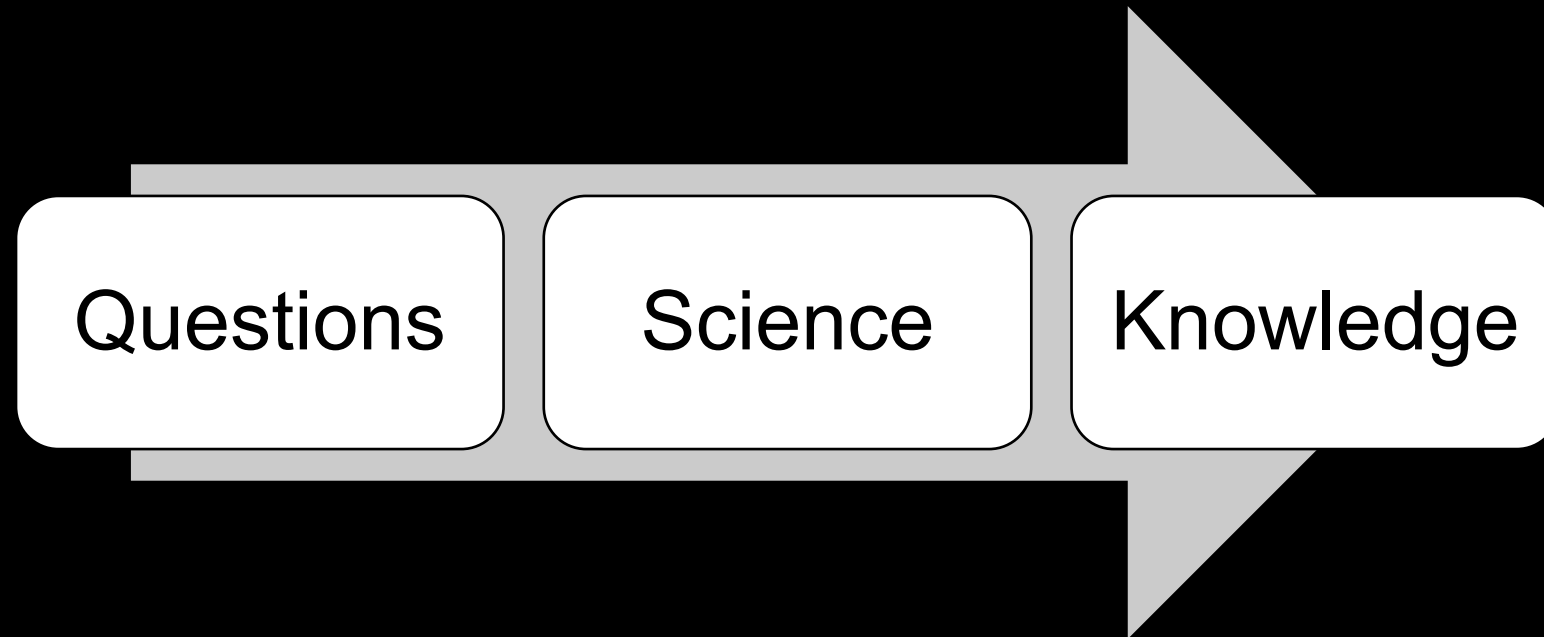
Possible ways of answering

- Introspection
 - E.g. Think about your motives for choosing a violent videogame
- Prior non-scientific knowledge
 - Asking someone else for their opinion on the subject, e.g. I ask my mom
- Unsystematic observation
 - E.g. Go to a games store and observe people
- We often rely on mental shortcuts (heuristics) when forming and maintaining our beliefs about the world.
 - Confirmation bias. We tend to seek out information consistent with our beliefs, and disregard information that is *inconsistent* with our beliefs.

→ Knowledge may be true but we can never be sure it is right

Psychological Science as problem solving

Producing knowledge that is robust and reliable



Scientific Psychology

1. Is guided by theory and hypothesis
2. relies on empirical evidence
3. employs systematic research methods
4. strives for objectivity

What is a hypothesis?

How to formulate a hypothesis

- A hypothesis is a precise problem statement that can be directly tested through an empirical investigation
- Compared with a theory, a hypothesis is a smaller, more focused statement that can be examined by a single study
- A hypothesis considers the relevant variables and their relation in the study

Types of hypothesis

Directional hypotheses

Causal

Non-causal

More A causes
more B

More A relates
to more B

Non-directional
hypotheses

Causal

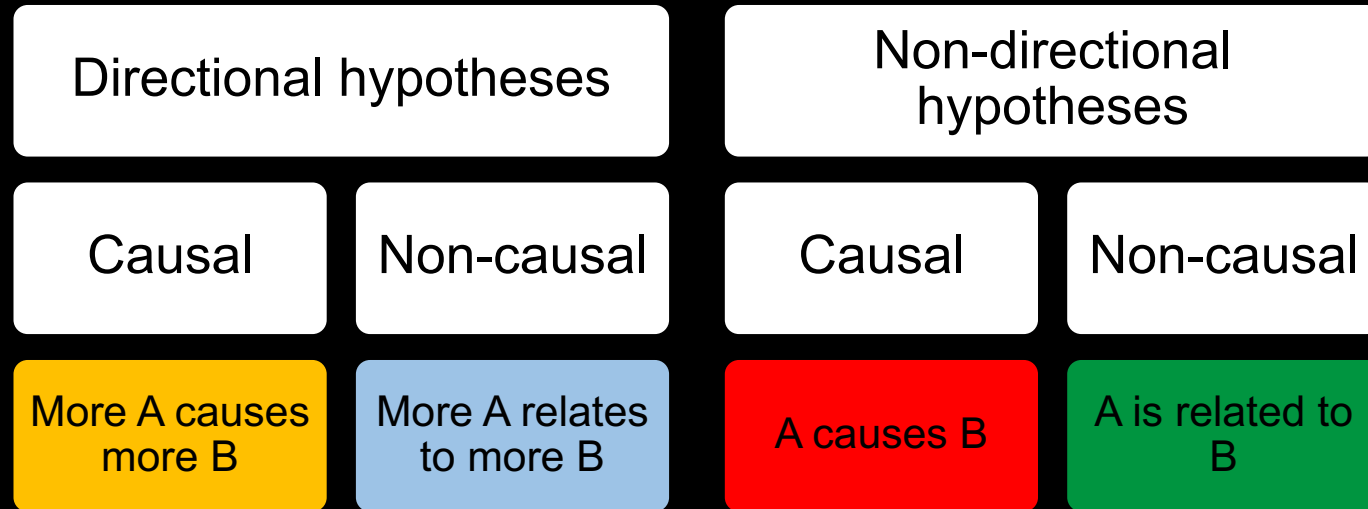
Non-causal

A causes B

A is related to
B

Map the hypotheses!

Slide will be updated with solution



1. Keyboard layout has a significant effect on task completion time
2. If typing experience increases then typing speed increases
3. Providing typing training will increase task completion time in the training group compared to users who did not receive any training.
4. Task completion time is related to age

Often formulated as

In practice

Causality

- Affects
- Influences
- Results in
- Has an effect on
- Brings about
- Causes
- Leads to

Direction

- The more
- The less
- Increases
- Decreases

Checklist for a good hypothesis

Formulation, Quantifiability, Operationalizability, Justifiability

- Is the hypothesis understandable?
- Can it be formulated as a conditional sentence?
- Does the hypothesis postulate a relationship between at least two variables?
- Can the hypothesis be informed by contrary evidence?
- Can we draft a study and collect data?
- Is the hypothesis backed up by theory?

How do we get data to evaluate hypotheses?

Types of empirical research in psychology

Ways of gathering empirical data

Cross-
sectional
research

Longitudinal
research

Experimental
research

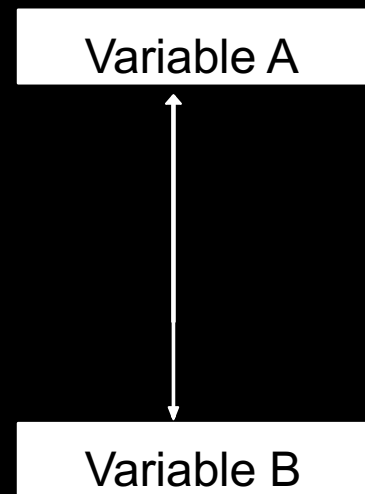


Why does exposure to violent video games (VVG) cause aggressive behavior?

Cross-Sectional research

Non-causal relationships; no control for confounds

- systematic measurement of variables → dependent variables
- two or more variables are measured at the same time



„The amount of video game exposure will be positively related to aggressive behaviour”

Table 2. Analyses of variance and mean scores of the three different groups of preference for aggressive video games for aggressive and prosocial behaviour ($N = 278$)

	No preference ^a		Moderate preference		High preference		d.f.	F
	M	SD	M	SD	M	SD		
Aggressive behaviour	1.11	1.08	1.42	1.35	1.96	1.83	(2, 243)	6.46*
Correction for IQ	1.11	1.09	1.46	1.36	1.96	1.83	(2, 234)	6.16*
Prosocial behaviour	1.54	0.59	1.21	0.68	1.16	0.63	(2, 243)	9.53**
Correction for IQ	1.54	0.59	1.22	0.68	1.16	0.63	(2, 234)	8.48**

* $p < .01$; ** $p < .001$.

Note. Higher values reflect more aggressive, or more prosocial, behaviour, respectively.

^a No preference: children who in their list of favourite video games mentioned no aggressive video games; moderate preference: children who in their list mentioned aggressive video games, but less than 50 per cent of their list contained aggressive video games; high preference: children whose list of favourite video games contained 50 per cent or more aggressive video games.

Anderson, C. A., & Dill, K. E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of personality and social psychology*, 78(4), 772.

Wiegman, O., & van Schie, E. G. (1998). Video game playing and its relations with aggressive and prosocial behaviour. *British Journal of Social Psychology*, 37(3), 367-378.

Longitudinal Research

Identification of non-causal relationships in time; no control for confounds

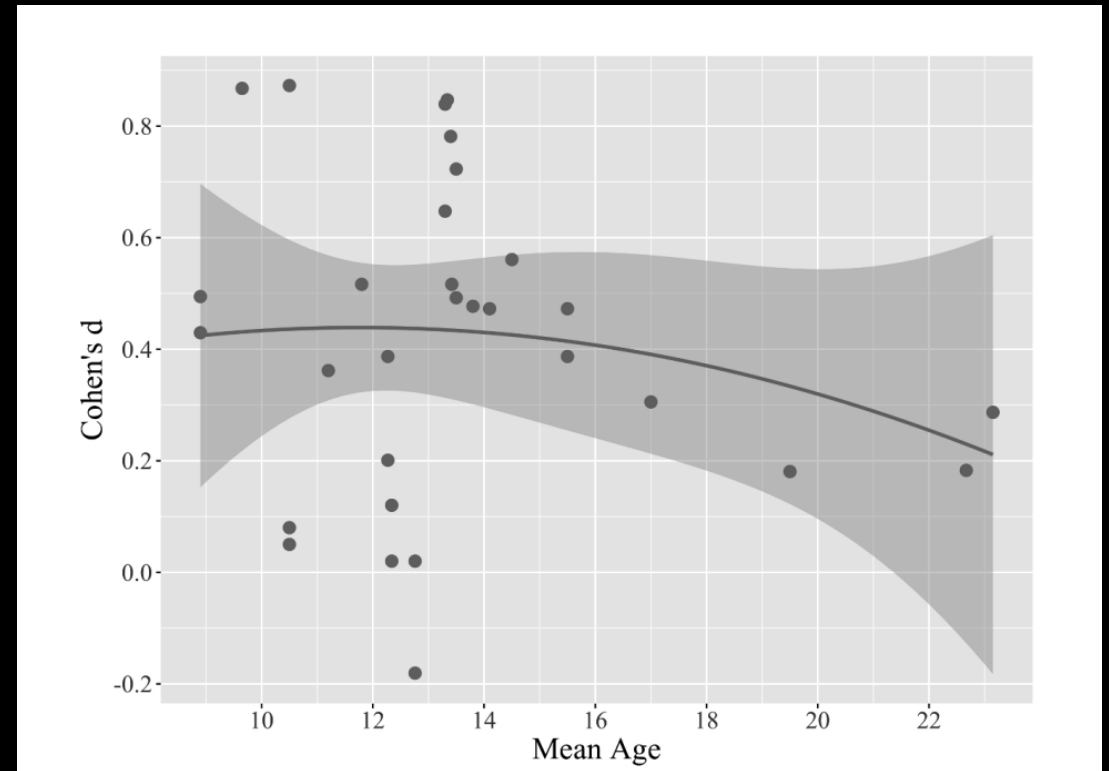
- systematic measurement of variables → dependent variables
- One or more variables are measured over time



Longitudinal Studies of VVG and aggression

„we expected an inverse U-shape curvilinear relationship between age and effect size”(VVG-effect)

- Data is sampled across time
- Can come from same sampling points (e.g. participants) but also be independent from each other



*cohen's d means of standardizing the strength of an effect and making it comparable across studies

Experimental Research

Identification of cause and effect-relationships; control for confounds

- systematic measurement of one or more variables → dependent variables
- systematic manipulation of one or more variables → independent variables



Spoiler

Experimental study shows that after exposure to a violent video game social interactions are interpreted as more aggressive

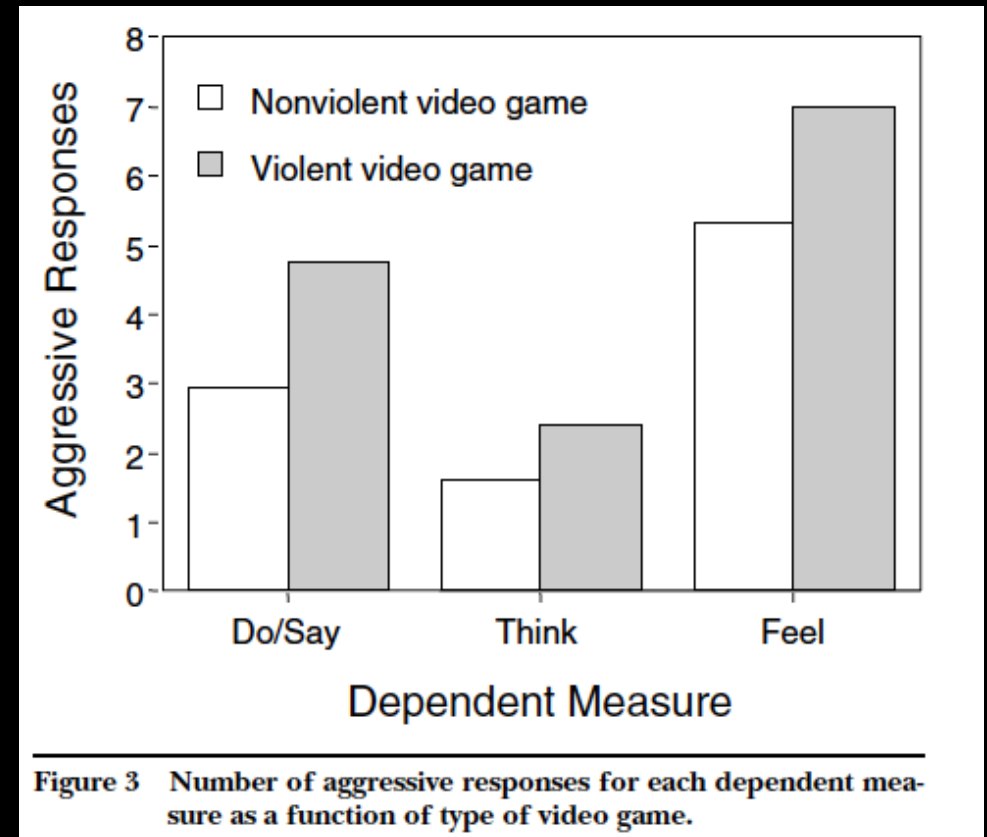


Bushman, B. J., & Anderson, C. A. (2002). Violent video games and hostile expectations: A test of the general aggression model. *Personality and social psychology bulletin*, 28(12), 1679-1686.

Manipulating VVG exposure

„brief exposure to violent video games can increase aggressive expectations”

- Participants (N = 224) played either a violent or nonviolent video game.
- Then, they read ambiguous story stems about potential interpersonal conflicts.
- They were asked what the main character will do, say, think, and feel as the story continues.



Psychological Science as problem solving

Questions

Science

Knowledge

Spoiler

Violent video games do have a small effect on physical aggressive behavior but pro-social games also have a positive effect on helping behavior



Anderson, C. A., Shibuya, A., Ihori, N., Swing, E. L., Bushman, B. J., Sakamoto, A., ... & Saleem, M. (2010). Violent video game effects on aggression, empathy, and prosocial behavior in eastern and western countries: a meta-analytic review. *Psychological bulletin*, 136(2), 151.

Types of research

Ways of applying the scientific method to human empirical data

Cross-sectional research	Longitudinal research	Experimental research
Easy to do	Time-intensive	Complicated
Causality problematic	Causality is possible	Artificial
Confounds are possible	Confounds are problematic	Confounds can be controlled

Types of research

Ways of applying the scientific method to human empirical data

Cross-sectional research

Longitudinal research

Experimental research

Combine and triangulate insights from different sources of data

Causality problematic

Causality is possible

Artificial

Confounds

Confounds are problematic

Confounds can be controlled

Spoiler

Violent video games do have a small effect on physical aggressive behavior this holds across these types of research approaches



Anderson, C. A., Shibuya, A., Ihori, N., Swing, E. L., Bushman, B. J., Sakamoto, A., ... & Saleem, M. (2010). Violent video game effects on aggression, empathy, and prosocial behavior in eastern and western countries: a meta-analytic review. *Psychological bulletin*, 136(2), 151.

Summary

- Psychological research and folk psychology use different methods to attain knowledge about the world
- Research questions are manifestations of a researcher's curiosity
- Hypotheses can differ in causality and direction
- There are different types of empirical research that can be used to answer research questions and evaluate hypothesis
- Violent video games
 - Increase aggression, however, effect sizes are small and confounded e.g. by age
 - Have shown to increase aggression across experimental, cross-sectional and longitudinal studies
 - Prosocial games can also promote prosocial behavior

Questions?

Exercise (15 minutes)

Groups of 5

Come up with a research question that combines technology and psychology.

Self-assessment

Lecture 1

1. How is data obtained in folk psychology and scientific psychology?
2. What kind of study type is this? (fictional)
 - Scientists have found that body height in adults is related to weight.
 - Scientists have measured weight from one sample of Finnish university students before and after the pandemic.
 - Scientists have tested typing speed in one sample of participants and compared two keyboard layouts.
3. Formulate a hypothesis for one of the studies above and classify causality and directionality.