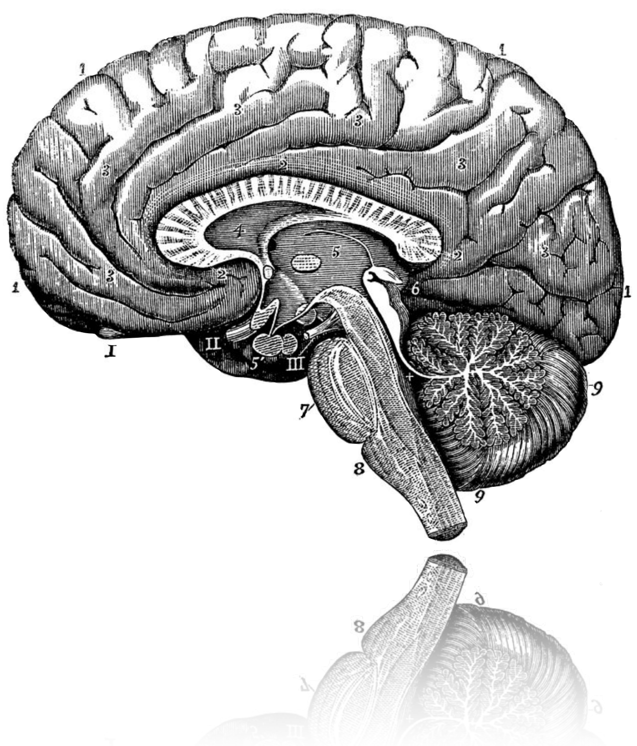
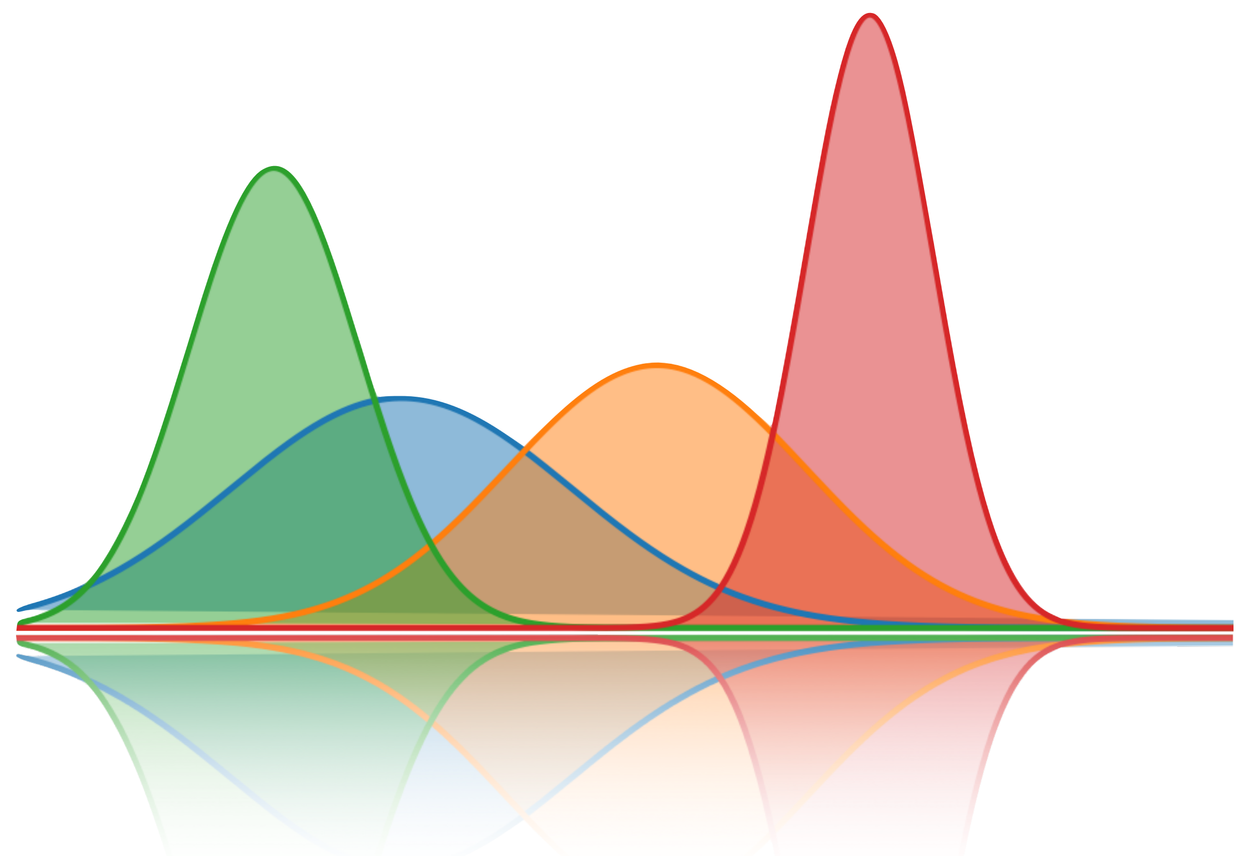




Introduction to research design

Methods 1, E2021 - Lecture 1
Tuesday 30/8/2021
Fabio Trecca

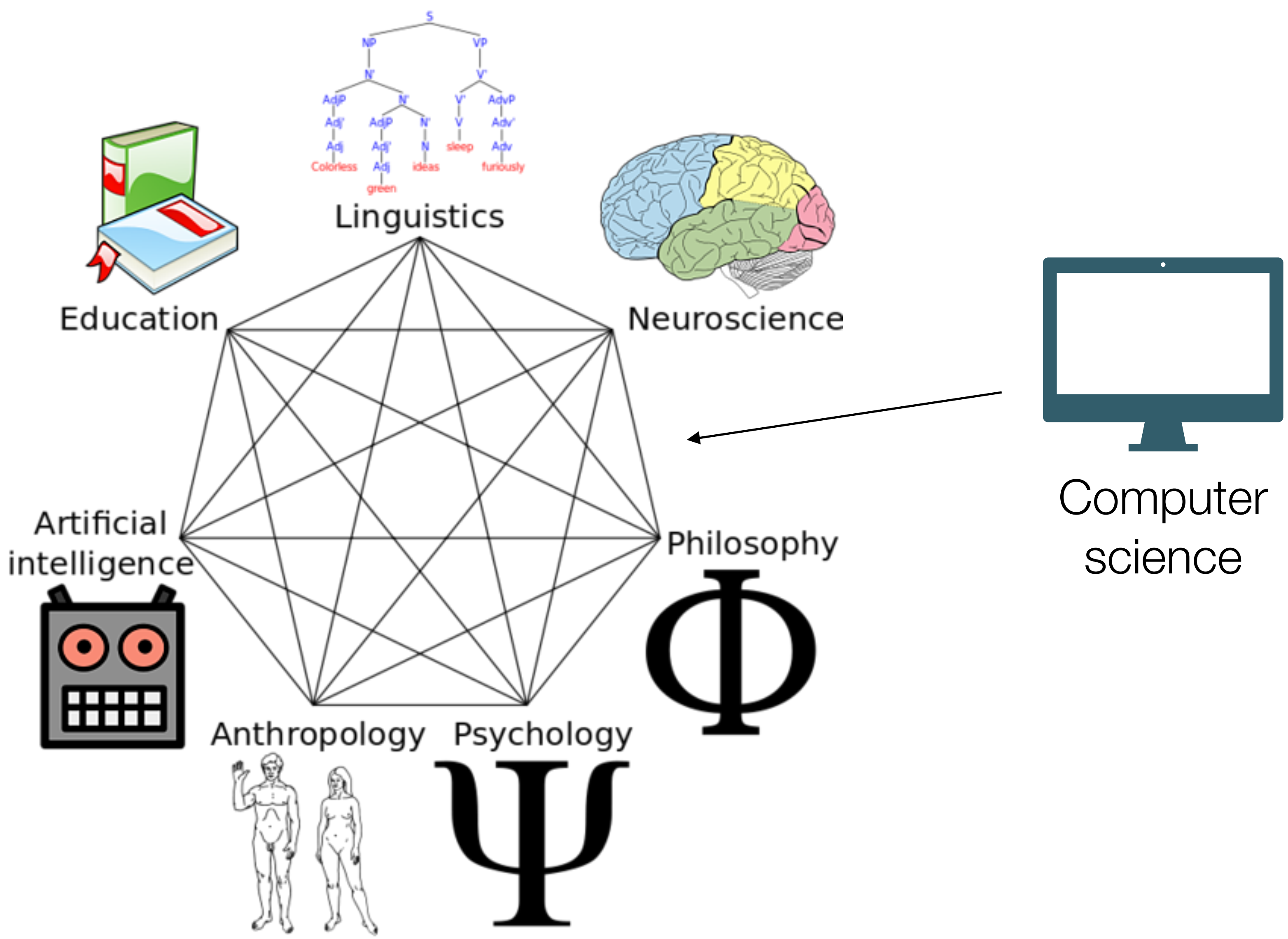
Fabio Trecca

- Ph.D. in Psychology of Language/Language Acquisition
- Assistant professor at the TrygFonden's Center for Child Research, Aarhus BSS and School of Communication and Culture
- Teacher at Cognitive Science and Cognitive Semiotics
- From Rome, Italy but lived in Denmark for many years
- Have been teaching the Methods 1 class for three years

Who are you?

- For next time, please make a slide about yourself
- There are no limits to your creativity!
    - Name
    - Picture
    - Favorite things/activities
- Send to me latest Friday Sept. 3rd

Methods 1:
A course about methods in the cognitive sciences



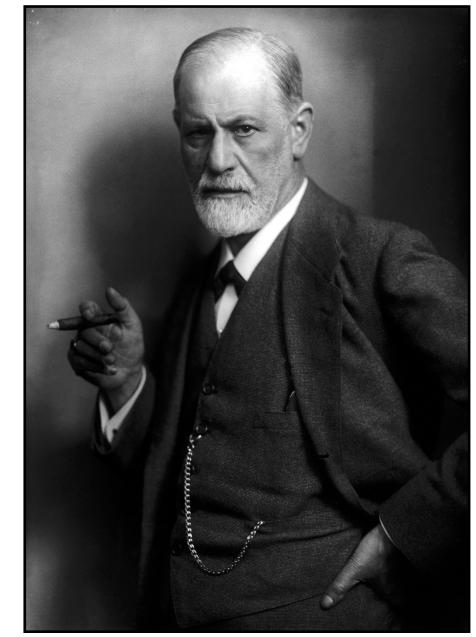
Theory

Methods

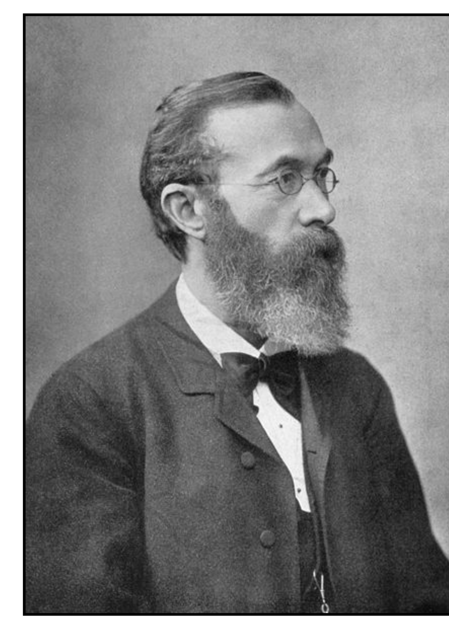
Multidisciplinary

Cognitive science as an **empirical** venture

- Goal of cognitive science: to uncover the general mechanisms underlying human reasoning, emotion, and behavior
- Clinical psychology:
  - concerned about the individual mind/case
  - explains behavior by reference to that individual
  - understand, predict, and influence the individual
- Experimental psychology:
  - 'the mind' as a generalized set of mechanisms: perceptual systems, memory systems, action/overt behavior, emotions, social cognition and interaction, etc.
  - understand, predict, and influence human cognition and behavior



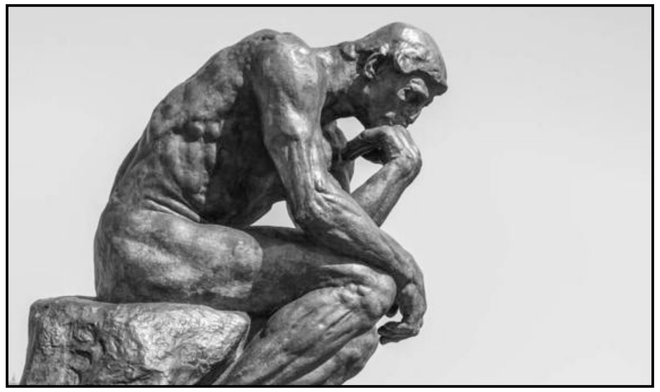
Sigmund Freud (1856-1939)



Wilhelm Wundt (1832-1920)

Three methodological approaches to research

- 1st person methods:
  Introspective reflection



- 2nd person methods:
  Asking people (e.g., interview)

- 3rd person methods:
  Observation (empiricism)

<u>1st person methods:</u> “Thinking myself out of issue X”

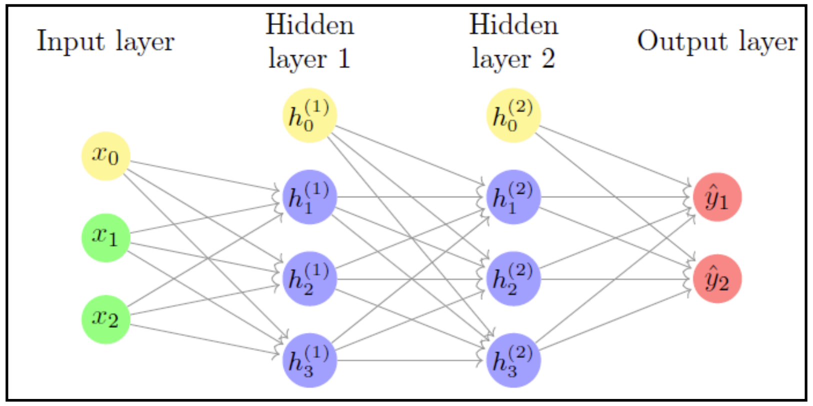
- **Introspection**
  - How do I <u>as an individual</u> think, experience the world, etc.
  - Thought experiments
- **Intuition**
  - How do I <u>as representative of a population</u> think, experience the world, etc.
  - E.g., grammaticality judgments (*I love you* vs. **love I you*)
- **Conceptual analysis**
  - I break down concepts into their constituent parts to gain a better understanding of a particular issue
  - E.g., concept[free will] → constituents[freedom, moral responsibility, determinism, …] + their interactions

<u>2nd person methods:</u>
"Asking others about issue X"

- **Qualitative interview**
  - More or less structured
  - Elicits others' introspections
- **Quantitative interview (= questionnaire)**
  - Answers to explicitly formulated questions
  - Multiple choice vs. open questions

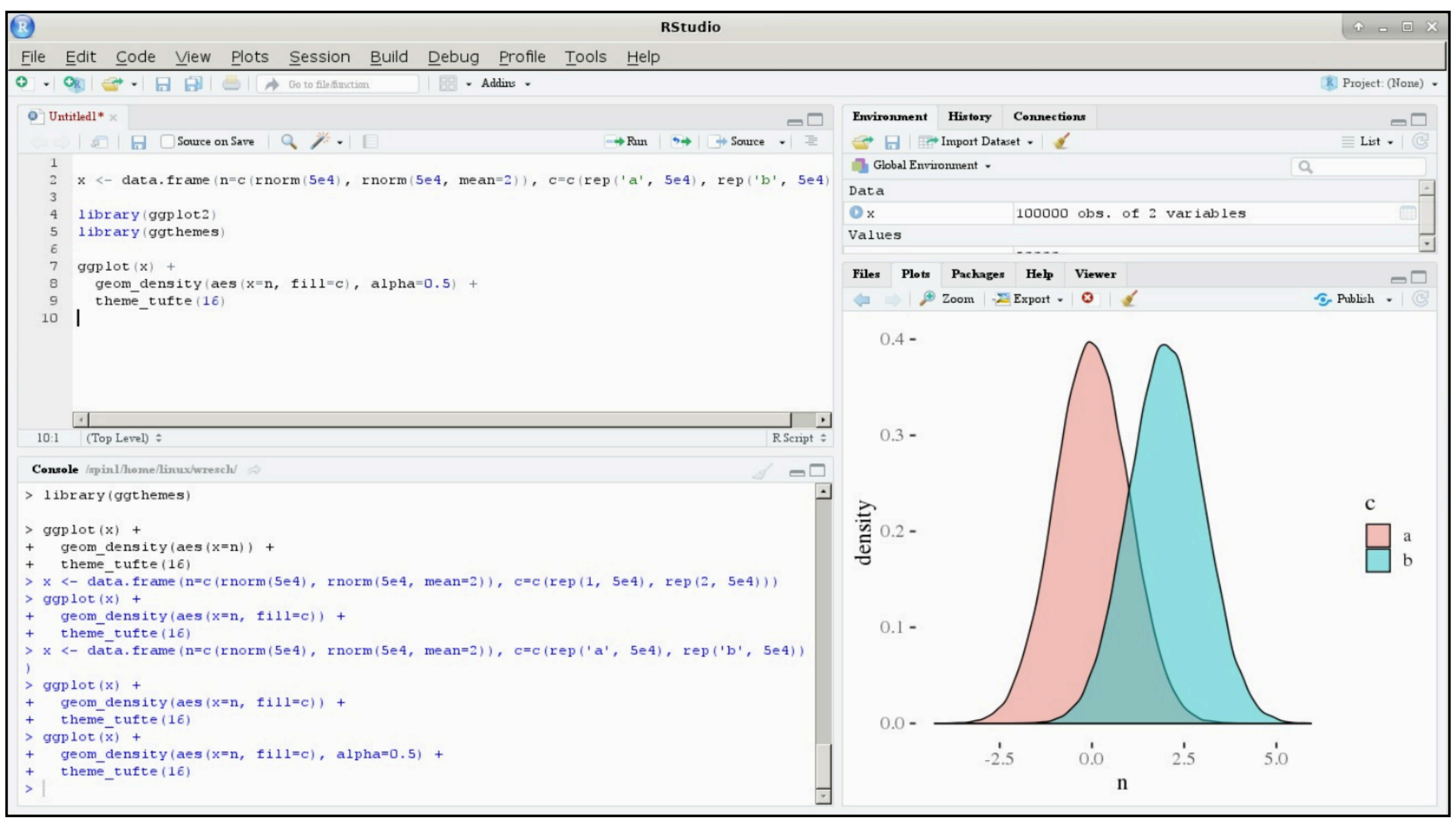
3rd person methods:
"Observing someone dealing with issue X"

- **Naturalistic observation**
  - Observation/description of human behavior in natural context (no intervention)
  - Ethnography, conversation analysis
- **Quasi-experiment**
  - Correlational study of naturally occurring variables
- **Experiment**
  - Elicitation of particular responses in a controlled laboratory setting (intervention)
  - Experimental psychology
- **Computational modeling**
  - Computer simulations of human behavior



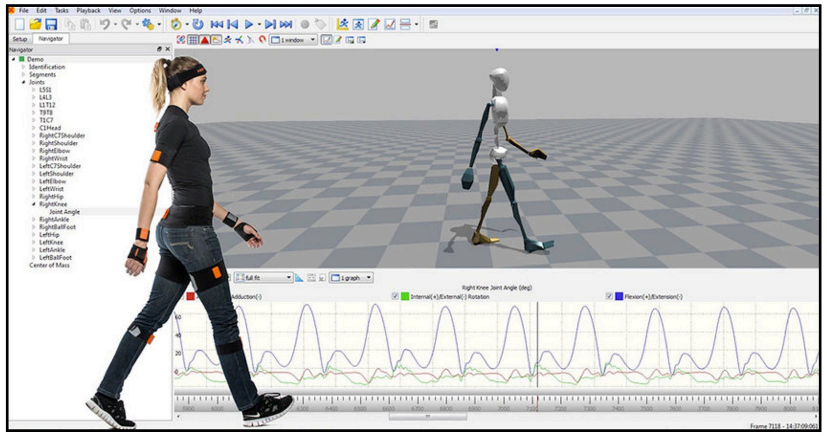
Why do i need to learn statistics and programming?

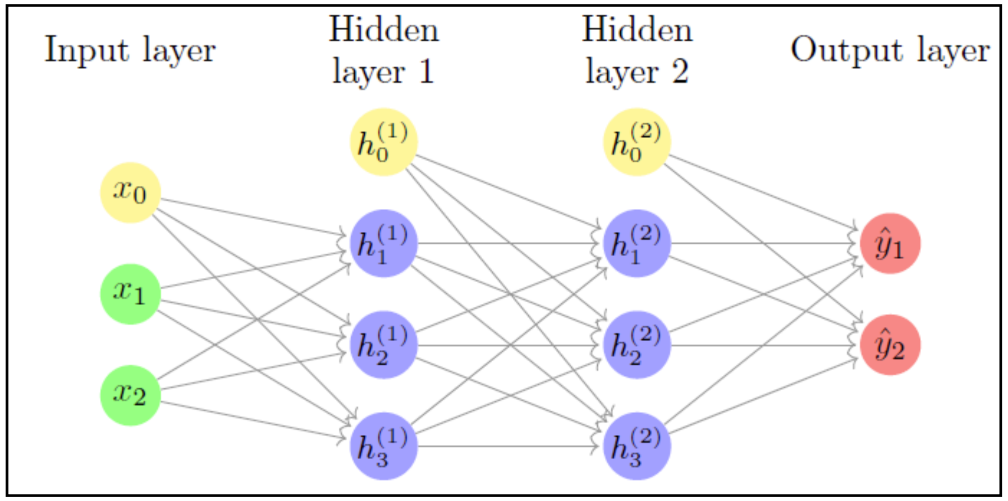
- I am interested in human thinking and human behavior, not in numbers and graphs!
- Why so much emphasis on methods?
- Why don’t we concentrate on conceptual investigations and leave the stats to statisticians?



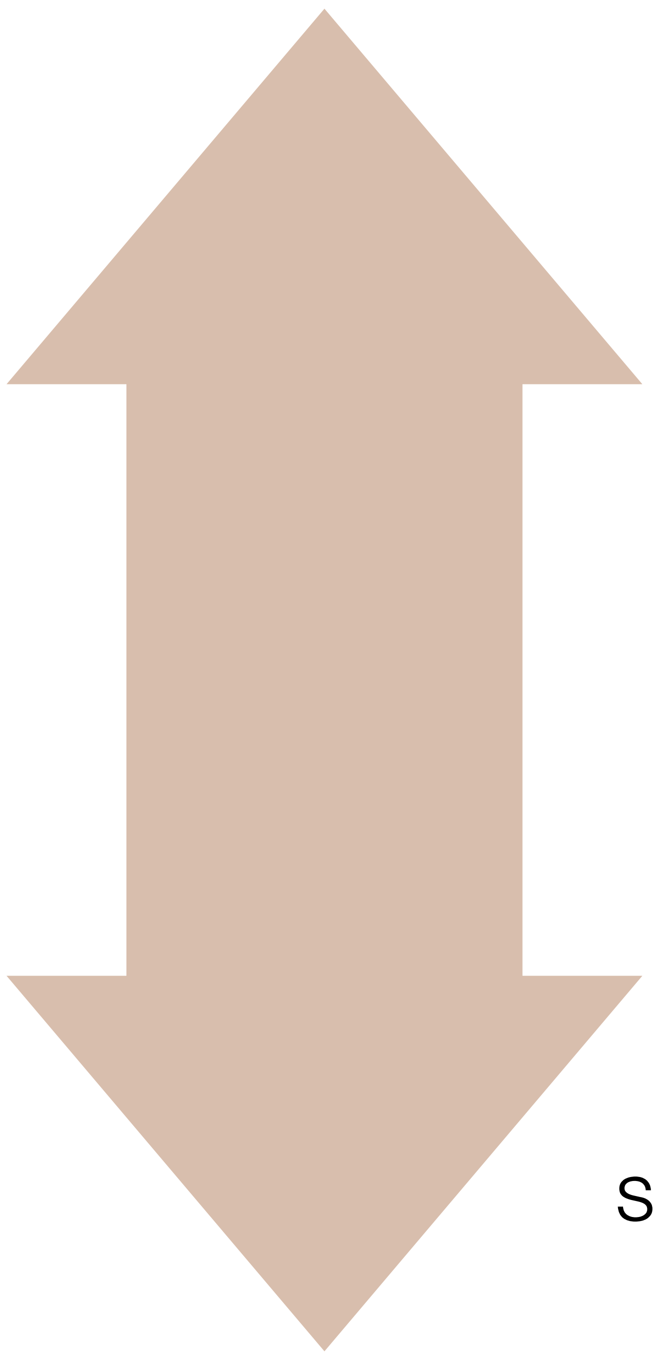
Why so much emphasis on methods?

- Bachelor of Science!
- Methods that help us answer questions about the human mind
- Functional approach to statistics/ programming
- You also get the conceptual side (e.g., Intro to CogSci, CogCom)
- Different tools allow us to answer different kinds of questions
- By learning the methods, we learn to think scientifically:
    - *Is this a satisfactory and scientifically sound answer to my research question?*
    - *Is the evidence I provide enough to prove or disprove a hypothesis?*





Methodological approaches to cognitive science



Observation:
rich but noisy human behavior

(Quasi-experimentation)
Experimentation:
control, causality, generalisability

Computational modeling:
simulating generative mechanisms of human behavior

Time for reflection

- What are the respective advantages of 1st vs. 2nd vs. 3rd person methodological approaches?

Advantages of experimental/quantitative methods

- **Well-established objective criteria** for what counts as evidence
  - → we can see when we are wrong!
- They help us minimise confounding factors:
  - confirmation bias, overconfidence effect, social desirability, etc
- They allow us to test for causal relationships (cause → effect)
- They give us the power to generalise to *unobserved* cases

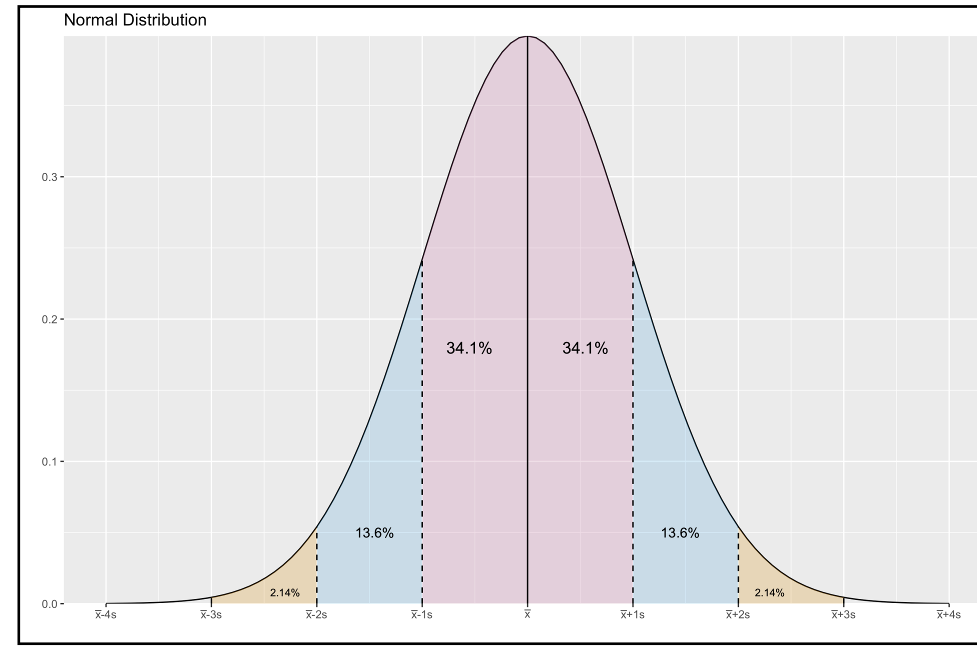
Take-home message

- The study of human cognition is interdisciplinary
- It must rely on insights from many disciplines
- It combines 1st, 2nd and 3rd person methods
- However, the word “Cognitive **Science**” reflects specifically the use of quantitative/experimental methods that characterize much of the discipline
- We learn methods of data collection and data analysis (stats/programming) as tools to answer our questions about mind and behavior

Two key terms in this course…
… that will come up again and again!

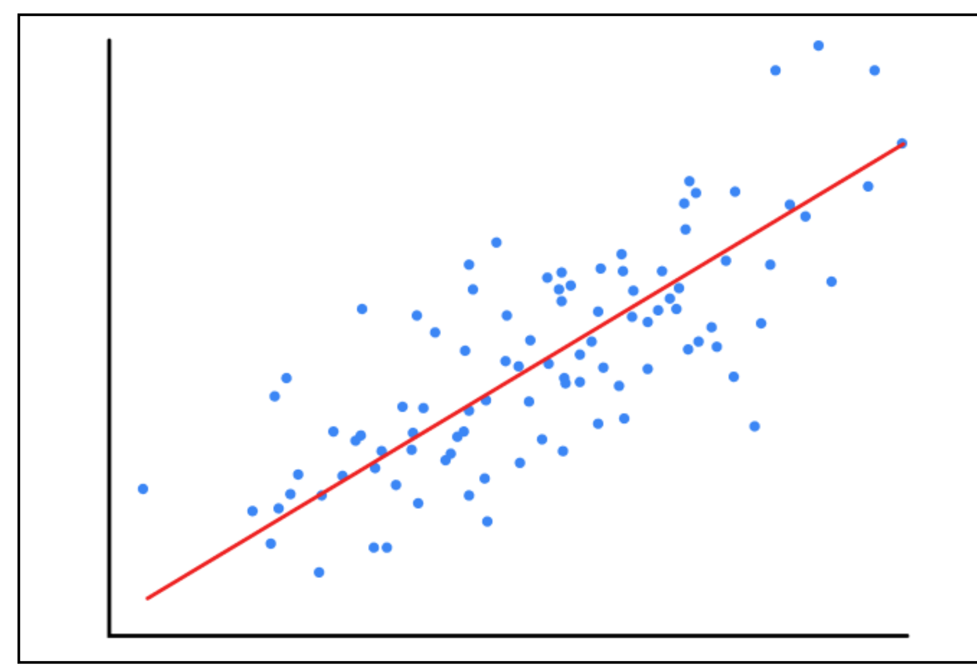
- **Distribution**:
  A numerical/graphical/mathematical description of some data

  - e.g., frequency distributions/probability distributions of variables in a data set with which certain values occur in a data set



- **Statistical model**:
  A numerical/graphical/mathematical summary of (the relationship between) some data

  - e.g.: linear models, non-linear models, hierarchical models



Exercise for next week

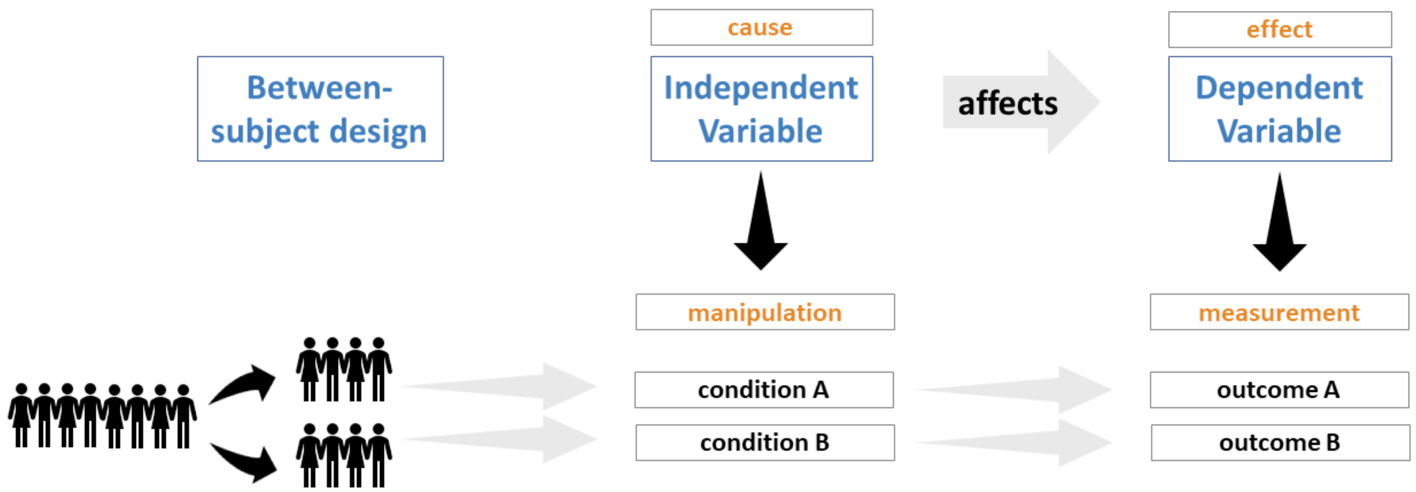
- We have looked at the distribution of age in our class as an example
- For next time, think about how the following types of data are distributed:
  - Height
  - Sex (male/female)
  - Randomly picked numbers between 1 and 5
  - Cups of coffee in a day

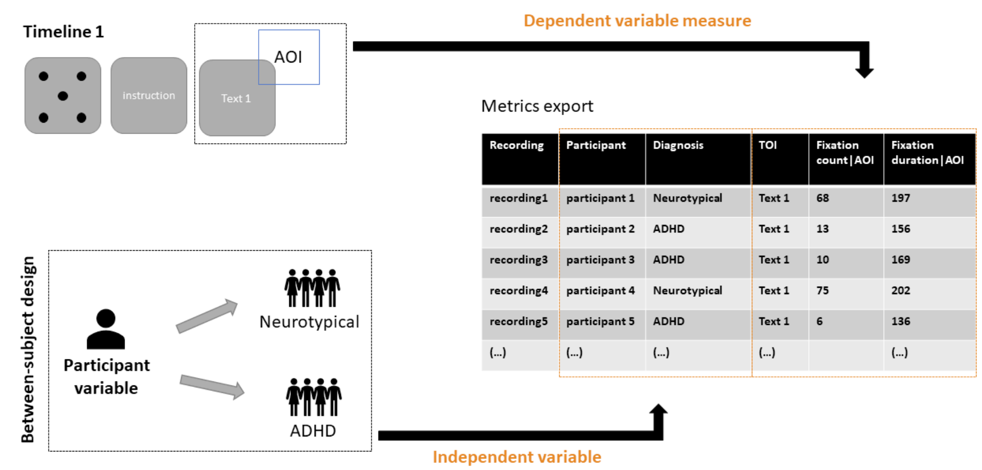
Principles of experimental design (1)

- **Between-subject design**
  - Each **participant** is tested in only one **condition**
  - **Random assignment:** each participant has an equal chance of being assigned to each condition and is assigned to a condition independently of other participants
  - **Block randomization**: the sequence of conditions is usually generated before any participants are tested, and each new participant is assigned to the next condition in the sequence
  - **Randomized control trial**: treatment vs no-treatment (control)

Participant	Random assignment	Block randomiz.
1	B	A
2	C	B
3	C	C
4	A	A
5	B	B
6	A	C
7	A	A
8	B	B
9	C	C
…	…	…

Principles of experimental design (2)





Recording	Participant	Diagnosis	TOI	Fixation count|AOI	Fixation duration|AOI
recording1	participant 1	Neurotypical	Text 1	68	197
recording2	participant 2	ADHD	Text 1	13	156
recording3	participant 3	ADHD	Text 1	10	169
recording4	participant 4	Neurotypical	Text 1	75	202
recording5	participant 5	ADHD	Text 1	6	136
(...)	(...)	(...)	(...)		(...)

Source: https://www.tobiipro.com/learn-and-support/learn/steps-in-an-eye-tracking-study/design/Between-and-within-subject-experimental-designs/

Example of between-subject design

- Loftus & Palmer (1974)
- n = 45
- 5 conditions, n = 9 per condition
- Experimental manipulation: verb used in stimulus sentences (contacted vs hit vs bumped vs collided vs smashed)

TABLE 1

SPEED ESTIMATES FOR THE VERBS USED IN EXPERIMENT I

Verb	Mean speed estimate
Smashed	40.8
Collided	39.3
Bumped	38.1
Hit	34.0
Contacted	31.8

TABLE 2

DISTRIBUTION OF "YES" AND "NO" RESPONSES TO THE QUESTION, "DID YOU SEE ANY BROKEN GLASS?"

	Verb condition		
Response	Smashed	Hit	Control
Yes	16	7	6
No	34	43	44

TABLE 3

PROBABILITY OF SAYING "YES" TO, "DID YOU SEE ANY BROKEN GLASS?" CONDITIONALIZED ON SPEED ESTIMATES

	Speed estimate (mph)			
Verb condition	1–5	6–10	11–15	16–20
Smashed	.09	.27	.41	.62
Hit	.06	.09	.25	.50

JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 13, 585–589 (1974)

Reconstruction of Automobile Destruction: An Example of the Interaction Between Language and Memory[1]

ELIZABETH F. LOFTUS AND JOHN C. PALMER

University of Washington

Two experiments are reported in which subjects viewed films of automobile accidents and then answered questions about events occurring in the films. The question, "About how fast were the cars going when they smashed into each other?" elicited higher estimates of speed than questions which used the verbs *collided*, *bumped*, *contacted*, or *hit* in place of *smashed*. On a retest one week later, those subjects who received the verb *smashed* were more likely to say "yes" to the question, "Did you see any broken glass?", even though broken glass was not present in the film. These results are consistent with the view that the questions asked subsequent to an event can cause a reconstruction in one's memory of that event.

How accurately do we remember the details of a complex event, like a traffic accident, that has happened in our presence? More specifically, how well do we do when asked to estimate some numerical quantity such as how long the accident took, how fast the cars were traveling, or how much time elapsed between the sounding of a horn and the moment of collision?

It is well documented that most people are markedly inaccurate in reporting such numerical details as time, speed, and distance (Bird, 1927; Whipple, 1909). For example, most people have difficulty estimating the duration of an event, with some research indicating that the tendency is to overestimate the duration of events which are complex (Block, 1974; Marshall, 1969; Ornstein, 1969). The judgment of speed is especially difficult, and practically every automobile accident results in huge variations from one witness to another as to how fast a vehicle was actually traveling (Gardner, 1933). In one test administered to Air Force personnel who knew in advance that they would be questioned about the speed of a moving automobile, estimates ranged from 10 to 50 mph. The car they watched was actually going only 12 mph (Marshall, 1969, p. 23).

Given the inaccuracies in estimates of speed, it seems likely that there are variables which are potentially powerful in terms of influencing these estimates. The present research was conducted to investigate one such variable, namely, the phrasing of the question used to elicit the speed judgment. Some questions are clearly more suggestive than others. This fact of life has resulted in the legal concept of a leading question and in legal rules indicating when leading questions are allowed (*Supreme Court Reporter*, 1973). A leading question is simply one that, either by its form or content, suggests to the witness what answer is desired or leads him to the desired answer.

In the present study, subjects were shown films of traffic accidents and then they answered questions about the accident. The subjects were interrogated about the speed of

[1] This research was supported by the Urban Mass Transportation Administration, Department of Transportation, Grant No. WA-11-0004. Thanks go to Geoffrey Loftus, Edward E. Smith, and Stephen Woods for many important and helpful comments. Reprint requests should be sent to Elizabeth F. Loftus. Department of Psychology, University of Washington, Seattle, Washington 98195.

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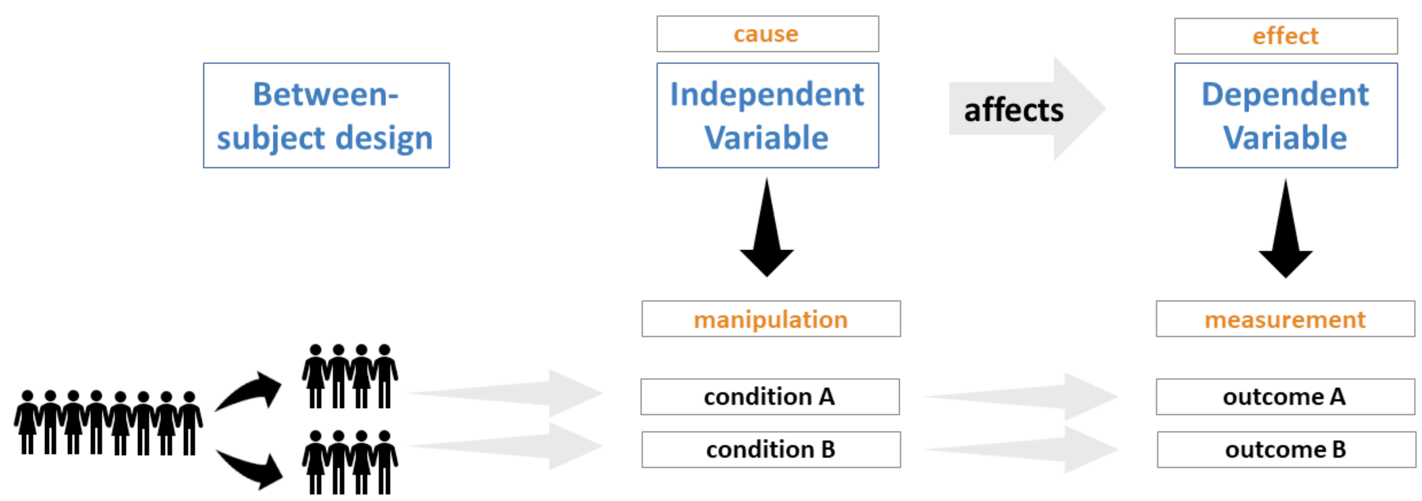
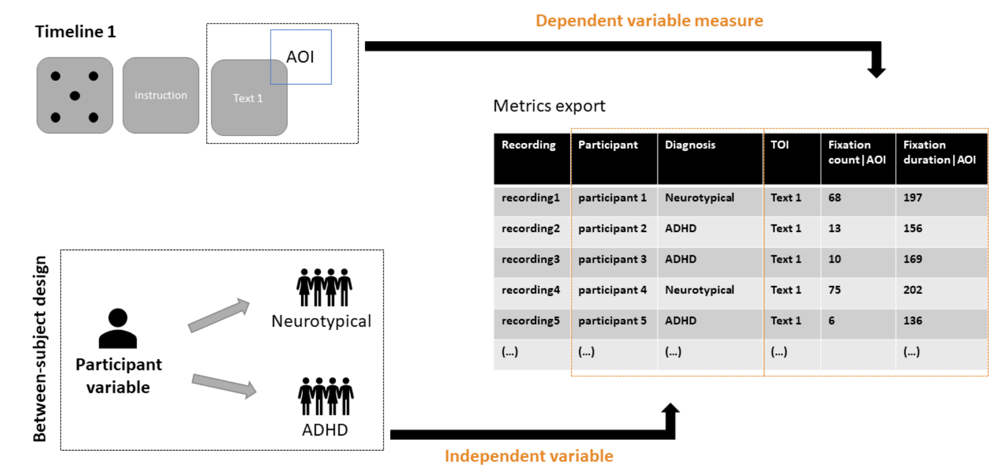
Principles of experimental design (3)

- **Within-subject design**
  - Each **participant** is tested under **all conditions** one after the other
  - **Counterbalancing:** which means testing different participants in different orders (e.g., some participants would be tested in condition A followed by condition 2, and others would be tested in condition 2 followed by condition 1)
  - **Simultaneous within-subjects design**: participants make multiple responses in each condition

Participant	Condition
1	A
1	B
2	A
2	B
3	A
3	B
4	A
4	B
5	A
5	B
…	…

Principles of experimental design (4)





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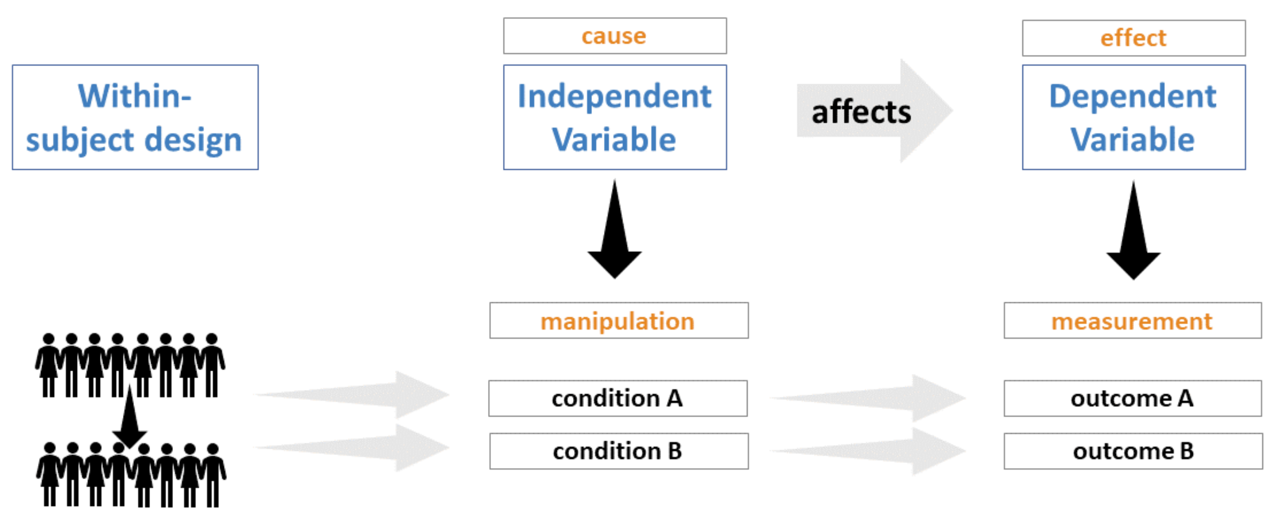

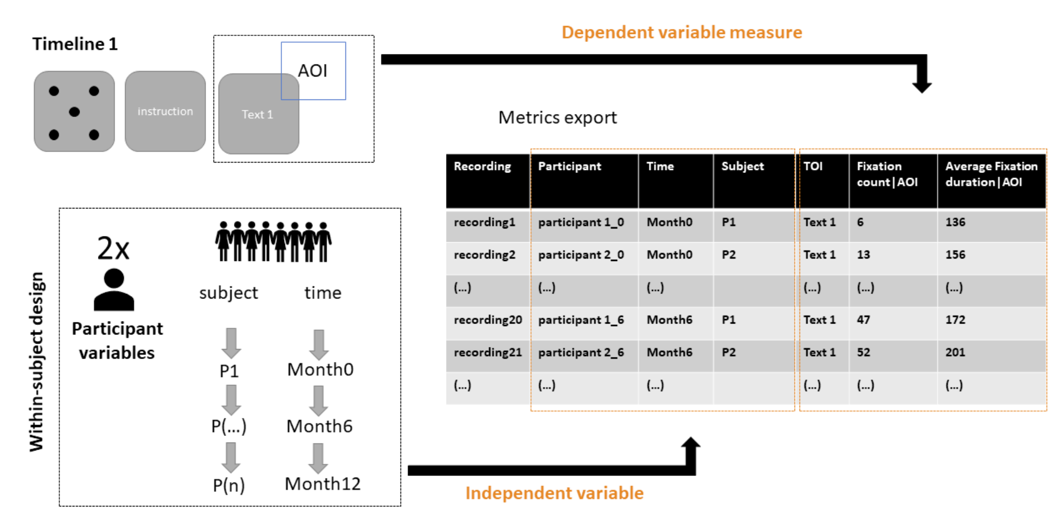

Recording	Participant	Time	Subject	TOI	Fixation count | AOI	Average Fixation duration | AOI
recording1	participant 1_0	Month0	P1	Text 1	6	136
recording2	participant 2_0	Month0	P2	Text 1	13	156
(...)	(...)	(...)		(...)	(...)	(...)
recording20	participant 1_6	Month6	P1	Text 1	47	172
recording21	participant 2_6	Month6	P2	Text 1	52	201
(...)	(...)	(...)		(...)	(...)	(...)

Source: https://www.tobiipro.com/learn-and-support/learn/steps-in-an-eye-tracking-study/design/Between-and-within-subject-experimental-designs/

Example of within-subject design

- Meyer & Schvaneveldt (1971) [Experiment 1]
- n = 12, 1 condition, n = 12 per condition
- Experimental manipulation: Words presented with either associated words, unassociated words, and nonwords

TABLE 1

MEAN REACTION TIMES (RTs) OF CORRECT RESPONSES AND MEAN PERCENT ERRORS IN THE YES–NO TASK

Type of stimulus pair: Top string	Type of stimulus pair: Bottom string	Correct response	Proportion of trials	Mean RT (msec.)	Mean % errors
word	associated word	yes	.25	855	6.3
word	unassociated word	yes	.25	940	8.7
word	nonword	no	.167	1,087	27.6
nonword	word	no	.167	904	7.8
nonword	nonword	no	.167	884	2.6

Journal of Experimental Psychology
1971, Vol. 90, No. 2, 227–234

FACILITATION IN RECOGNIZING PAIRS OF WORDS: EVIDENCE OF A DEPENDENCE BETWEEN RETRIEVAL OPERATIONS[1]

DAVID E. MEYER[2] AND ROGER W. SCHVANEVELDT

Bell Telephone Laboratories, Murray Hill, New Jersey — *University of Colorado*

Two experiments are reported in which *S*s were presented two strings of letters simultaneously, with one string displayed visually above the other. In Exp. I, *S*s responded "yes" if both strings were words, otherwise responding "no." In Exp. II, *S*s responded "same" if the two strings were either both words or both nonwords, otherwise responding "different." "Yes" responses and "same" responses were faster for pairs of commonly associated words than for pairs of unassociated words. "Same" responses were slowest for pairs of nonwords. "No" responses were faster when the top string in the display was a nonword, whereas "different" responses were faster when the top string was a word. The results of both experiments support a retrieval model involving a dependence between separate successive decisions about whether each of the two strings is a word. Possible mechanisms that underlie this dependence are discussed.

Several investigators recently have studied how *S*s decide that a string of letters is a word (Landauer & Freedman, 1968; Meyer & Ellis, 1970; Rubenstein, Garfield, & Millikan, 1970). They typically have presented a single string on a trial, measuring reaction time (RT) of the *lexical decision* as a function of the string's meaning, familiarity, etc. In one such experiment, RT varied inversely with word frequency (Rubenstein et al., 1970). When word frequency was controlled, lexical decisions were faster for homographs (i.e., words having two or more meanings) than for nonhomographs. To explain these results, Rubenstein et al. proposed that word frequency affects the order of examining stored words in long-term memory and that more replicas of homographs than of nonhomographs are stored in long-term memory.

In another experiment, Meyer and Ellis (1970) measured both the time taken to decide that a string of letters (e.g., HOUSE) is a word and the time taken to decide that it belongs to a prespecified semantic category. When the category was relatively small (e.g., BUILDINGS), the latter type of *semantic decision* was significantly faster than the former lexical decision. However, when the category was relatively large (e.g., STRUCTURES), the semantic decision was slightly slower than the lexical decision. To explain these and other results, Meyer and Ellis suggested that the semantic decision may have involved searching through stored words in the semantic category and that the lexical decision did *not* entail a search of this kind among the set of all words in memory.

The present paper provides further data about the effect of meaning on lexical decisions. To deal with this problem, we have extended the lexical-decision task by simultaneously presenting two strings of letters for *S* to judge. The stimulus may involve either a pair of words, a pair of nonwords, or a word and a nonword. In one task, *S* is instructed to respond "yes" if both strings are words, and otherwise to respond "no." In a second task, the instructions require *S* to respond "same" if the two strings are either both words or both nonwords, and otherwise to respond "different." In each task, RT for pairs of

[1] This paper is a report from work begun independently by the two authors at Bell Telephone Laboratories and the State University of New York at Stony Brook, respectively. We thank S. Sternberg, T. K. Landauer, and Alexander Pollatsek for their helpful comments, A. S. Coriell for preparing the apparatus, and G. Ellis and B. Kunz for running *S*s.

[2] Requests for reprints should be sent to David E. Meyer, Bell Telephone Laboratories, 600 Mountain Avenue, Murray Hill, New Jersey 07974.

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Pros and cons of different designs

Design	Advantages	Disadvantages
Within-subject	• More statistical power • Reduces the effect of individual variation • Smaller sample size • Has a natural anchor or baseline comparison	• Repeated exposure biases and related effects (practice, boredom, and fatigue) • High risk of the participant figuring out the experiment • Statistically more complicated as the scores of each condition are not independent of each other
Between-subject	• Little or no exposure bias (practice, boredom, and fatigue) • Less risk of the participant figuring out the aim of the experiment	• Larger sample sizes • Susceptible to individual variation

Some practical information about the course

Practical stuff: The study regulations (1)

- **Description of qualifications**:
    - The purpose of the course is to introduce the basic methodological toolkit required to understand and do cognitive science. The course will prepare students to design and carry out their own empirical research, to choose appropriate analyses for simple study designs, and to write their own data analysis scripts.
    - The course includes an introduction to experimental methods (including experimental design and data collection methods), statistics, and basic programming (using for for example R).
    - This course sets the methodological foundations for the rest of the degree programme. The methods learned in this course are applied in topic courses (e.g. cognition and communication), and will be built upon in the Methods 2: The General Linear Model, Methods 3: Multilevel Statistical Modeling and Machine Learning and Methods 4: Bayesian Computational Modeling.
- Source: https://kursuskatalog.au.dk/en/course/107424/Methods-1-Introduction-to-Experimental-Methods-Statistics-and-Programming

Practical stuff: The study regulations (2)

- Methods = 40 ETCS, “backbone” of the program!
- Makes the program special compared to related programs (e.g. psychology and linguistics)
- So: make sure to like this subject!

1. semester	Cognition and Communication (10 ECTS)	Introduction to Cognitive Science (10 ECTS)	Methods 1: Introduction to Experimental Methods, Statistics, and Programming (10 ECTS)
2. semester	Applied Cognitive Science (10 ECTS)	Methods 2: The General Linear Model (10 ECTS)	Philosophy of Cognitive Science (10 ECTS)
3. semester	Methods 3: Multilevel Statistical Modeling and Machine Learning (10 ECTS)	Perception and action (10 ECTS)	Internationalisation elective (10 ECTS)
4. semester	Cognitive Neuroscience (10 ECTS)	Methods 4: Bayesian Computational Modeling (10 ECTS)	Social and Cultural Dynamics (10 ECTS)

Practical stuff: The study regulations (3)

- **Exam details**:
  - Exam type: Portfolio-based take-home assignment on topic of student's choice (four assignments)
  - For the final exam, the four portfolios must be revised in the light of the feedback received during the course and handed in on the submission date.
  - Assessment: Pass/Fail
  - Grading: Internal co-examination
  - Due date for complete portfolio: Dec. 13th

Practical stuff: Overview of course topics

Week	Lecture	Class
1	Introduction to research design	The R/RStudio environment
2	Data collection: What to measure, and how to measure it	Data mining 1: Organizing data
3	Building statistical models	Data mining 2: Summarizing data
4	Parametric tests and their assumptions	Data mining 3: Visualizing data
5	*Python/PsychoPy 3 workshop w/ Kristian Tylén*	
6	Correlation: Looking at relationships in our data	Correlation analysis in R
7	Inferential statistics and hypothesis testing	The t-test
8	*Fall break*	
9	The linear model	Simple linear regression
10	Multiple regression with numerical and categorical predictors	ANOVA for model comparison
11	Repeated-measures design and multilevel regression	Linear mixed-effects models
12	Logistic regression	Logistic regression in R
13	Interaction analysis	Interactions and non-linear effects
14	Content analysis	Coding qualitative data in R

Practical stuff: Exam deadlines

- **Portfolio topics and deadlines** (may be subject to change):

  1. <u>Data mining report on "personality test" data</u>
     Deadline Sept. 29th (individual)

  2. <u>PsychoPy script for two-condition reading time experiment</u>
     + <u>Correlation and t-test analysis of data from reading experiment</u>
     Deadline Oct. 26th (group)

  3. <u>Report on a multi-condition group experiment</u>
     Deadline Nov. 16th (individual)

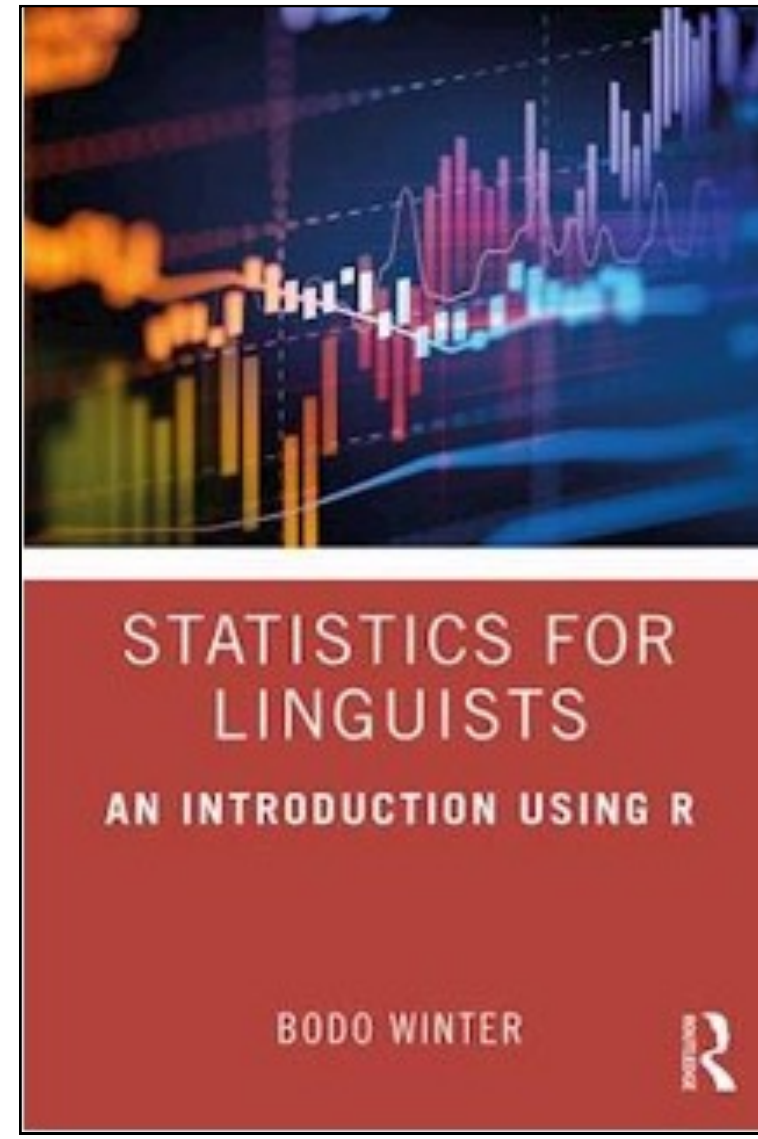
  4. <u>Logistic regression analysis</u>
     Deadline Nov. 30th (group)

Attendance registration

- In the first half of each lecture
- Brightspace > Course tools > Qwickly

Literature

- Textbook: “Statistics for linguists” Bodo Winter
- Get it at Stakbogladen or saxo.dk
- Selected articles and chapters from other sources (see Course schedule)
- Lecture contents not just repetition from the book
- Your responsibility to let me know if there’s something you didn’t understand



Software

- R + RStudio
- Python + PsychoPy3

Plan for Class 1

- Get acquainted with R and the RStudio environment
- Discuss and try out various basic procedures, such as how to assign various values to variables, lists and data frames and how to access these values again in order to manipulate and use them
- Make sure to install R and RStudio on your computers before showing up for class!
- If you have issues, then contact your instructor: Sigurd Fyhn Sørensen (e-mail)