

Week 2: Fundamentals of Science and How Cognitive Scientists Study the Mind/Brain

Research Methods in Cognitive Science

Jason Geller, Ph.D.

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Housekeeping

- Groups
 - Team 1: Awab, Anthony, Nish, Aniz
 - Team 2: Pratiyush, Veda, Samah, Harsh
 - Team 3: Cynthia, Cyann, Sachi, Cheyenne
 - Team 4: Nina, Nia, Divya, Cristina
 - Team 5: Paige, Justin, Franklin, Shahil, Max
- Team charter due on Sunday at 11:59 P.M.: <https://osf.io/zshc7/>
- Last day to drop is September 10th

Truth or Fiction?

☰ Meeting - 9/3/2021

Q&A

Polls

12

Live poll

Fact/Fiction

Most people use only about 10% of their brain capacity

Truth

Fiction

Student's learn best when teaching styles match their learning styles (e.g., visual, auditory, etc.)

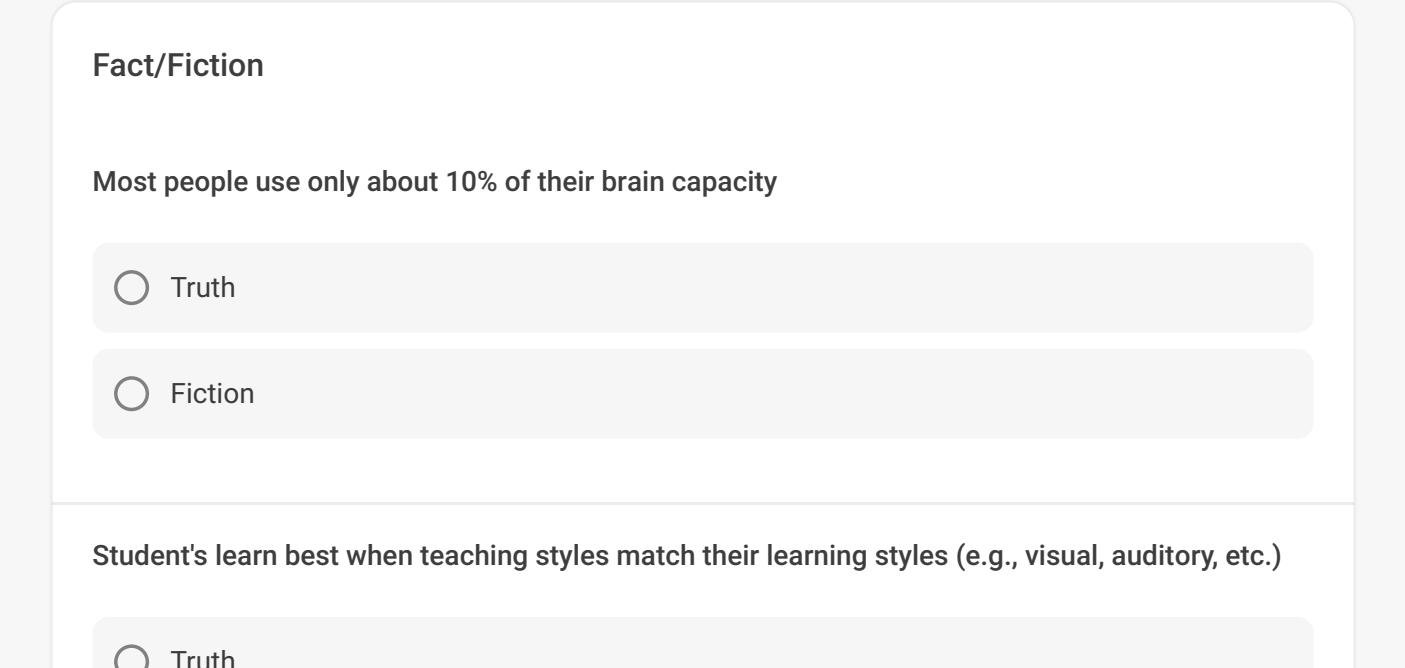
Truth

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Truth or Fiction?

- Most people use only about 10% of their brain capacity
- Student's learn best when teaching styles match their learning styles (e.g., visual, auditory, etc.)
- In general, it's better to express anger than to hold it in
- The lie detector (polygraph) test is 90-95 % accurate at detecting falsehoods
- Standing in a power pose with your hands on your hips and your feet apart makes you more confident

Truth or Fiction?

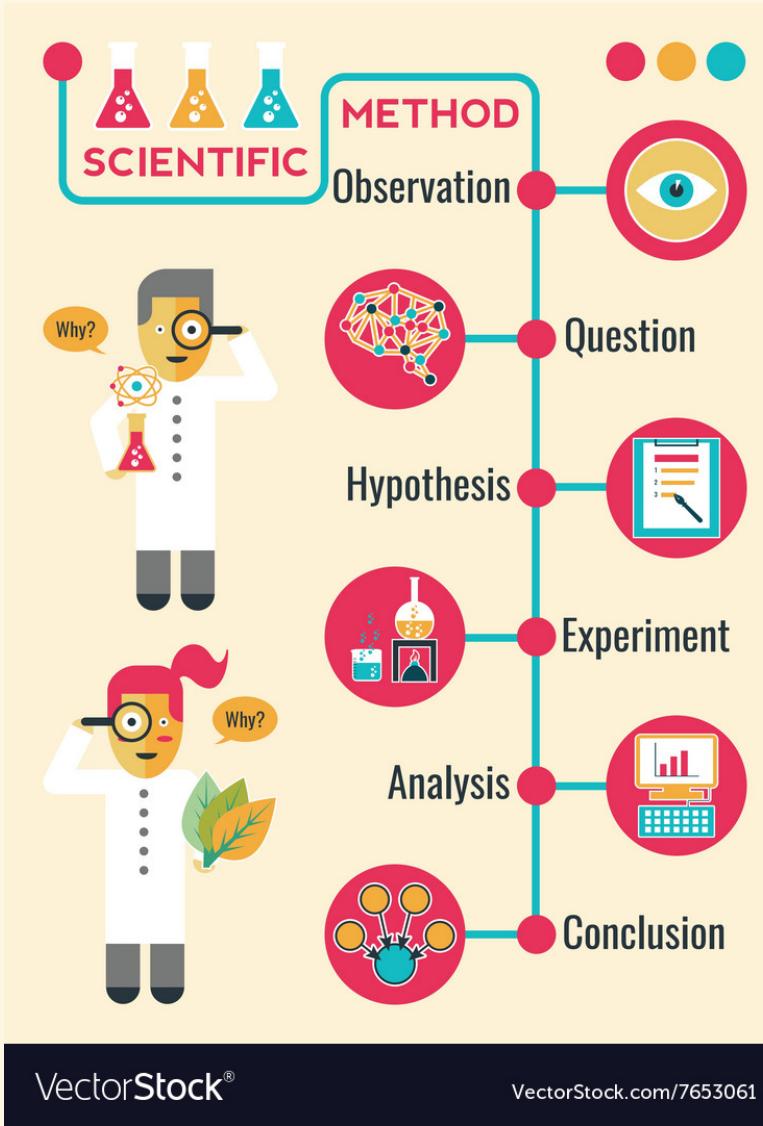
- People tend to be romantically attracted to individuals who are opposite to them in personality and attitude
- The more people present at an emergency, the more likely it is that at least one of them will help
- All effective psychotherapies require clients to get the root of their problems in childhood
- Napping just after learning new information will help you remember it better
- Studying material many times in short chunks (“spaced practice”) will lead to better test performance than cramming in one session just before the test

For the statements marked as true, how did you acquire that information?

Types of Knowledge

- Intuition/Anecdote
 - Acquire knowledge without proof, evidence, or conscious reasoning, or without understanding how the knowledge was acquired
- Authority
 - We acquire knowledge through authority (e.g., parents)
- Rationalism
 - We acquire knowledge through logic and reason
 - All people are mortal. You are a person. Conclusion: You are mortal.
- Empiricism
 - We acquire knowledge through experience and observation

The Scientific Method



Asking Questions

- Finding inspiration
 - Observations
 - Practical problem
 - Previous research

"Don't you forget
about me. Don't,
don't, don't, don't."

| Does Sans Forgetica enhance memory?

Hypothesis

| A simple, specific prediction about a phenomenon

- Should be driven by past studies in that area
 - Could be an exploratory question
- Must be testable and falsifiable (Popperian logic)
- Positive

| Hypothesis: Reading materials in Sans Forgetica typeface enhances memory

Experiment

- Geller, Davis, & Peterson (2020)
 - Had participants study word pairs in Sans Forgetica and Arial (**independent variable**)
 - Measure performance on final test (**dependent variable**)

Name Those Variables!

An organizational psychologist is interested in whether lowering the temperature in a factory will increase productivity (i.e., number of products assembled). At the factory, there are three rooms in which products are assembled. Each room is set at one of the following temperatures: 60 degrees, 70 degrees, or 80 degrees.

A psychologist is studying the effects of steroids on the aggressive behavior of male rats. Thirty rats receive twice-daily injections of a placebo, whereas another set of 30 rats receive twice-daily injections of a steroid. For one hour a day, the rats are placed in a cage together and all aggressive behaviors are recorded. For one week, lab assistants count the number of aggressive behaviors recorded to determine whether or not there is difference between the two groups of rats.

Analyze Data and Draw Conclusions

The screenshot shows a Slido poll interface. At the top, there is a blue header bar with the text "Name that analysis" on the left, a "Q&A" button in the center, a "Polls" button on the right, and a user profile icon on the far right. Below the header, the word "Live poll" is displayed. In the center, a question is shown: "What statistical analysis would I do with 2 groups and a continuous DV?". Below the question is a text input field with the placeholder "Type your answer ...". A green "Send" button is located at the bottom of the input field. To the right of the input field, it says "2" followed by a user icon. At the very bottom of the page, there is a dark footer bar with the "slido" logo. Below the logo, a message states: "Slido uses cookies to improve your experience, analyze traffic, and serve personalized ads. By clicking 'Allow all' you consent. [Learn more](#)". Three buttons are provided at the bottom of this bar: "Privacy settings" (white text on a light background), "Reject all" (white text on a green background), and "Allow all" (white text on a green background).

Live poll

2

What statistical analysis would I do with 2 groups and a continuous DV?

Type your answer ...

Send

Voting as Anonymous

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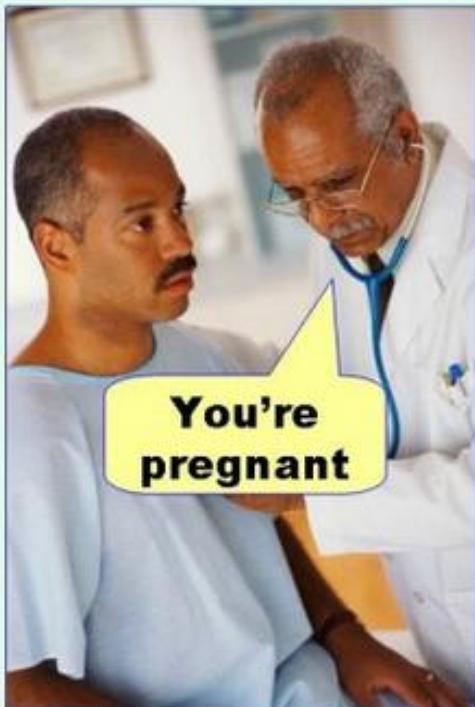
Allow all

Analyze Data and Draw Conclusions

- Is there a difference between Sans Forgetica and Arial typefaces?
 - Is this meaningful or **statistically significant?**
 - Inferential Statistics
 - Allows one to draw conclusions from our **sample** (small subset) to **population** (large group we are interested in)
 - Bayesian Statistics

Type 1 and 2 Errors

Type I error
(false positive)



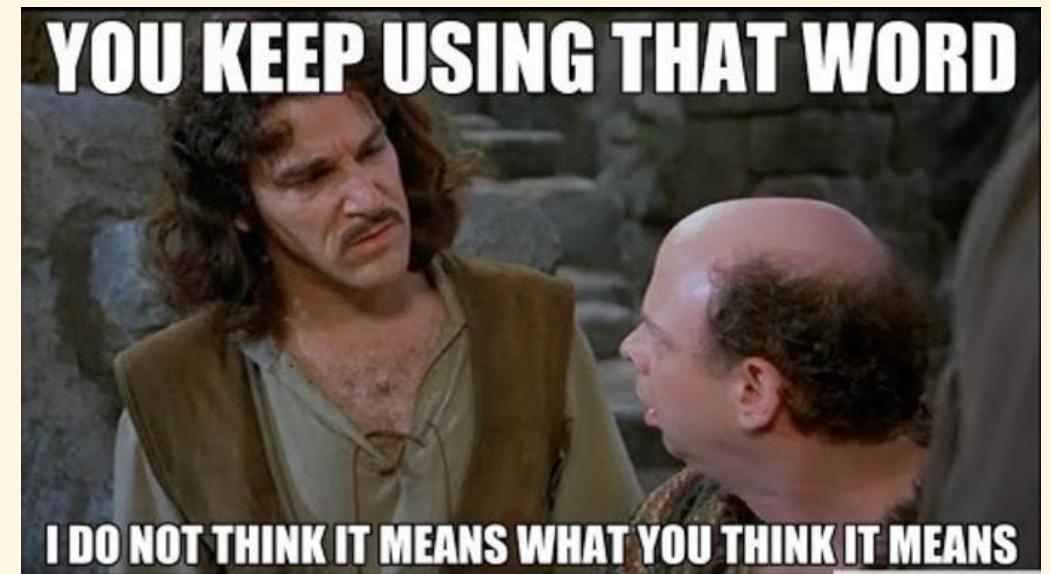
Type II error
(false negative)



Replication

Table 1: Types of "Replications" in the Behavioral, Social, and Cognitive Sciences

	...Using the same data	...By collecting new data
Same materials, methods, code (i.e., no deviation)	Reproducibility Analysis	Direct/"Exact" Replication
Different materials, methods, code etc.	Robustness Analysis	Generalizability Analysis (Extension; "Conceptual" Replication)



Features of Science

- Systematic empiricism
 - Design controlled studies to observe behavior and draw conclusions
- Empirically solvable
 - Questions can be answered
 - Falsifiability
- Public Knowledge
 - Present research in journals and at conferences so it can be observed, replicated, criticized, and tested

Goals of Science

1. Describe
2. Predict
3. Explain

Scientific Norms

- Mertonian Norms (1942)

1. Universalism

- Knowledge is knowledge regardless who comes up with it

2. Disinterestedness

- Our goal as scientists is to make advancements--not cash in

3. Communalism (communism)

- Science belongs to all of us
- Openly share knowledge - remove the paywall
 - <https://www.youtube.com/watch?v=L5rVH1KGBCY>

4. Organized Skepticism

- Accept nothing at face value!

Psuedoscience

Science vs. Pseudoscience

Science	Pseudoscience
Its goal is to achieve a more complete understanding of the physical world.	Its goal is more likely to be driven by personal or private gains (profit or fame).
There is research to back up their claims. Constantly looking to expand knowledge of the subject.	Little evidence to support their ideas and the research that is carried out tries only to prove they are right.
Explanations must be stated in clear, unambiguous terms.	Pseudoscientific explanations tend to be vague and ambiguous.

What Is Cognitive Science?

- “The interdisciplinary study of mind and intelligence”
- “Study of cognitive processes involved in the acquisition, representation, and use of human knowledge”
- “Scientific study of the mind, the brain, and intelligent behavior, whether in humans, animals, machines or the abstract”

Cognitive Science is the interdisciplinary (scientific) study of the mind as an information processor

- Goal of Cognitive Science: to understand the mind and how it works.

Cognitive

Cognitive Science is the interdisciplinary (scientific) study of the mind as an information processor

- Cognition – from Latin base cognitio – “know together”
- The collection of mental processes and activities used in perceiving, learning, remembering, thinking, and understanding and the act of using those processes

What is a mind?

- Cognitive Science is the interdisciplinary (scientific) study of the **mind** as an information processor
 - What would an answer to this question look like?
- Is it identical to the physical matter of the brain?
- Is it the organization or structure of physical matter?
- Is it equivalent to the operations the brain performs?
- Is it completely outside or beyond the physical brain?

Mind

- Do animals have minds?
- Do computers have minds?
- Does mind mean consciousness?
- Can a mind be distributed?
 - Working definition : a mind is a set of mental processes and cognitive capacities.

Disciplines in Cognitive Science

- Cognitive Science is the **interdisciplinary** (scientific) study of the mind as an information processor
- Anthropology
 - Study of human life and culture
- Psychology
 - Study of human behavior
- Neuroscience
 - Study of the brain
- Linguistics
 - Study of language
- Education
 - Study of Human learning and development



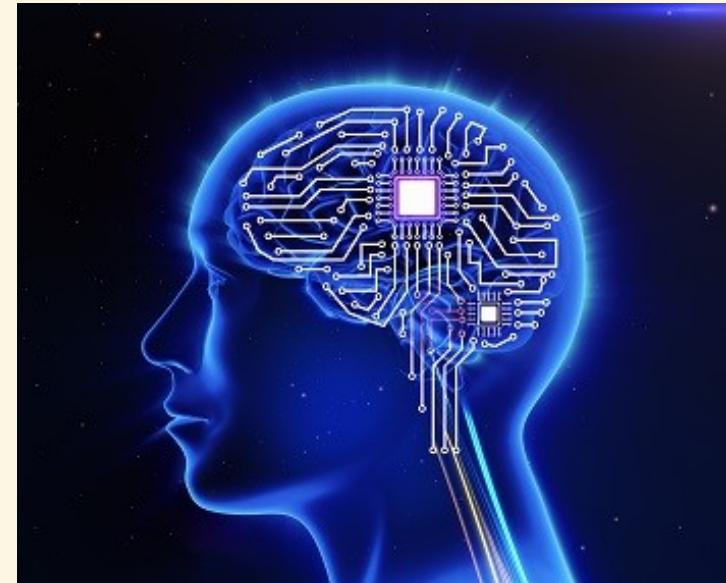
Information Processing

- Cognitive Science is the interdisciplinary (scientific) study of the mind as an **information processor**
- What is information?
 - Claude Shannon defined the bit as an atomic piece of information for computing
 - For computation, anything can be represented as information.
- Information processing

Computer Metaphor

We can think of the mind like a computer

- Input : perception (mouse, keyboard)
 - Processing : thought (CPU)
 - Storage : memory (hard disk)
 - Output : behavior (monitor, printer)



Methods of Cognitive Science

- Computational modeling (artificial intelligence, computational neuroscience, cognitive psychology)
- Correlation
- Experimentation (psychology, linguistics, neuroscience)
- Introspection, Argumentation, Formal Logic (philosophy, linguistics)
- Ethnography (cognitive anthropology)

Methods of Cognitive Science

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Coming
Soon

Eye-tracking

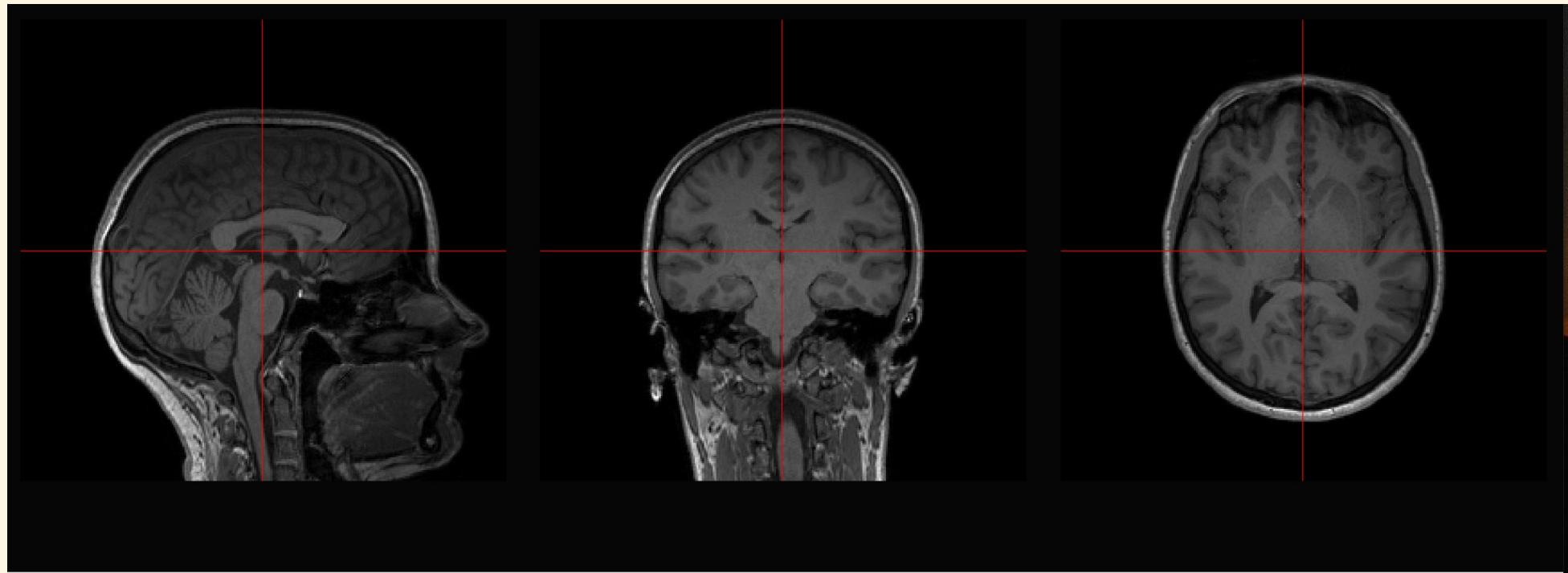
<https://www.youtube.com/watch?v=Y5KAxnFE2CI>

Cognitive Pupillometry

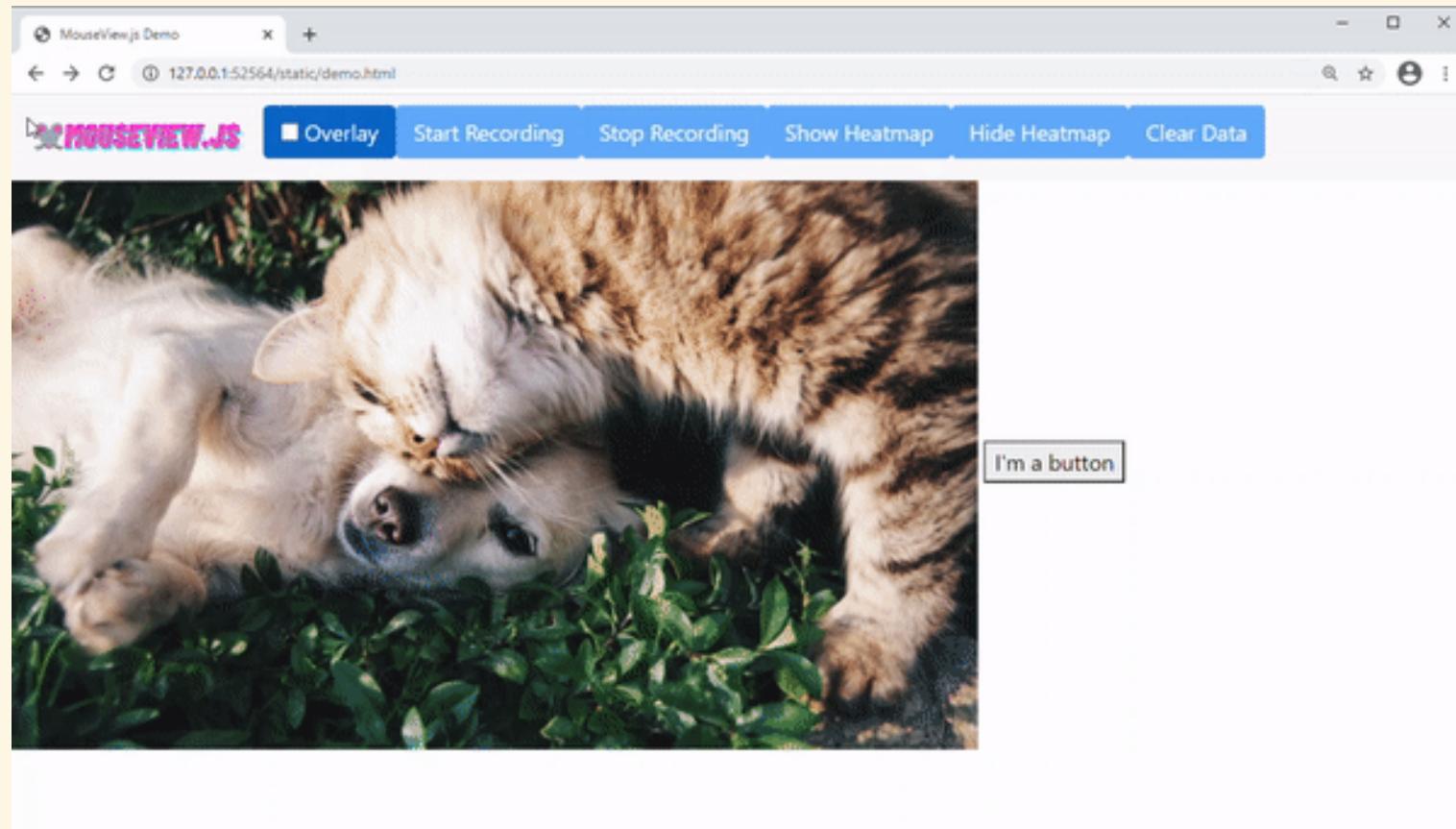


EEG

fMRI



MouseView



VR



RTs

<https://app.gorilla.sc/task/4553682>

TMS

https://www.youtube.com/embed/FMR_TOmM7Pc

fNIRs



MEG



