

The Science of Psychology & Neuroscience

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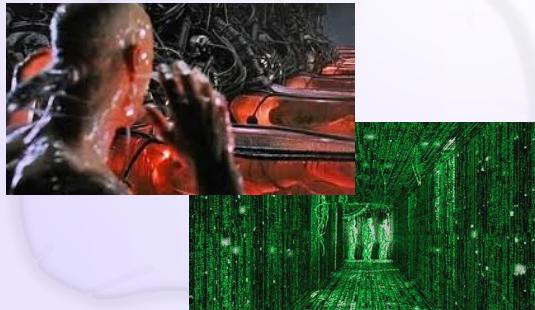
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Overview

- How can we possibly use “objective” science to study the subjective mind!?
 - Is science even objective in the first place??
- Brief history
- Methods: How to get and analyze data!

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Enter the Matrix..



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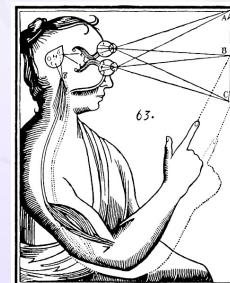
Descartes: Cogito Ergo Sum

I think, therefore I am

Subjective cognition is primary

Solipsism: subjective cognition is all there is!

Dualism: mind is separate from brain



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Subjective / Objective Perspectives

Perspective dualism: there are 2 fundamental perspectives of the world: subjective vs. objective.

Each individual has unique subjective experience, due to properties of brain, trajectory through space & time.

But through that experience, we can construct a sense of the objective world out there, from which we can see a “third person” view of self, like everyone else sees of us..

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Subjective Seems So Objective

The compression and predictive learning properties of the brain cause us to “transparently” perceive the world pretty darn accurately.

We have the “illusion” of objective understanding.

Some may not have even realized how subjective everything actually is..

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My Personal Perspective

My subjective version of the objective perspective is *consistent* with everything I've experienced, and makes sense to me.

In particular, my own subjective experience makes sense in terms of my objective knowledge of the brain.

I'm satisfied, if not particularly "happy" with being my brain..

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Simulation Hypothesis

Arguments for:

- Bostrom, Musk, et al: Technology will get so much better (if we survive), will have simulations indistinguishable from reality. So many of these would be possible, odds are we're in one..

Arguments against:

- Carroll: Self-contradiction: we most likely live in "bottom level" of simulated realities, where such simulations are not possible..
- Poundstone: Time contradiction: Why is our simulation of a time when we don't have sub-simulations?
- Kipping: Bayesian math says odds of reality $> .5$:
<https://www.youtube.com/watch?v=HA5YuwwJkpQ>

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My Take: Too Hard to Keep Story Straight

Everyone assumes you can just get by with simulating an individual's perception, which is waaaaay simpler than simulating entire universe -- if you have to simulate the universe, then it takes at least a universe... Who cares!?

But how many shortcuts can you actually take, without creating such a contradictory mess, that it would be obvious?

They assume you could just rewrite memories for every mistake, but that assumes a very naive modular form of memory – isolated little flashbacks like in movies: in fact memory is a massively interwoven network and trying to alter just one part would be very difficult.

And I can go to a library (i.e., the internet) and randomly lookup millions of sources of data, that all tell a consistent story at some level. This story includes the results of experiments that depend on geological and celestial events going back millions and billions of years. Science, and physics, is constantly working.

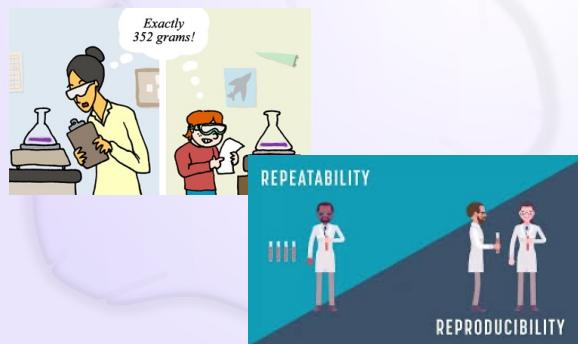
Getting all that right, without actually just running the universe itself, seems incredibly, incredibly hard. With no real point – even if someone could, why would they? The universe is likely infinite, so just go explore more of it.

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Reproducibility = Consensus



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The Scientific Method

- Have a question / informal **observation**,
- Form a **hypothesis**, with testable predictions
- Collect **data**, using *reproducible* procedures
- **Analyze** data: does it support predictions, beyond level of random chance / noise?
- Draw **conclusions**.

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The Scientific Method: Critique

- make an observation,
- form a hypothesis (based on *what???*)
- collect data,
- analyze data,
- draw conclusions. (yeah, like *what???*)

Hypotheses and conclusions are subjective, psychological constructs!!*

*Don't even get me started about measurement in quantum physics!

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Consistency (of pudding*)..)

Good hypotheses are those that are **consistent** with good theories, and good theories are those that tie together a large number of observations under a single, hopefully relatively simple, **consistent** framework.

* The brain

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Summary: Science is Hard, Imperfect

- And so are relationships, and everything else having to do with actual people..
- Psychology is actually the key to really understanding actual science, at many levels.

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In the Beginning: All was Spirit..



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No Harm in Trying: The History of Psychology

No Psychology in the Ancient World. But plenty of Philosophy!



Buddha: Suffering = patterns of thoughts, proscribed treatment (lose the attachments!)

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Ancient Greek Philosophy



Where / what is the mind? Reality real (Plato's Cave)

Nature vs. Nurture / Empiricism

Reason, Logic vs. Empiricism

Thought <-> Emotion

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Rationalism vs. Empiricism

Rationalism: Deduce what is true based on logical principles, axioms, etc. (Descartes)

Empiricism: Learn what is true based on experience. (Locke)

Can't we all just get along!?

Clearly you need both..



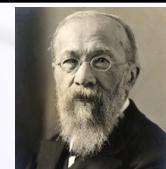
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Hey, How about some *Data*!

Wilhelm Wundt (1879):

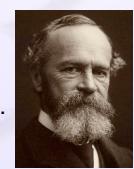
First to collect **scientific data** about human behavior! i.e., the first true Psychologist.

But unfortunately, the data was all *subjective*!



Titchener: **structuralism** = subjective contents of experience, through *introspection*

James: **functionalism** = largely theoretical (vs. experimental) ideas on specific *functions* of mind (not contents).



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Hey, How about some *Objective Data!* (1913-1950's)

Behaviorists: rejection of introspection – can only study and theorize about what is objectively observable: behavior! **Stimulus -> Response**



Pavlov



Skinner

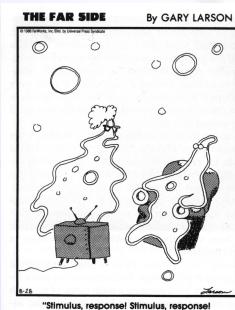


Watson

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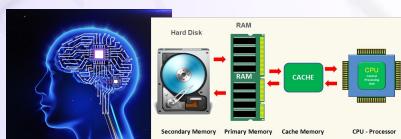
Cognitive Counter-Revolution (1960's)

Cognitive(ism): Yeah, maybe there is actually something going on inside the mind..

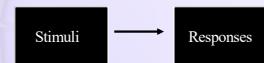


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Mind as Computer



Behaviorism:



Cognitive Psychology:

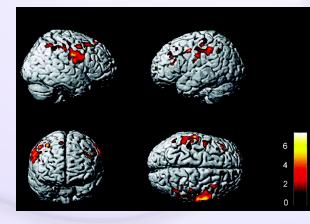


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Enter the Brain..

1960's-80's: Cognitive "boxology" based on idea that mind is a digital computer

1990's – now: **Cognitive Neuroscience!**



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Neural Networks
(Rumelhart & McClelland, Hinton)

Psychology:
currently taking
the AI world by
storm, 30 years
later...

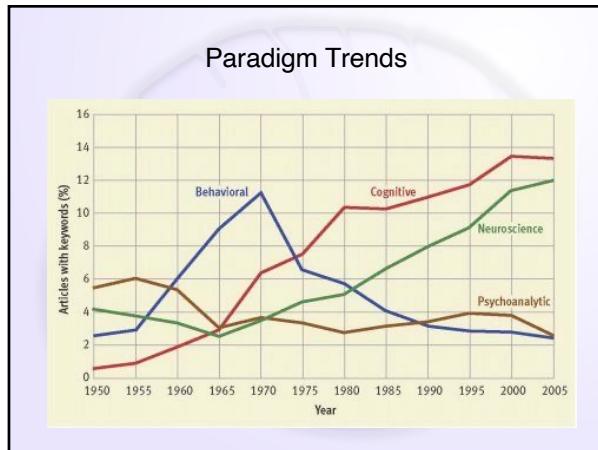
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It took a while, but..

We now have a mature science based on **objective data** about both **behavior** and the **brain** mechanisms that give rise to it!

Internal cognitive processes can be objectively measured in many ways, instead of just making stuff up about how computers might do stuff..

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Other Historical Trends

- Freud and psychoanalysis (1900-1920):
 - role of the unconscious, tripartite structure: id, ego, superego
- Gestalt psychology (1910-1940)
 - Whole is different than sum of its parts: emergence!
- Rogers, Maslow: Humanism (1950's – now)
 - Motivation, individual feelings, potential for growth
- Piaget: Developmental Stages, etc (1960's)
- And many others..

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Crazy Science vs. Sane Science

Crazy: all the different theories!
It's all just S->R? Mind is a digital computer?

Sane: all the data that was generated.
S->R learning data still very relevant.
Cognitive info processing data very relevant..

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Scientific Methods

Descriptive: **good:** doesn't interfere ("naturalistic")
bad: weak data – what are variables?

Correlational: **good:** also "naturalistic", has variables.
bad: no causality: **the third variable problem!**

Experimental: **good:** causal relationship between vars!
bad: requires random assignment (impossible for many important questions), "artificial" lab studies: poor **external validity**

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Real-world Scenario

Hypothesis: my romantic partner is cheating on me.

How do you determine if it is true or not?

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Methods in Action

Descriptive: observe behavior, note who they are hanging out with, paying attention to, whether they're acting strange / distant around me..

Correlational: plot frequency of sex, fights, good times, bad times over time: have things changed?

Experimental: probe them with challenging questions: "do you love those others as much as me?" – see how they react.. Get a "friend" to try to sleep with them..

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Pros / Cons

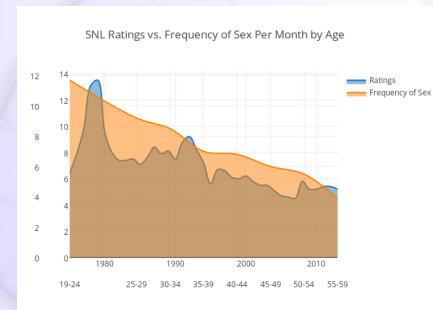
Descriptive: **good:** doesn't raise any suspicions ("naturalistic") **bad:** not much to go on..

Correlational: **good:** also "naturalistic" (no suspicions), more precise understanding of data. **bad:** other factors at work! e.g., old marrieds, etc **the third variable problem:** correlation does not equal causation!!

Experimental: **good:** could catch them in the act! **bad:** create false truth! e.g., bad questions = bad answers **external validity**

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Correlational Truth?



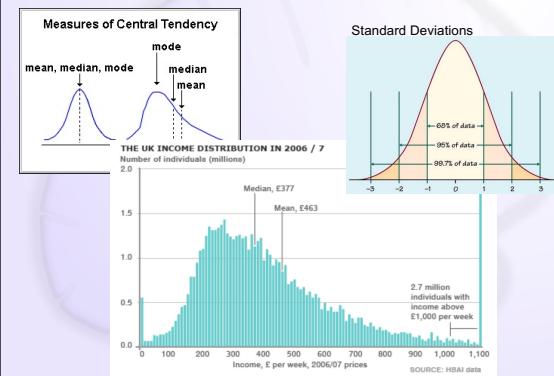
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Statistics

- Descriptive: mean, median, mode, std deviation
- Correlation: scatterplots
- Experiments: t-test, ANOVA (F)

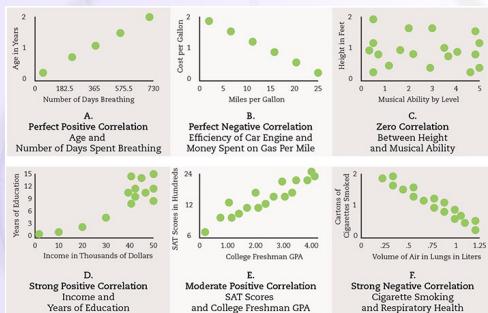
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Descriptive Statistics



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Correlations: Scatterplot



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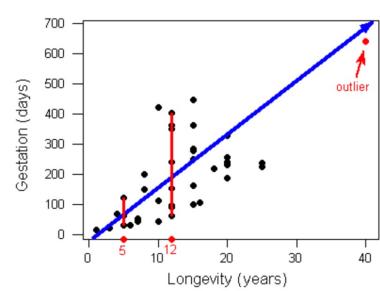
Correlation != Causation

EVERYBODY gets this wrong!

<http://www.tylervigen.com/>

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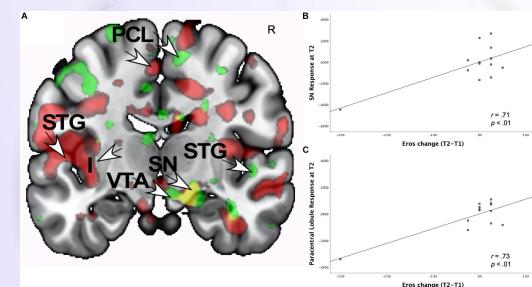
Beware of Outliers (super data influencers)



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Neuroimaging is Correlational

(Neural correlates of Romantic Love.; Acevedo et al., 2020)



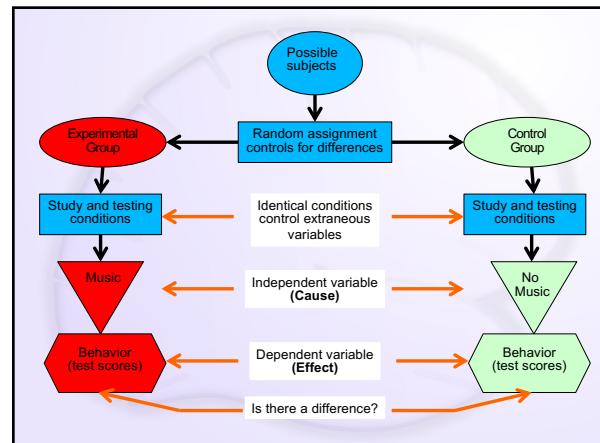
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True Experiments

Avoids 3rd variable problem, determines true causal relationships!

- **Random assignment** to conditions
 - Avoids 3rd variable of pre-existing conditions..
- 1 or more **control conditions**
 - Must compare manipulation to *something*
- **Control over confounds**
 - Eliminate all possible other 3rd variables

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Experimental Design

Independent variable: manipulated, cause

- e.g., does coffee improve learning?
- it's the (amount of) coffee!

Dependent variable: measured, effect

- measure of learning: post test – pre test

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Inferential Statistics

Is observed difference *unlikely* to be due to chance?

e.g., drug A is more effective than B, $p < .05$ that this is due to chance in the random sample I happened to encounter in my study.

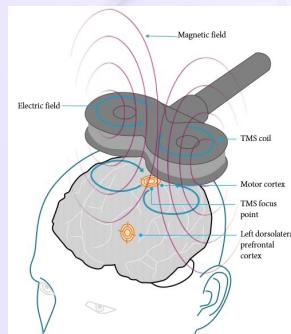
t-Test: developed to test Guinness beer!

F-Test, ANOVA: multiple factors

GLM: generalized linear model – works for everything!

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Causal Neuroscience



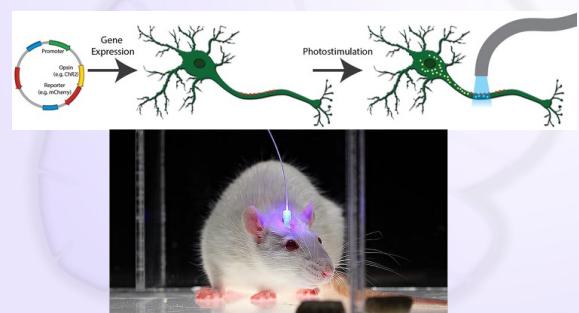
Transcranial Magnetic Stimulation: TMS

Good: causally affects brain function ("temporary lesion")

Bad: artificial brain stimulation / inhibition
– not simple lesion – introduces new activity

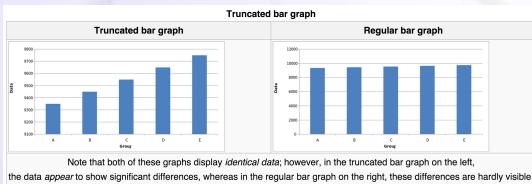
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Optogenetics: Cell-specific Excitation / Inhibition



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Damned Lies..



Beware of percentages! 100% of nothing is still.. Nothing!

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REPLICATION CRISIS

Many biases in favor of positive results, against negative:
 $p < .05$ is more like $p < 0.5$ is due to chance

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Critical Thinking!

- Be aware of your biases, and their biases
- Look carefully at the data – the actual data, not just summary stats, graphs, etc
- Correlation != causation

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Human Subjects Protections

get permission from ethics committee
informed consent

- ◆ right to terminate at any time
- ◆ legal age (18)
- ◆ procedures/risks
- ◆ confidentiality

debrief

(IF risk, weigh risk/benefit ratio.)

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Animal Subjects Protections

must get permission from ethics committee
comfort, health, humane treatment



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