COGS 105

Research Methods for Cognitive Scientists

Week 2, Classes 1 & 2:
Philosophy, Science, and Philosophy of Science

Logistics and Such

- **Exam dates** posted on website by next week.
- **Lecture slides posted**; study guide will be posted as exam approaches (I'll give you at at least 1 week advance).

Last Time

- Thought experiments
- Experimental philosophy

Today...

- Empiricism
  - Deductive vs. inductive argument.
  - "Contingent statement"
  - Importance of experience in bringing conceptual change
- Scientific method
- Positive vs. negative evidence

In Required Readings

Scientific Empiricism

- Science is built off the philosophical notion of **empiricism**.
- Old school empiricism: We are *tabula rasa*, not knowing anything about the world
  - We can only learn through our experience
- **Modern empiricism**: Genes may potentiate certain ways of doing things or thinking; to gain scientific knowledge and be sure, however, we must engage the world and probe it. Poke it. Shake it up.

Old Debate…

- There literally were these philosophers and "thinkers" called "rationalists" who thought most knowledge, if not all, should be derived through sheer logic and math, without any necessary need of experience…

no one is a pure rationalist these days. it's silly.

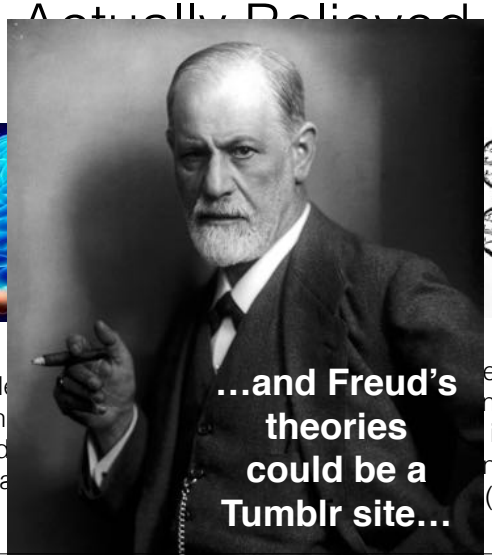
Descartes, 1700's…

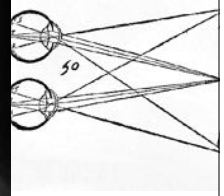
The Reality of Science

- An **argument**:
  - 1: Nothing discovered through experience is guaranteed to be true.
  - 2: Everything we discover through science we discover through experience.
  - Therefore: Nothing discovered through science is guaranteed to be true.
- All observations are **theory-laden and scientists** (and everyone!) are inherently biased by cultural experiences, world views, and so on. However, this doesn't have to lead to utter relativity and madness (**unless you want it to**).

Crazy Things Fancy People Actually Believed

Aristotl
the brain
the blood
in the hea





es thought
nking soul
in a gland
nter of your
(1700's)

Gradual Triangulation…

- Goal of science is to hold steadfastly to the goal of getting it **right about reality**, even though **we can never achieve that goal**! (*…or can we?*)
- Measures, observations, other methods, etc. **all possess different types of error**; our approaches are inherently flawed, we are flawed…
- But we make do by **triangulating through multiple techniques**, testing different ideas in different ways, and always questioning…

scientific culture

Science and Logic

- … both deductive and inductive methods.
- **Deductive**: a set of premises, rules, and a **conclusion that is logically guaranteed by the premises and rules**.
- **Inductive**: a set of premises, rules, and a conclusion that is based on **probability of the conclusion being true or false; not necessary or certain**.

Deductive

- **Premi** lay hocke
- **Premi**
- **Infere** d plays hocke
- (**Rule**: lso a Y.)

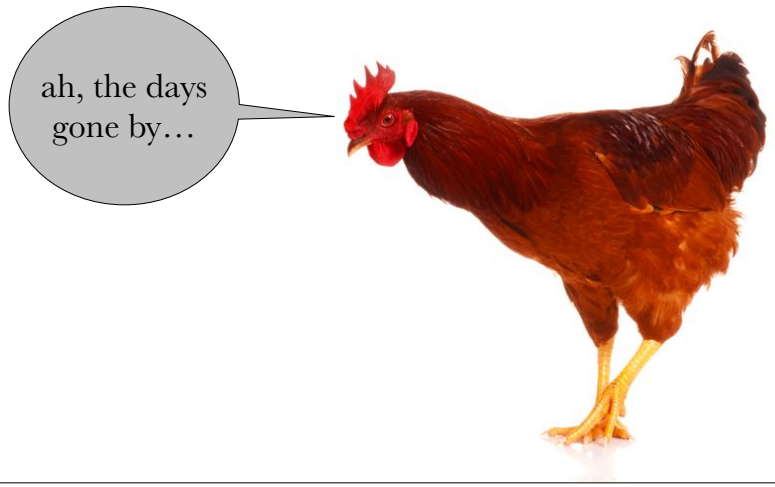
Logical Lingo

- An argument is **valid** if the inference (conclusion) flows logically from its premises.
  - An argument is **invalid** if it does not.
- An argument is **cogent** if it is both valid and the conclusion and premises are all actually true!
- Importantly: An argument can be valid but not cogent (e.g., if it's a rose, it's blue; it's a rose; therefore it's blue — valid but not cogent!)

Inductive

- **Observations**: The sun came up yesterday and the day before and the day before and the day before …
- **Probability statement**: Therefore the sun will come up again tomorrow (*also, bet your bottom dollar that tomorrow, there'll be sun or something*).
- (**Rule**: If event E happened before under condition X, then E will probably happen again if you bring about conditions for X.)
  - E.g., key idea in a couple of weeks: inductive arguments ("experiments") are supposed to be **replicable** (they can be replicated).

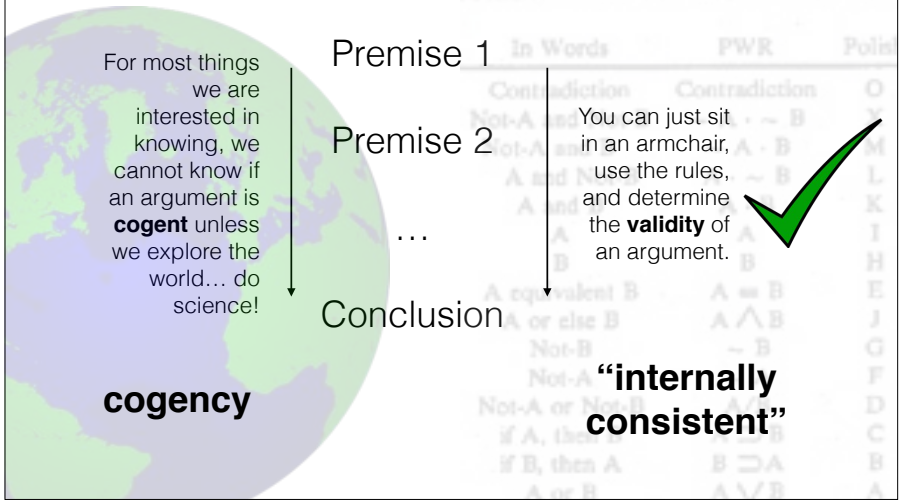
Russell's Chicken



Contingent Statement

- "Empirical claim": A **contingent** statement that might or might not be true about the world.
  - In particular, it should be **falsifiable** (or, to a certain degree, **verifiable**, too).
- **Contingent statements that are being entertained by science are called *hypotheses*, of course; they are to be sorted out by empirical methods.**

The Role of Experience



Scientific Method

- Step 1: Develop an empirical question.

Are common words
faster to process
than uncommon words?

*Can be "**big picture**"; brave, exciting exhilarating, you start having dreams about uncommon words like "obfuscate" and common ones like "like."*

Scientific Method

- Step 2: Develop a hypothesis.

Common words
are **detected as words**
faster than uncommon words

*Often **more specific**, **connects** to more concrete plans to conduct a study or carry out an experiment; **suggests** the methods you might need.*

Scientific Method

- Step 3: Choose a method.

Yeah, let's do **reaction time**.

*Should connect well to your hypothesis; the method will help you get measures to test the hypothesis; **generates relevant data**. Can be direct or indirect.*

Scientific Method

- Step 4: Be aware of any assumptions.

"People have a mind." (trivial?)
"Fingers are related to mental processing."
"RT indicates mental processing speed."
"Mental processing speed indicates ease." (nontrivial?)

*All plans for a study to be conducted to test a hypothesis are **rife with assumptions**; sometimes trivial ones, other times significant ones; sometimes called "**auxiliary hypotheses**."*

Scientific Method

- Step 5: Role of the assumptions.

Key assumption:
The speed of pressing a button
is a measure of the ease with which
a word can be "accessed"
or processed by the mind

*In cognitive science, **researchers often argue about the nontrivial assumptions**; for example, there is even debate about whether RT is useful and whether we are even thinking about it in the right way!*

Scientific Method

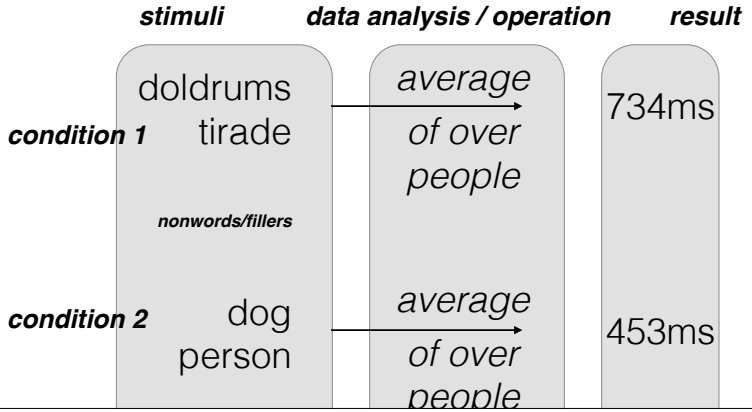
- Step 6: Perform the test and record the data.

let's do it!

respond with your right hand if the sequence of letters you see is a word of English

Scientific Method

- Step 7: Evaluate the hypothesis.



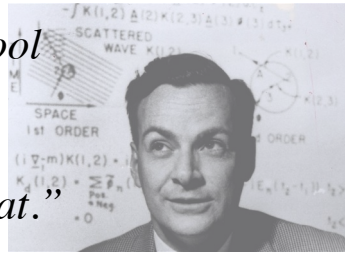
Scientific Method

- Step 8: Integrate and critique.

Adequate stimuli? (critique)
Adequate analysis?
Jive with other theories? (integrate)

We should always be willing to critique our own study; to push the limits of our own accounts; ***don't get comfortable in our view of the world, try to shake it up****.*

"The first principle is that you must not fool yourself--and you are the easiest person to fool. So you have to be very careful about that. After you've not fooled yourself, it's easy not to fool other scientists. You just have to be honest in a conventional way after that."



Feynman, 1974

Scientific "Method"

- Many of these steps are usually done quickly and implicitly; **scientists don't often carefully analyze all of their assumptions**, even though it can be a useful exercise. We should do it more.
- Usually any **test of a hypothesis is taking place in a whole backdrop of theories and facts**, and we reason through a broad knowledge of the scientific literature and how our results fit.

Positive vs. Negative

1. Nothing discovered through experience is guaranteed to be true.
2. Everything we discover through science we discover through experience.

∴ Nothing discovered through science is guaranteed to be true.

in our reading

philosophers of science have typically converged on the idea that **evidence that falsifies is more definitive** than evidence that supports a hypothesis…

however, even here there has been considerable debate…

Imagine…

- We ran our experiment and got this instead:
  - Uncommon words: 753ms
  - Common words: 723ms
- Imagine our statistics reveal that the tiny difference here (30ms) isn't meaningful.
- Did we just **falsify** my hypothesis?

No!

- It may have been **something in our assumptions went wrong**, underlying the whole experiment itself:
  - Maybe the stimuli were hard to see; task too difficult.
  - Bad instructions to participants?
  - Maybe the PhD student running the study
- **So… change it up (systematically) and try it again!**

Designing a New Study

important advice…

…if you do a new version, then only change one single, little thing! Just one thing!

why? you want to isolate what went wrong…

Imagine…

- We ran our experiment and got the results I originally thought we might get:
  - Uncommon words: 734ms
  - Common words: 453ms
- Imagine our statistics reveal that the difference is big and meaningful!
- Did we just **verify** my hypothesis?

No!

- Cognitive scientists still **fight over results** that come out meaningful.
  - **Maybe the uncommon words were too long** and so the result is based on some other variable (word length, not commonality).
  - Did participants get **subtly incorrect instructions** that caused them to process uncommon words differently (and unnaturally)?
- **So… fix any issues and check if it still comes out!**

Logic…

- This positive vs. negative evidence idea can be expressed in logic. The reading shows you how:

1. Let's assume that **H**.
2. Let's assume that **{A}**.
3. **H** and **{A}**.
4. If **H** and **{A}**, then **O**.
5. **O**.

∴ **H**.

positive outcome

wha!? but we assumed this!

1. Let's assume that **H**.
2. Let's assume that **{A}**.
3. **H** and **{A}**.
4. If **H** and **{A}**, then **O**.
5. Not **O**.

∴ Either **H** is false or **{A}** is false.

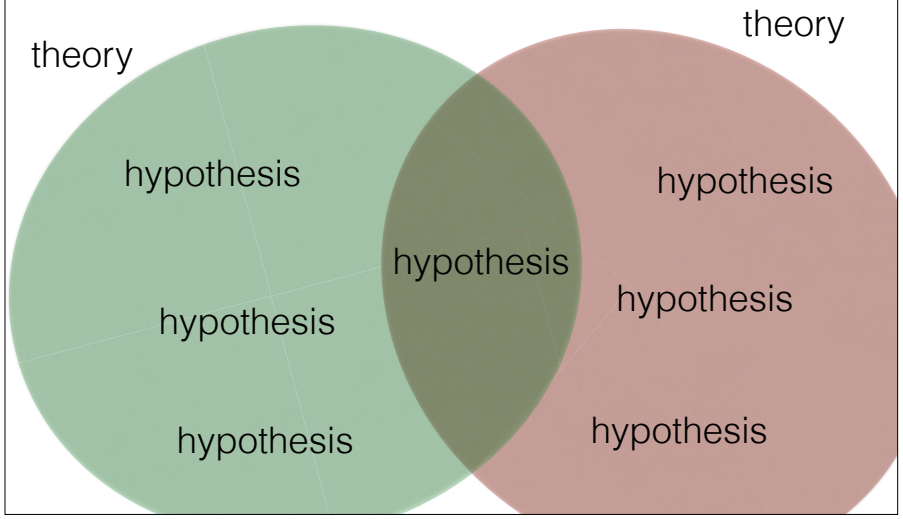
negative outcome

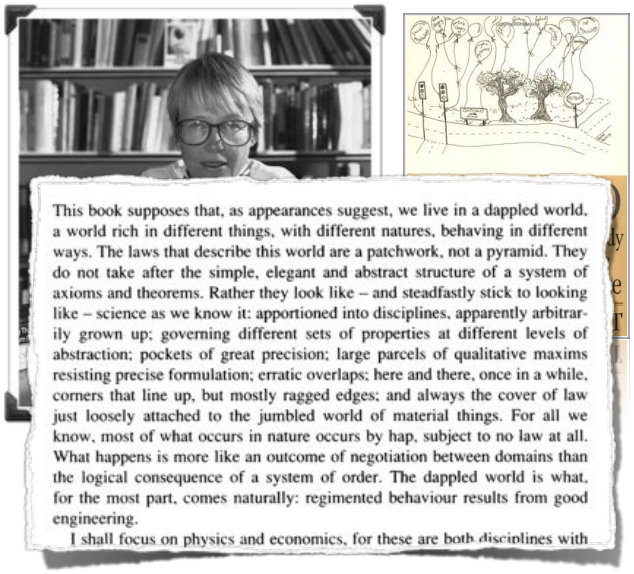
does not disconfirm!

"Critical Experiment"

- There is **no such thing as ONE critical experiment**.
  - ***Critical experiment****: A single study that, when results are obtained, would confirm or disconfirm a hypothesis (or a whole theory).*
- The world always seems to present enough complexity that **any (relative) certainty about the truth of a theory has to come from repeated and systematically varied experimentation**; explore and probe the world.
- *We're in it for the long haul.*

One Last Thing…





This book supposes that, as appearances suggest, we live in a dappled world, a world rich in different things, with different natures, behaving in different ways. The laws that describe this world are a patchwork, not a pyramid. They do not take after the simple, elegant and abstract structure of a system of axioms and theorems. Rather they look like – and steadfastly stick to looking like – science as we know it: apportioned into disciplines, apparently arbitrarily grown up; governing different sets of properties at different levels of abstraction; pockets of great precision; large parcels of qualitative maxims resisting precise formulation; erratic overlaps; here and there, once in a while, corners that line up, but mostly ragged edges; and always the cover of law just loosely attached to the jumbled world of material things. For all we know, most of what occurs in nature occurs by hap, subject to no law at all. What happens is more like an outcome of negotiation between domains than the logical consequence of a system of order. The dappled world is what, for the most part, comes naturally: regimented behaviour results from good engineering.

I shall focus on physics and economics, for these are both disciplines with

Today...

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- Scientific method
- Positive vs. negative evidence

In Required Readings

Next week…

- **Sections**: Jumping right into behavioral tasks — the Implicit Association Task! "Priming" us for later (you'll get this terrible joke later…).
- **Topic next week**: Basic issues of behavioral measurement and experimentation.