Lecture 2: Lab in Human Cognition

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Agenda for Today

- What makes a good experiment? Alignments between data and theory
- Discuss reading
- What makes a good experiment?
- Experiment 1 - collect data
First

What makes a good experiment?
Where does life come from?

- Since the 4th century B.C. the theory of *spontaneous generation* dominated thinking about this question

- Nile River floods -> enriches soil, etc... -> frogs appear -> frogs must come out of the mud
Francesco Redi (1668)
John Needham (1745)

- Boiled broth (thought to kill any micro-organisms), then let it sit out
- Still found evidence of micro-organisms
- Revived the spontaneous generation hypothesis
- Rigorously verified and examined by his peers and many agreed with him.
Pasteur solved it! (1859)
What went wrong and why?

A failure to detect **confounding variables**.

Was it sloppy science? Hard to say. The relevant variables themselves were poorly understood.
Confounding Variables

Big challenge in cognitive science... What information in the environment do people use and how? Difficult to control, must proceed with extreme caution.
2, 4, 6
- Claim: if vowel on one side, then even number on other

E K 4 7
<table>
<thead>
<tr>
<th>Vowel</th>
<th>Even</th>
<th>(Vowel → Even)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card</th>
<th>Verdict</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>No consonant or even number visible: MUST CHECK</td>
</tr>
<tr>
<td>K</td>
<td>Has consonant, NEED NOT CHECK FURTHER.</td>
</tr>
<tr>
<td>4</td>
<td>Has even number, NEED NOT CHECK FURTHER.</td>
</tr>
<tr>
<td>7</td>
<td>No consonant or even number visible: MUST CHECK</td>
</tr>
<tr>
<td>Option</td>
<td>Percentage</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>E and 7 (right answer)</td>
<td>0%</td>
</tr>
<tr>
<td>E</td>
<td>50%</td>
</tr>
<tr>
<td>E and 4</td>
<td>20%</td>
</tr>
<tr>
<td>K and 7</td>
<td>15%</td>
</tr>
<tr>
<td>7</td>
<td>5%</td>
</tr>
<tr>
<td>K</td>
<td>5%</td>
</tr>
<tr>
<td>All cards</td>
<td>5%</td>
</tr>
</tbody>
</table>
Confirmation Bias

Tendencies of human (scientists included) to seek positive examples of a theory rather than the things that would refute it.
Claim: If you are drinking alcohol, then you have to be 21.
Falsification
Karl Popper (1935) - philosopher of science

“The Logic of Scientific Discovery”
Popper argued strongly against the latter, holding that scientific theories are abstract in nature, and can be tested only indirectly, by reference to their implications. He also held that scientific theory, and human knowledge generally, is irreducibly conjectural or hypothetical, and is generated by the creative imagination in order to solve problems that have arisen in specific historico-cultural settings. Logically, no number of positive outcomes at the level of experimental testing can confirm a scientific theory, but a single counterexample is logically decisive: it shows the theory, from which the implication is derived, to be false. Popper's account of the logical asymmetry between verification and falsifiability lies at the heart of his philosophy of science. It also inspired him to take falsifiability as his criterion of demarcation between what is and is not genuinely scientific: a theory should be considered scientific if and only if it is falsifiable.

-Wikipedia Karl Popper entry
Falsifiable theories can *in principal* be ruled out by performing a critical experiment.
Operational Definition

Some observable phenomena that is associated with a hypothesis. Cognitive scientists must propose hypothesis about how the mind works, and also propose operational definitions (some observable phenomena that would be predicted from that hypothesis).
You notice a decline in stork populations and a decline in human birth rate. BABIES must come from storks!!
ENVIRONMENTAL POLLUTION

↓

HORMONE DISRUPTION

↓

FEWER BABIES

FEWER STORKS

CORRELATED CHANGE

ECONOMIC DEVELOPMENT

↓

FEMALE JOB EQUITY

LOWER FERTILITY

CORRELATED CHANGE

URBAN SPREAD

FEWER STORKS

CORRELATED CHANGE

SPACE ALIEN INFILTRATION

↓

HUMANS AS PETS

MISSING BABIES

FEWER STORKS

CORRELATED CHANGE

GALACTIC DELICACY

by David Ng
1. SELECT STORKS AND BABIES

2. EXPOSE ONLY STORKS TO POLLUTION

3. DOES CORRELATION STILL HOLD?
Correlational Study

Tracks the statistical relationship between two variables, with limited ability to assess CAUSATION. However, important tool.... suggests hypotheses for experimental studies! Correlations are informative also!
Examples

- **Individual Differences in W.M.** - We think that subjects who have higher working memory ability will perform better on a learning task. We measure each subject’s w.m. capacity prior to the experiment then give them the test. We find that the higher the score on the w.m. test, the better they are at the second test.

- **Brain imaging** - BOLD signal recorded in visual cortex in response to a visual memory task. Does this mean visual cortex is the locus of memory? No! Correlated signal... the memories could be elsewhere in the brain.
Experimental Study

Directly manipulate one variable and finding the consequence on another variable.

Independent variable - the variable the experimenter changes (outside of subject’s control)

Dependent variable - the variable the experimenter is measuring in response to the change.
Experimental Study

**Experimental group** - one group for which the independent variable is specifically changes

**Control group** - no change or baseline change for the independent variable. This was changes in the dependent measure can be specifically identified with the manipulation and not some other factor.
Experimental Study

Within subject - when the subject is in both the control and experimental condition (higher power since you control for individual difference in ability).

Between subject - different participants/subject in the control and experimental conditions (lower power, but removes confounds of repeated testing).
Examples

- **Transcranial Magnetic Stimulation (TMS)** - We believe some region of frontal cortex is critical for certain types of behavior. Using TMS selectively “deactivate” this region and measure behavior in the task compared to a control.

- **Category Learning** - We think certain types of categories are easier to learn than others. Given each set of subjects a different structure and measure error rate.
Alignment between theory and data.
These multi-layered graphs report a clouded relationship between temperature and conductivity for various elements, as measured by many different laboratories. Each set of connected points comes from a measurement taken by one or more laboratories. The graphs show a range of conductivities at different temperatures, indicating the variability in experimental results.

Level of Analysis.
Marr’s Three Levels

- **Computational Level**
  What is the goal of the process and why is it appropriate/adapted to the environment

- **Representational Level**
  How can the computational level be realized?
  How is information represented? What algorithms/processes are used?

- **Implementation Level**
  How is it accomplished in neural circuits?
What’s a good research question?
Scientific Methods in Six Easy Steps

1. See something.
2. Think of a reason why.
3. Figure out a way to check your reason.
4. and?? (write it up)
5. Now, everyone gets to dump on you.
6. Repeat until consensus formed.

inspired by David Ng
Secont,
Let’s talk about the reading...
Next,
Let’s talk about this final project (again)!
Broad Topics

- Perception

- Categorization (how do people learn new categories? how do people use categories to reason about the world?)

- Memory (how does structure of information influence memory performance? emotional/situational factors on memory)

- Learning (what factors improve human learning? effect of information order on learning, learning task, induction mode, etc...)

- Decision making (how does mental fatigue influence decision making? who do people make decision in complex task with many choice options)

- Language (how do people learn language-like materials? What influence does language processes have on basic perception processes, Whorfian-hypothesis, etc...)
Example final project’s from past years

- The factors influencing false memory.
- Influence of schemas on memory (is memory better for schema consistent versus inconsistent information?)
- Sperling’s partial report paradigm (visual short-term memory)
- Effects of categorization on memory (does categorizing something make you worse at remembering it?)
- Effects of presentation format on math problem solving (how does the spacing between elements influence mathematical problem solving?)
- Sequence learning (how do people learn different types of sequence structures?) What effect does the modality of presentation (auditory/visual) have on sequence learning?
- Serial position effects in recall from memory
- Perception of human faces and the extraction of “prototypes” from a set of faces
- Influence of active/passive learning on the acquisition of new materials.
Finally,
Let’s do an experiment!
For next time....

- Come prepared to start analyzing Exp. 1! Boot camp has begun.
- Watch for a video I place online over the weekend.
- Collect data source with about 10 points in two groups. Be creative!