

Reasoning in Research

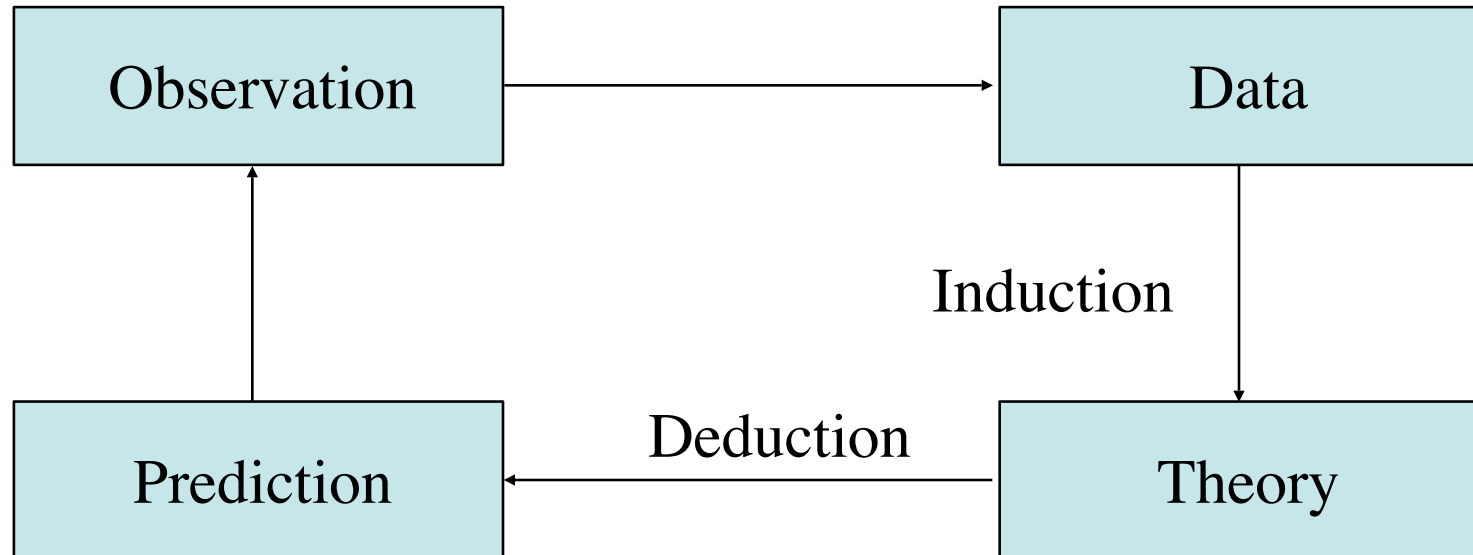
Inductive and Deductive Reasoning
and the process of research

Hippocampal functioning

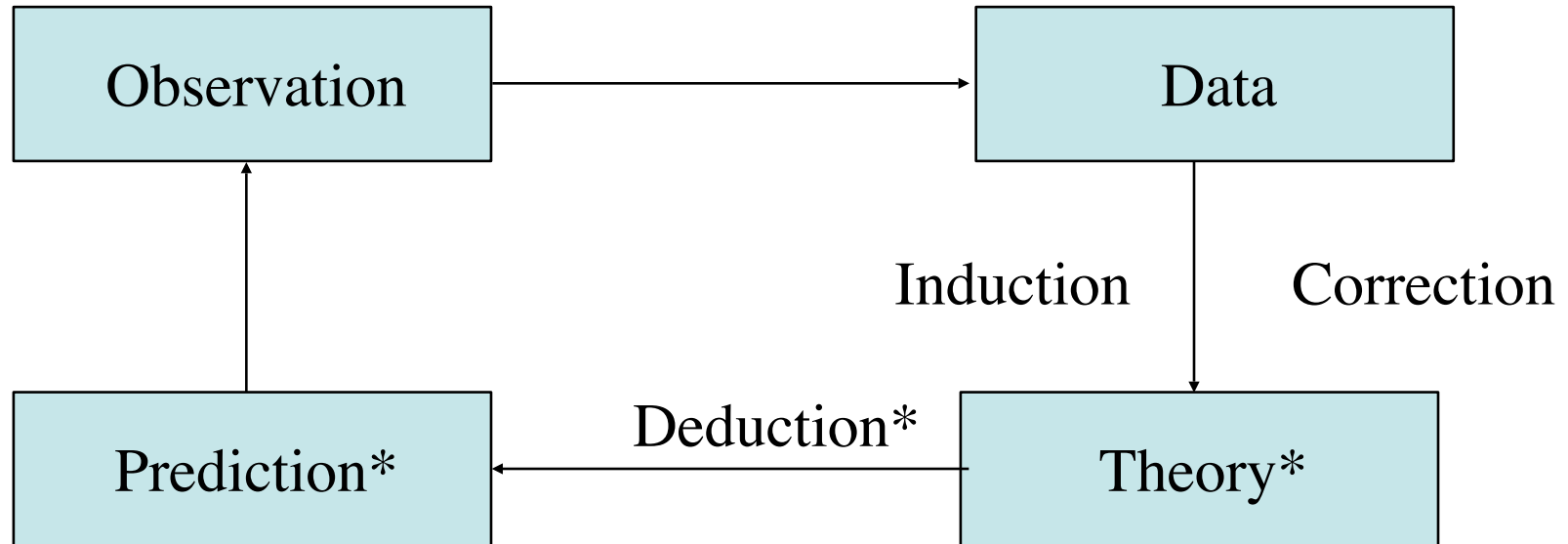
A certain investigator hypothesized that the hippocampus (a part of the brain) is related to complex thinking processes but not to simple thinking processes. He removed the hippocampus from a random sample of 20 rats. He had ten randomly selected rats learn a very simple maze and had ten randomly selected rats learn a very difficult and complex maze. The first group learned to run the maze without error within ten trials. It took the second group at least 30 trials to run the maze without error. Based upon these results, he concluded that his hypothesis had been confirmed -- rats without a hippocampus have more trouble learning a complex task than they do learning a simple task.

Criticize this experiment. Do the conclusions follow from the data? Why or why not? Do these results tell us anything about the role of the hippocampus in learning?

Reasoning in Research



Reasoning in Research an iterative process



Reasoning in Research

Consider the following sequence of numbers that are following a certain rule

2 4 8

What is the rule?

Create a hypothesis for the rule (Write it down)

Test the hypothesis by predicting X

Is it confirmed?

Does this mean that you know the rule?

Test it again (Predict Y)

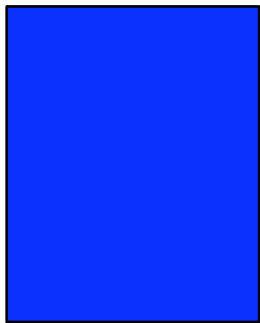
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- 2 4 8 X Y
- What was the rule that you had?
- One rule (the one used to generate the numbers) was ... (redacted)
There are, of course, many rules compatible with this general rule.
- Need to do tests that are not confirmations of rule but rather challenge the rule.
- Avoid the confirmation bias

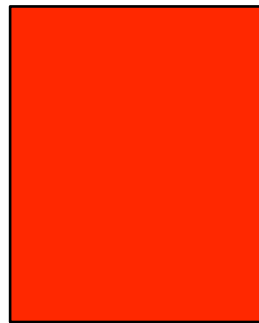
Reasoning in Research

- Consider the rule:
 - Cards are Blue or Red on one side and have numbers on the other side
 - All blue cards have an odd number on the other side
- Which of the following cards must you turn over to test this rule:

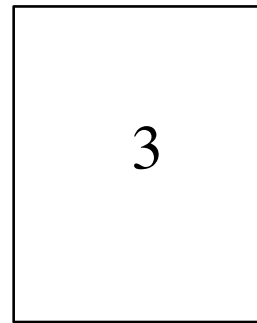
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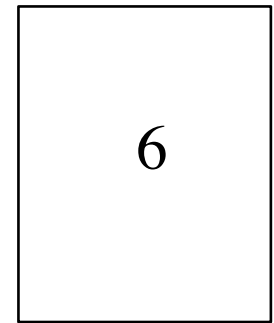
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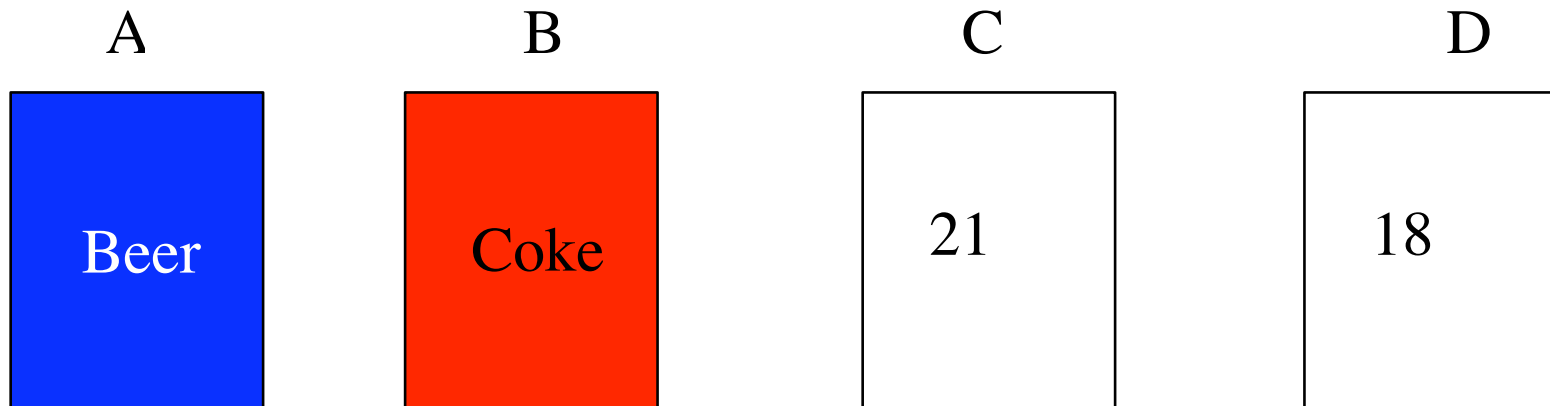


D



Reasoning in Research

- Consider the rule:
 - Some students are 18, some are 21, some are drinking beer, some coke.
 - You must be 21 to drink beer
- Which of the following students must you test to see if they are following this rule



Reasoning in research

- In both cases (blue \rightarrow Odd; drinking \rightarrow 21), the rule may be tested by affirming the antecedent and denying the consequent
 - Affirm the antecedent Blue \rightarrow Odd
 - Deny the consequent not odd \rightarrow not Blue
- Abstract cases typically are harder to deal with than concrete and familiar cases
- (Sometimes useful to convert abstract case into an analogous familiar case)

Principles of Logical Reasoning

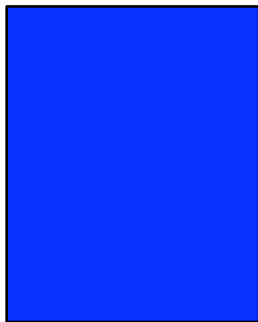
$P \rightarrow Q$ or if P, then Q

- Appropriate logical deductions
 - Affirm the Antecedent: $P \rightarrow Q$ (modus ponens)
 - Deny the Consequent: $\text{not } Q \rightarrow \text{Not } P$ (modus tollens)
- Incorrect logical deductions
 - Deny the antecedent: $\text{Not } P \rightarrow \text{Not } Q$
 - Affirm the consequent: $Q \rightarrow P$

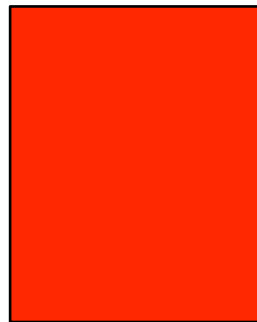
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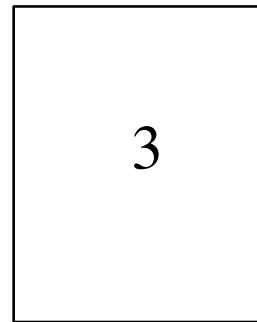
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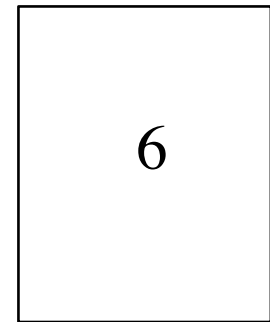
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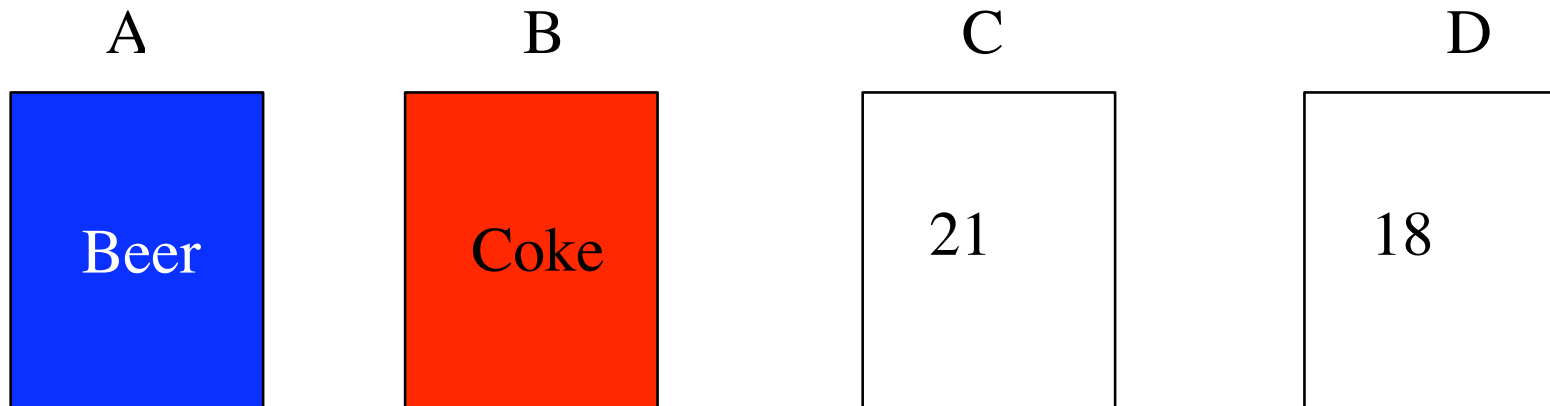


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Classic logical syllogisms

- All men are mortal, Socrates is a man, therefore Socrates is mortal (yes)
- All men are mortal, Raja is mortal, therefore Raja is a man (no)
- Truth tables as way of analyzing logical argument.

Reasoning in Research

- Karl Popper and the testability of theory
 - The hallmark of science is the testability of theory
 - Non-testable theories are not science
 - “it must be possible for all empirical scientific system to be refuted by experience”
 - Theories are not shown to be correct, they are shown to be incorrect
- Science is the process of asking questions that have answers (Rep. Rush Holt)

J. Platt and Strong Inference

(Science, 1964)

- 4 signs of strong science
 - Devising alternative hypotheses;
 - Devising a crucial experiment (or several of them), with alternative possible outcomes, each of which will, as nearly is possible, exclude one or more of the hypotheses;
 - Carrying out the experiment so as to get a clean result;
 - Recycling the procedure, making subhypotheses or sequential hypotheses to refine the possibilities that remain, and so on.

Strong inference

- A theory which cannot be mortally endangered cannot be alive. (Rushton, as cited by Platt)
- “The problems of how enzymes are induced, of how proteins are synthesized, of how antibodies are formed, are closer to solution than is generally believed. If you do stupid experiments, and finish one a year, it can take 50 years. But if you stop doing experiments for a little while and *think* how proteins can possibly be synthesized, there are only about 5 different ways, not 50! And it will take only a few experiments to distinguish these.” (Szilzard, as cited by Platt)

Platt and Strong Inference

“I will mention one severe but useful private test - a touchstone of strong inference - that removes the necessity for third-person criticism, because it is a test that anyone can learn to carry with him for use as needed. It is our old friend the Baconian “exclusion,” but I call it “The Question.” Obviously it should be applied as much to one’s own thinking as to others’. It consists of asking in your own mind, on hearing any scientific explanation or theory put forward, “But sir, what experiment could *dis* prove your hypothesis?”; or, on hearing a scientific experiment described, “But sir, what hypothesis does your experiment *dis* prove?” Platt, *Science*, 1964

Sherlock Holmes and Theory

- “By the method of exclusion, I had arrived at this result, for no other hypothesis would meet the facts” [*A Study in Scarlet* , pt. 2, ch. 7]
- “when you have eliminated the impossible, whatever remains, however improbable, must be the truth” [*The Sign of Four* , ch. 6]
- (From [Soshichi Uchii, Sherlock Holmes and Probabilistic Induction](http://www.bun.kyoto-u.ac.jp/~suchii/holmes_1.html). http://www.bun.kyoto-u.ac.jp/~suchii/holmes_1.html)

Sherlock Holmes and Theory

- “Most people, if you describe a train of events to them, will tell you what the result would be. They can put those events together in their minds, and argue from them that something will come to pass. There are few people, however, who, if told them a result, would be able to evolve from their own inner consciousness what the steps were which led up to that result. This power is what I mean when I talk of reasoning backward, or analytically." [*A Study in Scarlet* , pt.2, ch.7]

The problem of knowing the answer

- Everything is certain if you know how it turns out.
 - Easy to explain why something happened if you know that it did happen.
 - But this ease leads to false confidence of understanding.
- It is predicting what will happen in the future that is difficult.

Reasoning in Research

Observe, Induce, Deduce, Predict, Observe

Disconfirm, don't confirm

Prune the tree of alternative explanations

Be modest about the strength of your
explanations