Philosophy 240
Symbolic Logic

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Fall 2014

Class #19: Logic and the Philosophy of Science

Three Topics
In the Philosophy of Science

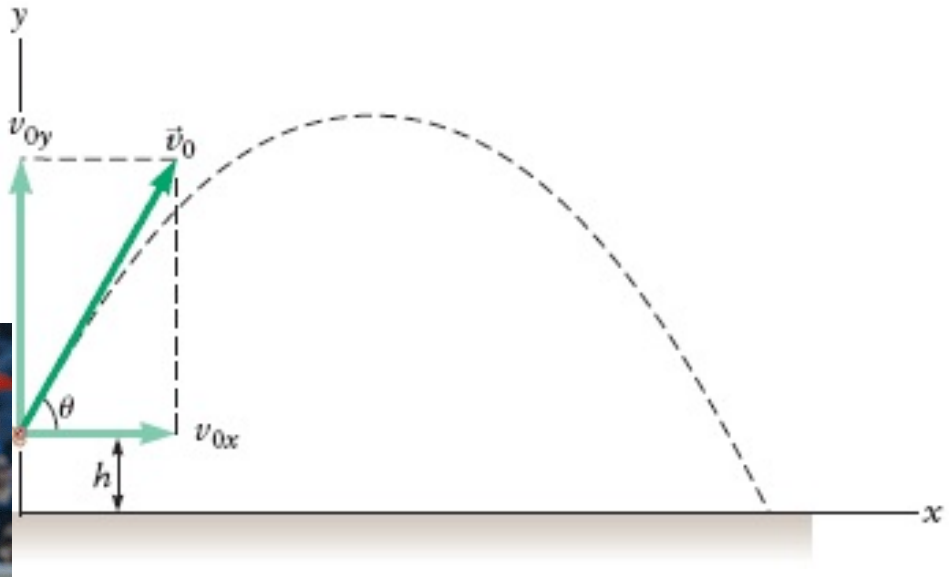
For which our logic is helpful

1. The Deductive-Nomological Model of Scientific Explanation
2. Confirmation and the Paradox of the Ravens
3. Resolving Contradictions

Explanations

- What is an explanation?
- Typical philosophical answer: explanations are answers to why questions.
  - Why do you study logic?
  - Why did the United States enter World War I?
  - Why does the Earth revolve around its axis?
- *Scientific explanations* solicit descriptions of the world which explain an event or phenomenon or law.

Why Does A Baseball Take a Particular Trajectory?



Laws and Initial Conditions

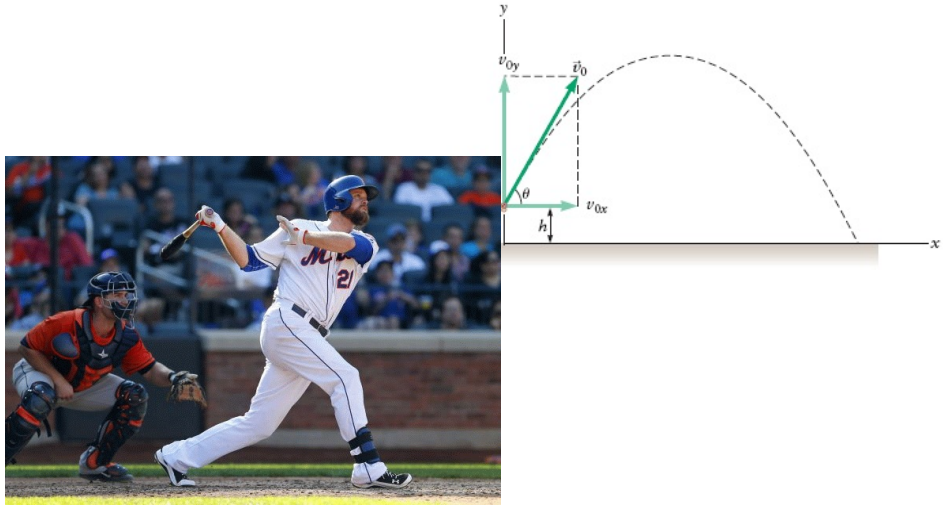
- Two aspects to any scientific explanation
- Laws are general principles
  - Physical Laws (mechanics, electromagnetism)
  - Biological laws (e.g. DNA, cicadas, honeycombs)
  - Chemical laws (ideal gas law)
  - Psychological laws (neuro-chemical, cognitive)
  - Historical?
- Initial conditions provide instances of laws
  - From observation
  - Events are subsumed under laws.

The Deductive-Nomological (D-N) Model of Scientific Explanation

$L_1, L_2, L_3,...L_n$	The relevant laws...
$I_1, I_2, I_3,...,I_n$	...and the relevant initial conditions...
----------	...logically entail...
E	...the explanandum.

The D-N Model and the Baseball Trajectory

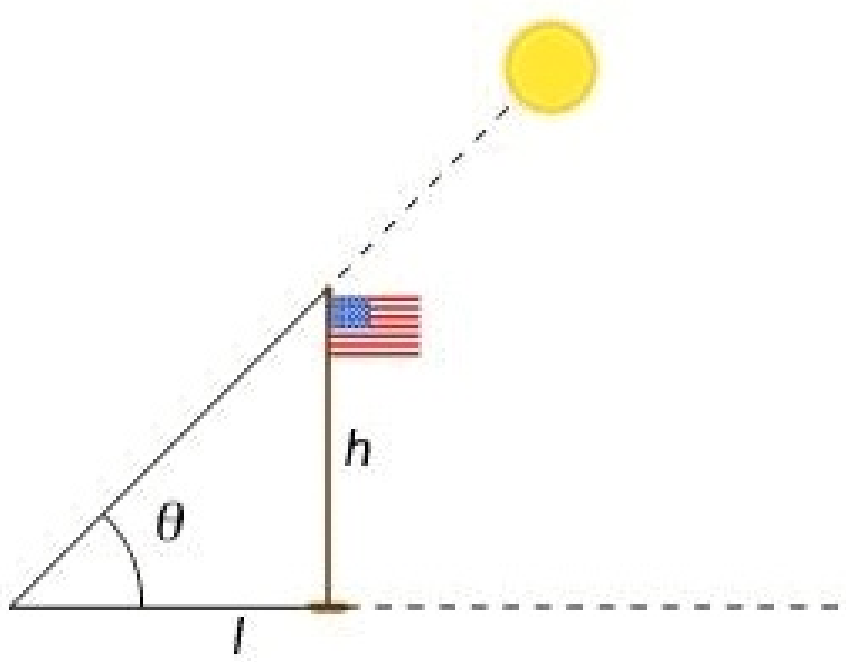
- Premises:
  - Laws
    - Transfer of momentum
    - Friction
    - Gravitational attraction?
  - Initial conditions
    - Mass of ball and bat
    - Velocities at impact
    - Air resistance
- Conclusion:
  - Flight of the ball



Gap-Free Inferences and Science

- Frege's *Begriffsschrift* promised a gap-free account of logical inference.
- If we can put scientific explanations into D-N forms, we can take advantage of the gap-free logic in science, too.
  - Explanations of particular events
- Explanations of lower-level laws from higher-level laws, too
  - Boyle's Law: $P_1V_1 = P_2V_2$
  - Charles's Law: $V_1/T_1 = V_2/T_2$
  - Ideal gas law: $PV = kT$

Problems with the D-N Model 1



- Given the height of the flagpole and the angle of the sun, we can explain the shadow.
- Given the length of the shadow and the angle of the sun, we can explain the height of the flagpole.
- Only one of those is ordinarily taken as an explanation.
- What's missing from the D-N model?

Problems with the D-N Model 2

- Wesley Salmon:
  - (L) All males who take birth control pills regularly fail to get pregnant
  - (I) John Jones is a male who has been taking birth control pills regularly
  - (E) John Jones fails to get pregnant
- Henry Kyburg:
  - (L) All samples of table salt that have been hexed by a witch dissolve in water
  - (I) This salt has been hexed.
  - (E) This salt dissolves in water.
- One might wonder about laws

Laws and Accidental Generalizations

- Laws are often universal.
- But universality is insufficient for lawhood.
  - All people in this room have DNA.
  - All people in this room know the difference between Modus Tollens and Constructive Dilemma.
- Our logical rules of inference are syntactic.
- It would be nice if we had a syntactic criterion for lawhood.
- But:
  - All gold spheres are less than one mile in diameter.
  - All uranium spheres are less than one mile in diameter.
- To identify the laws, we have to know science, not just logic or grammar.

The Paradox of the Ravens

On Confirmation

Nicod's Criterion

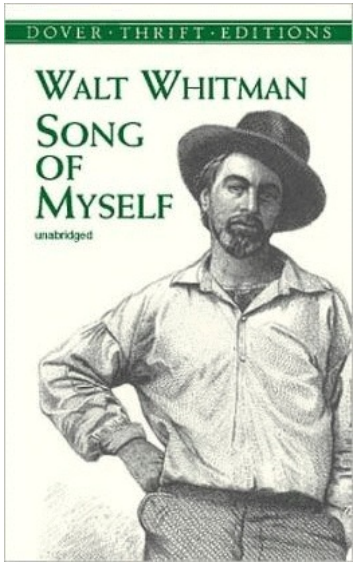
- In our class on conditionals we saw that Nicod's criterion captures how such scientific laws are confirmed.
  - Evidence confirms a law if it satisfies both the antecedent and consequent.
  - Evidence disconfirms a law if it satisfies the antecedent, and fails to satisfy the consequent.
- 'All ravens are black'
  - 'If something is a raven, then it is black.'
  - When we find a black raven, which satisfies the antecedent and the consequent, it confirms the claim.
  - If we were to find a raven which is not black, which satisfies the antecedent but falsifies the consequent, then it would disconfirm the claim.

The Paradox of the Ravens

- Any evidence which confirms a proposition should confirm any logically equivalent proposition.
  - Hempel's equivalence condition
- 'All ravens are black' is logically equivalent to 'all non-black things are non-ravens'.
  - Law of Contraposition!
- What evidence confirms 'all non-black things are non-ravens' (according to Nicod's criterion)?
- Uh-oh.
  - Accept the consequence?
  - Natural kinds?
  - Give up equivalence condition?
  - Change our logic?

Scientific Method

Contradictions and Theory Change



- A theory is a set of sentences.
- Our beliefs form a theory.
- Consistency is a basic condition of rationality.
  - Not for Walt Whitman
  - "Do I contradict myself? Very well, then I contradict myself,
  - I am large, I contain multitudes."
  - Not all of us are Whitman.
- Sometimes we discover that our belief set is inconsistent.
  - New observation which conflicts with background beliefs
  - Discovery of an unseen entailment
- In such cases, we are faced with a set of hypotheses and often want to restore consistency.
- We must choose which belief(s) to cede.
- A contradiction within a theory merely tells us that there is a problem in the theory, not how to resolve it.
- It need not tell us where the problem lies.

The Dull Weekend

- Imagine that you believe that there are going to be no parties this weekend.
- Then, you receive a flyer for a gathering on Friday.
- Adding the belief that there is a party on Friday to your prior set of beliefs is inconsistent.
- You could resolve the contradiction in various ways:
  - ★ You could give up your belief about there being no parties this weekend.
  - ★ You could check the date on the flyer; maybe there is a confusion about the data.
  - ★ You could redefine the term ‘party’ such that the gathering is not a party.
  - ★ et al.

The Dull Weekend, Regimented

- T: $S_1 \bullet S_2 \bullet S_3 \bullet ... \bullet S_n$
- Imagine that T yields some claim: O
  - $T \supset O$
- We get new information:
  - $\sim O$
- By modus tollens, we know that T is false:
  - $\sim T$
  - $\sim(S_1 \bullet S_2 \bullet S_3 \bullet ... \bullet S_n)$
  - $\sim S_1 \vee \sim S_2 \vee \sim S_3 \vee ... \vee \sim S_n$
- That's as far as the logic will take us.
- We don't know which of the sentences of the theory to reject.

Restoring Consistency

$$\sim S_1 \vee \sim S_2 \vee \sim S_3 \vee \ldots \vee \sim S_n$$

- We need methods for weighing evidence to choose among the options.
  - Governed by various abstract principles
- Various ways to proceed each fit the logical requirements.
  - Theories are generally under-determined by evidence.
  - Evidence often provides correlation without indicating causation.
  - Facebook users get lower grades in college.

Virtues of Theories

1. Conservatism
- Revise as little as possible.

2. Modesty
- We accept only the weakest, or most modest, principles, as the most plausible.
- "The lazy world is the likely world" (68).

3. Simplicity
- Simplicity for a large theory trumps simplicity for any portion of that theory when the two conflict.
  - 'Objects fall to the Earth' is simple, but conflicts with gravitational theory which is simpler overall, and more general.

4. Generality
- Explanatory Breadth

5. Refutability
- A theory which explains everything is empty.
- Good theories should be testable.