Philosophy of Science 1

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A Bit of Logic to Begin

- *Conditionals*: Sentences of the form: "If p, then q"
  - "p" and "q" themselves stand for sentences – *sentential* logic
  - (as opposed to *quantificational* logic, which deals with sentences containing quantifiers "For all…" and "There is…")
  - "If p": *antecedent*
  - "then q": *consequent*

•Let "p" be "Oslo is in Norway"
•Let "q" be "Oslo is in Scandinavia"

- Consider these *argument forms*:
- A: 1. If p, then q
- 2. p
- 3. Therefore, q

A Bit of Logic (2)

- *A* is a *deductively valid* argument form: If the *premises* are true, the *conclusion* must be true as well. The truth of the premises guarantees the truth of the conclusion.
- In *A*: If premises 1 and 2 are true, then conclusion 3 must be as well. (If 1. "If Oslo is in Norway, then Oslo is in Scandinavia", and 2. "Oslo is in Norway" are both true, then Oslo must be in Scandinavia.) This form is called *modus ponens*.
- *B*: 1. If p, then q
- 2. not-q (i.e., q is false)
- 3. Therefore, not-p
- *B* is also a valid form: If 1. is true, and if 2. Oslo is not in Scandinavia, then Oslo is not in Norway. This form is called *modus tollens*.
- *C*: 1. If p, then q
- 2. q
- 3. Therefore, p

A Bit of Logic (3)

- *C* is an *invalid* form: The truth of the premises does not guarantee the truth of the conclusion; the premises can be true yet the conclusion false. (Oslo might be elsewhere in Scandinavia.) This is the fallacy of *affirming the consequent*.
- *D*: 1. If p, then q
- 2. not-p
- 3. Therefore, not-q
- D is also an invalid form: Oslo might be in Sweden and so still in Scandinavia. This is the fallacy of *denying the antecedent*.
- Notice: *validity independent of truth of premises*. If "q" = "Oslo is in Asia", forms *A* and *B* are still *valid*. If an argument is valid and its premises are true, it is *sound*.
- What has all this to do with scientific reasoning?
- Consider the case of Semmelweis.

Semmelweis

- Puerperal (childbed) fever in mid-19th C at Vienna General Hospital: why were mothers dying at a greater rate in the First Division than the Second Division?
- *Explanatory Hypotheses*: epidemic influences; overcrowding; diet; general patient care; rough handling by medical students; scary priest with bell; position of delivery; cadaveric matter.
- The first 3 'born refuted': both Divisions the same.
- Next 2 incompatible with the known facts of the cases.
- Next 2 *disconfirmed* by *experimental test*.
- Finally, the last *confirmed* by test: medical students washed their hands in bleach (chlorinated lime) solution, and the mortality rate in D1 went down.
- Consider the logic of such tests:

Logic of Testing

- If H, then I: H = hypothesis; I = test implication. For example, consider H6:
- H=The higher rate of puerperal fever in D1 is caused by the priest, dressed in black, walking through the ward with a loud bell ringing, scaring the expectant mothers.
- Semmelweis reasoned: If H is true, then I: if the priest is removed, the rate of fever should decrease. (Note: I is itself a conditional.)
- 1. If H, then I
- 2. not-I
- 3. Therefore, not-H
- This form is valid: *modus tollens*. (Remember: if Oslo is not in Scandinavia, it's not in Norway)
- The test does not *prove*, but nevertheless provides good *evidence,* that H is false.

Logic of Testing (2)

- Same result for H7 re position of delivery.
- A lucky break for Semmelweis, though not for Kolletschka: stuck with a scalpel during an autopsy, K developed puerperal fever and died.
- This led Semmelweis to a new H: It is *cadaveric matter* (eventually broadened to *putrid matter* – this is before Pasteur and *germ theory*) that causes puerperal fever.
- He reasoned: If H (puerperal fever is caused by cadaveric matter), then I: If the medical students neutralize the cadaveric matter from their hands after autopsy by washing them in a bleach solution, the rate of death in D1 should go down. And that's what happened:
- 1. If H, then I
- 2. I (the rate went down after hand washing)
- 3. Therefore, H.

Logic of Testing (3)

- Note: This is invalid: *affirming the consequent*. Nevertheless, it is a *confirming instance* of H: it *supports*, constitutes *evidence* for, H.
- H also explains: why death rate in D2 was lower (examined by midwives who didn't do autopsies); why women who gave birth outside VGH had a low rate; etc.
- Even many such confirming instances do not *prove* H; they just *increase support* for H.
- 1. If H, then $I_1 + I_2 + \ldots I_n$
- 2. $I_1 + I_2 + \ldots I_n$
- 3. Therefore H
- is still an instance of *affirming the consequent*, so still invalid. $I_1 + I_2 + \ldots I_n$ doesn't *prove* H, but it provides *supporting evidence* for it. The support is *in*ductive rather than *de*ductive. (Long story to tell about "inductive logic".)

More Hempel

- Another example: Torricelli, the "sea of air" H, and the barometer.
- Not "narrow induction": Can't "observe and record the facts" without a guiding H; can't analyze and classify them pre-H either; can't derive H's from them. (What facts could Semmelweis collect without a guiding H? Could the "sea of air" H be derived from already collected facts?)
- Rather, scientists need guiding Hs to direct their inquiries. This requires *imagination*, *creativity*, and sometimes *luck*. (Would Semmelweis have come up with his "cadaveric matter" H without Kolletschka's unfortunate infection? Could he have *derived* it from the data he had?) *No inductive rules for deriving Hs*.
- Another example: Kekule's discovery of the structure of the benzene molecule (a hexagonal ring).

More on Hempel (2)

- We seem to need a *discovery/justification* distinction: How an H is discovered, invented, or imagined is not relevant to its evaluation. We evaluate them by *gathering evidence* for/against them. How we discover them is for psychology.
- Hempel uses the D/J distinction to secure the *objectivity* of science: D can be as creative and subjective as you like. It's the *context of justification* (Reichenbach) that secures science's objectivity. (Same in math: we invent theorems any way we can, but we accept only those that can be proved.)
- Hempel also requires a sharp *theory/observation* split: *Theory-neutral* observation is required for inductive support of Hs.
- Both the D/J and the T/O distinctions have been subjected to serious criticism. (The Hanson reading challenges the latter.)
- Hempel tries to secure the *rationality* of science in the same way: we're rational to accept well-confirmed Hs because they enjoy strong inductive support.

More on Hempel (3)

- *Auxiliary Hs*: Brahe and stellar parallax. If H and A, then I; not-I; therefore not H.
- But H was true; it was two As (that the stars were closer, and that our equipment could detect the parallax) that were wrong.
- *Ad hoc Hs*: Lavoisier, phlogiston, and "negative weight".
- (Note: Inductive inferences are *ampliative* inferences: they go beyond examined cases. They predict what we will find if/when we examine new, future, or so far unexamined cases.)
- *The Demarcation problem:* How distinguish scientific from non-scientific theories?
- For Hempel: *testability in principle*.
- We'll see Popper's alternative view soon.

Induction and Hume's Problem

- Scientific inquiry, we've seen, depends upon induction/inductive reasoning. But:
- Hume's *Problem of Induction*:
- Cause and effect/constant conjunction: we want the former, but all we can get is the latter.
- Laws of nature: same story.
- "Let the course of things be allowed hitherto ever so regular; that alone, without some new argument or inference, proves not that, for the future, it will continue so. In vain do you pretend to have learned the nature of bodies from your past experience. Their secret nature, and consequently all their effects and influence, may change, without any change in their sensible qualities. This happens sometimes, and with regard to some objects. Why may it not happen always and with regard to all objects? What logic, what process of argument secures you against this presupposition?"

Hume's Problem (2)

- 1. Lots of evidence that As are followed by Bs.
- 1a. Observed occurrences of As being followed by Bs constitute *evidence* supporting 2.
- 1b. The future will resemble the past. = Principle of the Uniformity of Nature.
- 2. Therefore, All As are followed by Bs. (Or: The next A will be followed by B.)
- But 2 doesn't follow from 1, unless we insert
- But 2 doesn't follow from 1 and 1a, unless we insert
- Hume's problem: Inductive reasoning depends upon 1b, but 1b cannot itself be justified.
- It can't be justified *de*ductively, because there is no contradiction in thinking that nature may change/is not uniform.
- It can't be justified *in*ductively; any such argument begs the question by assuming 1b.
- So: 1b cannot be justified. Inductive reasoning NG.

Popper on Induction and Falsification

- Hume's Problem led Popper to reject inductive reasoning altogether in his account of scientific reasoning.
- Instead of induction, Popper held that science requires, and scientists use, only *de*ductive reasoning.
- On this view, we don't inductively confirm Hs or Ts. Instead, we deductively *falsify* them, via *modus tollens*. We don't gather evidence that Hs are true or probable. Instead, we prove, deductively, that they are false.
- Popper: There is no such thing as positive, supporting evidence.
- There is only negative, refuting evidence.
- *Falsificationism* eliminates Hume's Problem (no induction), and solves the Demarcation Problem: to qualify as scientific, an H must be *falsifiable*.
- Popper's favorite example: Einstein and General Relativity (GR).

Popper (2)

- Newton: Space is uniform. A light beam, for example, will continue in a straight line indefinitely.
- Einstein: Space is not uniform: it "bends" or "curves" around massive objects.
- Test of GR: in a total solar eclipse, light from a distant star passing near the sun should be "shifted" from its apparent position.
- Eddington's eclipse observations constituted (in practice) a *crucial experiment*: Both Ts make predictions; only one can be right; if wrong, T falsified.
- Popper calls Einstein's H a *bold hypothesis*: it ran a great risk of being falsified.
- But it wasn't falsified: instead, its test implication proved to be correct.
- So, Popper's slogan: *Bold Conjectures and Severe Tests*.
- When a bold H survives a severe test, it's not confirmed. Rather, he says, it's *corroborated*.

Popper (3)

- Scientific knowledge is *conjectural* and *hypothetical*: we can't say that the world *is* the way T says it is, but only that so far we haven't shown that it *isn't* that way.
- *Scientific method*: "Try out, and aim at, bold Ts, with great informative content [by telling us all the ways the world isn't]; and then let these bold Ts compete, by discussing them critically and by testing them severely."
- *The boldness* of a T is measured by its *risk of clashing with reality*, and thus its *falsifiability*. A falsifiable T forbids the world to be a certain way; it "excludes an infinity of conceivable possibilities" and so is highly refutable.
- Such an H can be *immunized* from being shown false by way of *auxiliary* Hs. And sometimes that's the right thing to do, e.g. Adams, Leverrier, and the discovery of Neptune. This *increased* the testability of Newton's T.
- But *ad hoc* Hs are "bad" immunizations, because not *independently testable*, and so are not acceptable.
- Though in practice it's sometimes hard to tell the difference.

Popper (4)

- Scientific Ts enjoy *no positive support*, because there's no such thing as inductive support.
- Nevertheless we can rationally prefer some conjectures to others, if
- 1) they've been tested severely and corroborated, and
- 2) enjoy more informative content (by ruling out all the ways the world isn't).
- There's much more to Popper's philosophy of science. Of particular interest are his views on '*rationalism*' and his limited defense of it, and his view of the growth of scientific knowledge. Sorry we can't go further.
- But we've seen enough to note some problems:

Problems with Popper

- 1. Demarcation doesn't work. (Strictly speaking, Uranus' trajectory falsified Newton's theory. Adams and Leverrier did exactly what Popper says they shouldn't have done: they should have rejected Newton's T because it rendered an incorrect prediction.) In fact,
- There does not seem to be a clear demarcation between science and non-science. (Long story to tell here.)
- 2. Popper's theory *can't account for the role of predictions in scientific inquiry*. We want, not Ts that can be shown to be false, but Ts that are true. Do we in fact make predictions only to refute Ts?
- 3. Popper's theory *fails to avoid induction*. When a T is 'corroborated', we're rational to think more highly of it. But doesn't that itself constitute *inductive support*? If not, why does corroboration count in favor of T?
- 4. Don't we *value* inductive support? When we test a new vaccine and learn that it is effective, don't we think that says more than "we haven't shown it to be ineffective yet"? Same for Semmelweis, Eddington, and other triumphs?
- 5. If no positive support, why think any T is better than any other T?

Knowledge: Justified True Belief?

- This is the 'standard view' of knowledge, with us since Plato, although challenged often (including by Plato), most recently by E. Gettier.
- *Justification*: a putative knowledge-claim is justified by relevant *reasons* or *evidence*. (Kvernbekk: "evidence is something that has a bearing on the truth-value of a hypothesis (theory; belief)… it is something that supports or confirms the hypothesis, justifies our belief in it.")
- Evidence provides (in the positive case) *good reason to think that the claim is true*.
- So *justification is a fallible indicator of truth*: 'p is justified' = 'p is at least somewhat likely to be true' -- but even a well-justified claim can turn out to be false.
- Justification is thus a question of *evidential support.*
- Kvernbekk: "What makes something evidence is that it stands in a certain relation to a hypothesis, namely confirmation or disconfirmation."
- How likely the hypothesis is depends upon the *strength* of the evidence: claims can be more or less justified. Justification is a *matter of degree*.

Truth

- The *correspondence* theory: p is true *iff* it *corresponds with reality.* ('*iff*' = 'if and only if')
- Aristotle: "To say of what is, that it is not, or of what is not, that it is, is false; whereas, to say of what is, that it is, or of what is not, that it is not, is true."
- Tarski's schema: "'p' is true *iff* p".
- Example: 'Oslo is in Norway' is true *iff* Oslo is in Norway.
- Great difficulty for the correspondence theory: explaining the nature of the alleged correspondence. (How can a sentence 'correspond' to a fact or state of affairs?) Many views about this. (I recommend Alvin Goldman's modest *truthmaker* view: 'p' is true *iff* some fact or state of affairs makes it true. Example: it is the facts concerning Oslo's location that makes 'Oslo is in Norway' true. Goldman, *KSW*, ch. 2)
- Rival theories of truth: the *coherence* theory and the *pragmatic* theory.

Truth (2)

- *Coherence* theory: 'p' is true *iff* it coheres with other claims we take to be true.
- Problem: 'coherence' must be more than consistency. What else?
- Problem: Fictional worlds cohere, and yet are false. (The world of Sherlock Holmes is perfectly coherent, but there is no Sherlock Holmes, and "Holmes lives at 221B Baker Street" is false.)
- *Pragmatic* theory: 'p' is true *iff* p is *useful* to believe, and helps us achieve our practical ends.
- Problem: False beliefs are often useful. (Example: the sextant, which helps ships determine their locations at sea, but depends upon the falsehood that the Earth is at the center of the solar system.)
- So: all three theories have problems; still widely debated. But the correspondence theory is the most intuitive, esp. when couched in modest metaphysical terms a la Goldman.

What Ought We to Believe? The Ethics of Belief

- Clifford: "It is wrong always, everywhere, and for anyone, to believe anything upon insufficient evidence."
- James: "Our passional nature not only lawfully may, but must, decide an option between propositions, whenever it is a genuine option [i.e., living, forced, and momentous] that cannot by its nature be decided on intellectual grounds; for to say, under such circumstances, 'Do not decide, but leave the question open' [which is what Clifford recommends] is itself a passional decision – just like deciding yes or no – and is attended with the same risk of losing the truth."
- James' idea: whatever *belief policy* one pursues (Believe only proven truths; Believe in accordance with the evidence; Believe everything; Believe nothing; Believe whatever makes you feel good; etc.), one runs a *risk*. Clifford runs the risk of missing truths, while James runs the risk of gaining falsehoods. James: Each person is *entitled to choose his/her own form of risk*. "Dupery for dupery…"
- The Philips reading discusses the Clifford/James debate.

Philips (2)

- "Faith-based belief is, by definition, belief without evidence."
- "Since what we believe affects others, belief is an *ethical* matter." (This is emphasized by Clifford too.) Hence the 'ethics of belief'.
- "The more the lives and welfare of others depend on the accuracy of our beliefs, the higher our standards of evidence should be."
- Philips' conclusion: "We are entitled to believe without evidence…subject to two strict requirements: the issues must be ones we can't decide on the basis of evidence and arguments… [and] our adopting the belief in question must present no significant risk or harm to others."
- Is Philips right? In general? With respect to scientific hypotheses and beliefs?

Relativism: What Is It?

- Note: speaking only of *epistemic* relativism.
- What is relativism, and what is the problem with it?

Relativism: What Is It? (2)

- *ER*: For any knowledge-claim *p*, *p* can be evaluated… only according to… one or another set of background principles and standards of evaluation $s_1,\ldots s_n$; and, given a different set… of background principles and standards $s'_1,\ldots s'_n$, there is no neutral… way of choosing between the alternative sets in evaluating *p* with respect to truth or rational justification. *p*'s truth and rational justifiability are relative to the standards used in evaluating *p*. (Siegel 1987, p. 6)
- That is:
- 1. Whether or not something counts as knowledge, or true, depends on the standards one uses to judge; and
- 2. There is no way to evaluate, or rationally prefer, alternative standards.

The Problem with Relativism

- Problem: Relativism is *self-referentially incoherent* or *self-refuting*, in that *defending* the doctrine requires one to give it up. Why?
- *Reflexivity*: applying the doctrine to itself is the problem. One way to articulate the problem:

The Problem with Relativism (2)

- *Instantiation*: *ER'*: *ER* can be evaluated…only according to… one or another set of background principles and standards of evaluation s_1,…s_n; and, given a different set… of background principles and standards s'_1,…s'_n, there is no neutral… way of choosing between the two (or more) alternative sets in evaluating *ER* with respect to truth or rational justification. *ER*'s truth and rational justifiability are relative to the standards used in evaluating *ER*.

The Problem with Relativism (3)

- Another way to articulate the problem:
- Insofar as she is taking issue with her non-relativist philosophical opponent, the relativist wants both (a) to offer a general, non-relative view of knowledge (and/or truth or justification), and assert that that general view – i.e., that knowledge is relative – is epistemically superior and preferable to its rivals;

The Problem with Relativism (4)

- and also (b) to deny that such a general, non-relative view is possible or defensible.
- The relativist needs to embrace *both* (a), in order to see her position both as a rival to, and, further, as epistemically superior to, the position of her non-relativist opponent; and (b), in order to honor the fundamental requirements of relativism.

The Problem with Relativism (5)

- But the mutual embrace of (a) and (b) is logically incoherent. For the embrace of (a) forces the rejection of (b):
- if relativism is the epistemically superior view of knowledge (i.e., (a)), then one general view of knowledge is both possible and defensible as epistemically superior to its rivals (contrary to (b)).

The Problem with Relativism (6)

- Similarly, the embrace of (b) forces the rejection of (a): if no general, non-relative view of knowledge is possible or defensible (i.e., (b)), then it cannot be that relativism is itself epistemically superior to its rivals (contrary to (a)).
- This argument strongly suggests that the assertion and defense of relativism is incoherent.
- One more way to couch the problem: *impotence*.

Relativism and Impotence

- The *assertion and defense* of relativism requires one to presuppose neutral standards in accordance with which contentious claims and doctrines can be assessed.
- But relativism denies the possibility of evaluation in accordance with such neutral standards.
- Thus the doctrine of relativism cannot be coherently defended – it can be defended only by being given up.
- Relativism is thus *impotent* – incapable of defending itself – and falls to this fundamental reflexive difficulty:

Relativism and Impotence (2)

- Defending relativism non-relativistically is logically impossible, in that any such defense must appeal to that to which the relativist cannot appeal except by giving up relativism;
- while 'defending' relativism relativistically is not *defending* it, i.e., providing any non-question-begging reason for thinking it to be in any way epistemically superior to non-relativism.

Dewey and Pragmatism

- Pragmatism: a philosophical movement encompassing pretty much the whole of philosophy, including metaphysics, epistemology, and most of the rest of the subject.
- Main theme: ideas, policies, proposals, beliefs, theories, etc., are *good* insofar as they're *useful, workable, and practical*, when *tested in experience by our actions and evaluated in terms of their consequences*.
- For example, the quality of a scientific theory is not a matter of the usual *theoretical virtues: evidential support, predictive power, fertility*, etc. (Kuhn's "good-making features": accuracy, consistency, scope, simplicity, fruitfulness.)
- Rather, a theory or belief is good just insofar as it produces desirable consequences.
- Dewey made many important contributions to educational theory: his emphases on engaging the learner by taking account of their interests; the development of critical ("reflective") thinking and a "scientific attitude of mind" (Hitchcock *SEP*); the importance of student self-direction, activity and experimentation; etc.
- But here we'll focus on the course reading.

Dewey (2)

- Dewey: criticizes the "quest for certainty" manifest in older philosophies of science in favor of "experimental empiricism".
- Note: Every philosopher of science considered thus far similarly rejects certainty.
- Dewey equates *uniformity*, *fixity*, and *certainty*. These are not equivalent.
- In denying any "final certainty" (p. 118), he seems to be denying the Principle of Uniformity of Nature (PUN) discussed by Hume. Is he solving Hume's problem or simply ignoring it?
- "The authority of thought depends upon what it leads us to through directing the performance of operations." (137)
- "…ideas are worthless except as they pass into actions which rearrange and reconstruct in some way…the world in which we live." (138)
- Dewey's emphasis on 'operations' and experiments presupposes PUN.

Dewey (3)

- PUN doesn't require certainty, or necessity, but rather uniformity. These are not equivalent.
- He also *psychologizes* by criticizing theories (e.g. Newton's) on the basis of the psychological needs (fear) of the theorist . This is a clear and elementary philosophical error, in effect saying that a belief is bad because of the psychological motivation of the believer.
- But why S believes that p is one thing; whether or not p enjoys evidential support and so is worthy of belief is quite another.
- (Note: the same mistake is often made concerning Descartes. Even if it's true that Newton's and Descartes' theories were motivated by fear of lack of certainty, so what?)
- More importantly, it completely disregards science's quests for *explanation* and *understanding*. Are these really "worthless" if they don't yield positive consequences?
- Morris Cohen: Dewey "stressed the value rather than the dignity of thought."