The Rationality of Science in Relation to its History

Sherri Roush
Professor, Department of Philosophy
Chair, Group in Logic and the Methodology of Science
U.C. Berkeley

Pessimistic Induction (PI)

“Optimism about the Pessimistic Induction,” in *New Waves in Philosophy of Science* (2010).

“The Rationality of Science in Relation to its History,” in *Kuhn’s Structure of Scientific Revolutions*: *50 Years On,*” BSPHS, 2014.

The Objective

The Pessimist needs an Induction.

1. He needs an argument, not merely counterexamples.
2. **Induction requires a similarity base**:

All **swans** I’ve seen are white.

— — — — — —

All **swans** are white.

The Pessimist needs an Induction.

1. He needs an argument, not merely counterexamples.
2. **Induction requires a similarity base**:

All **swans** I've seen are white.

— — — — — —

All **paper towels** are white.

The Pessimist needs an Induction.

1. He needs an argument, not merely counterexamples.

2. Induction requires a similarity base:

All swans I’ve seen are white.

— — — — — —

All swans are white.

Cross-induction (Reichenbach)

If there is a property X that is relevant to the conclusion property, and X is not uniform between data- and target- populations, the inference is undermined.

E.g. There is often color variation within the same species in different habitats. (X = habitat)

The Pessimist needs an Induction.

1. He needs an argument, not merely counterexamples.

2. Induction requires a similarity base.

3. The similarity base must not be trumped by available evidence of a more specific property plausibly relevant to the conclusion property.

   (No available cross inductions.)

Underdescription of the evidence and the target of the hypothesis can hide the irrelevance of the evidence to the conclusion.

Similarity base between past and present science?

Suppose predecessor scientists’ conclusions were wrong a lot.

Why is that relevant to our conclusions?

Why is the failure of the ***theory of bodily humors*** relevant to whether we should be confident in ***Quantum Mechanics***?

Similarity base between past and present science?

Suppose predecessor scientists' conclusions were wrong a lot.

Why is that relevant to ours?

Sometimes it *is* the same subject matter.

And similar theories: *Newton's theory* and *QM* share a core of structural similarities.

Similarity: content of claims about world

Was our predecessors' ***evidence*** similar to ours in content?

Either supportive, counter-evidence, or irrelevant to our theories.

→ At worst our theory is false because of particular counter-evidence, not because of an *induction* over the history of science.

Were their ***theories*** similar to ours in content?

→ If their theories were false, and we retained the false parts, then our theories are false too, but that's not an induction. If their theories were true and ours are similar then not pessimism.

Similarity: content of claims about world

Was our predecessors' ***evidence*** similar to ours in content?

Either supportive, counter-evidence, or irrelevant to our theories.

→ At worst our theory is false because of particular counter-evidence, not because of an *induction* over the history of science.

Were their ***theories*** similar to ours in content?

→ If their theories were false, then if there's the right kind of similarity, ours are false, but that's not an induction. If their theories were true, and ours are similar then that's not pessimism.

$\Rightarrow$ **Either not an induction or not pessimistic**

Similarity base?

Our predecessors were ***doing science,*** had beliefs that were ***justified relative to their evidence*** and were often wrong**.**

— — — — — —

We who are ***doing science***, and have beliefs that are ***justified relative to our evidence***, are likely often wrong.

Similarity base?

Our predecessors were ***doing science in a justified way*****,** and their theories were often wrong (= they were unreliable)**.**

— — — — — —

We who are ***doing science in a justified way*** are likely often wrong.

The justifiedness they had and we have must be *similar*.

Otherwise no induction.

2nd Order properties

"justified relative to available evidence"

"unreliable"

These are properties of beliefs, not of the world the scientist is forming those beliefs about.

$\Rightarrow$ The pessimist's argument must have two parts.

Similarity base?

Our predecessors were ***doing science in a justified way,*** and their theories were often wrong. **(= they were unreliable)**

— — — — — —

We who are ***doing science in a justified way*** are likely often wrong **(= we are unreliable)**.

Unreliability is a property of *beliefs*, not of the convection currents in the interior of the Sun.

Why should learning about our beliefs have an effect on what we think about the interior of the Sun?

Whether we reliably *believe* this or that about the interior of the Sun doesn't make a difference to what the interior of the Sun is doing.

Pessimist’s argument must have two parts

their unreliability $\rightarrow$ our unreliability

$\downarrow$

withdrawal of confidence about the Sun’s interior.

Suppose their unreliability supports the claim that we’re unreliable. What would follow from that about the Sun?

Pessimist's argument must have two parts

their unreliability $\rightarrow$ **our unreliability**

$\downarrow$ **?**

withdrawal of confidence about the Sun's interior

Suppose their unreliability supports the claim that we're unreliable. What would follow from that *about the Sun's interior*?

Why Descend?
Calibration

It's good to be calibrated:

Confidence = Reliability

Degree of belief in q = reliability in q-like matters.

Subject is ***calibrated*** on q iff

$p(q/P(q) = x) = x$, for all x

➡ *If* the pessimist gives us reason to believe we are unreliable in q-like matters, then we should dial down our confidence in q.

Pessimist's argument must have two parts

?

their unreliability → our unreliability

↓

withdrawal of confidence about the Sun.

Suppose they were unreliable at getting true theories.

Does induction give us that we likely are unreliable too?

Pessimist's argument must have two parts

?
their unreliability → our unreliability

↓

withdrawal of confidence about electrons.

Suppose they were unreliable at getting true theories.

Does induction give us that we likely are unreliable too?

Why think we are justified (relative to our evidence) *similarly* to the way our predecessors were?

Similarity base?

Our predecessors were ***doing science in a justified way,*** and their theories were often wrong. (= they were unreliable)**.**

— — — — — —

We who are ***doing science in a justified way*** are likely often wrong.

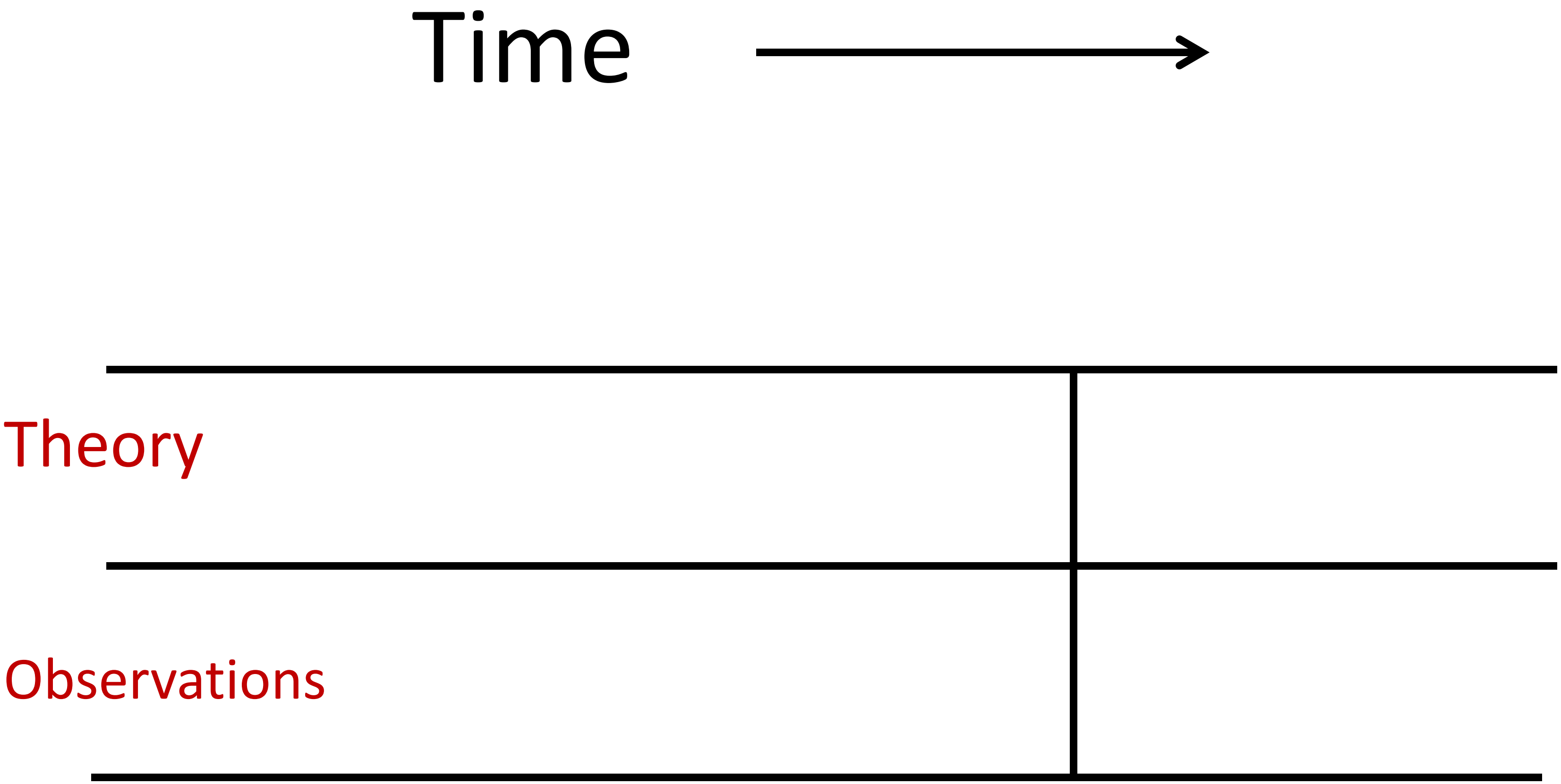
(= we are unreliable)

Everyone uses **The Scientific Method**!

Cross-Induction on Method

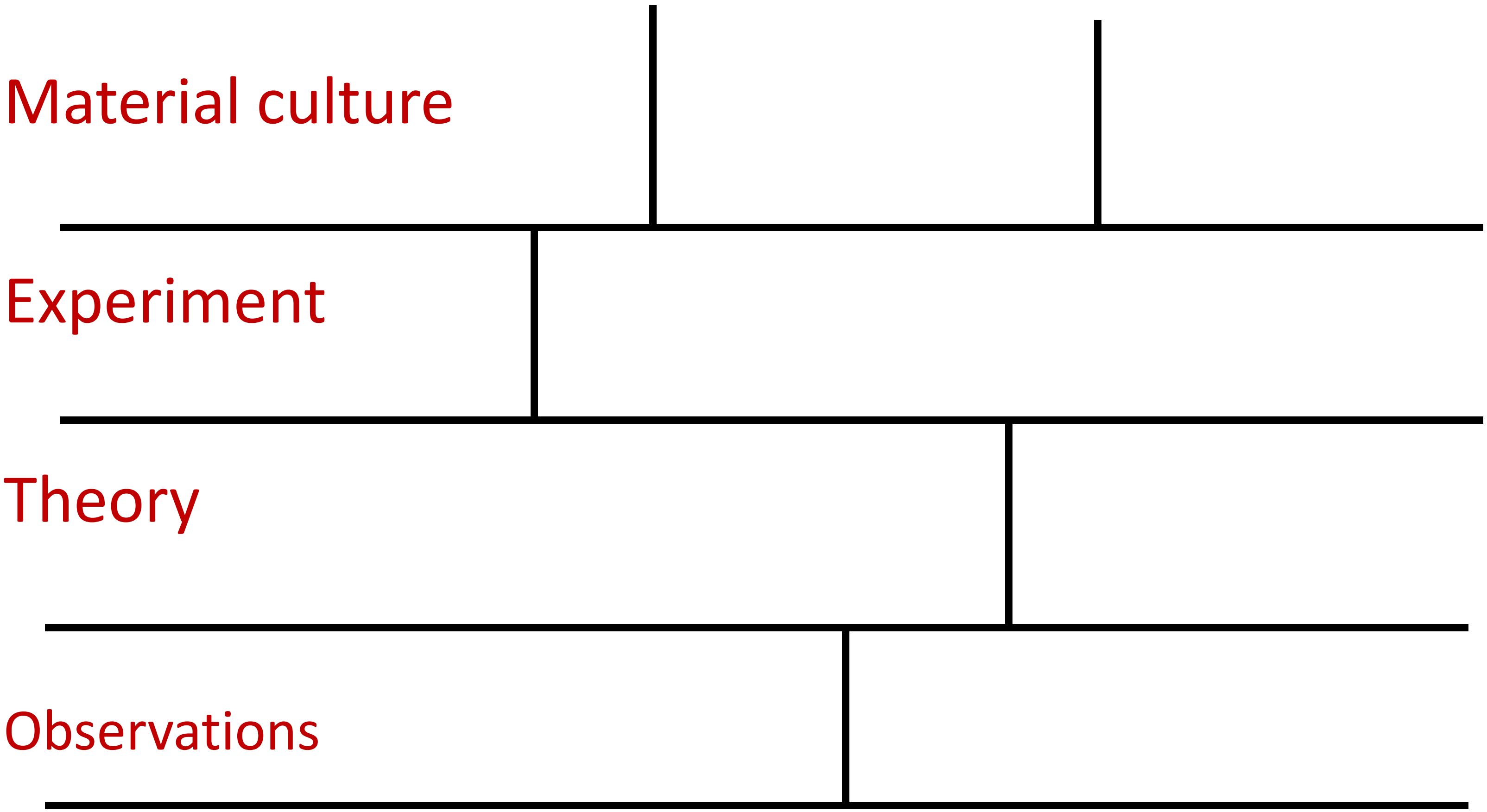
We use methods that are different from those of our predecessors in ways that are relevant to reliability.

Underdescription of scientific method hides irrelevance of many past scientific failures to our legitimate confidence in our hypotheses.



Paradigm Shift Problem: What is there that can be a neutral arbiter and tell us why it is rational to change theories?

Intercalation (PLG)



It’s not just that “the paradigm changes”. There are more specific levels of description that show lots of continuity.

Methods

Specific machines *more specific*

Specific materials

Specific experimental designs

Specific questions

Psychology, biology, physics

AIC, BIC, computational methods, etc.

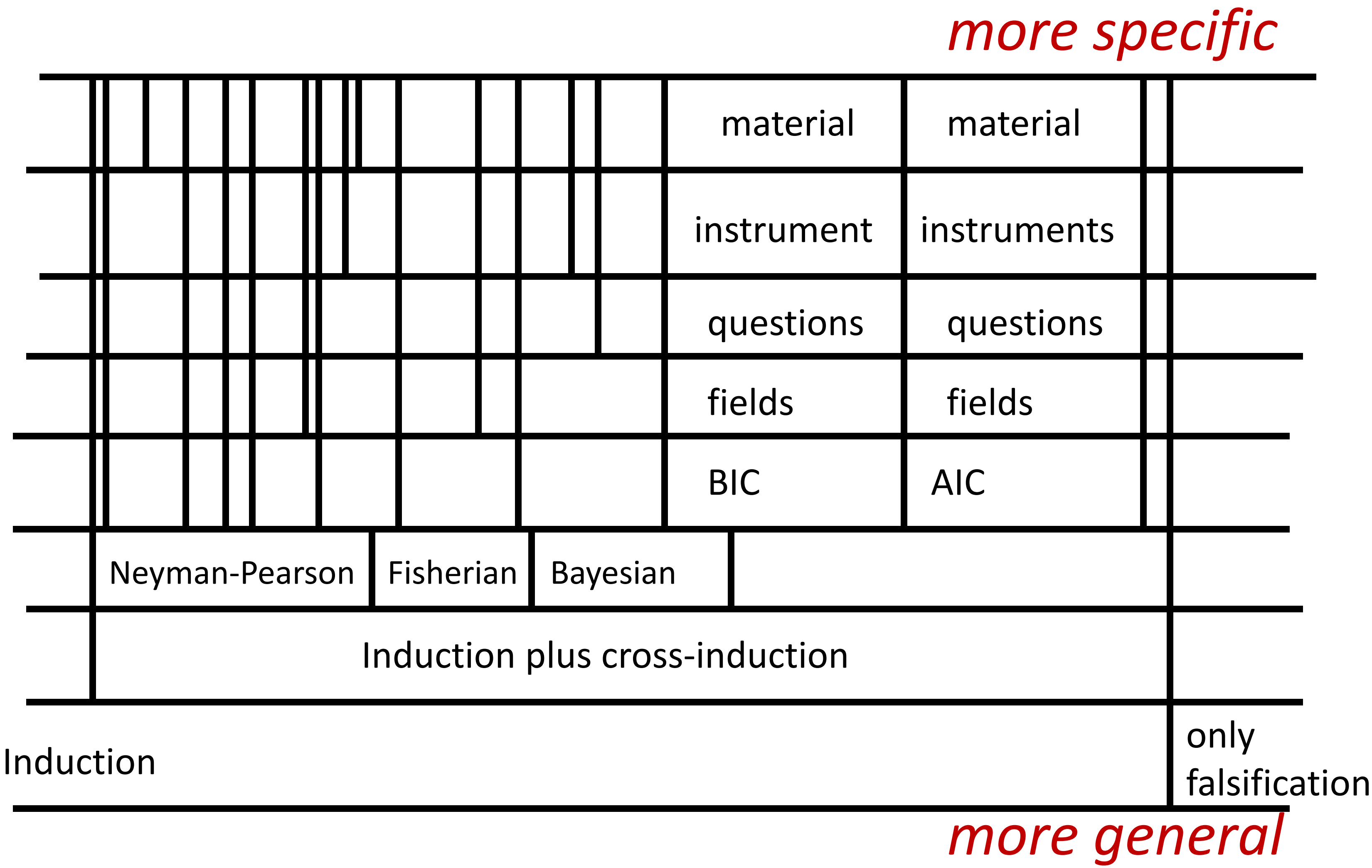
Neyman-Pearson, RCT, Fisherian, Bayesian

Next case, universal generalization, cross-induction

Induction (non-deductive), only falsification

more general

What is the scientist doing?



Unconceived Conceivables

F = People were subject to unconceived conceivables.

G = People were unreliable, mostly wrong (about unobservables).

All previous F were G.

==================

All F (including us) are G.

Unconceived Conceivables

F = People were subject to unconceived conceivables.

G = People were unreliable, mostly wrong (about unobservables).

X = Remaining cases (we) use different methods, ***methods relevant to how reliable one is when faced with a possibility space of unconceived alternative theories***. We can rule out alternatives without conceiving them. We can rule out alternatives faster, top-down, infinite sets of them at a time.

All previous F were G.

X

==================

All F (including us) are G.

Another Pessimistic Induction?

Again and again, an apparently spiffier method wasn't good enough to make our predecessors reliable.

Infer:

Generally *method is not relevant to reliability*.

Another Pessimistic Induction?

Again and again, an apparently spiffier method wasn’t good enough to make our predecessors reliable.

Infer: Generally *method is not relevant to reliability*.

REPLY:

Why use induction here rather than counter-induction?

This argument is self-undermining. The conclusion undermines the rule used to get to it.

Too good to be true?

Surely *something* is right about the pessimistic induction.

Calibration and Re-calibration

Cal (synchronic constraint)

$$P(q/P(q) = x \,.\, \mathcal{p}(q/P(q) = x) = y) = y$$

Re-Cal (diachronic constraint)

$$\mathbf{P_f(q) = P_i(q/P_i(q) = x \,.\, \mathcal{p}(q/P_i(q) = x) = y) = y}$$

To be *s-calibrated* is for one's confidence in q to match one's rational confidence in one's reliability about q. (x = y)

To *re-calibrate* is to update one's confidence in light of information about one's reliability. (x → y)

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To be *s-calibrated* is for one's confidence in q to match one's rational confidence in one's reliability about q. (x = y)

To *re-calibrate* is to update one's confidence in light of information about one's reliability. ($x \rightarrow y$)

Definition:

P(q) = x if and only if

subject's rational degree of belief in q is x

Fallibility

$\mathbf{P}(q_1), \mathbf{P}(q_2), \mathbf{P}(q_3), \ldots \mathbf{P}(q_5)$ each = 100%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_5)$ = 100% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_5)$ = 0% (at least one false)

Fallibility

$\mathbf{P}(q_1), \mathbf{P}(q_2), \mathbf{P}(q_3), \ldots \mathbf{P}(q_5)$ each = 99%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_5)$ = 95% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_5)$ = 5% (at least one false)

Fallibility

$\mathbf{P}(q_1)$, $\mathbf{P}(q_2)$, $\mathbf{P}(q_3)$, … $\mathbf{P}(q_{16})$ each 99%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{16})$ = 85% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{16})$ = 15% (at least one false)

Fallibility

$\mathbf{P}(q_1), \mathbf{P}(q_2), \mathbf{P}(q_3), \ldots \mathbf{P}(q_{40})$ each = 99%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{40})$ = 73% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{40})$ = 27% (at least one false)

Confidence in conjunction drops fast with confidence in individual hypotheses.

$\mathbf{P}(q_1)$, $\mathbf{P}(q_2)$, $\mathbf{P}(q_3)$, … $\mathbf{P}(q_{16})$ each = **95**%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{16})$ = 43% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{16})$ = 57% (at least one false)

What is a theory like the Standard Model?

Perhaps you can write it as a small set of independent axioms, but that has no empirical consequences without substantive auxiliaries.

Huge Conjunction

$\mathbf{P}(q_1)$, $\mathbf{P}(q_2)$, $\mathbf{P}(q_3)$, … $\mathbf{P}(q_{10,000})$ each 99%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{10,000})$ 35% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{10,000})$ 65% (at least one false)

Huge Conjunction

$\mathbf{P}(q_1)$, $\mathbf{P}(q_2)$, $\mathbf{P}(q_3)$, … $\mathbf{P}(q_{\mathbf{1,000,000}})$ each = 99%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{\mathbf{1,000,000}})$ = 15% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{\mathbf{1,000,000}})$ = **85% (at least one false)**

Huge Conjunction

$\mathbf{P}(q_1), \mathbf{P}(q_2), \mathbf{P}(q_3), \ldots \mathbf{P}(q_{\mathbf{1,000,000}})$ each = **95**%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{\mathbf{1,000,000}})$ = 4% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{\mathbf{1,000,000}})$ = **96**% (at least one false)

High confidence in particular hypotheses (about unobservables) is consistent with (*demands*) high doubt about the truth of a sufficiently general theory that implies these hypotheses.

High doubt that *the theory is true* is consistent with high confidence in many, many particular claims it implies (even about unobservables).

Conformably it happens that the pessimistic induction also has a stronger effect at the level of high theory.

Consider what we can say about the methods used to test *The Standard Model*.

It will have to be things that all the methods for testing its implications have in common. These are necessarily less specific than the features of each method (bubble chamber, spark chamber, SLAC, LHC, …) used on a particular hypothesis.

We have less to draw on to counter a pessimistic induction for high theory.

Alternative histories

Same current situation of evidence and theories, but

History of past failures

vs.

History of past successes

Alternative histories

Same current situation of evidence and theories, but

History of past failures
vs.
History of past successes

Surely that makes a difference to what we are entitled to believe about our theories.

Alternative histories

Same current situation of evidence and theories, but

History of past failures

vs.

History of past successes

These histories can’t lead to the same current situation with regard to particular evidence for our theories.

5. – 6.

-- The pessimistic induction is susceptible to a cross-induction on method.

-- Whether there is a cross depends on the case, and is a question the good scientist already addresses.

-- High confidence in particular hypotheses is consistent with extremely low confidence in their conjunction (in high theories).

-- There is a covariation between this and a hypothesis's susceptibility to the pessimistic induction (via less resources for cross-induction).

-- Conjecture: the pessimistic induction doesn't add anything to where scientists already end up when focusing on specific hypotheses and evidence.

Objection

In order to do the cross-induction the scientist must have reason to believe her new method has a better reliability than the old one for distinguishing true from false theories.

She must show that the difference in method matters to confirming *unobservables*.

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No, she must show that Gallium is more likely to catch low energy neutrinos than Chlorine is.

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She must show that the difference in method matters to confirming *unobservables*.

No, she must show that Gallium is more likely to catch low energy neutrinos than Chlorine is.

You may argue she can't do that in principle because you can never get unobservables from observables, but that requires a very different argument than the pessimistic induction.

Horizontal vs. Vertical Induction

Unobservables (theories)

↑

Observations

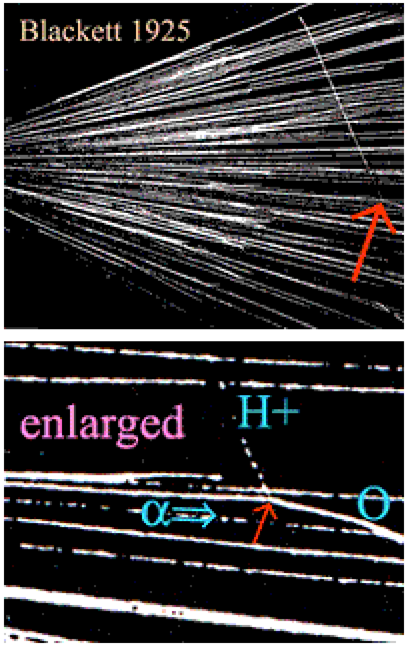
Observations → Observables

proton

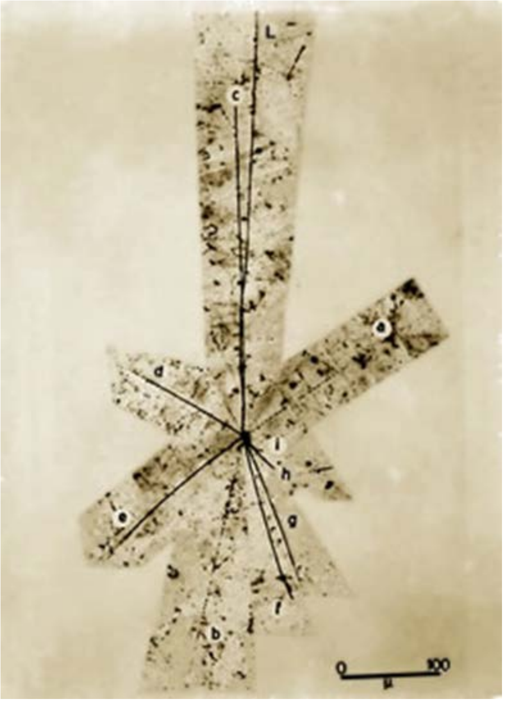
6.2 GeV

Nitrogen

Liquid Hydrogen



Cloud Chamber



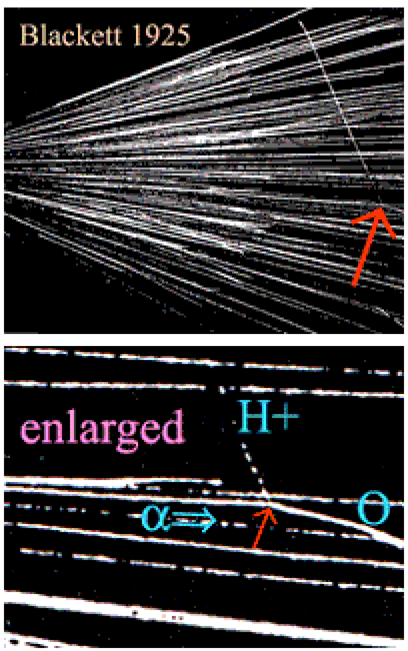
Bevatron

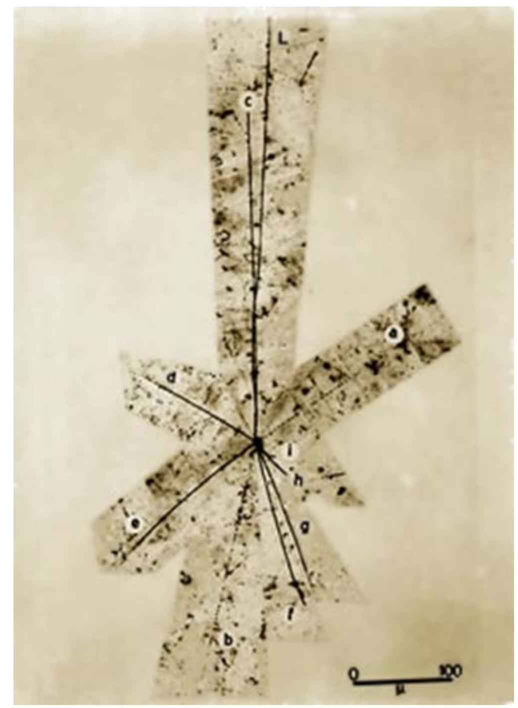
proton

6.2 GeV

Nitrogen

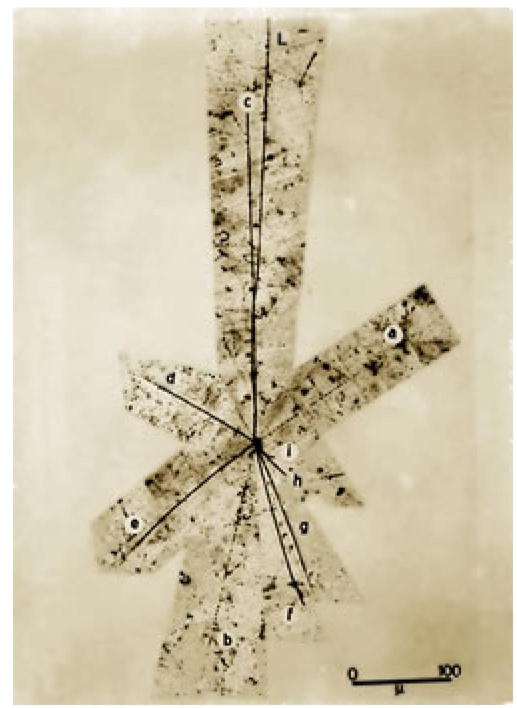
Liquid Hydrogen





Cloud Chamber

Bevatron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Girls can't WHAT?

Fallibility

$\mathbf{P}(q_1), \mathbf{P}(q_2), \mathbf{P}(q_3), \ldots \mathbf{P}(q_{1,000})$ each very high

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_{1,000})$ very low

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_{1,000})$ very high

Pessimist's argument must have two parts

their (un)reliability → **our (un)reliability**

↓

withdrawal of confidence about electrons.

Re-Cal (diachronic constraint)

$$P_f(q) = P_i(q/P_i(q) = x \,.\, p(q/P_i(q) = x) = y) = y$$

End.

Pessimist needs:

(Letting F = uses scientific method, G = unreliable)

their unreliability → our being unreliable

↓

withdrawal of confidence in QM.

Pessimist needs:

(Letting F = justifiably believes, G = unreliable)

their unreliability → our being unreliable

↓

withdrawal of confidence in QM.

Now: Were we to show we're unreliable, what would follow from that?

Unreliability is a property of *beliefs*, not of electrons and muons.

Why does learning about it have any relevance to our beliefs about electrons and muons?

Whether we (reliably) believe electrons have spin is not relevant to whether they have spin.

Why Descent?
Calibration

Because it’s good to be calibrated:

Confidence = Reliability

Degree of belief in q = reliability in q-like matters.

→ *If* the pessimist gives us reason to believe we are unreliable in q-like matters, then we should dial down our confidence in q.

Subject is ***calibrated*** iff

$$PR(q/Pr(q) = x) = x$$

confidence matches reliability.

New rule of conditionalization:

$$Pr_f(q) = Pr_i(q/Pr_i(q) = z \,.\, PR(q/Pr_i(q) = z) = x) = x$$

Calibration and Re-calibration

Cal (synchronic constraint)

$$P(q/P(q) = x\ .\ \mathit{PR}(q/P(q) = x) = y) = y$$

Re-Cal (diachronic constraint)

$$\mathbf{P_f(q) = P_i(q/P_i(q) = x\ .\ \mathit{PR}(q/P_i(q) = x) = y) = y}$$

To be *calibrated* (here) is for one's confidence to match one's believed reliability. (x = y)

To *re-calibrate* is to update one's confidence in light of information about one's reliability. (x → y)

Advertisement

“Second Guessing: A Self-Help Manual,” *Episteme* (2009)

Coming soon

“Rational Self-Doubt: The Re-Calibrating Bayesian,” manuscript

Justified Belief

Reasons vs. Causes

Traditional Justified Belief

1. The justifiers (e.g., evidence) of the belief are possessed by the ***individual***.

2. The justifiers and the reasons they are justifying must be ***consciously available***. Subject could give an argument.

3. The subject is ***accountable*** for the belief.

4. The subject is **checking** *herself*.

Justified Belief: what we really want

1. The justifiers of the belief (e.g., evidence) are possessed by the ***individual***.

2. The justifiers and the reasons they are justifying must be ***consciously available***. Subject could give an argument.

3. The subject is ***accountable*** for the belief.

4. The subject is checking *herself*

= self-monitoring and self-correcting belief

Justified Belief

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2. The justifiers and the reasons they are justifying must be ***consciously available***. Subject could give an argument.

3. The subject is ***accountable*** for the belief.

4. The subject is **self-monitoring, self-correcting belief**.

Mistake: Thinking 1 and 2 are necessary for 3 and 4.

Calibration and Re-calibration

Cal (synchronic constraint)

$$P(q/P(q) = x \,.\, \mathit{PR}(q/P(q) = x) = y) = y$$

Re-Cal (diachronic constraint)

$$\mathbf{P_f(q) = P_i(q/P_i(q) = x \,.\, \boldsymbol{\mathit{PR}}(q/P_i(q) = x) = y) = y}$$

To be *calibrated* (here) is for one's confidence to match one's believed reliability. (x = y)

To *re-calibrate* is to update one's confidence in light of information about one's reliability. (x → y)

Conclusions

The specific and discontinuous parts of methods, and the factual history of beliefs

are relevant, in the *normative* sense, to whether beliefs are justified.

Rational
Self-Doubt

Artist: Stan Welsh
Stan Welsh.com

$$P_f(q) = P_i(q/P_i(q) = x \,.\, \mathit{PR}(q/P_i(q) = x) = y) = y$$

Several things to say about this move:

1. It's a move to *general*izations about us and them. Similarity base is what we do to come to beliefs and what they did.

2. It's a move to method.

3. It's a move to the second-order.

2 and 3 lead to serious problems for the argument. Suppose we succeeded in an induction from their unreliability to ours. So, we have evidence that we are unreliable. Why should that make us revise our confidence in our hypotheses *about gluons*? Evidence about us is not evidence about gluons. Pessimist needs an answer to the question why descend, and how? Here's where other work of mine helps the pessimist where no one else does *or will*. It's the right thing to do so we do it. Now back to the induction from them to us (2). Why is their unreliability a reason to take ourselves to be unreliable?

Similarity base?

Our predecessors were ***doing science in a justified way,*** and their theories were often wrong (= they were unreliable)**.**

— — — — — —

We who are ***doing science in a justified way*** have good reason to drop our confidence in our theories.

Everyone uses **The Scientific Method**!

Methods, Rules, Generality: Good

1. Reliability means you have a *way* of getting it right repeatedly.

2. Contra Mach, and Popper, our *conclusions* say more than the data right in front of us.

3. More evidence (with same result) yields more justification of your conclusion.

4. Doing something different every time is associated with ad hockery.

5. Scientists often do the same procedure repeatedly.

Cross-Induction on Method

Underdescription of scientific method will undermine science.

We use methods that are different from those of our predecessors in ways that are relevant to reliability.

Our Predecessors – a new similarity

They could also cross the induction from their predecessors to them: they used different methods from their predecessors.

(Yes, and that's one reason we think of them as in some sense justified.)

We're similar to them in being able to make this induction, and they were wrong/unreliable!

We're similar to them in this, but also relevantly different: we have different theories, evidence, use different methods.

Fallibility

$\mathbf{P}(q_1)$, $\mathbf{P}(q_2)$, $\mathbf{P}(q_3)$, … $\mathbf{P}(q_5)$ each 99%

$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_5)$ 95%

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_5)$ 5%

Fallibility

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$\Leftrightarrow$

$\mathbf{P}(q_1 \wedge q_2 \wedge q_3 \wedge \ldots \wedge q_5)$ 95% (all are true)

$\Leftrightarrow$

$\mathbf{P}(-q_1 \vee -q_2 \vee -q_3 \vee \ldots \vee -q_5)$ 95% (at least 1 false)

New rule of conditionalization:

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