PHIL 890-1 Seminar on the Philosophy of Experimentation F2009

San Francisco State University
Time: Mon. 1900-2145   Location: HUM 381

<check class schedule for possible location change>

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SYLLABUS

The general topic of this seminar is the practice of experimentation in the sciences, with special attention to the entanglement of theory, models, and experiments.

Philosophers of science have traditionally been interested especially in general theories, but lately the attention has shifted to conceptual problems that relate to measuring, experimenting and modeling, and how these practices act as mediation between scientific theories and the studied natural phenomena. We will engage the controversies in this subject with reference to a number of examples of sustained experimentation in the history of science as well as in recent scientific research.

- The main textbook is Hans Radder, *The Philosophy of Scientific Experimentation*, but additional lecture material and associated readings will be available electronically on this site and on iLearn.
- **Course requirements:** There will be a strong emphasis on class participation, which includes both presentations and preparation for in-seminar discussion (35%). There will be a paper due in the 5th seminar session (see the details below; 30%) and a final paper (NEW DATES: draft due on Wednesday Dec. 2, 10%; revised final version due Monday Dec. 21, 25%).

(In the readings listed below, the notation “[Radder]” indicates that the source is a chapter in *The Philosophy of Scientific Experimentation*)

Aug 31. SESSION 1. GENERAL INTRODUCTION: what about experiments and experimentation?

An overview of topics and issues to be taken up in the seminar as a whole.

An introduction, with examples, to the use of experimentation and models in the sciences, and to the varying philosophical views on what experiments are and how they play a role in scientific practice.

Suggested Reading:
[A] Hasok Chang and Nancy Cartwright, "Measurement"

[B] Ian Hacking, On the Stability of the Laboratory Sciences

The paper by Hacking is part of a symposium that will be discussed in the 2nd seminar session. Questions for discussion concerning Hacking's paper:

- One idea suggested in the sections "Stability" and "Maturity and Stability" is that older, officially superseded, theories remain "right" ("true") for accounts of phenomena in their own 'domain'. What could be the relation between the domains of that series of successively created theories, each superseding the previous ones, that could support this suggestion? How can we understand "right" here?
- Hacking's numbered elements (5)-(7) pertain to data -- is there any leeway in this description for the question of which data are *relevant* or *significant*?
- Hacking refers to 'Duhem's Thesis' (sometimes called the "Duhem-Quine Thesis"), namely "that, if an experiment or observation is persistently inconsistent with a systematic theory, you need not abandon the theory, for in principle you can revise the theory of the instrument". Hacking strengthens this by attributing "plasticity" to every one of the 8 sorts of elements he found in experimentation. Does this raise difficulties for his *stability* thesis?

<note: Monday Sept 7 Labor Day holiday>

Sept. 14 SESSION 2. GENERAL INTRODUCTION: philosophy of science in the 20th century

[A] Discussion continued from 1st session, concerning experimentation.

Assigned Reading:

A Symposium on the Philosophical Significance of Experimentation -- APA (East) 1988
[1] Ian Hacking, On the Stability of the Laboratory Sciences
[2] Patrick Heelan, Experiment and Theory: Constitution and Reality
[3] Peter Galison, Philosophy in the Laboratory

[B] Background of our subject in 20th century philosophy of science

Philosophy of science itself went through some revolutionary changes during the twentieth century, reflected in changing views of theories, models, and modeling. Today we will survey this background to our present concerns.

To begin, the 'received view' (loosely associated with logical positivism and logical empiricism, which flourished ca. 1920-1960) did not involve any essential differentiation between observation and experimentation. Models were mainly viewed as heuristic devices to aid theorizing.

This was replaced by the 'semantic view' that regards a theory itself as the presentation of a range of models and introduced the distinction between theoretical models and data models derived from experimentation.

Finally, both the 'received' view and the 'semantic' view were followed most recently by new approaches that shifted the emphasis from theory and models to scientific practice, including today's concern with the entangled activities of modeling and experimentation. The readings below present, as background to today's concerns, the shift from the 'received' to the 'semantic' view that happened some decades ago.

Assigned Reading:

Hilary Putnam, "What theories are not" (1962) This is a paper at the cusp: it criticizes the received view, and insists on a more realistic attitude toward the understanding of the language of science. But it is still written -- a bit frustratingly, for today -- with such a concentration on issues of language, that it has not yet escaped from the confines of that framework.

BvF, "Theories and models" -- a brief introduction to the advent of the semantic approach

BvF, "Theorizing and experimenting" -- how these activities look from within the semantic approach

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Sept. 21 SESSION 3. "An experiment in physics is not simply the observation of a phenomenon" (Duhem)

Topics and Assigned Reading:

[1] **Galileo Galilei**, the Leaning Tower: experiment as means of gaining knowledge versus experiment as demonstration

Read: Chapter 2 of *The Prism and the Pendulum* which includes Robert Crease's distinction between genuine experiments and 'demonstration[experiment]s'
Read: Galileo Galilei, selection from *Two New Sciences*, on falling bodies

Questions:

What was Aristotle's account of falling bodies?
What were the conceptual difficulties with Aristotle's account?
How did Stevin, Galileo et al offer empirical evidence against Aristotle's account?
Was anything more than simple observation involved in gaining this evidence?
What new questions for scientific investigation were suggested by the results?
When is the reproduction of an experiment itself an experiment and when is it merely *demonstration*?
An experiment, unlike a demonstration, is conducted to acquire new knowledge or information -- but of what sort? Consider both the theoretical/practical and theoretical/observational distinction.

[2] **Pierre Duhem**, how theoretical interpretation is involved in experimentation from the very beginning
Read: Chapter 4 of Part II of Duhem, *The Aim and Structure of Physical Theory*
Questions:

Why is it not right to think of 'doing an experiment' as simply 'producing a phenomenon under conditions where it may be observed and inspected with instruments'?
Is there a part to the procedure followed in an experiment that can be done without any knowledge of science?
When an experiment is designed, to answer a question, can that question [ever, sometimes, rarely] be understood without any knowledge of science?
What is the result of an experiment? (distinguish the result from reports of the result; think of specific examples)
How does the technical language of the scientist differ from the technical language of a business, trade, or other practical activity?
Why does Duhem conclude that theoretical interpretation of phenomena is required for the possible use of instruments?

Additional Reading Suggested for this Session

Hans-Jörg Rheinberger, *Toward a History of Epistemic Things*

Chapter One. "After All: an Epistemology of the Beginning"

Chapter Two. "Experimental Systems and Experimental Things"

Sept. 28 SESSION 4. Harré and Bohr's view of experimentation

Topic and Assigned Reading:

[1] Rom Harré [Radder**] "***The materiality of instruments in a metaphysics for experiments***" [only sections 1, 3, and 5]**
[2] Niels Bohr, Excerpt from "Discussion with Einstein" and from "On the notions of causality and complementarity"
[3] Karen Barad, Excerpt from *Meeting the Universe Halfway*
[4] Joseph Rouse, Excerpt from *How Scientific Practices Matter*

Questions:

Does Harré's answer to "what is an experiment?" differ significantly from Duhem's
What is Harré's distinction between instrument and apparatus? is there a sharp line to be drawn?
What exactly is 'back inference', what forms can it take, how does it work?
Harré distinguishes two cases in experimentation: "a domesticated, simplified version of a material set-up found also 'in the wild'"
and another kind for which he gives the slogan "ice-cream does not occur in nature". Do the examples he gives show
that this is a principled, clear distinction? Did the concept of experimenting change so as to allow the
creation of new phenomena in an experiment, or was this an inessential broadening of experimental practice?

Compare Harré's account of Bohrian experimentation with Bohr's own text.
Recall Ian Hacking, "On the Stability of the Laboratory Sciences" which was discussed in the first session.

- Hacking begins with a short description of laboratory science as where "we investigate nature by the use of apparatus in controlled environments, and are able to create phenomena that never or at best seldom occur in a pure state before people have physically excluded all "irrelevant" factors." How does this compare to Harré's concept of an experiment?
- Hacking distinguishes "apparatus" and "instrument". How is his distinction related to Harré's?

Oct. 5 SESSION 5. Discussion: history of the experiments leading up to "PV=rT"

- **Explanation of the manometers used by Boyle and Dalton PDF document**

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Paper assignment due today, for the following Assigned Readings and accompanying questions:

1. **Robert Boyle's original Experiment**
2. **John Dalton's experiment on thermal expansion**

   [note: Dalton's work is not often mentioned because it was superseded by the much more precise and extensive research of Gay Lussac, on the same subject]

3. **Gerald Holton, discussion of this history and surrounding theories**

Questions:

Background theory: this is not usually made explicit in the experimental report. Identify in Boyle's and Dalton's account some relevant facts that they take for granted as already established in science, and on which they rely.

Identify instruments and apparatus, distinguished in the sense of Harré, in these experiments

Indicate what is classified as the *materiel* by Hacking, distinguishing target, apparatus (in his sense), and detector, in these experiments

To what extent does theory enter into the reports of the results by Boyle, by Dalton? Does theory only enter in the discussion of what sorts of models fit the behavior of gas under these varying conditions? Do these examples bear out, or throw doubt on, Duhem's contention that theoretical interpretation plays a role throughout?

Identify the initial question of each experiment and how it determines which data are relevant, are to be collected, to answer the question -- and discuss critically what Harré calls the back inference from the experimental result

Additional Suggested Reading for this Session:

4. Hans-Jörg Rheinberger, *Toward a History of Epistemic Things*

Chapter Five. "Reproduction and Difference"

Chapter Nine. "Conjunctures, Hybrids, Bifurcations, Experimental Cultures"

Oct. 12 SESSION 6. Varying conceptions of theory-ladenness in experimentation

Topics and Assigned Reading:

[1] Michael Heidelberger, [Radder] "Theory-ladenness and scientific instruments in experimentation" **Section 1 only.**
(Section 2 postponed to session on instrumentation)

Questions:

Is the discussion of *perception* helpful for the topic of how theory is involved in experimentation?
How do Hanson's, Duhem's, and Kuhn's views of theory-ladenness differ from each other?
Does being 'theory-guided' consist simply in reliance on 'background theory'?
Discuss Heidelberger's contention that even if all experimentation were theory-guided, that would not entail that observations of experimental results are theory-laden,
for it does not imply any connection between the meaning of observational terms and the meaning of the theory that guided the experiment.

[2] Hans Radder, [Radder]"Technology and theory in experimental science"

Questions:

Radder argues for the irreducibility of the theoretical meaning of replicable experimental results, first of all by describing and criticizing the German constructivist school of Lorenzen, Janich, and Lange. What is his main objection, and how weighty is it?
How does Radder distinguish reproducibility and replicability?
How, why, and when does theoretical interpretation enter into the condition or requirement of replicability?
Radder contends that the essential step from experiment to theory is to ***disconnect*** theoretical concepts from the particular experimental processes in which they
have been realized so far, and that this disconnection bestows ***nonlocal*** meaning on those concepts -- what is meant by that?
Radder makes his claim, that theory-free experimentation is impossible, precise in the third and fourth claims examined in section 2.1. These two claims seem closely
related -- what, if anything, does either add to the other? And how well are they supported?

Additional Reading:
Joseph Rouse, "Two concepts of scientific practices"
from *How Scientific Practices Matter*, Chapter 5

Oct. 19 SESSION 7. Varying conceptions of theory-ladenness in experimentation

[1] Nancy Cartwright, *The Dappled World: a Study of the Boundaries of Science* Chapter 3, "Nomological machines and the laws they produce" **Part 1** - **Part 2**

Questions

- What is a nomological machine? ((top page 50) What notions must we already understand in order to understand the answer?
- What do we make of Cartwright's strong claim on page 58, bottom? She claims that whenever we can explain a regularity, the explanation provides a nomological machine. In addition, when we know a regularity that we don't think needs an explanation, that is because we already see it as a (simple) machine. So if nomological machines are rare in nature, then not much of what happens in nature is regular and orderly.
- Capacities – just what are they? The answer has to fit the ordinary examples ("I am irritable and my husband is inaccurate" – page 54) and also the notion of force (middle of page 52), and the discussion about dispositions or tendencies (p. 59ff).
- Cartwright rejects the demand on science that it should provide complete or completable theories, in a particular sense of "complete". What is this sense, and what sorts of reasons does she give for the rejection?

[2] Thomas Kuhn, "The Function of Measurement"

ADDITIONAL READINGS:

Thomas Kuhn, Excerpt from Ch. X of *The Structure of Scientific Revolutions*

Question:

what is your reaction to this statement by Kuhn: "until that scholastic paradigm was invented, there were no pendulums, but only swinging stones, for the scientists to see. Pendulums were brought into existence by something very like a paradigm-induced gestalt switch" (*Structure of Scientific Revolutions, Ch. X*, p.120)?

William Brewer and Bruce Lambert, "The Theory-Ladennessof Observation and the Theory-Ladennessof the Rest of the Scientific Process"

Oct. 26 STATE MANDATED FURLOUGH DAY

Nov. 2 SESSION 8.   Instruments, instrumentation, Instrumentarium

Topics and Assigned Reading:

[1] Michael Heidelberger, [Radder] "Theory-ladenness and scientific instruments in experimentation" **Section 2 only.**

Questions:

What differences are there between the four functions that Heidelberger ascribes to instruments (productive, constructive, imitative, representative)?
Heidelberger uses Ohm's experiment to illustrate these functions. What other simple illustrations can you suggest?

[2] Davis Baird,   [Radder] "Thing knowledge: outline of a materialist epistemology"

Questions:

At the outset, Baird suggests a comparison between words and artifacts, so as to support his view that things 'bear knowledge'. How good or strong is the analogy between the two? In what sense can we 'read' an artifact like a can opener or a vacuum cleaner? In what sense does the can opener 'bear knowledge' of what cans are like, that could be taken as analogous to the way a text like "cans are finite cylinders, made of thin metal, with a rim around the top and bottom" contains something we know about cans?
Working knowledge: what does Baird mean with this? Can a text bear working knowledge?
"Theories come and go, but a new instrumentally created phenomenon endures." How does this statement by Baird relate to his examples, where it seems that theoretical information is built into the things we make?

Nov. 9   SESSION 9.   Instruments, instrumentation, Instrumentarium

<u>Suggested additional reading</u>:

[1] Alan Chalmers, <u>"The theory dependence of the use of instruments in science"</u>

Questions:

- Atomic theory explains how an electron microscope works, specifies the conditions under which it functions properly, and interprets its output as providing information about structures at the atomic level (see quote from Kosso, p. 495). Does this by itself really pose the threat that evidential support for atomic theory is circular?

- Collins' "experimenter's regress" (mentioned p. 493): experimenters need to know whether their experiment is working, but all they can check is whether the results are or are not in accordance with theoretical expectations -- so it seems that they have to get the right answers in order to know that the experiment is working, but need to know that the experiment is working, to know that they are getting the right answer. Does this raise a serious skeptical doubt about scientific practice?
- On p. 505 Chalmers writes "Our example illustrates that experimental scientists have a whole arsenal of techniques for tackling any epistemological problems posed by the fact that the use of instruments are theory dependant." Besides arguments from coincidence (discussed in his next section), can you list other techniques that he found in this arsenal?
- At several points, Chalmers indicates that the coincidence (sense 1) between observation and predictions from a theory is used to support both the observations and the theory [e.g. p. 501], and considers this good practice, because the alternative that this result is a coincidence (sense 2!) is to be rejected. Is that rejection simply an instance of arguing that the best or only available explanation must be the true one?
- In section 5, are there serious qualifications to the 'argument from coincidence'?

[2] Hans Radder, "Experimenting in the natural sciences: a philosophical approach" [omit sections 4 and 7]

Questions:

- "The general idea is that some information about the object can be transferred to the apparatus by means of a suitable *interaction.* That is, the interaction should produce an (ideally complete) correlation between some property of the object and some property of the apparatus." (p. 58) Puzzle: in some cases, this could be checked with *alternative* ways of measuring each of these two properties separately; if there is an end to that checking process, the next source to consult would be a theory that applies to both object and apparatus. Doesn't this remark of Radder's immediately yield the puzzle of Collins' 'experimenter's regress'?
- How does notion of the material realization of an experiment answer "the question is whether there is a way to describe and analyze the performance of an experiment other than in terms of the particular theoretical description that is in fact used to perform it"(p. 60)?
- Boyle's experiment is cited as illustrating the separability of material realization and theoretical design. But the illustration is not Boyle's report, but its description in a book by Shapin and Schaffer (p. 64). Does the *different* experiment by Boyle that was our subject on Oct.5, *as reported by Boyle himself*, also serve to illustrate that?
- What are Radder's three types of <u>reproducibility</u>? What is a <u>replication</u>, in his terminology (p. 66)? Why is that important (compare p. 71)
- " … the norms of reproducibility under a fixed theoretical interpretation and of replicability of an experimental result are best regarded as regulative, rather than constitutive, norms." (p. 79) What is the distinction between regulative and constitutive norms?

Nov. 16 SESSION 10. Numerical versus material experimental research -- simulations and thought experiments

One of the most famous thought experiments in physics is Galileo's quick demonstration of inconsistency in Aristotle's law for falling bodies:

> Salviati. If then we take two bodies whose natural speeds are different, it is clear that on uniting the two, the more rapid one will be partly retarded by the slower, and the slower will be somewhat hastened by the swifter. Do you not agree with me in this opinion?
>
> Simplicio. You are unquestionably right.
>
> Salviati. But if this is true, and if a large stone moves with a speed of, say, eight while a smaller moves with a speed of four, then when they are united, the system will move with a speed less than eight; but the two stones when tied together make a stone larger than that which before moved with a speed of eight. Hence the heavier body moves with less speed than the lighter; an effect which is contrary to your supposition. Thus you see how, from your assumption that the heavier body moves more rapidly than ' the lighter one, I infer that the heavier body moves more slowly (from Galileo Galilei, Two New Sciences, First Day, National Edition paging 107-108)

What is more convincing, the 'Leaning tower of Pisa' sort of material realization, or the logical demonstration in this thought experiment?

Topics and Assigned Reading:

> **[1] Mary Morgan** [Radder] "Experiments without material intervention: model experiments, virtual experiments, and virtually experiments"
>
> **[2] Eric Winsberg,** "A tale of two methods" (about simulation vs. physical experimentation)

Questions:

(note: Morgan's view is related to Guala's by Winsberg, so the two papers are closely related**)**

- Winsberg points out that not all simulations are computer simulations. Computer simulations are just mechanized versions of paper and pencil calculations, but there are also physical simulations of processes under study by other processes that are antecedently better understood. Can you suggest some examples of such physical 'analog' simulation, earlier and simpler than his?
- Is this category of physical simulations different from or the same as Harré's category of experiments which study "a domesticated, simplified version of a material set-up found also 'in the wild'"?

- Do such physical simulations fit the description “in a simulation one is experimenting with a model rather than the phenomenon itself" (Gilbert and Troitzsch, quoted on p. 3)?
- In the example Winsberg gives at the very beginning, isn’t the first scientist actually conducting a physical simulation? (Compare p. 4) So did Winsberg load the dice by that choice of example?
- Does Guala’s proposal for distinguishing the two sorts of simulation presuppose specific notions, e.g. of causality or similarity, that are themselves questionable?
- Winsberg still wishes to draw a clear conceptual distinction between two kinds of activities, which can be usefully distinguished using the terms “experiment” and “simulation”. How does his distinction between simulation$_R$ and simulation$_A$ serve this purpose?

Suggested additional reading:

Evelyn Fox Keller, [Radder] “Models, simulation, and ‘computer experiments’”

David Atkinson, critique of Galileo’s thought experiment to refute Aristotle’s law of fall

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Nov. 23 ------------ RECESS -----------

Nov. 30 SESSION 11. Numerical versus material experimental research -- simulations and thought experiments

Topics and Assigned Reading (Questions to be posted yet):

[1] John Norton, “Why Thought Experiments Do Not Transcend Empiricism”

[2] John Forge, “Thought experiments in the philosophy of physical science” (discusses differences and similarities between views of Kuhn and Norton)

Dec. 7   SESSION 12.   Causality

Woodward's currently influential account gives a role to the distinction between what can and cannot be manipulated, and the effects manipulation can have, to define the notion of causal connection. He insists that the account is not anthropomorphic (it makes no reference to specifically human action; there is a category of "natural experiments" not carried out intentionally), while at the same time, a main virtue claimed concerns how the account applies to human manipulation in the design and performance of experiments.

Topics and Assigned Reading:

[1] Woodward, [Radder] "Experimentation, causal inference, & instrumental realism"

Questions:

On this account, what is a cause?

What is an *appropriately designed experimental manipulation* of B (an "intervention"), to ascertain whether or not B causes S?

Why is the moon's orbit's effects on the tides causal, on this account, although manipulation is not technically possible?

According to Newton's theory of gravity, a difference in meteor impacts on the moon can make a difference (very slight!) to the motion of your car. Would this relationship appear in all of Woodward's arrow diagrams representing e.g. your drive to work this morning?

How could it be true, on Woodward's account, that being female causes one to be discriminated against in the workplace? (page 107)

[2] Peter Kroes, [Radder] "Physics, experiments, and the concept of nature"

Questions:

Given Kroes' discussion of the concept of nature underlying views of experimentation, how would you classify Woodward's article?

What are technological artifacts and technological pseudo-artifacts, and what sort of thing is definitely not an artifact? Distinguish these senses of "artifact" from its sense in such phrases as "artifact of the procedure", "artifact of measurement".

Can something be an artifact (or pseudo-artifact) at one time and not at another time?

If new phenomena are created in an experiment, is the scientist studying artifacts rather than nature?

Comment on this reflection (p. 83): "the functional properties of the artifact … and its design are not created by realizing the appropriate physical phenomena in a physical object. A creative or inventive act is necessary to exploit a physical phenomenon (object) and to turn it into a tool for realizing a goal"

Suggestions for further reading:

Christopher Hitchcock, "Causation" -- this is a quick overview of different recent accounts of causation

Adam Elga, "Isolation and folk physics"

Questions:

- In view of Elga's argument, is there any role for causality in fundamental physics? in social science?
- Does it suggest any qualification or modification for Woodward's concept of causation?
- Should we treat "making a difference" as a matter of degree?
- If it is a matter of degree, is there a role for norms or values in causal judgment, to fix a degree that matters?

Dec. 14 SESSION 13.

Topics and Assigned Reading (Questions to be posted yet)

[1] Elisabeth A. Lloyd, "Varieties of support and confirmation of climate models"

[2] C. Kenneth Waters, "Causes that make a difference"