

Structure in Philosophy, Mathematics, and Physics

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Phil 246, Spring 2010

Class schedule: F 1:00-3:50pm, HSS 7077 (Philosophy seminar room)
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The goal of this seminar is to get to the ground of the recent (and sometimes not so recent) hype about *structure* in various branches of philosophy. Structuralism in epistemology is rather old (by certain standards), going back to Russell. More recently, drawing on older traditions such as the Erlangen programme and the Bourbaki group, authors such as Resnik and Shapiro have revived structuralism as an approach to understanding the foundations of mathematics. About twenty years ago, Worrall has reminded philosophers of science of structural realism, a view going back to Poincaré, as a way to adjudicate between traditional realism and empiricism concerning scientific knowledge. This has spawned an entire literature, now thriving in the journals in philosophy of science. Over the last years, fundamentality, structure, and identity have been hotly debated in metaphysics, structuralism has gained currency as a response to the hole argument in the foundations of spacetime theories, and the debate concerning identity and individuality has been reinvigorated by authors such as Saunders and Muller.

As you can see, the goal before us is perhaps unattainable, but I hope that participants will walk away from the seminar with both an understanding of the basic issues in all these various areas as well as an appreciation of the many analogies that connect the questions asked, the positions defended, and the objections raised in these fields.

Prerequisites: I assume no particular background either in philosophy, physics, or mathematics. Having said that, however, there will be some more technically and scientifically more involved readings. If you don't want to present or write on these—which is fine—you should at least be prepared to make a reasonable effort to grasp the material.

Distribution requirements: This course can be counted towards the fulfillment of the distribution requirement in philosophy of science.

Required texts

All mandatory (and perhaps some recommended) readings will be made available through e-reserves or online. The Stanford Encyclopedia of Philosophy entries are downloadable from <http://plato.stanford.edu/>. Go to the course web page for links.

Course requirements and evaluation

The following are necessary and jointly sufficient conditions to obtain letter grade credit for this seminar:

1. **Participation:** You are expected to attend all classes and to actively participate in discussions. If you have to miss a class, you must let me know in advance.
2. **Class presentations:** Every participant gives two presentations of no more than 15 minutes. You are expected to do something visual (blackboard, overheads, handout). Do not try to be comprehensive; rather, synthesize the important parts (main thesis, main argument) and offer some critical thoughts for discussion.
3. **Short papers:** Submit 7 short papers of 2 to 3 pages, reflecting one of the readings for the meeting when the paper is submitted. I want to see a clear statement of the main thesis of the article you are discussing, a brief summary of the main argument, and your independent judgment and critical reflection.

or

Seminar paper: Submit a term paper of 15 to 20 pages or so, on a topic approved by me. Please submit a paragraph-long outline of your project by Friday, **21 May 2010**. The full paper is due on Thursday, **10 June 2010**.

Topics and readings

Please note that the topics listed do not map bijectively to meetings; the plan would to just go through them more or less in order. The reading list is tentative and may still change, in particular upon popular demand.

(1) Structure in mathematics

I will start off by giving a little blackboard introduction to different notions of structure and related concepts, mostly as they can be found in mathematics, e.g. in mathematical logic, category theory, model theory, graph theory. Some of this will be fairly formal, but do not despair—I will not quiz you and the rest of the seminar will be less technical.

Then, we will start with structuralism in the foundations of mathematics with (a subset of) the following readings:

- Michael Resnik, “Mathematics as a science of patterns: Ontology and reference”, *Noûs* **15** (1981): 529-550.
- Michael Resnik, “Mathematics as a science of patterns: Epistemology”, *Noûs* **16** (1982): 95-105.
- Stewart Shapiro, *Philosophy of Mathematics: Structure and Ontology*, Oxford University Press (1997). Selections from Part II (“Structuralism”).

Background reading and further study:

- Leon Horsten, “Philosophy of mathematics”, in E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*, §4 “Structuralism and nominalism”; available at <http://plato.stanford.edu/entries/philosophy-mathematics/> (2007).
- Erich Reck and Michael Price, “Structures and structuralism in contemporary philosophy of mathematics”, *Synthese* **125** (2000): 341-383. A survey article focussing on the different notions of structure and different versions of structuralism.
- Jukka Keränen, “The identity problem for realist structuralism”, *Philosophia Mathematica* **9** (2001): 308-330. The article from which I took the clue for my critique of spacetime structuralism.

There are two special volumes of *Philosophia Mathematica* devoted to structuralism: **4/3** (1996) and **9/3** (2001). The latter also includes the article by Keränen on the identity problem.

(2) Structure and identity in metaphysics

There has been a recent spate of papers devoted to structuralist approaches to ontology, and to a reconsideration of issues of identity in metaphysics. We will read (a subset of) this literature for its own sake, but also because some of it will set the stage for later discussions in this seminar.

- Kathrin Koslicki, *The Structure of Objects*, Oxford University Press (2008); Chapter 7 (“Objects as structured wholes”) and Chapter 9 (“Structure”).
- John Hawthorne, “Causal structuralism”, *Noûs* **35** (2002): 361-378.
- Ted Sider, selections from *Writing the Book of the World*, manuscript.
- Katherine Hawley, “Identity and indiscernability”, *Mind* **118** (2009): 101-119.

Background reading and further study:

- Harold Noonan, “Identity”, in E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*; available at <http://plato.stanford.edu/entries/identity/> (2009).
- Peter Forrest, “The identity of indiscernibles”, in E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*; available at <http://plato.stanford.edu/entries/identity-indiscernible/> (2006).
- Max Black, “The identity of indiscernibles”, *Mind* **61** (1952): 153-164. A classic.

(3) Structure in epistemology

Is the structure of our knowledge of the physical world the same as the structure of its object? Russell (1927) famously thought so, until Newman came along and pointed out what Russell himself considered a fatal flaw of his theory. Newman criticism is influential in that essentially the same objection has been raised against proposals similar to Russell's causal theory of perception in many fields.

- Bertrand Russell, *The Analysis of Matter*, Routledge Kegan Paul (1927); Chapter 20 (“The causal theory of perception”).
- M H A Newman, “Mr. Russell’s causal theory of perception”, *Mind* **37** (1928): 137-148.

Background reading and further study:

- Peter Ainsworth, “Newman’s objection”, *British Journal for the Philosophy of Science* **60** (2009): 135-171.

(4) Structural realism in philosophy of science

Since Worrall’s 1989 landmark article, philosophers of science hotly debate the merits of the proposed *via media* of structural realism, which supposedly steers clear of the Charybdis of the No-miracles-argument and the Scylla of the pessimistic meta-induction. According to Worrall, structural realism is the best of both worlds, i.e. of both traditional scientific realism and traditional antirealism or empiricism. But can it have it both ways?

- James Ladyman, Don Ross, (with David Spurrett and John Collier), *Every Things Must Go: Metaphysics Naturalized*, Oxford University Press (2007); Chapter 2 (“Scientific realism, constructive empiricism, and structuralism”).
- Stathis Psillos, “The structure, the *whole* structure, and nothing *but* the structure?” *Philosophy of Science* **73** (2006): 560-570.
- Bas van Fraassen, *Scientific Representation: Paradoxes of Perspective*, Clarendon Press (2008); Chapter 11 (“An Empiricist Structuralism”).

Background reading and further study:

- James Ladyman, “Structural realism”, in E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*; available at <http://plato.stanford.edu/entries/structural-realism/> (2009).
- James Ladyman, “What is structural realism?” *Studies in History and Philosophy of Science* **29** (1998): 409-424.
- John Worrall, “Structural realism: The best of both worlds?” *Dialectica* **43** (1989): 99-124. The literature’s vantage point.
- Stathis Psillos, “Ramsey’s *Ramsey-Sentences*”, in M.C. Galavotti (ed.), *Cambridge and Vienna: Frank P. Ramsey and the Vienna Circle*, Springer (2006), 67-90. Helpful for those eager to understand what all the fuss regarding Ramsey sentences is about.

(5) Structure in physics

One way to fulfill the promissory note issued by structural realists is to identify, in a rigorous manner, the pertinent structures in physics. Here are some recent articles which attempt exactly that, as well as some contributions to the same literature with more foundational motivation.

- John Norton and Jonathan Bain, “What should philosophers of science learn from the history of the electron,” in J.Z. Buchwald and A. Warwick (eds.), *Histories of the Electron*, MIT Press (2001), 451-465.
- Jill North, “The structure of physics: A case study”, *Journal of Philosophy* **106** (2009): 57-88.
- Jill North, “Structure in classical mechanics”, manuscript.
- Jill North, “The structure of a quantum world”, manuscript. This article will lead into the next topic.

(Most likely, we will only read a subset of these items).

(6) Spacetime structuralism

Structural realist interpretations have also been proposed as a response to the so-called *hole argument*, a central problem in the foundations of general relativity. I will present the basic problem, and we will then discuss the merits of the structuralist response.

- Michael Esfeld and Vincent Lam, “Moderate structural realism about space-time”, *Synthese* **160** (2008): 27-46.
- Christian Wüthrich, “Challenging the spacetime structuralist”, *Philosophy of Science* **76** (2009): 1039-1051.
- Fred Muller, “Structuralism and the general theory of relativity”, manuscript.

Background reading and further study:

- John Norton, “The hole argument”, in E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*; available at <http://plato.stanford.edu/entries/spacetime-holearg/> (2008).

(7) Structure and identity in quantum theory

Philosophers sympathetic to structural realism have recently reinvigorated the old debate about identity in quantum mechanics. After setting up the basic problem, we will look at the most recent exchanges concerning structure, identity and individuality in quantum mechanics.

- James Ladyman, “Of the identity and diversity of objects in a structure”, *Proceedings of the Aristotelian Society Supplementary Volume* **81** (2007): 21-43.
- Simon Saunders, “Are quantum particles objects?” *Analysis* **66** (2006): 52-63.
- Fred Muller and Simon Saunders, “Discerning fermions”, *British Journal for the Philosophy of Science* **59** (2008): 499-548.
- Fred Muller and Michiel Seevinck, “Discerning elementary particles”, *Philosophy of Science* **76** (2009): 179-200.
- James Ladyman and Tomasz Bigaj, “The principle of the identity of indiscernibles and quantum mechanics”, *Philosophy of Science* **77** (2010): 117-136.

Background reading and further study:

- Steven French, “Identity and individuality in quantum theory”, in E.N. Zalta (ed.), *Stanford Encyclopedia of Philosophy*; available at <http://plato.stanford.edu/entries/qt-idind/> (2006).