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Stud. Hist. Phil. Biol. & Biomed. Sci. 36 (2005) 373–395

Studies in History and Philosophy of Biological and Biomedical Sciences

www.elsevier.com/locate/shpsc

Beyond reduction: mechanisms, multifield integration and the unity of neuroscience

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Abstract

Philosophers of neuroscience have traditionally described interfield integration using reduction models. Such models describe formal inferential relations between theories at different levels. I argue against reduction and for a mechanistic model of interfield integration. According to the mechanistic model, different fields integrate their research by adding constraints on a multilevel description of a mechanism. Mechanistic integration may occur at a given level or in the effort to build a theory that oscillates among several levels. I develop this alternative model using a putative exemplar of reduction in contemporary neuroscience: the relationship between the psychological phenomena of learning and memory and the electrophysiological phenomenon known as Long-Term Potentiation. A new look at this historical episode reveals the relative virtues of the mechanistic model over reduction as an account of interfield integration.

Keywords: Mechanism; Reduction; Unity of science; Fields; Neuroscience; Memory; Long-term potentiation

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1369-8486/$ - see front matter
doi:10.1016/j.shpsc.2005.03.008

1. Introduction

Neuroscience is a multifield research program.[1] Its departments, journals, societies, and textbooks include perspectives from anatomy, biochemistry, computer science, developmental, evolutionary and molecular biology, electrophysiology, experimental psychology, ethology, pharmacology, psychiatry, and radiology to name just a few. The Society for Neuroscience (SfN) was founded in 1969 with the mission to:

> Advance the understanding of the brain and the nervous system by bringing together scientists of diverse backgrounds, by facilitating the integration of research directed at all levels of biological organization, and by encouraging translational research and the application of new scientific knowledge to develop improved disease treatments and cures.[2]

Understanding the structure of contemporary neuroscience requires understanding how these multiple fields, embodying distinct perspectives, techniques, and vocabularies, manage to integrate their work.

Most philosophers who have discussed interfield integration in neuroscience (e.g., Bickle, 1998, 2003; Churchland, 1986; Oppenheim and Putnam, 1958; Schaffner, 1993a,b) describe it using models of intertheoretic reduction. According to the 'classical' model of reduction, from which each of these authors' models descends, reduction is a species of deductive nomological explanation: one theory is reduced to another when it is possible to identify the theoretical terms of the first with those of the second and to literally derive the first from the second. On the assumption that fields and theories correspond, reduction then serves as a model of interfield integration as well.

There are many reasons why philosophers of neuroscience have found reduction attractive for thinking about interfield integration. First, the reduction relation can be defined precisely using formal logic (e.g., Schaffner, 1993a,b) or set theory (e.g., Bickle, 2003), and so the thesis that fields are integrated through reduction is clear and testable. Second, there is a long tradition of using reduction models in the philosophy of physics, chemistry, and biology, and it is natural to suggest that the models can be extended to the neurosciences. Finally, at least since Oppenheim and Putnam's manifesto (1958), reduction has been nearly synonymous with the explanatory unity of science: the unity of science is achieved by reducing the theories of all fields to the theories of the one field describing fundamental ontology. For these reasons, reduction seems natural as a model of interfield integration in the neurosciences.

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[1] In the spirit of Darden & Maull (1977), I understand fields as groups of researchers related by common problems, techniques, and vocabularies. The boundaries between fields are fuzzy and change with time, but there is no pressing need to tidy them up for present purposes.

[2] Society for Neuroscience web page (2003) at http://web.sfn.org/content/AboutSfN1/Mission/mission.htm.