

Joel Walmsley,  
PhD Student,  
Department of Philosophy, University of Toronto.

Mailing Address:

Department of Philosophy,  
9<sup>th</sup> Floor, 215 Huron Street,  
Toronto,  
Ontario,  
Canada,  
M5S 1A1

Phone: (+1) 416-944-8773  
e-mail: joel.walmsley@utoronto.ca

Paper Title:

*Dynamical Systems, Emergence and Explanation*

Major Themes:

Dynamical Systems, Explanation, Emergence, Interaction, Autonomous Agents

*Extended Abstract:*

This paper is, by and large, a call for help -- how do we square the notion that dynamical systems language is suitable for describing emergent phenomena with the fact that dynamical explanations are covering law explanations? In the first portion of the paper, I outline this essential tension.

The use of concepts and tools from dynamical systems theory in cognitive science and artificial-life is a burgeoning and laudable project, but it seems to face a dilemma. On the one hand dynamical language seems to be ideal for describing and explaining emergent properties. Many systems in A-life, for example, display behaviours which result from the collective, interactive behaviour of a system's components, rather than from the action of any single component, and the emphasis on "total state" explanations in dynamical systems theory seems to capture this to the point where dynamical language has even been vaunted as one of the "calculi of emergence" (Crutchfield, 1994). Furthermore, these emergent behaviours are often unanticipated (perhaps unplanned or unprogrammed in the case of A-life), giving rise to many conceptions of emergent properties in terms of novelty or unpredictability.

Emergentists, then, must be fundamentally opposed to the deductive-nomological model of explanation whereby an explanandum is a deductive consequence of an explanans consisting of the conjunction of a statement of a general law together with a statement of initial conditions. After all, if a putative emergent property, E, can be *deduced* from the conjunction of a law or set of laws,  $L_1...L_n$ , and initial conditions,  $C_1...C_m$ , then E cannot be emergent *qua* unpredictable, since it follows *a priori*, as a deductive consequence from  $L_1...L_n$  and  $C_1...C_m$ .

And yet, with the insistence on "total state" explanations, and the quest to find the differential equations which govern a system's temporal trajectory through state-space, it would seem that dynamicist's goal is to find covering laws and hence provide deductive-nomological explanations. Some, such as Bechtel (1998), explicitly liken dynamical explanations to covering-law explanations. Others, most notably Van Gelder (1991) deny that dynamical explanations are covering-law explanations. Yet Van Gelder still writes:

"In studying and explaining the behaviour of dynamical systems one aims at formulating equations which describe the evolution of the system, and can consequently be used to explain why the system is in the state it is in, or to predict what states it will come to be in" (p.500)

In the second portion of the paper, I examine one way in which we might attempt to circumvent such a tension. One initially promising strategy might be to deny the second horn of the dilemma, that is, to strengthen Van Gelder's claims and say that dynamical explanations are *not* covering-law explanations. This strategy will not work, however. There are several lines of reasoning which converge on the conclusion that dynamical explanations are a special case of covering law explanation. Firstly, whilst we can defend dynamical explanations from the charge that they are mere descriptions by noting the fact that they are intended to illuminate counterfactuals (see Clark, 1998), Bechtel contends that this is further evidence of their status as covering-law explanations. Secondly, Van Gelder's arguments *against* the claim that dynamical explanations rest on too narrow a conception of what a covering-law model actually is. For one thing, it does not seem necessary that the law stated in the explanans actually be a basic law of physics -- a covering law deduction is still explanatory, in the sense that it still satisfactorily answers a "why" question, if  $L_1...L_n$  are laws of some other sort. But in any case,

even if true deductive-nomological explanations *are* only those which state a law of physics in the explanans, the dilemma still stands, since whether or not  $L_1 \dots L_n$  are basic laws of physics, from their conjunction with initial conditions, E is still deducible *a priori*, and so cannot count as emergent in the sense outlined above.

The final section of the paper attempts to get clear on the precise conception of emergence which is at issue here, for it seems that the only alternative strategy to resolve the tension is to re-work our understanding of emergence. Van Cleve's (1990) definition of emergence, where E is emergent if and only if E supervenes with nomological necessity, but *not* with logical necessity, on the properties of the parts of the system that possesses it, is the one at stake. But this view derives from the *locus classicus* of emergentist literature, Broad (1925), who set the stage for future debate on emergence by defining it as dependence and determination *without deducibility*. Resolving the tension in this fashion, then, will require a radical rethink of the very concept of emergence, the prospects of which, given some standard taxonomies of emergence (e.g. Silberstein 2001, De Sousa, 1994), look very difficult indeed.

#### References:

- Bechtel, W. (1998) "Representations and Cognitive Explanations: Assessing the Dynamcists' Challenge in Cognitive Science" *Cognitive Science* **22** 295-318
- Broad, C.D. (1925) *Mind and Its Place in Nature* (London: Routledge and Kegan Paul)
- Clark, A. (1998) "Time and Mind" *Journal of Philosophy* **95** 354-76
- Crutchfield, J. P. (1994) "The Calculi of Emergence: Computation, Dynamics, and Induction", *Physica D* **75** 11-54.
- De Sousa, R. (1994) "Individualism and Local Control in Complex Systems" *Canadian Journal of Philosophy* suppl. vol. **20** pp165-185,
- Silberstein, M. (2001) "Converging on Emergence: Consciousness, Causation and Explanation" *Journal of Consciousness Studies* **8(9-10)** 47-61
- Van Cleve, J. (1990) "Mind-Dust or Magic? Panpsychism Versus Emergence" *Philosophical Perspectives* **4**, 215-226
- Van Gelder, T (1991) "Connectionism and Dynamical Explanation" *Proceedings of the 13<sup>th</sup> Annual Conference of the Cognitive Science Society*