as true, or whether it will be greatly modified or totally rejected. However, we all know that the CH was inspired by scholars (including Alan Newell) who were concerned with the limitations of the standard science of their day, and who were intimately involved in the development and empirical testing of psychological models of human performance and AI models of intelligent computer functionality.

Scientific work in the trenches leaves many with a deep appreciation of observed anomalies, as well as the limitations that affect both general formulations and focused models of empirical domains; both are subject to empirical limits and boundary conditions. So why would a seminal thinker like Simon formulate so bold a hypothesis? One reason is found in the politics of science. During the reign of behaviorism, the study of the higher mental processes was moribund and in serious need of revitalization. The CH and all its ancillary doctrines appealed to frustrated behavioral scientists as a new and exciting way of looking at many aspects of psychological phenomena. Second, personal experience with empirical conundra in the study of human behavior may have predisposed Simon, Newell, and others to an awareness of limits and an openness to other points of view. (See also Newell [1992] and the multiple book review of Newell's *Unified Theories of Cognition* in BBS 15[3].) My reading of Newell's and Simon's views is that they are consistent both with imposed intelligibility and the limits CH places on claims about what the entities and systems investigated ultimately turn out to be when expressed in computational or other types of theory.

I could not find the statement "the mind (or the brain) is a computer" in either Newell's or Simon's work.[1] What is consistently present is the creative assignment of class membership. Classes are something thought up by people to impose intelligibility on the contents of the observable and conceptual universe (Munitz 1986). The CH, however bold (or outrageous) it appears, contains cautions as well as significant lacunae which can, in principle, be filled. Nowhere is the computer fully elucidated, nor is the underlying theory of automata. According to the CH, the vast variety of brain and cognitive systems responsible for the enormous range of behavior of cognitive agents cannot all be explained solely by a symbol system account or any other single formulation.

How does the bounded CH compare with the formulation of the dynamical hypothesis (DH)? Van Gelder (1998t) declares that "cognitive agents are dynamical systems" (p. 615). This identity claim is insensitive to the limits of scientific theorizing, the complexities of natural systems, and to the intelligibility that needs to be imposed to generate a scientific knowledge product. The hypothesis is further extended: "For every kind of cognitive performance exhibited by a natural cognitive agent, there is some quantitative system instantiated by the agent at the highest relevant level of causal organization [that] can and should be understood by producing dynamical models." The coverage of van Gelder's hypothesis is vast; it ranges over a universe that includes most behavior of most living things. This is clear in spite of the many possible meanings of "dynamical systems" and "highest relevant level of causal organization."

Any assumption that a particular dynamical idealization and a natural system are identical, raises insurmountable problems; an identity claim assumes that an end state has been achieved in knowledge concerning some system. At our present stage of inquiry (perhaps at any stage), it is foolhardy to imagine that we have arrived. It is near certain that an alternative cognitive model will supersede those currently preferred, whether the current model is based on symbol systems or connectionism. There can be no assurance that the currently preferred scientific pictures of cognition will never undergo drastic, even revolutionary, change.

An alternative interpretation of dynamical systems is one based on the doctrine of imposed intelligibility and it may be expressed as follows: The formalisms of dynamics imposed on a natural system, if there is a close enough fit, can serve as an explanatory framework to render the represented system predictable and intelligible. The equations of any scientific formalism, including dynamics, come embedded in natural language commentary. The combination of equations and commentary is the resultant scientific knowledge that explains a system. The knowledge product is not the system; to propose otherwise can lead to the bizarre or comic. Whittaker (1942, p. 17) offers an interesting example:

> [I]t happens very often that different physical systems are represented by identical mathematical description. For example, the vibrations of a membrane which has the shape of an ellipse can be calculated by means of a differential equation known as Mathieu's equation; but this same equation is also arrived at when we study the dynamics of a circus performer, who holds an assistant balanced on a pole while he himself stands on a spherical ball rolling on the ground. If we now imagine an observer who discovers that the future course of a certain phenomenon can be predicted by Mathieu's equation, but who is unable for some reason to perceive the system which generates the phenomenon, then evidently he would be unable to tell whether the system in question is an elliptic membrane or a variety artiste.

Recent debate among philosophers concerning realism and its alternatives has been of little help to the concerns of scientists and hence of little interest. The elucidation of the relationship between the knowledge products of science and the natural systems the products represent would be of real value. It is unfortunate that so few philosophers of science now show interest in work such as Munitz's (1986) book, which illustrates reasonable approaches to that relationship.

NOTE

**1.** "I am sure that somewhere in print I said specifically that brains are computers" (H. A. Simon, personal communication).

# Author's Response

## Response to Lachman

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Lachman claims that the Dynamical Hypothesis (DH) is "untenable." His own position is a version of the "The DH is epistemological, not ontological," objection to the target article, which is dealt with in section R2.3 of my original response (van Gelder 1998r). Additional objections are that the coverage of the hypothesis is "vast" and that the DH presupposes we have reached the end point of scientific theorizing. Indeed, the DH is very broad, but it does not presuppose that science has ended; that's why we call it a "hypothesis."

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