**SPECIAL ISSUE:**

# Connectionist Models and Their Applications

# Introduction

The human brain is an information processing system, but one that is quite different from conventional computers. The basic computing elements operate in the millisecond range and are about a million times slower than current electronic devices. Since reaction times for a wide range of tasks are a few hundred milliseconds, the system must solve hard recognition problems in about a hundred computational time steps. The same time constraints suggest that only simple signals can be sent from one neuron to another. The human information processing system is also adaptable, context-sensitive, error-tolerant, etc., in ways that far outstrip our current computational devices and formalisms.

What is the relevance of all this to Cognitive Science? One traditional view that is no longer tenable is that the brain is just a different system for directly interpreting formal descriptions such as mathematical logic, production systems or transformational grammars. It is possible that human cognition can be *characterized* in these ways, but the hundred-step constraint precludes any direct use of such formalisms by the brain. Even if it turns out that transformational grammar is a complete theory of language, an additional theory of how the brain actually processes language will be required. We can still choose to focus on characterizing intelligent activity and leave to other disciplines and other epochs the questions of how it is carried out. But, even if we do defer implementation questions, the radically different computational architecture of the brain might suggest alternative formalisms for expressing theories in Cognitive Science. Theories expressed in such formalisms should not require a conceptually distinct reduction to neural realization.

The "new connectionists" share the working assumption that theories and scientific languages based on the computational character of the brain are productive (even essential) in many areas of Cognitive Science. The six papers in this issue suggest how Cognitive Scientists are using these connectionist models directly in their work and some of the current efforts to explore the computational properties of these systems. It is not yet clear how far the connectionist paradigm extends, but for some kinds of problems it is already apparent that the approach is quite effective.

The first three papers describe connectionist models of specific cognitive tasks: Dell on speech production, Sabbah on perception of Origami fig-

ures, and Waltz and Pollock on the selection of structure and word meaning in context. One important aspect of all three papers is that each incorporates a significant theory of the domain under consideration. Using connectionist models does not eliminate the need for principled elucidation of the primitives and structures underlying the behavior.

In addition to specific modelling efforts, Cognitive Scientists of the connectionist persuasion are working extensively on the computational properties of massively parallel systems. What distinguishes these efforts from other theoretical studies of computation is the focus on issues pertinent to cognitive modelling—all of the groups represented here are also involved in specific tasks like those presented in the first three papers. Rumelhart and Zipser point out how a classical approach to learning in connectionist models can be used to construct useful representational primitives without an external teacher. McClelland is concerned with a question of general importance in cognitive models—how can knowledge be brought to bear in multiple places. Ackley, Hinton, and Sejnowski explore a connectionist system based on statistical mechanics and show how it exhibits significant learning in a principled way.

This issue of *Cognitive Science* presents only a sample of connectionist research. The field is changing far too rapidly for even a provisionary encapsulation. The papers collected here indicate some of the paths that connectionists are following and illustrate some of the promise of the approach.

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