EDITORIAL

The Science of the Mind

In his thoughtful book on the emergence of cognitive science, Howard Gardner quotes George Miller's recollection of a meeting in 1956: "I went away from the Symposium with a strong conviction, more intuitive than rational, that human experimental psychology, theoretical linguistics and computer simulation of cognitive processes were all pieces of a larger whole, and that the future would see progressive elaboration and coordination of their shared concerns."*

The promise that Miller envisioned in those early days has come to pass. Numerous interrelated disciplines are now engaged in the attempt to understand the mechanisms underlying normal and abnormal mental processing. The boundaries between these disciplines (which now include anatomic and computer studies of neural circuits, animal and human lesion studies, neurophysiology, neuropsychology, neuroimaging, neuropharmacology, and experimental cognitive psychology) have become increasingly less distinct. The remarkable progress that has been made in recent years is beginning to generate excitement outside of the scientific community because of its relevance to our daily lives in shedding light on normal cognitive functions (such as language, memory, and planning) and on brain-related diseases (such as schizophrenia and Alzheimer's disease).

There are several things worth noting about cognitive neuroscience that are also reflected in the Articles in this special issue of *Science*. First is the idea that distributed brain networks underlie complex behaviors. In the early days of the field, most neuroscientists focused on individual brain regions and their responses. The sensory domain was particularly captivating; one could, for example, appropriately talk about hypercomplex cells in the visual system that responded to corners or the existence of cortical columns as the organizing basis for somatosensory input. It is becoming clear, however, that the processing of information that leads to complex behaviors such as learning and memory involves multiple brain regions that must operate in an interactive synchrony.

Second is the increasing ability to look at these networks within a time dimension. Models that do not take time into account appear to be less accurate. For either computational modeling or examination of responses to single-cell activity, the time dimension is critical. Current neuroimaging techniques permit an examination of brain function that is close to real-time activity. For example, although functional magnetic resonance imaging (fMRI) currently has a brief delay that is related to the hemodynamic nature of the measurement (a 2-second latency between stimulus onset and fMRI response, and at least a 4-second latency between stimulus onset and peak response), this methodology now allows researchers to examine the responses of distributed brain networks while an individual is performing a task, and techniques will surely be developed to come even closer to real-time observation.

Concurrent with this issue of *Science* is a special issue of the *Journal of the American Medical Association* (JAMA),† which focuses on Alzheimer's disease (AD). These studies emphasize that another discipline has now been added to the already broad interdisciplinary network of cognitive neuroscience: genetics. Five of the eight articles in the issue involve the genetics of AD. Studies pertaining to apolipoprotein E (ApoE) predominate, because the ApoE-4 allele is a risk factor for the late-onset form of AD (onset after age 60 to 65), which affects the overwhelming majority of AD patients. The other genes discussed in the *JAMA* issue, which act in an autosomal dominant manner, influence the development of early-onset AD, which is relatively rare. Although the way in which ApoE-4 influences the development of AD is still unclear, the findings with respect to ApoE have had a dramatic effect on the way in which cognition is studied, particularly in the elderly. Less than 4 years after the original report on ApoE, no longitudinal study of cognitive function in the elderly is likely to be conducted without the inclusion of ApoE data because of their potential for explaining at least some of the variance in patients' cognitive performance over time. Genetics has thus become another piece of the cognitive neuroscience whole.

Marilyn S. Albert

The author is associate professor of Psychiatry and Neurology at Harvard Medical School and director of the Gerontology Research Unit at Massachusetts General Hospital, Boston, MA.

*H. Gardner, *The Mind's New Science* (Basic Books, New York, 1985), p. 29. †*JAMA*, issue of 12 March 1997.