Making a Connection

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McClelland Attributes Learning, Memory, and Cognitive Development to a Strong Neuron Network

James L. McClelland, Carnegie Mellon University, describes his distributed connectionist model of learning, memory, and cognitive development at the APS Annual Convention.

How would you pronounce the nonsense word grook? Would you say it like book or spook? According to James L. McClelland, Carnegie Mellon University, it all depends on the connections among your neurons.

McClelland presented this finding during his William James Fellow Award Address, “Learning, Memory, and Cognitive Development: They’re All in Your Connections,” at the APS 16th Annual Convention. In his distributed connectionist model, McClelland theorizes that learning, memory, and cognitive development arise from the strength and pattern of neuron connections. When someone learns to read, develops an understanding of the world, or forms a memory, “changes are made to the strengths of connections among the neurons participating in the representation and processing of the experiences,” McClelland said. “Learning occurs through the adjustment of the strengths of these connections.”

A recipient of the Grawemeyer Award in Psychology and member of the National Academy of Sciences, McClelland is a pioneer in developing the principles of connectionist modeling and applying them to a broad range of psychological phenomena. Together with David E. Rumelhart and other colleagues, he developed the Parallel Distributed Processing framework, a revolutionary architecture in cognitive psychology and cognitive neuroscience. In this framework, information is distributed across a network, memory and knowledge of specific things are not stored explicitly but rather in the connections between units, and learning can occur with gradual changes in connection strength due to experience. The idea that knowledge exists in neural connections revolutionized the approach psychologists take to understanding knowledge and memory. “Connectionist models offer alternatives to traditional approaches to learning, memory, and development,” McClelland said. “They show that knowledge of regularities and idiosyncrasies can co-exist in the same mechanism. The core idea that language and reading are rule-governed processes may itself need to be rethought.”

Previously, the belief was that to read certain words required a set of grapheme-phoneme correspondence rules, whereas to read other words required a lexical entry specifying pronunciation. The connectionist model deals with both kinds of items in the same distributed network of connections: Words with similar spelling and pronunciation activate overlapping sets of input and output units, and connections are adjusted when each word is seen so that the input tends to activate the output. This suggests that certain outputs become more likely based on a specific input term or phrase. For example, if the input is “A robin can,” then the output options would be “grow,” “move,” or “fly,” as opposed to “swim,” or “drive.” As humans develop, the possible outputs become more precisely linked to the input. “Because the connections used by similar items overlap, what is learned tends to transfer from one to the other,” he said.

Development of connections occurs in the brain, which, McClelland suggests, contains two learning systems – one based in the neocortex and one in the hippocampus. The neocortical learning system is relatively slow, operating through a gradual buildup of experiences. In contrast, the hippocampus provides a mechanism for rapid learning, the results of which are gradually integrated into the neocortical system. “Components work together so that overall performance may be better than the sum of the independent contributions of the parts,” McClelland said. With regard to memory in particular, the hippocampus and the neocortex maintain a synergistic relationship. “Fast learning in the hippocampus builds on the prior cortical knowledge,” he said.

The coordination between the hippocampus and neocortex also makes it easier to remember a new facet of something you already know a little about. Should the hippocampus be damaged, a person may not be able to remember events that occurred just prior to or after the injury, but he or she can recall events from before the damage occurred. McClelland gave the example of an amnesic patient with damage to his hippocampus, for whom each visit to the lab was a novel experience; the patient was unable to remember ever meeting the researchers or visiting the campus.

The implications of connectionist models are significant and, like the processes they explain, may need a while to develop a distinct relationship. “Connectionist models are changing our thinking about the representation of procedural and declarative knowledge and the organization of human memory,” McClelland said.

Staff writer Phillip Ciske contributed to this article.