# Integrated Models of Perception, Cognition, and Action

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"One thing wrong with much theorizing about cognition is that it does not pay much attention to perception on the one side or motor behavior on the other... The result is that the theory gives up the constraint on...cognition that these systems could provide. The loss is serious--it assures us that theories will never cover the complete arc from stimulus to response, which is to say, will never be able to tell the full story about any particular behavior." Allan Newell, *Unified Theories of Cognition,* pp. 159-160.

When that quote was delivered to the audience of William James lectures more than a decade ago, Cognitive Science as a field was guilty as charged of neglecting the integration of cognition, perception, and action. However, in recent years serious efforts have been made to construct models that encompass all three systems and take seriously the mutual constraints they impose on one another. These include: EPIC-Soar, a system based on integrating Soar and the EPIC perceptual-motor architecture (Chong); ACT-R/PM, which integrates the ACT-R cognitive architecture with a system of EPIC-like perceptual-motor modules (Byrne); and APEX, a system inspired by the Model Human Processor (MHP) designed to model performance in complex, dynamic environments (Freed). A more generic perceptual-motor system, able to interact with multiple cognitive architectures and designed to interact with multiple real-world tasks, has also been proposed (Ritter).

Research on these systems has been fruitful practically, empirically, and theoretically. Each symposium participant will be asked to discuss the issues involved and the hurdles they have overcome in constructing systems that coordinate cognition, perception, and action. Examples include:

- What new empirical questions have been raised by broadening the scope of research from cognition to include perception and action?
- How has the inclusion of perception and action capabilities constrained or informed the development of the cognitive aspects of models developed with your system(s)?
- Conversely, have the cognitive capabilities of the system constrained or influenced the design of the perceptual-motor systems?
- What kinds of tasks and domains are you able to model that you could not have modeled successfully without serious consideration of perceptual-motor capabilities?
- Working at "lower" levels of analysis required to model perception and action in detail may also have costs. For example, has it become more difficult to model higher-level cognition such as problem solving and reasoning?
- How is learning affected by perception and action? Conversely, how are perception and action affected by changes in cognition?
- How is communication between the three subsystems managed?
- What technical issues have you had to overcome to develop a more integrated approach?
- What model of visual attention is used in your system? What is your system's perspective on the relationship between gaze position and attention?