Towards an Integrative Approach to Cognitive Development

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Introduction

In Spring, the Electrotechnical Laboratories began a new project towards understanding the mechanisms of human cognitive development. In the spirit of cognitive science, we hope that an integrative approach that combines methods from robotics, computer science, linguistics and neuroscience (in addition to psychology) will better facilitate our search for mechanisms. We anticipate that a broader integrative approach will better constrain the modeling process. Here, we outline our areas of interest and the approaches we take.

Spatial Learning & Robotics

We propose using autonomous robots as the subject of cognitive development, and constructing computer programs by which robots can behave analogously to infants(Hiraki et al., 1996). The advantage of using robots is that it forces us to use the same input stimuli and action goals as the infant. By contrast, in computer simulation, the shape of the input/output representations is generally assumed. The use of robots also permits us to construct a theory absorbing "activeness", which has recently been emphasized in the development of spatial knowledge. We propose "feature abstraction" (Hiraki, 1994) for a model of spatial learning. Our final target is to clarify the mechanism of change from egocentric- to allocentric-based behaviour, including mental tracking (Hiraki et al., 1997), in young children.

Reasoning & Relational Theory

Halford (1993) and Halford, Wilson and Phillips (submitted) proposed relational complexity as a metric developmental change. Briefly, stages in development correspond to the capacity to process increasingly higher arity relations (i.e., unary, binary, ternary, etc). Based on psychological experiments, children below the age of five years are said to be limited to tasks requiring at most binary relations, whereas children above five can perform tasks involving ternary relations. We hope this theory will become a benchmark for theories of developmental change. Toward this goal, methods from relational theory in computer science have been applied to psychological experimental paradigms in an effort to clarify (objectively) relational complexity and its link to child development (Phillips, 1997).

fMRI for neuronal basis

We are preparing to incorporate fMRI techniques for the study of cognitive development. In preliminary studies, we will test whether cognitive developmental phenomena are detectable by these methods, while fulfilling all ethical and saftey requirements. We expect fMRI will have great potiential for the study of cognitive development.

Integrated Approach

Our approach to the issue of the mechanism driving cognitive development is to use methods from robotics, computer science and neuroscience. Rather than address multiple problems within a single framework, we propose combining apparently disparate methods toward resolving a single problem. As one example, complexity analysis from computer science suggested ways in which Halford's relational theory from psychology could be tested using brain imaging techniques in neuroscience (Halford, et al, submitted; Phillips, Hiraki, Nakai, Niki, 1997). Clearly, the mechanism of development is complex, but this just underscores the need for a wider approach to the problem.

References

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