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<b>13. ABSTRACT (Maximum 200 words)</b>  To study hybrid architectures of complex learning, especially as applied to a simulated minefield navigation task, we developed a hybrid connectionist model CLARION as a demonstration of the approach of bottom-up skill learning (from procedural to declarative knowledge).  The model essentially consisted of two levels for capturing both procedural and declarative knowledge and enabling bottom-up learning, which differed markedly from existing models. Our Computational and psychological experiments during the past five years demonstrated matches of the model with human data in several domains.			
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FINAL REPORT

GRANT #: N00014-95-1-0440

PRINCIPLE INVESTIGATOR: Ron Sun

INSTITUTION: University of Missouri-Columbia

GRANT TITLE: Hybrid models for sequential decision making

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OBJECTIVE: To investigate hybrid architectures of complex learning, especially as applied to a simulated minefield navigation task.

APPROACH: Both human experiments and model developments were undertaken. Model developments were informed by human data, which in turn helped to design further human experiments.

ACCOMPLISHMENTS: We developed a hybrid connectionist model CLARION as a demonstration of the approach of bottom-up skill learning (from procedural to declarative knowledge). The model essentially consisted of two levels for capturing both procedural and declarative knowledge and enabling bottom-up learning, which differed markedly from existing models. Our experiments during the past five years demonstrated matches of the model with human data in several domains. Our focus has been on the minefield navigation (MN) task. A number of other skill learning tasks have also been chosen to be simulated that span the spectrum ranging from simple reactive skills to more complex cognitive skills. The tasks include serial reaction time (SRT) tasks, dynamic control (DC) tasks, the Tower of Hanoi (TOH) task. A good fit was found between the model and the human data, although the work is not yet complete.

In addition, several different ways of incorporating symbolic structures to enhance reinforcement learning are developed in some detail. Different from existing work using symbolic structures in RL, we focus on autonomous learning from scratch without requiring a priori domain-specific knowledge. Thus the role of symbolic methods lies truly in enhancing learning, not in providing a priori domain-specific knowledge to alleviate the need for learning. The key advantage of our methods is that they are more autonomous, more generic, and less expensive to apply, compared with existing methods that rely more on a priori knowledge. Some of our methods generate explicit, symbolic knowledge that are more suitable for comprehension, explanation, and communication of resulting knowledge. Several different domains and their variations have been tackled by our methods.

CONCLUSIONS: A new theoretical framework has emerged that suggests a new way of understanding skill learning — bottom-up learning that goes from procedural to declarative knowledge. There is still much work that needs to be done. Such work include: further development of techniques of autonomous learning, further development of cognitive models and verifications of such models by investigating their fit with new cognitive data in new cognitive domains, and related experimental and theoretical work. Such work can lead to significant advances in several areas.

SIGNIFICANCE: The model we developed suggests the possibility of alternative ways of skill learning different from existing accounts, and highlights an approach that has been

largely neglected. Comparisons with existing learning models (in AI and psychology) showed that our approach as embodied in CLARION has some unique characteristics that other approaches or models did not capture, most notably the bottom-up development and continuous interaction of both declarative and procedural knowledge (different from top-down declarative-to-procedural learning, and beyond separate, parallel learning of the two types of knowledge). The match with human data across various conditions/manipulations is significant, in that it provides evidence with regard to the cognitive validity of the model as well as providing new ideas for further research.

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