Cognitive Models of Human Expertise and their Scientific and Practical Value

James J. Staszewski

Department of Psychology, Carnegie Mellon University
Pittsburgh, PA 15213, USA
jjs@cmu.edu

Abstract

Understanding of human expertise and its acquisition has progressed substantially since Chase & Simon's seminal studies of chess expertise. Computational theories of expertise have been developed in domains such as memory, mental calculation, chess, and problem solving that explain expert performance at the level of cognitive structures and processes. Basic and use-inspired studies have demonstrated the generative property of cognitive models of expert skill. The latter show the value of such models for solving practical, high-stakes problems, e.g., landmine detection. The fundamentally adaptive nature of human expertise makes expert models valuable resources for understanding intelligence and engineering solutions to difficult problems.

Expert performance defines the boundaries of the adaptive capability of human intelligence as well as the explanatory challenges facing unified theories of cognition, or cognitive architectures. Although the scientific significance of theoretical integration is considerable, as is its challenge, understanding the cognitive bases of human expertise has practical utility that should not be overlooked.

Well-validated computational equivalents of the human mind limited to a selected domain of expertise have been developed for several domains. They include mental calculation (Staszewski 1988), chess (Gobet 1997), and exceptional mnemonic skill (Richman, Staszewski, and Simon 1995). The latter model not only simulates extraordinary performance in multiple memory tasks, it also traces the development of a clearly exceptional skill.

Laboratory studies have shown that expert models have a noteworthy generative property, having proven useful for accelerating the development of expertise (Biederman and Schiffrar 1987; Chase and Ericsson 1982; Staszewski 1988; Wenger and Payne 1995).

Recent field studies of expertise and skill acquisition have generalized this finding to a problematic, high-stakes domain: landmine detection (Staszewski 2008). Analyses of expert operation of two handheld landmine detection systems yielded models explaining the experts' outstanding performance. The models were then used as blueprints to design training programs for military personnel. Field-testing showed that overall detection rates improved substantially and manifold gains were achieved against the previously most difficult-to-find landmines. Based on the results the U.S. Army has adopted and now uses both training programs. These outcomes confirm the generative nature of models of human expertise as well as the practical value.

Just as microbiologists can decipher the genomes of various well-adapted species to reproduce them, cognitive scientists can dissect the bases of expert performance in domains in which adaptation has occurred mainly through learning rather than natural selection and use the resulting models to develop scientifically principled and practical solutions to difficult problems.

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