

Acquisition of Cognitive Skill: Do We Already Have a Theory?

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Background The acquisition of cognitive skill is studied in artificial intelligence, cognitive anthropology, cognitive psychology, robotics and other cognitive sciences. Researchers have produced multiple, apparently competing theories. I argue that the seemingly diverse theoretical proposals are in fact components of a unified theory and that the latter is already in a technical sense complete.

Framework for a Unified Theory Improvements in a skill cannot come out of thin air. A learning mechanism takes information of some sort as input. For example, generalization might take a rule but also some positive examples as input and produce a more general version of that rule (*Information Dependence*).

Information that might be available in a skill learning scenario comes in different types, and each type requires a different learning mechanism. To learn from positive examples requires a different mechanism than to learn from errors, which in turn requires a different process than learning from direct instruction (*Information Specificity*).

It is plausible that people evolved to be maximally effective learners, i.e., we can make use of every type of information (*Maximally Effective Learning*). A unified theory of skill acquisition should therefore include (at least) one learning mechanism for each information type.

Core of the Theory The types of information available to a learner during practice include the following nine: (a) Direct instructions. (b) Declarative knowledge. (c) Weak methods. (d) Demonstrations/solved examples. (e) Solutions to analogous problems. (f) Positive outcomes. (g) Negative outcomes. (h) Internal execution traces. (i) Statistical regularities in the environment. I claim that this is the complete list of relevant information types. But cognitive scientists have already specified learning mechanisms for all nine information types. In conjunction, those mechanisms constitute a complete and unified theory.

Discussion There are three implications: First, it is useless to test psychological models of single mechanisms against data. Second, adaptive A.I. systems should be equipped to learn from each type of information. Third, intelligent tutoring systems are maximally effective when they support all nine modes of learning.

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