

Development of Expertise

General Empirical Results

Stages of skill learning (Fitts & Posner '67)

cognitive

declarative, verbal

slow

associative

errors detected & eliminated

connections strengthened

autonomous

automated and rapid

requires less attention, fewer resources (Qin et al. 2003)

Power Law of Practice

(log-log coordinates) "cognitive component will go to zero?"

Kolers (1979) inverted text

training and retraining

Aspects of Development of Expertise

1. Proceduralization

compiling declarative knowledge into specific rules

Anderson 1982

geometry proof using SAS

practice -> faster, briefer

no verbal rehearsal, or retrieval pauses

postulate matched in single step

2. Tactical Learning

sequences as chunks

computation -> retrieval

Logan & Klapp, 1991 Letters + digit

3. Strategic Learning

Physics

backward -> forward search (e.g., Larkin 1981)

(also seen in geometry)

backward - memory strain

forward - requires knowledge of which inferences are relevant

problem categorization by deeper principles

(seen also in math, programming, and medicine)

Programming

no change to working forward

depth first -> breadth first

parts not completely independent

deeper representation

language independence

4. Problem Perception

Physics

problem categorization by deeper principles
(implicit in surface features)
(seen also in math, programming, and medicine)

Chi, Feltovich & Glaser 1981
classification
"angular speed" -> conservation of energy

Medicine

Lesgold et al. 1988
x-rays - distinguish cases with richer set of features

also Mathematics & Programming

5. Pattern Learning and Memory

domain specific memory

de Groot 1965, 1966 memory for chess board configurations
no advantage for random boards - discomfort
(seen in other domains since)

memory of patterns

Chase & Simon, 1973
chunking (glance, pause)
more patterns, larger patterns than novices
patterns are meaningful

Simon & Gilmarin 1973 ~50k chunks

Newell & Simon 1972
Human Problem Solving
chunks = productions (patterns + actions)
experts "see" what to do (reasoning -> retrieval)
reduces errors
allows conscious effort to focus on higher level
aspects of problem

6. Long Term Memory and Expertise

patterns are basis for memory recording

Charness 1976

chess patterns after 30 sec. interference task

Chase & Simon, 1973

remember more patterns

chunk define by 2 sec. pause

master: 3.8 pieces
 7.7 patterns / board
 = 29.26 total (ceiling?)

beginner: 2.4 pieces
 5.3 patterns / board
 = 12.72 total

Chase & Ericsson 1982

digit span -> 81! with 200 hours of practice

7. Deliberate Practice

Ericsson et al. 1993

best vs. good violin students

7000 vs 5000 hours of practice

claim all expertise accounted for by amount of practice,
almost no room for talent

nature vs. nurture?

correlational studies vs. experimental

talent -> practice?

problem of restricted range

deliberate practice

motivated to learn

given feedback

monitor performance

focus on eliminating deviations from ideal

Transfer of Skill?

"faculties of the mind", exercise,

vs.

Thorndike - theory of identical elements

abstract elements

"learning to learn"

Educational Implications

componential analysis & mastery learning

Intelligent Tutoring Systems