# Cognitive Task Analysis 2

# Plan for Today

- Quick reviews of:
  - Original cognitive task analysis: Newell & Simon's "Human Problem Solving" in 1972
  - Some highpoints of Clark paper
- Discussion
  - Review readings prompted by Assistment questions & by reading reports
- Connect CTA to your own research
  - What tasks would you analyze?

# To do for next time

- See discussion forum for Jan 24
  - Read 1, skim 2, post
  - Indicate some task(s) in your domain of interest on which you could do a CTA

# Newell & Simon

Newell, A., & Simon, H. A. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice-Hall.

- First deep analysis of performance on complex tasks (taking about 30 mins)
- To understand & improve learning we need to understand performance
  - "the study of learning, if carried out with theoretical precision, must start with a model of a performing organism" (p. 7)
- Empirical, not experimental
  - Means?

# What drives human performance?

- Newell & Simon asked:
  - "whether a theory of problem solving (or thinking, or learning) is really a theory about human beings or a theory about the nature of the task environment" (p. 14)

- Simon's ant on the beach metaphor

# Task Environment

- Number scrabble example
  - Point: External representations (part of the "task environment") can greatly change human performance

- Task environment contains
  - Possible stimuli, what student can see
  - Possible actions, what student can do
- Can behavior be described in terms of mental connections of the following simple form:
  - If some stimulus, then some action
- What do you think?

# N&S knowledge components

- No, not quite!  Need to include goals!
- Behavior can be described in terms of mental connections ("knowledge components"):
  - If some goal & some stimulus
    then some action or new goal
- A set of such "production rules" make up a "production system"

# Example production system of playing tic-tac-toe

**FIGURE 3.4**
**production system for playing tic-tac-toe**

tic-tac-toe-strategy:

1. side-to-move = opponent → stop.
2. ⟨own-winning-pattern⟩ (⇒ blank-square) → play (blank-square).
3. ⟨opponent-winning-pattern⟩ (⇒ blank-square) → play (blank-square).
4. ⟨own-forking-pattern⟩ (⇒ intersection-square) → play (intersection-square).
5. center = blank → play (center).
6. ⟨opponent-on-side⟩ → find corner = blank; play (corner).
7. ⟨opponent-on-corner⟩ → find opposite of corner; play (opposite).

# Problem Space

- The "space in which problem solving activities take place"
  - Essentially what are the production rules to chose from & in what combinations can they be carried out
  - Feasible to define for a "task domain"
    - Example task domains: chess, logic theorem proving, generating a good argument, translating German to English
- Productions:
  - Operate on "states" of the environment
  - Produce an "action" that results in a new state
  - The problem space is all the possible states & actions

# Clark's CTA Families

- Strategies for knowledge elicitation (empirical)
  - Observation and interviews
    - Informal
  - Process tracing
    - More structured
  - Conceptual techniques
    - Formal, with fixed protocols for interaction with participants
- Formal models (theoretical)
  - Simulations of task performance or "cognitive models"

# Clark’s steps

- Collect preliminary knowledge
- Identify knowledge representations
- Apply focused knowledge elicitation methods
- Analyze and verify data acquired
- Format results for intended application

# Knowledge representations schemes

- Clark's
  - Concept maps
  - Flow charts
  - Semantic nets
  - Learning hierarchy
- Other's
  - Goal trees
  - If-then rules written in English
  - Cognitive modeling, like ACT-R

# Reviewing purpose & steps…

# CTA Purpose

- Many ed research methods are about *how to teach*
- CTA is primarily about *what to teach*
  - How come that's not obvious?

# General Steps In CTA

- What are instructional objectives?
  - Standards, existing tests, signature tasks
- Literature review
- Specify space of tasks
- Do either or both:
  - Theoretical task analysis: Create a model that is sufficient to deal with space of tasks
  - Empirical task analysis: Do think aloud, difficulty factors assessment, expert interviews…

# Connecting to your research

- What domain would you do a CTA in?
- What tasks would you analyze?
- How would you do it?
  - Empirical or theoretical/rational?
  - Descriptive, prescriptive?
  - Which technique?
- How might you represent your results?
- How would you use your results to redesign instruction?