PHIL/PSYCH 256
INTRODUCTION TO COGNITIVE SCIENCE
Week 3: Rules

PLEASE TURN OFF AND PUT AWAY ALL
ELECTRONIC DEVICES

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Rules

Rule: Mental representation of the form

IF .... THEN ...

Not just a moral instruction.

Simpler than logic.

Examples: What are some rules that describe your knowledge of how to enjoy the weekend?

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History of Rules

- Production systems

- Newell & Simon, General Problem Solver, 1950s-1960s

- Expert systems, 1970s-1990s

- SOAR: Newell, Laird, etc.

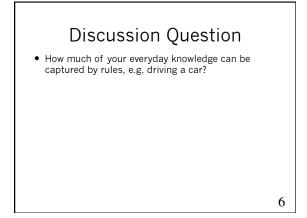- ACT, 1983-now, John Anderson, CMU (reading)

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Rules: Computational Power

- Problem solving as search
  - planning
  - explanation
  - forward chaining: string rules together, matched against working memory of current state
  - backward chaining: work back from goal to start

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Rules: Computational Power

- Learning
  - generalize to form new rules
  - specialize to form more specific rules
  - abduction to form explanations
    - If CAUSE then EFFECT
    - EFFECT
    - So, maybe CAUSE
  - chunking to build rules from old

- Are some rules innate?

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Discussion Question

- How much of your everyday knowledge can be captured by rules, e.g. driving a car?

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Strengths of Rules

- Modular, easy to add to.

- Apply to much problem solving and learning.

- Practical applications, e.g. tutors.

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Limitations of rules

- Inflexible

- Overgeneral

- Difficult to control

- Hard to understand operation

- Knowledge acquisition is difficult: tacit knowledge. Non-verbal representations.

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Anderson

- Cognitive skills are realized by production rules.

- Production rules are organized around a set of goals.

- Complex cognitive processes involve a sequence of production rules.

- Productions are matched against working memory.

- Rules are psychologically realistic, because they describe many aspects of skilled behavior, and predict the details of that behavior.
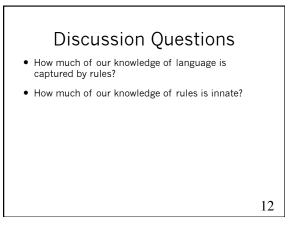
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Key Points

- Rule-based representations and procedures have been used to explain many psychological phenomena.

- But they may not capture the full range of human thinking.

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Linguistic Rules

- Phonetic, e.g. "finger", "cats"
  - ghoti

- Tenses, e.g. "ed". Pinker.

- Syntactic, e.g. forming questions

- Innateness

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Discussion Questions

- How much of our knowledge of language is captured by rules?

- How much of our knowledge of rules is innate?

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Psychological Plausibility

- Applied to many tasks, e.g. arithmetic, chess. John Anderson reading.

- Models learning, as new rules are constructed and chunked. Quantitative fit: power law of learning.

- Learning in rats.

- Learning of social rules, physical systems.

- Language learning

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Neurological Plausibility

- Are there rules in the brain?

- Connectionism as an alternative.

- Anderson (new): find neural correlates of rule-based reasoning.

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Pinker

- English has both regular past tenses formed by adding "ed" and irregular past tenses, e.g. "sang".

- The rule-rote theory, which says that irregular verbs are just memorized, is implausible, but such verbs fall into families, e.g. "sang" and "rang".

- Associationist theories are implausible, because they produce behavior that differs from human languages.

- Past tenses are computed by a combination of rules and associative memory.

- Some language impairments can be explained on the assumption that people use rules.

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Key Points

- Rules have much psychological plausibility, for example in explaining the learning and comprehension of language.

- But other phenomena may require alternative kinds of representations.

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