HUMANS LEARNING A COMPLEX TASK ARE PICKY, STICKY, AND LEAPY

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Background/Rationale: Learning a complex skill requires searching a potentially enormous search space. While artificial intelligence (AI) can now approach human levels of performance in many complex tasks, they require much more training than humans. This may be because only humans can infer and apply generalizable principles from limited experiences. However, the statistics that underlie this learning process are both poorly understood and hard to investigate in the large state spaces found in most complex tasks.

Research Questions: How do people learn to solve a complex task? What is a cognitive task that is simple enough to study using the tools of psychophysics, but complex enough to induce intelligent search? We aim to define the statistical principles that shape efficient search to improve models of natural and artificial intelligence.

Methods: We designed a puzzle with minimal verbal instruction and thousands of potential solutions, only a few of which meet the criterion of success. We launched the game as a smartphone-based app, allowing us to collect data from a large online population and compared their learning to artificial neural networks (ANNs).

Analysis: We analyzed data from >10,000 online users and compared their behavior to that of Deep-Q Networks (DQNs) in the first level of the task. We looked at the distribution of action sequences ('strategies') of each player type, the probability that a strategy would change across trials, and the reward the subject collected on each trial. These quantities were compared between humans and AIs.

Results: Unlike the AI, humans 1) search a highly restricted subset of the policy space; 2) attempt even poor solutions many times before discarding them; 3) arrive at the optimal policy suddenly and unpredictably with a "leap of insight".

Discussion: Our data suggest a "top-down" learning process in which people learn by proposing explanatory theories which they refine or replace only upon collecting sufficient evidence to the contrary.

Keywords: Problem Solving, Intelligence, Skill learning, Decision making, Epiphany

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