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Cognitive Science Needs Powerful Research Strategies

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It seems reasonable to believe that problem solving with the Tower of Hanoi (TOH) task has been studied thoroughly enough to be well understood. Yet, the discovery of a new class of affordance-based strategies was reported recently (Guimberteau, 2003), with the finding that problem solving strategies issued from that class are capable of explaining the famous TOH protocol from Anzai & Simon (1979).

The above discovery enriches the set of known strategies for the task, formalized several decades ago (Simon, 1975). Importantly, it also raises an issue, given the prolific nature of the research area concerned with problem solving with the TOH task: Why has not the new class been specified earlier?

Such a question may be dismissed on the grounds that certain aspects of scientific inquiry are not explainable. Another approach is to consider that question closely, as an opportunity to learn from the past. The present analysis takes a first step in the latter direction. It examines past modelizations of Anzai & Simon (1979)’s first problem solving episode (Episode 1), looking for clues to explain why those modelizations have not considered the affordance-driven explanation of the learner’s problem solving behavior.

The strategy put forth to explain Episode 1 – Selective Search – constitutes a classic result in the cognitive science literature. The strategy simplifies search by not repeating moves (Anzai & Simon, 1979; Ruiz & Newell, 1989; VanLehn, 1991). It is made of three heuristics: “Don’t reverse a move just made”, “Don’t move the same disk twice in a row,” and “Don’t transfer the smallest disk and later return it to its previous peg.” Those heuristics constrain move selection in such a way that search becomes unnecessary after the first move.

Good fits and convergence of results form the basis of the credibility of the Selective Search strategy. Past accounts simulate problem solving in Episode 1 using the Selective Search strategy and show that they can reproduce the transitions between the learner’s strategies (Anzai & Simon, 1979), with a good fit to the learner’s moves (Ruiz & Newell, 1989), and to her goal utterances as well (VanLehn, 1991). Specifically, Anzai & Simon (1979) build a production system that can make the same strategy transitions as the ones they hypothesize for their human learner. The Soar simulation from Ruiz & Newell (1989) produces moves that correspond to 77% of the subject’s observed moves in her first problem-solving episode. The production system from VanLehn (1991) accounts for all but one of the subject’s 130 observed moves and all but 3 of her 41 goal utterances.

A close examination of the Selective Search modelizations reveals three observations. Certain aspects of the episode (e.g., a bottom-disk focus) are not explained by the Selective Search strategy, requiring additional modeling mechanisms. In addition, two conflicts between the heuristics and data from the episode need addressing. Finally, the fact that those simulations overlook certain aspects of the data raises the possibility that other mechanisms may be able to explain both the unexplained and the explained data. Indeed, a stronger explanation of the problem solving strategies used in Episode 1 is affordance-driven, and not based on the above Selective Search heuristics: The subject recognizes task-specific affordances during problem-solving, from which she devises affordance-driven strategies (e.g., moving the second smallest disk first because that disk affords moving less than the smallest one.) In other words, the Selective Search characterization rests on a foundation that does not address issues of exhaustive protocol coverage, conflict prevention, and parsimony.

The Selective Search strategy discussed here constitutes one of the classic results of cognitive science. Yet, the two major criteria underlying its credibility – good fits with the protocol data and convergence of past analyses of those data – are insufficient. Other classic results may suffer from similar limitations. The present finding calls for the definition of powerful strategies for cognitive science research.

References