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Opinion

Quo Vadis CPS? Brief answers to big questions

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Research on complex problem solving (CPS) has reached a stage where certain standards have been achieved, whereas the future development is quite ambiguous. In this situation, the editors of the Journal of Dynamic Decision Making asked a number of representative authors to share their point of view with respect to seven questions about the relevance of (complex) problem solving as a research area, about the contribution of laboratory-based CPS research to solving real life problems, about the roles of knowledge, strategies, and intuition in CPS, and about the existence of expertise in CPS.

Why should there continue to be problem solving research (in addition to research on memory, decision-making, motivation etc.)?

The ability to solve problems (i.e., tasks for which no apparent solution is readily available) has, in our view, become one of the quintessential abilities for both professional and personal life. By now, machines can complete most repetitive tasks, leaving humans more time to focus on creating new knowledge and applying this knowledge to solve problems. While computers can help us overcome some of our human limitations (e.g., externalize our memory or help with decision processes), ultimately we as humans need to define the problems we want to solve and find ways to use the appropriate tools and strategies. Research on how people approach problems, why they fail to solve them, and how they can be supported to succeed in the future, needs to be continued. However, the field is also in need of either a clear delineation to other, often overlapping, fields such as dynamic-decision making or of stronger efforts to synthesize adjacent fields to see what problem solving research can learn from fields such as decision making and vice versa.

What are the connections between current CPS research practice and real problems? Where do you see potential for development towards stronger relations?

Most of the current research on CPS focusses on complex systems with only few variables or that, in some way, do not fully resemble the complexity of the real world (Greiff, Fischer, Stadler, & Wüstenberg, 2015). Despite the justified criticism that reality is far more complex, this limitation in contemporary assessment instruments might still be appropriate to represent "real-world" problem solving. If, for example, your cat is sick it is certainly appropriate to identify everything it ate (few variables) and then systematically rule out potential causes of the illness. Obviously, some problems are either too complex to fully understand the influence of each individual variable, not stable enough to actually specify any consistent rules, or there is not enough time to explore the system comprehensively. Such systems were used to study CPS in the field's "early days" with the aim of emulating "real world" problems as closely as possible. We argue, though, that most people deal with sick cats more frequently than they become almost omnipotent rulers of midsized cities (the scenario of one of the most famous CPS tasks; Dörner, Kreuzig, Reither, & Stäudel, 1983). While there is a great deal of research on problem solving in controllable systems (such as the food you feed your cat), research on uncontrollable systems needs to be strengthened. For instance, we face the problem of how to talk to our colleagues during our daily interactions with them. Telling jokes (i.e., an "input variable") may make some people like you more, whereas others may not appreciate it (i.e., "outcome variables"). Systematically isolating colleagues to tell them jokes in order to measure their response is obviously not feasible. However, based on data that has been generated in the past, we could generate knowledge and then use this knowledge to solve future problems. This line of research is exciting and might help us understand "real-world" problem solving in diverse situations.

Given the artificiality of the laboratory situation, do participants really adopt the presented problems? What insights can be gained despite this artificiality and which cannot?

In our experience, the artificial nature of the problem situation is not problematic as long as the cognitive (and non-cognitive) processes involved are the same. There seems to be no reason to assume that a person who is able to solve a problem in a laboratory situation will not be able to solve a similar problem in a more naturalistic situation. Examples come from the fields of both medical, military, and teacher training where complex skills are usually trained and assessed using simulations (for an overview see Chernikova, Heitzmann, Fink, Timothy, Seidel, T., & Fischer, 2019).

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What evidence exists for the influence of other kinds of knowledge besides structural knowledge on the results of CPS? Which of these kinds of knowledge should be examined in future research?

The amount of evidence on the impact of knowledge on CPS is plentiful. As mentioned above, various fields such as medical, military, and teacher training use complex simulations in which participants need to engage in CPS in knowledge-rich situations. Combining the theories of these fields with the methodology and theory of the more cognitive research on "knowledge lean" CPS will, in our view, be one of the most exciting challenges for future research.

What evidence is available for the impact of strategies (except VOTAT) on the results of CPS? Which of these strategies should be examined more closely?

Interestingly, the VOTAT strategy has, by far, received the highest level of attention when it comes to understanding strategic behavior in CPS. This is mirrored in the field of science inquiry in which the very same strategy only with the different label CVS (control of variables) has received a similar amount of attention. Moreover, a study based on the PISA 2012 data found that use of VOTAT in one task was highly predictive of overall CPS score that required solving tasks with different strategies (Greiff, Wüstenberg, & Avvisati, 2015). Thus, VOTAT (just as other strategies) might not be limited to a specific behavior but also indicate a more general level of strategic competence. We know little about what this competence might be even though some recent studies have looked at other strategic behaviors in CPS research (Beckmann, Birney, & Goode, 2017; Schoppek & Fischer, 2017). An often neglected way forward might be to look at (longer) sequences of behaviors instead of the single use of strategies using (educational) data mining techniques to discover those fuzzy relations (Stadler, Fischer, & Greiff, 2019). Another interesting topic are heuristics that are needed in complex environments and that have not been sufficiently focused from an individual difference perspective (Gigerenzer & Gaissmaier, 2006).

Is there intuitive CPS?

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What distinguishes experts in CPS from laypersons?

The term "experts" is often employed in the context of specific domains in which individuals can – partly through practice and experience – achieve an extremely high level of competency and/or knowledge with chess experts being the classical example (Detterman, 2014). Thus, usually experts are found in specific areas and we are not sure whether the term equally applies to a broad mental ability such as CPS. In fact, one would not consider highly intelligent people as experts in intelligence and a gradual distinction between different levels of CPS might be more appropriate (for an example that distinguishes a continuous scale into distinct level for ease of communication, see the PISA 2012 problem solving assessment; OECD 2010). Of course, people with high levels of CPS are likely to differ from people with low levels of CPS, for instance with regard to fundamental cognitive abilities, meta-cognition, or the available set of strategies. To the best of our knowledge, there is no research indicating clear qualitative shifts (e.g., from layperson to expert) beyond what could be described in quantitative models of CPS.

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