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Roger L. Dominowski (1939-2020): his contribution to the study of insightful problem solving

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ABSTRACT
Roger Dominowski made a very substantial and lasting contribution to the study of higher mental processes and particularly to the area of insight problem solving. This is a tribute to his work.

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Roger Dominowski contributed greatly across a wide range of topics in the study of higher mental processes and particularly to the area of insight problem solving. His early publications, starting in 1964, grew out of his doctoral dissertation on anagram problem solving which was carried out at Northwestern University in Evanston, Illinois, under the supervision of Carl P. Duncan. As well as work on anagram solving, Dominowski published extensively at the start of his career, from 1965 to 1970, on laboratory studies of well defined concept learning, which had become a fertile research area after Bruner et al.'s (1956) *A Study of Thinking*.

In the history of research on thinking and problem solving, the early Gestalt focus on insight in problem solving had been largely set aside as "mentalistic", untestable or even as unscientific during the peak period of Behaviourism in the 1930s and 40s in American and British psychology. The cognitive revolution in the mid-1950s, inspired by early work on artificial intelligence and computer simulation of cognition (Newell et al., 1958; Newell & Simon, 1956), revived interest in complex problem solving and soon led to a growing focus once again on the topic of insight, as well as on more routine ways of problem solving, such as through heuristic search processes.

Dominowski took a strong interest in the ideas of the early Gestalt pioneers such as Köhler, Maier and Wertheimer, as shown in his 1994 article on the history of thinking research (Dominowski & Bourne, 1994) and in his synthesising chapters in 1995 (Dominowski & Dallob, 1995) and in 1997 (Dominowski, 1997). These last two chapters provide exceptionally clear analyses of the key concepts of insight, creativity, re-structuring, fixation, and functional fixity, and still re-pay careful study. His conceptual analyses gave rise to predictions. For example, given his definition of insight as "a form of understanding of a problem and its solution" which results from appropriate re-structuring, it was predicted and found that memory for self generated insight solutions was much superior to that for solutions simply presented to participants (Buyer & Dominowski, 1989). At the time, the topic of solution memory (i.e. recalling solutions of previously presented problems) was a largely neglected area of research, with two notable exceptions: Slamecka's generation effect (Slamecka & Graf, 1978) which refers to the more ubiquitous observation that any type of generation of material (e.g. filling in missing letters) has beneficial effects on memory for that material. Another example of the generation effect is the persistence of self-generated false memories (as elicited by the Deese-Roediger-McDermott procedure) which can act as primes for problem solving (Howe et al., 2010, 2016). Second, some early work was conducted by

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Auble and colleagues on the connection between memory and the subjective Aha! experience (Auble & Franks, 1978; Auble et al., 1979). Dominowski further pursued the topic, and brought these two overlapping areas of research together. He replicated the "re-solution effect" (better recall for self-generated, correct solutions than for solutions that had been presented after failure to solve) and demonstrated that the effect disappeared if the connection between the problem and the solution was not meaningful, but arbitrary – because in this case, no restructuring is possible (Dominowski & Buyer, 2000). Based on retrospective verbal protocols about the solution process, he found that solvers' problem representations differed from those of nonsolvers (who had been shown the solution) with regard to coherence and structural understanding, offering a possible explanation for the superior memory performance of solvers. This series of experiments supported the Gestalt position that re-structuring plays an important role for solution memory. In fact, this work inspired a recent line of research on the "insight memory advantage" (Danek et al., 2013; Kizilirmak et al., 2016; Danek & Wiley, 2020) – the finding that self generated solutions for which an Aha! experience is reported are remembered better than those without Aha! experience. Thus, it seems that not only the cognitive component of insight (the restructuring process), but also the affective component (the Aha!) contribute to solution memory.

In addition to purely theoretical issues, Dominowski was concerned with the important practical question of improving people's typically poor ability to tackle insight problems and his work on training to improve insight problem solving led in encouraging directions. For example, Jacobs and Dominowski (1981) found a training effect over trials with eight different insight tasks (in random orders over trials). Interestingly, a secondary part of that study found no effects of allowing actual manipulations of physical problem materials as against paper-and-pencil presentations with only mental explorations possible – a null finding which has recently been replicated in a much larger study with different problems by Chuderski et al. (2021) and which is problematic for the embodied cognition approach to problem solving (Vallée-Tourangeau, Steffenson, Vallée-Tourangeau, & Sirota, 2016; Vallée-Tourangeau, Ross, Ruffatto Rech, & Vallée-Tourangeau, 2021). A second training study (Ansburg & Dominowski, 2000) showed that even limited training, designed to give practice in Ohlsson's (1992, 2013) re-structuring processes of elaboration, re-encoding and constraint relaxation, had significant effects, aiding later solving of insight problems. Similar independent results confirming the value of elaboration in re-structuring can be seen in McCaffrey's work (2012) on the Generic Parts Technique where problem representations are improved by detailing the make-up of problem components (e.g. the parts of a candle, where the wick may be used in a novel way); and also in the Dissassembly strategy in Alternative Uses tasks (Gilhooly et al., 2007) by which a familiar object is mentally disassembled and its parts used in novel ways (such as shoe lace removed from a shoe and used as a bracelet). Dominowski (1990) pointed to the important role of meta-cognition in evoking such strategies. This idea was taken up in later studies that successfully trained problem solvers in using meta-cognition to identify inconsistencies in their problem representations, yielding clear improvements in performance (Patrick & Ahmed, 2014; Patrick et al., 2015). In contrast to cueing procedures that are often highly problem-specific, such meta-cognitive procedures could theoretically be applied to various unfamiliar problems. This paves the way for future work on how to facilitate insight which remains a question of keen interest for both researchers and practitioners.

Search for training possibilities led to a concern with why insight might fail to occur, since training could then be aimed at sources of failure. Overtight goal constraints are a likely factor in producing fixation in many cases and Lung and Dominowski (1985) demonstrated this in relation to the 9-dot problem by instructing participants that in order to solve, the lines must go outside the 9-dot box. This instruction boosted solution rates from a control level of 9% to 34%. Instruction plus added practice with related problems raised solution rates still further to 59%. These results indicated that misleading constraint assumptions are a large part (but not all, as shown by Kershaw & Ohlsson, 2004) of the difficulty of the 9-dot problem and presumably of many other insight problems. In fact, since that 1985 study, a growing number of studies has demonstrated that constraint relaxation is a key mechanism that enables insight, as postulated by Ohlsson's representational change theory (1992). Given that the main constraint that prevents a solution in a particular problem can be identified,

e.g. through task analysis, cues can help to achieve insight into the solution. For example, relaxation of the 2-D constraint (the assumption that coins can only be moved in the plane whereas the solution requires stacking them on top of each other) significantly increased solution rates in the Eight-Coin Problem (Öllinger et al., 2013). Even in relatively complex problem solving tasks such as magic tricks, specific cues targeted at relaxing the misleading assumptions yield higher solution rates than a baseline condition (Pétervári & Danek, 2020). Such studies advance our understanding of the mechanisms of how insight is achieved (and how it fails to occur). In future work, it would be desirable to move beyond cueing procedures that necessarily remain problem-specific, and look for possibilities to improve a more general skill to identify and relax constraints that might prevent us from gaining insight.

To sum up – through careful conceptual analyses and solid experimental studies, Roger Dominowski made a very substantial and lasting contribution to the renaissance of insight research, which began in the 1980s and continues strongly in the present.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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