Paradoxes, Principles, and Prospects for the Future of Creative Cognition

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Paradoxes and Principles

The contributing authors to this book have addressed, and in many cases clarified or resolved, some of the major issues and controversies that have surrounded the subject of creativity. In doing so, they dem- onstrate the value of the creative cognition approach (Finke, Ward, and Smith 1992), showing that creativity can be better understood if it is studied in the context of contemporary cognitive science. The chapters show how creativity can be effectively studied scientifically, using experiments, case studies, and computational modeling. In this concluding chapter we will review and integrate the major themes in these chapters, attempt to resolve some of creativity's paradoxes, suggest ways in which creative thinking might be improved, and conclude by considering future prospects for the creative cognition approach.

One paradox the authors addressed is that creative thinking appears to involve special processes and abilities, such as insight, incubation, or divergent thinking, yet creativity is also considered to be part of our regular collection of cognitive skills, underlying such everyday activities as recalling events, forming images, using language, and dreaming. Does creative thinking involve special abilities, or normal everyday processes?

Many of the authors clearly endorse the claim that creative thinking consists of the same mental processes involved in noncreative thinking (Bowers, Farvolden, and Mermigis; Freyd and Pantzer; Mandler; Schank and Cleary; Smith; Ward; Weisberg). Mandler, for example, states that the ability to produce novelty is necessary even in common everyday thinking, suggesting that the mechanisms that underlie cre- ative thinking are normal ones. Weisberg and Ward emphasize the importance of prior knowledge in creative endeavors—Weisberg from the standpoint of knowledge retrieval and Ward in terms of antecedent cognitive structures that underlie idea generation and exploration. Incubation, a seemingly mysterious phenomenon in creative problem solving, has also been attributed to normal cognitive mechanisms, such as spreading activation (Bowers, Farvolden, and Mermigis) or contextual fluctuation (Smith). Dynamic qualities of creative thinking are linked by Freyd and Pantzer to dynamic mental representations that typically give rise to memory distortions. Schank and Cleary show that only slight variations of computational models of comprehension are needed to account for creative thinking. These cognitive mecha- nisms—knowledge retrieval, spreading activation, contextual fluctua- tion, memory distortion, and comprehension—are the same as those currently studied in noncreative contexts.

On the other hand, other chapters indicate that special creative processes do exist. Dominowski emphasizes the importance of insight and productive thinking in creative problem solving, distinguishing them from reproductive uses of prior experience. Schooler and Melcher indicate that the processes that underlie insight in problem solving are not verbalizable; in fact, these authors find that verbali- zation inhibits success on insight problems, suggesting that insight processes differ from analytical problem-solving operations. Martin- dale also characterizes the special nature of creative processes, de- scribing how the simultaneous activation of disparate elements during creative cognition differs from noncreative cognition.

How can creative thinking be both special and ordinary? Although this paradox may not be completely resolved, it can at least be clarified. First, it should be obvious that not all creative thinking follows exactly the same pattern. Whereas some classic discoveries appear to have resulted from flashes of insight (e.g., Archimedes' displacement prin- ciple, Kekule's benzene ring), others seem to have resulted from in- cremental applications of prior knowledge (e.g., Watson and Crick's discovery of the structure of DNA). Just as different memory tasks may require different types of cognitive processes, so, too might dif- ferent creative endeavors. One task may be done by restructuring, another by reproductive knowledge retrieval, and yet another by a combination of the two operations.

Also helping to resolve this special-vs.-ordinary paradox is evidence that special processes such as insight, incubation, and activation of disparate elements can also be seen in noncreative tasks. Verbaliza- tion, which interferes with insight problem solving (e.g., Schooler and Melcher, chap. 5), also interferes with face recognition (e.g., Schooler and Engstler-Schooler 1990). Incubation has been found not only in problem-solving situations but in memory tasks as well (e.g.. Smith and Vela 1991). Likewise, dreaming, a daily activity, often involves juxtapositions of disparate elements. Whether or not a particular cog- nitive process is deemed special, it is clear that none are uniquely encountered in creative thinking.

Another paradox addressed by the chapter authors is that, whereas creativity involves the use of old knowledge, it also requires that we do things in new ways. Are we therefore to use or reject prior knowl- edge in creative thinking? How are we to decide when we are told not to fall into ruts in our thinking and yet to have the sense not to repeat the mistakes of history?

The predominant view expressed in these chapters is that prior knowledge is usually needed for creative cognition. For example, both Mandler and Bowers, Farvolden, and Mermigis note the importance of Pasteur's idea that a prepared

mind is essential for creative thinking. Weisberg's thesis is that major creative leaps can arise from the repro- ductive use of prior knowledge. Smith's description of the use of plans in constructive searches also underscores the importance of prior knowledge in creative thinking. The use of established concepts that guide the generation and exploration of new ideas is also a basic theme of Ward's chapter.

But is the prepared mind sufficient for producing creative ideas? Perhaps some would agree, but most of the contributing authors do not. Schank and Cleary, who support the idea that knowledge is necessary for creative thinking, define creative thinking as an "intel- ligent misuse" of knowledge. That is, knowledge that one has acquired must be playfully manipulated to achieve creative ends. Similarly, Mandler describes how the nondeliberate use of memory structures in dreaming can produce novelty. Having knowledge is not enough; one must use that knowledge in unconventional ways to produce creative thoughts. Finke describes an excessive adherence to prior knowledge as "conservative realism," which consists of uninteresting extensions of what is already known, whereas "creative realism" re- quires an imaginative use of known cognitive structures.

Acknowledging the importance of prior knowledge in creative cognition helps to resolve another paradox: are creative methods and abilities domain specific, or are there general prindples that describe and explain creative thinking in all domains? Although there have been notable exceptions, most people who have made significant creative contributions have done so in only a single domain, such as sports, science, or the arts, rather than shining in many unrelated domains. Paradoxically, the creative cognition approach posits that the basic cognitive processes that underlie creativity are essentially the same in all domains. If one's creative abilities can function across domains, why does that tend not to occur?

Because domain-specific knowledge is necessary for most creative contributions, as noted in many of these chapters, it follows that most individuals can make creative advances only in the domains in which they have cutting-edge expertise. Therefore, the playful or "intelligent misuse" of expertise, which can yield creative ideas in any domain, tends to be seen only in an individual's area of specialization.

The idea that creativity involves a playful or unusual use of expert knowledge helps to resolve another paradox: that imagination and practicality are the two primary criteria used to assess creativity. We typically think of these as the opposite ends of a continuum rather than as qualities that are found together. Imagination so often seems impractical, and practicality seems so unimaginative. How can imag- inative ideas by practical or realistic? Ideas can be practical if they are based on expert knowledge that is well integrated, and they can be

imaginative if the underlying knowledge is used in novel ways. Finke's emphasis on structural connectedness in creative realism and Ward's assertion that knowledge structures are used to guide creative thought show how creative ideas can also be practical.

The rarity of important creative discoveries makes real-world cre- ativity difficult to study in a scientific way. The idea of "everyday" creativity, however, is endorsed by many of these chapters as psycho- logically similar to that which underlies great discoveries. As Mandler notes, the important question to the psychologist is how someone gets an idea rather than the personal or cultural importance of the idea. Therefore, researchers have turned to relatively simple labora- tory tasks that require no expertise beyond that of an average college-aged adult. These laboratory tasks, which include insight problems (e.g.. Bowers, Farvolden, and Mermigis; Dominowski; Schooler and Melcher), Remote Associates Test (RAT) problems (e.g.. Bowers, Far- volden, and Mermigis; Smith), and mental synthesis problems (Finke 1990) are used as microcosms for creative problem-solving activities. From studies of these problems, one can learn to overcome mental blocks, reformulate problems, restructure knowledge, and acquire new insights.

Another approach to studying creative thinking that does not require special expertise has been to use activities that are normatively familiar to subjects. For example. Smith, Ward, and Schumacher (1993) asked subjects to generate novel ideas for toys or imaginary creatures. Subjects may not have extraordinary expertise in the domains of these tasks, but they nonetheless have enough knowledge about toys and animals to display a good deal of creativity about them.

Although the apparent conflict between the use of knowledge ver- sus the suspension of it in creativity has been somewhat clarified, it has not been completely resolved. Dominowski cites obstacles to solv- ing insight problems: functional fixedness, inappropriate organization of the problem, inadequate monitoring of the efficacy of one's solution, and fixation. Smith notes that memory processes, such as priming of inappropriate information, can negatively affect problem solving and creative idea generation, even among professional design engineers (Jansson and Smith 1991). Weisberg, on the other hand, notes the importance of using, rather than rejecting, prior knowledge in real- world examples of creative discovery. Distinguishing between situa- tions in which prior knowledge must be used and those in which it should be rejected continues to be important issue.

Another paradox in creative cognition is that creative ideas might not occur when one deliberately attempts to work on a problem but rather when one's attention is turned away, at least momentarily, from the problem at hand. This "catch-22—

" that you can do something creative only when you are not trying—resembles other phenomena that can be attributed to implicit processes, such as the performance of certain motor skills or the forgetting of unwanted information. Finke's research with preinventive forms, for example, has shown that more creative inventions are discovered if subjects do not have a specific purpose in mind at the time they generate their forms, which then inspire their subsequent creative thinking. Lubart and Stemberg note that creative performance in their studies was negatively affected by having too high a level of motivation, also suggesting that too much goal focus may detract from creative thinking.

Several explanations of the role of nontask processing in creative cognition are offered in these chapters. Bowers, Farvolden, and Mer- migis suggest that unconscious semantic activation may support the generation of solutions to problems, a notion that has been used to explain incubation effects (Yaniv and Meyer 1987). Mandler states that novel concatenations of existing knowledge, such as those generated during dreams, arise from problem-initiated activation that spreads throughout one's knowledge without the typical constraints of reality. He cites a number of cognitive mechanisms that may explain why deliberate work on ideas is sometimes fruitless. If deliberate process- ing encourages verbalization, then Schooler and Melcher's research shows that insights may be prevented by trying to verbalize one's thoughts. Smith theorizes that rather than allowing unconscious pro- cesses to construct solutions, nontask processing changes one's cog- nitive context, leading to a new problem representation that avoids the mental blocks encountered on previous attempts. Finally, Martin- dale's emphasis on the importance of combining disparate elements in discovering creative ideas suggests that nontask processing in- creases the accessibility of material that is not obviously related to the problem. Any or all of these explanations of nontask processing may occur in creative cognition, and all are empirically testable.

The chapters also show different ways in which creative cognition can be computationally modeled. Schank and Cleary consider how creative ideas could be generated by a computer program, tracing the development of artificial intelligence programs designed to under- stand and explain discrepancies in text and natural language. Cheng and Simon model a different aspect of creative cognition, looking at the way one- and two-dimensional diagrams can be used to guide the induction of scientific principles. Their HUYGENS program spots sys- tematic regularities in diagrams and uses heuristics and logical oper- ators to simulate scientific discoveries. Martindale's connectionist approach considers the type of knowledge that is activated during creative work on a problem. This model uses simulated annealing to characterize a search for ideas; when the search becomes bogged down in a local minimum (analogous to blocking or fixation), an increase in "temperature" (analogous to lowering arousal) helps

extricate the search from the block and improve the chances of finding a global minimum (analogous to a creative idea or solution).

Finally, the chapters indicate various ways in which people can improve their creative thinking. The principles noted above suggest some general strategies for improving creative performance. One prin- ciple is that both prior knowledge and a playful or imaginative use of that knowledge are important in creative thinking. The classic edu- cational question—whether to focus on skills and knowledge in the classroom, or allow students to think freely so that their creativity will not be stifled—is thus resolved: knowledge is necessary but not suf- ficient for creativity.

Another principle is that one should try to recognize mental blocks and implicit assumptions that may prevent insight. When a design engineer, architect, artist, scientist, or writer is at an impasse, working harder with traditional methods might not bring success. An aware- ness of what is blocking success may be the first step toward a solution and might be achieved by sticking with the task and developing a more abstract representation that makes underlying assumptions ex- plicit. An alternative strategy for dealing with implicit blocks is to put the task aside momentarily. Nontask processing may therefore be helpful, particularly when impasses are reached, because it can de- stabilize the use of inappropriate approaches, encourage restructur- ing, and make remotely associated knowledge more accessible.

Another principle—that nonverbal processing, including visualiz- ation, often enhances creative insight—also suggests useful applications. One is that protocol analyses of interviews with experts may be limited because the verbalization required by the procedure may inhibit creative thinking. It also indicates that both people and computer programs can make use of visual representations to recognize system- atic or meaningful relationships.

Other principles for enhancing creativity can also be found in these chapters. Lubart and Sternberg note the importance of knowing when to invest one's efforts in creative endeavors, recommending that one should take risks and work hardest on a creative idea while it is still popularly unknown and withdraw efforts once the idea becomes a bandwagon if one is to achieve success with creativity. To encourage creative realism, Finke suggests taking advantage of structural con- nectedness without overstructuring the creative process by blindly adhering to a plan. Dominowski states that practice on insight prob- lems, as well as reformulation training, in which solutions and false assumptions in practice problems are pointed out, can improve per- formance on unfamiliar insight problems. Cheng and Simon note the usefulness of diagrams as representations for data when searching for higher-order rules that explain one's observations. The usefulness of these principles is underscored by the fact that they are based

not only on logic and the internal consistency of the ideas but also on empirical findings.

The Future of the Creative Cognition Approach

The research and ideas in these chapters represent important advances in our understanding of creative cognition, but they by no means answer or even address all of the important and relevant issues. Researchers must continue to investigate creative cognition in such areas as knowledge retrieval, conceptual structure, problem solving, visual representation, comprehension, and computational modeling. In addition, inquiry in other areas of cognition is also essential. Those issues, which have only been touched on in this book, include analogy, metaphor, mental models, conscious and unconscious processes, metacognition, and language.

The creative cognition approach also suggests new strategies for studying conventional issues in human cognition. For example, mem- ory retrieval can be considered as a constructive search with open- ended outcomes rather than as a task with a single correct answer. Representations of categories in studies of concept formation, for instance, must be flexible enough to account for the wide range of novel variations that subjects can create in exemplar generation tasks. A model of comprehension that relies too heavily on bottom-up infer- encing in the course of explaining propositions may be thorough in terms of discovering every possible interpretation of an ambiguous text, but it would be too slow to understand complex texts that people can easily comprehend, and it would fail to take advantage of prior experiences with similar texts. Future research in cognitive science could thus benefit by examining phenomena of interest in flexible, open-ended, creative situations.

The development of computational models of creativity described here and elsewhere suggests that computer programs may eventually be constructed that will generate creative ideas and products. On the other hand, Lubart and Sternberg point out the importance of moti- vational variables in creativity, and Mandler notes that affect is also an important consequence of novel thought. Machines, outside of science fiction, do not appear to have motivational or affective qualities and may therefore fail to be truly creative (however, see Boden 1991 for a consideration of some philosophical aspects of this issue). It is possible that cognitive scientists will eventually find ways to combine human and computer systems, with both humans and machines en- hancing creativity by contributing to different components of the cre- ative process.

Developing theoretically motivated and empirically tested methods for training and improving creative expertise should be another goal of future research in creative cognition. In personality approaches to creativity, one assumes that

traits are enduring characteristics of in- dividuals; consequently, this approach is concerned more with the creative individual than the creative process. The creative cognition approach, on the other hand, focuses on the process and therefore should be more directly relevant to teaching people how to be more creative. The chapters consider training to some extent, but there is much more to be learned about how to improve creativity.

Will there eventually be a single overarching theory of creativity that can explain all aspects of creative functioning across situations? The chapters in this book make it very clear that such a theory is not likely. Creative cognition, like noncreative cognition, is by its very nature diverse and affected by many processes. To understand creativity, we must begin to assess those processes in creative contexts. An overarching theory of creativity is no more likely to be found than a unified theory that could explain all cognitive phenomena. Instead, it might be better to pursue more focused theories that can inform us about the role of spedfic processes in creative functioning.

Finally, the impact and potential of the creative cognition approach, as shown by the contributions to this book, marks the fall of yet another barrier previously assumed to be insurmountable: the idea that creativity cannot be studied scientifically. Historically, sober- minded scientists have avoided, spurned, or denied important cognitive phenomena that were supposedly intractable to scientific research, such as higher-level mental processes. These phenomena are now studied routinely with increasingly sophisticated methods of manipulation, observation, and analysis. With barriers to the scientific study of creative cognition removed, we can expect important strides in this area in the coining years.

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