Creativity

Intermediate article

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Creativity is the result of the convergence of basic cognitive processes, core domain knowledge, and environmental, personal, and motivational factors which allow an individual to produce an object or behavior that is considered both novel and appropriate in a particular context.

INTRODUCTION

One of the most salient features of the human mind is its capacity to generate novel ideas that are useful and appropriate for a given task or problem, that is, to exhibit creativity. Creativity is a complex phenomenon, determined by a wide range of factors, and requiring a multifaceted approach to arrive at even a partially complete understanding of the topic. This article addresses some of the issues that are important to that understanding, including a consideration of whether or not there are different types of creativity, what cognitive processes are most associated with creative outcomes, the extent to which machines can be said to be creative, the factors that limit creativity, the techniques that have been purported to enhance creativity, and the sources of individual differences in creative performance.

TYPES OF CREATIVITY

Although it is possible to describe creativity as the production of novel and useful outcomes from a convergence of skills, processes, knowledge, personal traits, environmental factors, and motivation, this general statement belies potentially important distinctions among types of creativity. These distinctions include contrasts between extraordinary and more mundane instances of creativity, and between general and specific manifestations of creativity.

Examples of the attempt to differentiate between extraordinary and commonplace forms of creativity include Boden's (1992) distinction between psychological (P) and historical (H) creativity, Gardner's (1993) contrast between 'little C' and 'big C' types of creativity, and Czikszentmihalyi's (1988) separation of personally creative and unqualifiedly creative individuals. Ideas that are P-creative are said to be novel in the mind of the individual currently having the idea, although the same ideas may have occurred to many other people before; in contrast, H-creative ideas are novel with respect to all of human history. Similarly, 'little C' creativity is manifested in everyday, small variations on themes, whereas 'big C' creativity occurs rarely and can represent a striking departure from what has come before. Personally creative people can adopt original perspectives, but unqualifiedly creative people radically alter whole domains of endeavor.

Sternberg's (1999) propulsion model introduces still more distinctions among various types of creative contributions. The model views creative work as propelling a field in different ways. These include replications that keep the field where it is, redefinitions that provide a new perspective, incrementations that move the field further in the direction it is already going, and redirections that take it in a new direction.

A question of some debate is how best to account for extraordinary versus everyday manifestations of creative behavior. One approach is to suggest that the minds of those who make notable creative contributions operate according to fundamentally different sets of rules than the minds of those whose generative accomplishments are more mundane. Alternatively, the cognitive processes may be similar, but major breakthroughs may occur only with very special convergences of personal, social, historical, and societal factors. The thought processes presumed to be involved in generating novel ideas (e.g. combining of concepts, analogical reasoning, imagery) are ones available to most humans, albeit on perhaps a lesser scale for most, but it remains for future research to delineate the ways in which these processes are invoked in everyday and extraordinary creative accomplishments.

Another long-standing issue in the field is whether creativity can best be characterized as domain-specific or domain-general. Do creative individuals, in general, possess some common, core set of traits and abilities that would allow them to function creatively in any of a variety of domains, or do the traits and abilities needed for creative accomplishment differ considerably from one domain to the next? One approach to providing evidence on this question has been to assess the personality traits of creative artists versus those of creative scientists. Data from these types of studies support a position between the extremes of pure domain-specificity and complete domain-generality. Creative artists and creative scientists appear to share some traits and differ on others (Barron and Harrington, 1981; Feist, 1999). For example, creative artists have been reported to be more open to experience, fantasy-oriented, imaginative, driven, and ambitious, and to demonstrate higher levels of anxiety, emotional sensitivity, and independence than non-artists. Creative scientists, on the other hand, have been described as possessing traits of arrogance, drive, introversion, flexibility of thought, ambition, and independence. Thus, in either domain, a basic level of unorthodox thought and behavior is characteristic, but achieving eminence in a scientific frontier may require a greater degree of conscientiousness, responsibility, and emotional stability than that which is found in the creative artist.

Another approach to the question of how different or similar artistic and scientific creativity are is to examine the cognitive processes associated with the production of novel ideas in each of the domains. Although specialized skills would be expected to contribute differentially to success in particular domains (e.g. visuo-spatial ability for art or pitch discrimination for music), many of the most basic generative processes, such as combining previously separate concepts and using analogies, are relevant in virtually all creative domains (e.g. Finke *et al.*, 1992).

INCUBATION, INSIGHT, AND OTHER CREATIVE PROCESSES

A widely noted creative phenomenon is incubation, defined as a temporary withdrawal from the problem at hand, which may culminate in an illumination or insight; that is, a sudden realization of a problem solution. Interestingly, there is much less experimental evidence regarding incubation than would be expected from the broad dissemination of the term. Historical anecdotes abound, including Archimedes' purported recognition of the principle of displacement while bathing, and Kekulé's realization regarding the circular structure of benzene while dozing by the fire. What such anecdotes have in common is a solution sequence in which the thinker devotes considerable deliberate effort towards solving a problem, reaches an impasse, withdraws temporarily, and is then struck with a sudden realization for a problem solution.

Although the phenomena of incubation and insight are broadly noted, the mechanisms by which incubation may facilitate insights are not well established. Theoretical mechanisms that have been proposed include conscious work, unconscious work, forgetting of interfering material, recovery from fatigue, and assimilation of cues encountered by chance during the incubation period.

According to the conscious work hypothesis, deliberate effort can continue on the problem while the thinker is engaged in routine tasks, such as bathing, which require only limited cognitive resources. Because the conscious thoughts that led to the solution may be quickly forgotten, the insight may appear to come 'from out of the blue'.

The unconscious work hypothesis also holds that work continues on the problem during the incubation phase, but the work occurs below the level of conscious awareness. That is, the effort is not consciously noted and then forgotten, but rather it is not available to consciousness at all.

The forgetting hypothesis states that inappropriate strategies adopted and ideas considered during initial work on a problem may be forgotten during incubation, which can facilitate the retrieval or generation of more appropriate ideas.

Recovery from fatigue holds that incubation serves as a kind of rest period during which the problem-solver can recover from the debilitating effects of an extended period of deliberate mental effort on the problem.

Finally, according to the opportunistic assimilation view, the problem-solver remains sensitive to cues in the environment that may relate to unsolved problems, even while not engaged in deliberate effort on the task.

There is little experimental research that clearly favors one view of incubation over the others, but at least some laboratory studies by S. Smith and his collaborators (e.g. Smith, 1995) are consistent with the forgetting hypothesis.

Some models of insight attempt to specify component processes that work in concert to produce the phenomenon. For example, Sternberg and Davidson's (1995) model includes subprocesses of selective encoding of problem-relevant information, selective comparison of new and old information, and selective combination of different pieces of information.

Experimental findings do reveal some differences between insight problem-solving and analytic or logical problem-solving. For example, Metcalfe (1986) has shown that feelings of 'warmth' or progress towards a solution increase gradually as subjects near solutions to analytic problems, whereas they jump dramatically for insight problems. In addition, J. Schooler has shown that verbalization can interfere with insight problem-solving, but not analytic problem-solving (Schooler and Melcher, 1995). Such results suggest that insight may be the result of special processes unlike those involved in noncreative problem-solving. However, Weisberg (1995) has attempted to show that insights, even those described in historical anecdotes, are the result of ordinary cognitive processes applied to existing knowledge. By this view, what appears as a dramatic change in awareness of a solution may well reflect a more incremental building of solution-relevant knowledge.

Although incubation occupies a special historical role in attempts to understand creative functioning, several fundamental cognitive processes have been either theorized or demonstrated to be central to the production of novel and useful ideas (see, e.g. contributions to Ward *et al*., 1997). These include conceptual combination, analogical reasoning, and mental imagery.

In conceptual combination, the thinker merges two concepts that had previously been separate. Anecdotal accounts from creative individuals often include reference to a combining of concepts underlying some important creative advance. In addition, some theorists (e.g. Rothenberg, 1979) suggest that a simultaneous consideration of opposing concepts, termed 'Janusian' thinking, is a particularly important source of emergently creative ideas, and laboratory research on how people interpret novel combinations of concepts is beginning to provide support for this idea.

Analogical reasoning, in which a thinker uses information from a familiar domain to aid in understanding a less familiar domain, is also a central process underlying creative accomplishment. Historical cases abound in science, music, art, and literature. Recent analyses, such as Gentner's (1997) examination of Johannes Kepler's use of analogy in reasoning about the nature of the solar system, have related historical accounts directly to principles from contemporary process theories. That work has helped to establish the validity of claims that analogies between distant knowledge domains can underlie great creative advances. Studies of reasoning among contemporary scientists, such as Dunbar's (1997) look at the ongoing activities of molecular biology laboratories, also reveals that analogies to closely related domains (as opposed to distant domains) often dominate the day-to-day reasoning involved in creative breakthroughs.

MAKING MACHINES CREATIVE

A number of attempts have been made to get computers to function creatively, and Boden (1992) has provided a thorough account of these efforts. An important goal of such computational approaches is to develop a better understanding of human creativity by attempting to simulate it. In that sense, to the extent that creative outcomes spring from fundamental cognitive processes, even computational models of basic processes such as analogy (e.g. Structure Mapping Engine, or SME) are relevant to the issue of making machines creative.

In addition to computational attempts to understand broad processes such as analogy, there are also more direct attempts at simulating specific instances of creativity (e.g. scientific discovery). One of the best-known examples of such an attempt is BACON, which used heuristics to simulate the discovery of scientific laws (Bradshaw *et al*., 1983). BACON was shown to be able to rediscover Kepler's laws of planetary motion from a set of heuristics and data on observations of planetary motion, although it has come under criticism for underrepresenting the complexities involved in real-world instances of discovery. Such programs, along with others concerned with creativity in drawing, literature, and music, still leave much to be desired, but they do represent important first steps.

LIMITS TO CREATIVITY

Both individual and environmental factors can provide limits to creativity. It is clear that below some minimum level of intellectual ability (e.g. an IQ of 85), a person would have a limited capacity to generate and express creative ideas, although studies tend not to examine creative functioning in those individuals. Studies on individuals with somewhat higher scores have shown that creative performance is linked with intellect in individuals with an IQ below 120, but this link all but disappears in individuals with IQs above 120 (Barron and Harrington, 1981).

Environmental factors also play a role in the expression of creativity. Extensive research by Amabile has found that the use of external rewards or evaluations decreases task motivation for creativity and overall creative performance in both adults and children (Hennessey and Amabile, 1988). This negative effect of reward on creative performance is so strong, in fact, that Amabile found that merely the expectation of some sort of external reward or evaluation diminished creative task motivation and performance in the same way that actually using such external constraints had.

TECHNIQUES FOR IMPROVING CREATIVITY

A wide variety of techniques have been developed with the goal of trying to improve creative performance. Some have emphasized the dynamics of group interaction, others the learning of specific idea-generation techniques, and still others the enhancement of intrinsic motivation.

One of the earliest and best-known techniques is brainstorming. Developed by Osborn (1953), this technique is designed to enhance creativity by encouraging groups (and individuals) to generate as many ideas as possible about a problem without expressing criticism towards those ideas. By eliminating criticism and allowing individuals to 'piggy-back' on ideas suggested by other group members, brainstorming is supposed to result in more ideas being generated, some of which may be extremely creative and provide excellent solutions to the problem being considered. Although there is some support for the usefulness of the procedure, a number of studies have actually shown a productivity loss in groups. That is, groups sometimes produce fewer ideas than the same number of individuals working independently. Thus, the question of where, when, and how brainstorming improves creative performance is yet to be resolved.

Another well-known attempt to enhance creativity is Edward deBono's (1970) lateral thinking approach, which encourages people to engage in thinking that moves off in different directions and to adopt many different perspectives on a problem, rather than thinking along a single narrow path. A major aspect of the approach is to teach people specific techniques designed to facilitate this type of broad attack on a problem, including the 'six hats' approach, in which people 'wear different types of hats', that correspond to different modes of thought (e.g. critical versus generative) (de Bono, 1985). An approach that makes use of idea-generation techniques and principles to facilitate group interaction is Gordon's (1961) synectics procedure, in which group members are coached to generate ideas using analogies and metaphor while also being instructed to suspend criticism of ideas generated by others.

Brainstorming, lateral thinking, synectics, and a host of other procedures have enjoyed a great deal of popular success, but do they make people more creative? To some extent the answer depends on how one defines and measures creativity. Although any given technique may be shown to facilitate performance on a particular task, the extent to which such changes in generative performance last or generalize beyond the immediate situation is less clear. Thus, it may be more appropriate to state that various training procedures can alter patterns of performance on a range of generative tasks, rather than to claim that they make people more creative.

Another avenue of training for improving creativity has been to increase creative motivation. Developed by Amabile and colleagues, this training paradigm, called inoculation training, seeks to increase creativity by training individuals to focus on the intrinsic joy that creative activities bring (Hennessey and Amabile, 1988). Developed as a way to counteract the negative effects of external reward on creative performance, inoculation training involves talking to groups about the internal or intrinsic rewards of behaving creatively. This is done in conjunction with watching videos demonstrating others behaving creatively in the face of external reward and finding pleasure in just engaging in the creative act alone. The use of this type of training has been shown to increase creative performance of both schoolchildren and adults on tasks which have an element of reward or evaluation associated with them.

MODELS OF CREATIVITY

Models of creativity differ in their scope, in the factors they emphasize, and in the tendency to view creativity as stable or malleable. Although historical models of creativity sought to explain creative behaviors as a reflection of differences in individual personalities, beginning with Guilford (e.g. 1967, 1968) creativity began to be viewed as a set of traits which, though stable, were influenced by motivation and temperament (Brown, 1989). Creativity was seen as the result of a set of traits such as problem sensitivity, fluency, flexibility, complexity, evaluation, the use of novel ideas, the ability to break down existing symbolic structure, and the general tendency to organize ideas into larger patterns. When conceptualized this way, variations in creativity could be measured using a variety of open-ended tests.

Torrance modified Guilford's definition slightly, viewing creativity as the combination of ability, skills, and motivation (Ford and Harris, 1992). By including skills in the account of individual differences, creativity became a teachable entity to the degree that a person's creative skills could be improved.

In a further departure from the focus on creativity as a personality trait, Amabile developed a model in which creativity cannot be simply the result of a single isolated personality trait or process, but rather must be accounted for by a constellation of personal characteristics, cognitive abilities and processes, and social environment factors. By this approach, creativity emerges from the confluence of domain-relevant skills, creativity-relevant skills, and task motivation (Amabile, 1990).

Gruber (1988), in what is known as the evolving systems approach, has also regarded creativity as the merging of personal knowledge, affect, and purpose. According to this developmental approach, creativity is the result of developmental changes in knowledge systems that result from the increasingly different situations that a person encounters over time. In this theory, creativity is an extended process, with a person having more than one insight or metaphor over time, and with multiple changes in thoughts and knowledge systems along the way.

A focus on a concert of factors as the root of creativity can also be seen in the burgeoning of research attempting to explain creativity as a multifaceted concept. Called *componential theories of creativity*, such theories hold that creativity occurs when a variety of biological, cognitive, and social factors merge or interact. As an example of one of the modern componential theories, Czikszentmihalyi (1988) regards creativity as an interaction of components both within and outside the individual. According to this model, creativity results from the interaction of the individual with any given domain of knowledge and those controlling the field of that domain. An individual is creative only to the extent that he or she can use cognitive processes, personality traits, and motivation to alter a particular domain in a way that is acceptable to the field at large. More recently, Sternberg and Lubart (1999) have also pursued this idea of creativity as the convergence of multiple components. In their *investment theory of creativity*, creative people are those who can 'buy low and sell high'; that is, generate or adopt ideas before they become popular, then popularize them, thus becoming associated with novel, impact-producing ideas. Such behavior is thought to require the merging of six resources: intellectual abilities, knowledge, thinking styles, personality traits, motivation, and environment.

In contrast to componential approaches, which provide a global account of the factors that interact to determine the creative impact of novel ideas, cognitive models focus more narrowly on the way in which basic cognitive processes operate on existing knowledge structures to produce those novel ideas. The models acknowledge that social and motivational factors can influence the likelihood or intensity of engaging in particular processes. Similarly, they acknowledge that factors outside the individual's thought processes will determine the extent to which an idea is judged acceptable or has an impact. However, they view cognitive processes as the crucial source of the ideas to be judged, and to some extent of the judgments as well.

Often called *process approaches*, these cognitive models focus on the acts of problem-identification and solution-generation as the keys to creative production. An example of this type of model is the Geneplore model of Finke *et al*. (1992), which characterizes the development of novel and useful ideas as resulting from an interplay between *generative* processes, that produce candidate ideas of varying degrees of creative potential, and *exploratory* processes that expand on that potential. Generative processes such as retrieval, conceptual combination, and analogical reminding are assumed to result in candidate ideas, which vary in their apparent novelty, surprisingness, aesthetic appeal, or other factors that would influence the creative person's perception that they hold promise for solving the current problem. People can use such properties to determine which ideas to develop by way of exploratory processes that modify, elaborate, consider the implications, assess the limitations, or otherwise transform the candidate ideas. The model also assumes that real-world constraints, such as the social acceptability of particular ideas, can influence the form of initially generated ideas, the person's judgment about which ideas to explore, or the way in which a candidate idea is modified through exploratory processes.

Other models focus on the production and retention of novel ideas, and make use of a Darwinian perspective: many variations on ideas may be developed but only the fittest will be selected and survive. Simonton (1999b) has extended the evolutionary view and claimed that the production of creative ideas should be viewed as akin to blind variation, in which the creator does not have any notion of whether a given generated idea will be successful or not. While others adopt a somewhat similar generation/selection view, they do not necessarily endorse the blind variation notion (e.g. Johnson-Laird, 1988; Perkins, 1998; Sternberg, 1998).

UNDERSTANDING INDIVIDUAL DIFFERENCES IN CREATIVITY

Traditional research concerned with individual differences in creative performance attributes those differences to one of two sources: differences in the ability or tendency to use particular creative thought processes, and differences in personality attributes thought to be related to creative behaviors. The work has made use of psychometric procedures as well as assessments of the historical record of the achievements of eminent creators.

Research concerned with thought processes has focused on individual differences in the ability to identify or recognize problems or solutions that have creative potential, to tap into broad thought networks, and to apply this expanded base of knowledge to the task at hand. Defining differences in creativity as the result of individual differences in the ability to associate or bring together different elements of thought to form new and useful creations is the hallmark of the associative approach to creativity (Brown, 1989). This associative approach is not a new one in psychology, as can be seen in the many introspective studies and historical anecdotes concerning the creative process (Barron and Harrington, 1981; Brown, 1989). Mednick (1962) extended this approach by defining creativity as the forming of associative elements into new combinations, which either meet specific requirements or are in some way useful. By this view, individual differences would be attributable to the ability to access remote associations, which in turn gives rise to the use of the Remote Associates Test as a measurement technique (Mednick and Mednick, 1967).

Individual differences in creative thought have also been explained by variations in divergent thinking ability, including fluency (the tendency to produce many ideas), flexibility (the tendency to produce differing ideas), and originality (the tendency to produce ideas that are normatively uncommon). A classic example of a divergent thinking task used to measure such differences is the Torrance Test of Creative Thinking (Torrance, 1974) in which people generate questions, unusual uses, and/or drawings in response to particular stimuli.

One question that can be raised about paper-and-pencil measures of divergent thinking ability is whether or not performance on those measures is indicative of real-world creative skill. Although various researchers have found a relationship between test performance and real-world indicators, such findings have not been consistent. Measures of divergent thinking, while related to some indices of creative achievement, are often unable to significantly predict creative achievement and behaviors in a real-world setting (Barron and Harrington, 1981; Brown, 1989). In addition, concerns have been raised about the domain-specificity of divergent thinking.

Another type of explanation for individual differences in creativity focuses on personality traits, and assumes that creativity differences are based on variations in personality attributes that are thought to contribute to creative production. The characteristics that have been identified as important to creativity are tolerance for ambiguity, openness, independence, positive sense of self, high energy, general curiosity, wide interests, as well as introversion, attraction to complexity, need for recognition, and a variety of others (Barron and Harrington, 1981). As indicated previously, however, the importance of each of the characteristics may vary according to the domain of creativity being pursued. In fact, the search for the single set of 'creative personality' traits that map onto real-world creative performance has, so far, been unsuccessful.

Variations in intrinsic motivation are another possible source of individual differences in creative performance. For instance, Amabile, in her seminal research on the relationship between intrinsic motivation and creativity, found that creative performance in such areas as writing and art can be both enhanced and hindered by changes in intrinsic interest in a task. Hennessey and Amabile (1988), in a continuation of this line of research, have proposed the intrinsic motivation principle of creativity which says that people will be the most creative when they feel motivated to perform primarily by the interest and enjoyment of the task, and not by external factors such as reward or punishment. Thus, all individual differences in creative performance are due to those differences in motivation towards the task at hand, and hence, all creativity is, at heart, domain-specific to the interests of the individual.

Although much contemporary work on individual differences relies on tests or laboratory observations of a broad sampling of participants, another approach involves detailed, narrative case studies of a small set of highly creative individuals in history. Somewhere between these extremes is Simonton's (1999a) historiometric approach in which historical data (e.g. number of publications, citations, performances, and so on) is sampled for a large number of contributors to a field, and statistical tests are performed to relate those measures to other indices. The approach can be used to examine a broad range of factors, including intellectual precocity, family background, and propensity towards mental illness. It goes beyond paper-and-pencil measures of the attributes of the many to a detailed look at individual differences among the eminent.

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Cultural Differences in Abstract Thinking

Introductory article

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CONTENTS

Abstract thinking is a central part of reasoning and the highest cognitive attainment in Piagetian theory. Studies of cross-cultural differences and similarities in abstract thinking show its relationship with culture.

INTRODUCTION

There are two research traditions in cognitive psychology for examining the relationship between culture and abstract thinking: the formal and the informal approach (Table 1). In formal research the scientific approach is the normative model of good problem-solving; there is an emphasis on the application of inductive and deductive reasoning, the solution of formalized problems that are unlikely to be met in everyday life, and the correctness of solutions (e.g., ‘continue the following series: 1, 2, 4, 8, 16, …’). In the informal tradition the ‘bricoleur’ (jack-of-all-trades) is the implicit model of problem-solving. There is an emphasis on problem-solving in everyday life: an example would be,