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## Models of the Creative Process: Past, Present and Future

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*ABSTRACT: The creative process, one of the key topics discussed in Guilford's (1950) address to the American Psychological Association and his subsequent work, refers to the sequence of thoughts and actions that leads to novel, adaptive productions. This article examines conceptions of the creative process that have been advocated during the past century. In particular, stage-based models of the creative process are discussed and the evolution of these models is traced. Empirical research suggests that the basic 4-stage model of the creative process may need to be revised or replaced. Several key questions about the creative process are raised, such as how the creative process differs from the noncreative process and how process-related differences may lead to different levels of creative performance. New directions for future research are identified.*

The creative process—the sequence of thoughts and actions that leads to a novel, adaptive production—has been one of the key topics of creativity research during the past century. In his presidential address to the American Psychological Association, Guilford (1950) noted that there was “considerable agreement that the complete creative act involves four important steps” (p. 451), traditionally identified as (a) preparation, (b) incubation, (c) illumination, and (d) verification.

Guilford (1950), however, was not very satisfied by the four-stage description of the creative process. He wrote, “Such an analysis is very superficial from the psychological point of view. It is more dramatic than it is suggestive of testable hypotheses. It tells us almost nothing about the mental operations that actually occur” (p. 451). He went on to identify certain abilities that may be involved in creativity, including a sensitivity to problems, a capacity to produce many ideas (fluency), an ability to change one's mental set (flexibil-

ity), an ability to reorganize, an ability to deal with complexity, and an ability to evaluate. He proposed a program of research concerning the identification, measurement, and validation of these creativity-relevant abilities. After 50 years of research, our comprehension of the abilities and basic cognitive processes involved in creativity has grown a great deal.

Starting with a brief description of the classic four-stage model, I then examine how this model has fared during the past half-century. Following this review, some fundamental questions about the creative process are raised. Research that illustrates how these questions may be addressed is discussed.

### The Classic Four-Stage Model of the Creative Process

The basic elements of the four-stage model of the creative process were evoked early on in some introspective accounts of the creative act. For example, at the end of the 19th century, Hermann von Helmholtz, the physicist and physiologist, described how after investigating a problem thoroughly, “happy ideas came unexpectedly without effort, like an inspiration” (cited in Wallas, 1926, p. 80). Ideas did not come if he was tired or at his working table, but rather when he was taking a break such as a walk outside (Ochse, 1990; Wallas, 1926).

Poincaré's (1908/1985) description of his discovery of Fuchsian functions is particularly noteworthy.

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Poincaré, a French mathematician, began with days of conscious work, trying to prove that Fuchsian functions could not exist. He “tried a great number of combinations and reached no results” (p. 26). After drinking coffee one evening, he could not sleep: “Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. . . . I had established the existence of a class of Fuchsian functions” (p. 26).

Poincaré formalized his results in writing, elaborated on his initial idea, and guided by an “analogy with elliptic functions,” explored the mathematical properties of Fuchsian functions. He then had to travel and “forgot” about his work. At one moment during his trip he stepped on a bus and an idea came to him “without anything . . . seeming to have paved the way for it”: The transformations involved in Fuchsian functions were the same as those in non-Euclidean geometry (p. 26). After returning from his trip, Poincaré verified his idea and then began work on some seemingly unrelated mathematical issues without much success. He decided to take a break for a few days near the sea. There, during a walk, another idea concerning non-Euclidean geometry came with “brevity, suddenness, and immediate certainty” (p. 26). On his return, he thought about this idea, exploring systematically its implications for Fuchsian functions. His work, however, led him to realize that there was one difficulty that remained. At this point he went away for his military service. Although his mind was “very occupied” by his duties, one day an idea of how to solve his mathematical problem “suddenly appeared.” After returning from his military service he had “all the elements and had only to arrange them and put them together” (p. 26). He wrote his finalized ideas in a single stroke.

Poincaré went on in his essay to note that the creative process seems to start with conscious work on a problem. This is followed by unconscious work, which if successful, results in a “sudden illumination.” Then another phase of conscious work follows “to put in shape the results of this inspiration,” to explore the consequences, to formalize and to verify the idea (p. 27).

Based on this kind of introspective evidence, Wallas (1926) formalized the four-stage model of the creative process. Preparation involves a preliminary analysis of a problem, defining and setting up the problem. Preparation involves conscious work and draws on one’s education, analytical skills, and problem-relevant knowledge. The incubation phase follows. During incubation, there

is no conscious mental work on the problem. A person may be working consciously on other problems or simply relaxing, taking a break from the problem. Unconsciously, however, the mind continues to work on the problem, forming trains of associations. Many associations or idea combinations are believed to occur during incubation. The unconscious mind rejects most of these combinations as useless but occasionally finds a promising idea. Poincaré referred to aesthetic criteria that unconsciously allowed promising ideas to be selected and the vast majority of useless ideas to be rejected. A third phase, called illumination, occurs when the promising idea breaks through to conscious awareness. Illumination can be characterized by a “flash,” a sudden enlightenment. Wallas suggested that illumination is often preceded by an intuitive feeling that an idea is coming. He called this “intimation,” which occurs at the “fringe” of consciousness (p. 97). The illumination phase is hypothesized to be somewhat delicate, easily disturbed by outside interruptions or trying to rush the emerging idea. Following the illumination, there is a phase of conscious work called verification, which involves evaluating, refining, and developing one’s idea. Wallas (1926) noted that during creative problem solving a person could return to earlier phases in the process. For example, if an idea proves to be flawed during verification, one may incubate on how to resolve this difficulty. Also, the phases could co-occur if a person was, for example, engaged in preparation for one aspect of a problem and incubation for another aspect of the problem.

Some early empirical research on the creative process lent support to the four-stage model. For example, Patrick (1935, 1937, 1938) conducted a series of studies with poets, visual artists, scientists, and laypeople. The participants thought aloud as they composed a poem, produced a painting, or solved scientific problems. Patrick observed their actions, noted their verbalizations, and divided each protocol into four parts based on the total length of the protocol. She concluded that her observations of the creative process fit well within the four-stage model. For example, incubation (noted when a previously expressed idea recurred while thinking about another idea) was observed for more than two thirds of the participants. Instances of revision and a critical survey of the whole work tended to occur in the third or fourth quarters of each participant’s work, supporting the idea of a verification phase. Some overlap between the stages was noted, such as preparation and incubation co-occurring. In her

studies, Patrick also compared the creative process in experts and novices, examining, for example, protocols from established visual artists and nonartists. She found that the same basic process seemed to hold across levels of expertise and across task domains. In his observations on mathematical creativity, Hadamard (1945) also supported the four-stage model (see also Rossman, 1931, for a study of inventors).

### Stage-Based Models: Alive and Well?

#### The Four-Stage Model: An Update

For a number of researchers, the four-stage model or a variant of it has served and continues to serve as the basis for understanding the creative process (Busse & Mansfield, 1980; Cagle, 1985; Goswami, 1996; Ochse, 1990; Osborn, 1953; Stein, 1974; Taylor, 1959; Taylor, Austin, & Sutton, 1974). For example in a relatively recent proposal, Amabile (1996) incorporated a version of the basic stage model into her componential model of creativity. The creative process is described as consisting of several phases: (a) problem or task identification, (b) preparation (gathering and reactivating relevant information and resources), (c) response generation (seeking and producing potential responses), and (d) response validation and communication (testing the possible response against criteria). A final phase of decision making about further work is proposed; based on the outcome of response validation and communication, a person may either stop because a successful product is achieved, stop due to failure, or return to one or more phases in the process for further work. These stages, which do not necessarily occur in a fixed sequence, describe the creative process in individuals and small groups. In organizational settings, similar stages are proposed (Amabile, 1988). Amabile (1996) noted that incubation may occur during the creative process and may involve selective forgetting or changes in motivation. As in many creative process models framed in terms of problem solving, the term *problem* is conceived broadly as any task that an individual seeks to accomplish. Thus, artists who seek to express their feelings, scientists who seek to understand a complex phenomenon, and people who seek to solve conflicts in their everyday lives are all considered to be engaged in problem solving (see Runco & Dow, 1999).

Some relatively recent empirical work also draws clearly on the four-stage model. For example, Moriarty and Vandenberg (1984) surveyed creative people in advertising agencies who had won awards in a national competition. They found support for the four-stage model in the obtained descriptions of the creative process. In a series of studies, Gustafson and Norlander (1994; Norlander & Gustafson, 1996, 1997, 1998) explored how alcohol consumption influences the preparation, incubation, illumination, and verification phase of the creative process. These studies used Patrick's (1935) methodology with some modifications and analyzed problem-solving protocols for specific indicators of preparation, incubation, illumination, and verification.

In terms of extending or enhancing the basic four-stage model, several authors have suggested that it is important to distinguish a problem-finding or problem-formulation phase from the preparatory phase in which relevant information is gathered and preliminary ideas are advanced (Amabile, 1996; Getzels & Csikszentmihalyi, 1976; Osborn, 1953). Problem finding involves recognizing that a problem exists, finding gaps, inconsistencies, or flaws with the current state of the art. Einstein and Infeld (1938) noted the importance of raising new questions, formulating a problem and seeing old problems from new angles. In a related vein, Isaksen and Treffinger (1985) proposed that creative problem solving begins with a "mess finding" stage from which problems are defined. Some authors distinguish problem finding (noticing that something is not right, not good, or lacking) from problem posing (expressing the problem) and problem construction (developing a detailed representation of the problem; Mumford, Reiter-Palmon, & Redmond, 1994). Empirical studies on problem finding have operationalized this activity either in terms of the time spent manipulating or exploring problem elements before proposing an initial idea or in terms of question-asking behaviors (Getzels & Csikszentmihalyi, 1976; Glover, 1979; Jay & Perkins, 1997; Kay, 1991; Rostan, 1994).

With regard to other phases of the creative process, some authors have suggested that a phase of frustration occurs after the preparatory phase when the analytic mind reaches its limit on dealing with the problem; frustration may provoke incubation (Goleman, Kaufman, & Ray, 1992; Hutchinson, 1949). Sapp (1992) proposed that between incubation and the moment of illumination there may often be a "point of creative frustration" (p. 24). A person may become

blocked or fail to find creative ideas during incubation. At this point of frustration one can either start over and fall into the same traps, accept a less-than-optimal solution (perhaps rationalizing that it is creative), or push ahead, exploring further alternatives or moving in a new direction, perhaps reconceptualizing the problem. Thus, the point of creative frustration involves making a decision on how to deal with difficulties encountered during problem solving.

The nature of incubation—a period during which a problem is “put aside” often due to an impasse in problem solving—has also been explored (Guilford, 1979; Smith & Dodds, 1999). Incubation may involve automatic spreading of activation in memory, passive forgetting of problem details or entrenched ideas that do not work, broad attention and use of serendipitous cues from the environment, or associative thinking through a random or directed combination process (Ochse, 1990; Olton, 1979; Smith & Dodds, 1999). Concerning the final part of the creative process, some authors have proposed an implementation phase or communication phase in which the creative production is presented in a social environment (Amabile, 1996; Stein, 1974).

### **Moving Away From the Basic Four-Stage Model**

Eindhoven and Vinacke (1952) criticized Wallas’s (1926) conception of the creative process. In their study, artists and nonartists were observed while producing a picture that illustrated a poem presented at the beginning of the study. Indexes such as the amount of time spent reading the poem, time spent formulating the initial picture, and the number of different sketches made were noted. Participants completed their pictures over several sessions of work and recorded their thoughts or sketches between sessions in a notebook. Eindhoven and Vinacke found no evidence supporting four discrete stages in the creative process; they described the creative process as a dynamic blend of processes that co-occur, in a recursive way throughout the work. In addition, the creative process varied from one individual to another. Patrick’s (1935, 1937, 1938) earlier studies, which supported the four-stage model, can be criticized on several points (Bailin, 1988; Eindhoven & Vinacke, 1952; Vinacke, 1952; Weisberg, 1986). Patrick’s observations may have been biased by an a priori theoretical conception of the four-stages and her specific

operationalization of Wallas’s stages was debatable. For example, preparation was noted when thought changes led to new sentences in participants’ think-aloud protocols, incubation was noted when a person returned to an idea that had been mentioned earlier in his or her work, and illumination was defined as the moment when the basic idea for a painting, poem, or scientific problem solution was first formulated. Patrick’s division of each protocol into four equal sections can also be criticized.

After analyzing descriptions of the creative process by contemporary novelists, Ghiselin (1952/1985, 1956, 1963) rejected “superficial” stage-based descriptions of the creative process, favoring an integrated approach. This more complex view of the creative process has been evoked in a number of other studies. For example, Doyle (1998), based on interviews of fiction writers, described the creative process of writing fiction as beginning with a “seed incident” that interests or provokes an author, which is followed by “navigating” between different “spheres of experience” to develop a story (e.g., moving between a fictional sphere, the written work, and a revising mode). Studies of the creative process in art through introspection, interviews, observations, and examinations of sketchbooks and finished works show that the creative process involves a series of high-speed short interactions between productive and critical modes of thinking, as well as planning and compensatory actions (Israeli, 1962, 1981). Based on interviews with artists, Calweli, Rappaport, and Wood (1992) found evidence for the simultaneity of processes such as centering on a topic, working on new ideas, expanding ideas, evaluating, and taking distance from one’s work. In Getzels and Csikszentmihalyi’s (1976) seminal study of art students making a still-life drawing, activities involved in formulating or defining the artistic problem were observed both in the predrawing phase and the drawing production phase. Getzels and Csikszentmihalyi noted, “In a creative process, stages of problem definition and problem solution need not be compartmentalized” (p. 90). Finally, through protocol analysis of the sketching process in architectural designers, an overall conception of an architectural design emerged in which new designs were formed in parts with deletions, transformations, a dialectic movement between general design qualities and issues in the specific task, and moments of active sketching mixed with moments of contemplation (Goldschmidt, 1991).

These studies suggest that the basic four-stage model of the creative process may need to be revised or re-

placed. In Guilford's (1950) address we can see the beginning of a new line of work on the creative process: research on key processes that are involved in creative thinking. For example, Guilford noted, "It is not incubation itself that we find of great interest. It is the nature of the processes that occur during the latent period of incubation, as well as before it and after it" (p.451). These processes may include problem definition and redefinition, divergent thinking, synthesis, reorganization, analysis, and evaluation (Guilford, 1950, 1967). Thus, according to Guilford (1950), the creative process may be effectively studied, at least for a start, by examining the subprocesses that play a role in creative work.

### Multiple Subprocesses Involved in Creativity

During the past 50 years, a large number of studies have explored the nature of the subprocesses involved in creativity (Lubart, 1994a; Ochse, 1990; Sternberg, 1999; Sternberg & Lubart, 1995). For example, problem finding, problem formulation, and problem redefinition processes have been extensively investigated (Getzels & Csikszentmihalyi, 1976; Jay & Perkins, 1997; Mumford, Baughman, Threlfall, Supinski, & Costanza, 1996; Reiter-Palmon, Mumford, O'Connor Boes, & Runco, 1997; Runco, 1994; Smilansky, 1984). Divergent thinking—the process of generating many alternative ideas—has been another key topic in the creativity literature (e.g., Guilford, 1967; Khandwalla, 1993; Runco, 1991). Concerning the synthesis or combination of information, there has been research on several processes such as bisociation (Koestler, 1964), Janusian thinking (Rothenberg, 1979, 1996), homospatial thinking (Rothenberg, 1979, 1986), articulation (Rothenberg, 1979), analogy and metaphor (Ward, Smith, & Vaid, 1997; Weisberg, 1993), remote association (Mednick, 1962), emotional resonance (Lubart & Getz, 1997), and feature mapping (Baughman & Mumford, 1995; Boden, 1992; Mumford, Baughman, Maher, Costanza, & Supinski, 1997). The process of forming idea combinations through random or chance-based processes has also been developed (Campbell, 1960; Simonton, 1988). Furthermore, the process of reorganizing information as part of creative thinking has been studied, with special attention to processes involved in insight (Baughman & Mumford, 1995; Sternberg & Davidson, 1995). In terms of ana-

lytic-evaluative processes, work has been conducted on artistic, literary, and organizational problem solving (Basadur, 1995; Houtz, Montgomery, Kirkpatrick, & Feldhusen, 1979; Lubart, 1994b; Mumford, Supinski, Threlfall, & Baughman, 1996; Osborn, 1953; Perkins, 1981). Other subprocesses hypothesized to play a role in creativity have also been investigated, such as perception and information encoding (Mumford, Baughman, Supinski, & Maher, 1996; Smith & Carlsson, 1990), using heuristics (Langley, Simon, Bradshaw, & Zytkow, 1987) and the process of forgetting, which has been found to play a role in changing one's approach to a problem and overcoming initial mental blocks (Smith & Dodds, 1999).

Some authors have proposed creative process models that organize the subprocesses involved. For example, Mumford, Mobley, Uhlman, Reiter-Palmon, and Doares (1991) specified a set of core processes for creativity that operate on information organized in categorical structures. These processes, which occur in the following loosely structured sequence, are problem construction, information encoding (and retrieval), category search (specifying relevant information schemas), specification of best fitting categories, combination and reorganization of category information to find new solutions, idea evaluation, implementation of ideas, and monitoring. The model is dynamic and allows for cycling between different processes as deemed necessary during problem solving. The core processes for creativity are themselves complex and involve more specific processes. For example, combination and reorganization involve reasoning, analogy use, and divergent thinking processes. Mumford and his colleagues examined several of the proposed processes in a series of studies and showed that beyond general ability measures (e.g., grade point average, Scholastic Assessment Test scores, divergent thinking), different processes mentioned here (problem construction, information encoding, category selection, and category combination) explained variance in creative performance on problem-solving tasks concerning advertising and managerial or public policy issues (Mumford, Supinski, Baughman, Costanza, & Threlfall, 1997).

Focusing on two sets of creative processes, Finke, Ward, and Smith (1992) advanced the *geneplore* model, in which creativity involves generative and exploratory processes. The generative processes concern the construction of loosely formulated ideas called *preinventive* structures. Generative processes include

knowledge retrieval, idea association, synthesis, transformation, and analogical transfer. The exploratory processes concern the examination, elaboration, and testing of the preinventive structures. Exploratory processes include interpretation of preinventive structures, hypothesis testing, and searching for limitations. These two sets of processes are combined together in cyclical sequences that lead to creative products.

Other diverse proposals about the creative process have focused on the processes of idea generation and idea evaluation (e.g., Hitt, 1965, Runco, in press). Basadur (1995) characterized creative problem solving in terms of ideation–evaluation cycles that vary in their frequency according to the nature of the problem to be solved and the point in problem solving (e.g., at the beginning vs. in a final implementation phase). Runco and Chand (1995) proposed that ideation and evaluation together with problem finding are the primary components of the creative process; knowledge and motivation influence these processes. In the psychodynamic approach to the creative process, primary and secondary processes and their interaction are discussed (Kris, 1952; Kubie, 1958; Suler, 1980). The primary process operates on unstructured, illogical, subjective thoughts and yields ideational material that is then shaped by the reality-based, controlled, evaluative secondary process. In the chance-based theories of the creative process, there is a process of idea formation through random variations and combinations and a process of evaluation that leads to selective retention of the best ideas (Campbell, 1960; Simonton, 1988).

Some models that initially proposed a stage-based view of the creative process have been revised, reflecting more emphasis on subprocesses. For example, the creative problem solving framework, which developed from Osborn's (1953) work, proposed a stage-based view of the creative process (Isaksen & Treffinger, 1985; Parnes, 1967). However, a recent reformulation of the model moves away from the idea of a fixed sequence of activities in favor of three sets of processes (Treffinger, 1995). These are understanding the problem, generating ideas, and planning for action. Understanding the problem includes the processes of mess finding, data finding (which includes information search), and problem finding (which involves generating many possible questions and then focusing). Generating ideas is concerned with idea finding through divergent thinking, elaboration of ideas, and convergent thinking with evaluation of ideas. Planning for action

concerns developing and implementing ideas through solution finding (evaluating, selecting, and refining options) and acceptance finding (promoting an idea, seeking support, and noting resistance). Within each set of processes, both divergent and convergent thinking play a role. The sequence in which these processes occur can vary across problem tasks or problem solvers. For example, processes involved in understanding the problem may be invoked toward the start of problem solving, after initial attempts to generate solutions, or after attempts to implement a potential solution.

Finally, it is interesting to note that Guilford (1967) proposed a model of problem solving that addressed creative production (Michael, 1999; see also Merrifield, Guilford, Christensen, & Frick, 1962). Based on his structure of intellect framework, Guilford's model consisted of an initial stage of filtering (attention aroused and directed), a stage of cognition (the problem is sensed and structured), a stage of production (ideas are generated with divergent and convergent thinking involved), with, eventually, another stage of cognition (new information is obtained) followed by another stage of production, in a cycle that can continue until the task is completed. A process of evaluation is hypothesized to occur between each of the stages just described. The processes operate on information coming from both internal and external sources. There is a hypothesized progression between the stages, as well as some flexibility on the order of the stages and the possibility to cycle several times through a subset of stages. Problem solving may terminate at several points in the model: (a) early on the problem may be rejected, or deemed unimportant; (b) after some work the problem may be dropped because it is unsolvable; or (c) work on the problem may be postponed, which allows for incubation (drawing on subprocesses such as the transformation of information due to interactions between stored knowledge and new information from the external world; Guilford, 1979). Finally, work will stop once a satisfying solution is obtained. This model seems to represent a blend between the earlier stage models of the creative process and the view that emphasizes subprocesses.

### **Moving Toward a New Conception of the Creative Process**

After examining the work on the four-stage model, revisions of this model, subprocesses involved in the

creative act, and theories of the creative process based on groups of subprocesses, several key questions about the creative process remain. The first and perhaps most fundamental question is what makes the creative process creative. In the following section, I examine possible responses to this question, drawing on existing theoretical proposals and relevant empirical evidence. Then, further questions about the creative process are raised, such as whether the creative process is domain or task specific.

### What Makes the Creative Process Creative?

Does the problem-solving process that leads to creative results differ from the process that leads to noncreative, run-of-the-mill results? If so, how does it differ? One response to these questions involves postulating qualitatively different process models, one for creative work and another for noncreative work. If there is such a dichotomy, then a subsidiary question can be raised: Within the creative process, how can we account for different levels of creativity (from highly creative to minimally creative)? Perhaps the creative process itself comes in two varieties: the creative process that leads to eminent work and the creative process that leads to more “everyday” levels of creativity.

A second possible response to the question of how the creative and noncreative processes differ focuses on a continuum rather than a dichotomy. A single basic process may yield highly creative, moderately creative, slightly creative, and noncreative productions. The differences in the outcome arise by varying certain process-relevant parameters (e.g., the time spent on a particular subprocess). This kind of model would parsimoniously account for a range of differences in the creativity of the final production.

A third response is that there is no specifically process-related difference between creative and noncreative work. The same sequence of thoughts and actions can lead to more or less creative or noncreative outcomes. What is important for creative work is the quality of the material (e.g., knowledge) used in each part of the process. Metaphorically, the engine is the same but some people use better grade fuel than others.

Given these alternatives, it is interesting to return first to the classic four-stage model of the creative process to see how it can be positioned. An examination of

the literature reveals that proponents of the four-stage model have not taken a clear stand on the fundamental issues raised here. In fact, the four-stage model can fit with each of the previously evoked views. The four-stage model can fit with a dichotomy between the creative and noncreative process; a certain stage of the process, such as incubation, may be present in the creative process and absent from the noncreative process. Alternatively, the four-stage model can fit with the “continuum” view. For example, the four stages may always be present but more time is spent on a certain stage in the creative process than in the less creative or noncreative process. Another possibility is that the stages are sequenced differently during creative, less creative, and noncreative problem solving; however, this possibility does not fit easily within the four-stage model. Finally, the creative and noncreative processes may involve the same four stages, in the same sequence, with the same time devoted to each stage, with the only difference being the quality with which each stage is executed. Thus creative productions would result from preparing well, incubating effectively, and verifying well the quality of one’s ideas. In this vein, Taylor (1959) suggested that “during the incubation stage, experiences mill and flow freely about for the highly creative person ... [whereas] for the noncreative person it is merely a matter of sorting experiences into tight, comfortable mental compartments” (p. 64).

Similar propositions could be formulated concerning a creative process composed of an array of subprocesses. If we take the “special process” view, certain subprocesses essential for creativity may be absent from less creative or noncreative work. For example, the creative process may involve bisociation or Janusian thinking, whereas the noncreative process does not. Alternatively, if we take the “continuum” view, certain subprocesses may be used more frequently or for a longer time in the creative process as compared to the less creative or noncreative processes (or, inversely, some subprocesses may be used less frequently in the highly creative process than in the less creative process). For example, creative work may involve frequent episodes of divergent thinking, which help to increase the variety of considered ideas. Another possibility is that the creative, less creative, and noncreative work involve the same subprocesses used with the same frequency but these processes are combined in different sequences. Thus creative work may proceed by a search for relevant information followed by a clear definition of the prob-

lem to be solved, whereas less creative or noncreative work begins with clearly defining the problem (Jay & Perkins, 1997). Osborn (1953) proposed that one of the hallmarks of the creative process is deferred judgment because early evaluation can kill new ideas that need time to develop and be elaborated. Thus the creative process may be characterized by avoiding evaluation early in the problem-solving process. Finally, the hypothesis can be advanced that the creativity of the outcome of problem solving depends simply on the quality with which each subprocess is executed (see Newell, Shaw, & Simon, 1962; Weisberg, 1986, 1993).

### Existing Theoretical Proposals

There is relatively little work that addresses specifically how the creative process as a whole differs from the noncreative or less creative processes. Guilford (1967) was, for example, rather vague on this point, claiming that “there is something creative about all genuine problem solving” (p. 312). His model did not, however, specify whether certain subprocesses were present in highly creative problem solving and absent or reduced in less creative problem solving, whether the sequence of subprocesses differed, whether the skill with which each subprocess was accomplished differed, or whether a combination of these led to differences in the creativity of the problem solution. From the earliest models of problem solving the specificity of creative work has been unclear. Dewey’s (1910) model, comprising stages of perceiving a difficulty, locating or defining the problem, suggesting possible solutions, elaborating implications of these solutions, and testing the validity of the solutions, is often cited as an early model of the creative process even though it was meant to describe problem solving in general.

In terms of more recent theoretical proposals, Amabile’s (1996) componential model accounts for differences in the level of creative productions through individual differences in task motivation (interest and commitment to the task), domain-relevant skills (knowledge, technical skills), and creativity-relevant processes (ability to break mental sets, heuristics for idea generation). These three components may influence the quality with which a particular process stage is accomplished or perhaps the time devoted to a certain stage of problem solving. For example, task motivation (especially intrinsic motivation) influences particularly

the problem identification and response-generation phases, domain-relevant skills influence the preparation and response-validation phases, and creativity-relevant processes influence the response-generation phase. Amabile indicated also how her model can account for both heuristic tasks, in which the path to a solution is unknown, and algorithmic tasks, for which there is a known sequence of operations that will solve the problem. During the preparation stage a person may identify an algorithm that can solve the problem (available in the person’s domain-relevant skills); this algorithmic procedure then will be applied during the response-generation phase, without any exploration of other possible pathways. Thus, the response-generation phase is reduced in noncreative work to the rote execution of a pre-existing algorithm.

Mumford et al. (1991) indicated that the creative problem solving process and the standard, noncreative process differ in four main ways. First, creative problem solving involves ill-defined problems more than routine problem solving. This places an emphasis on the problem-construction phase in creative work. Second, in the creative process people must generate new, alternative solutions that involve divergent and convergent thinking. In routine problem solving, people apply previously acquired procedures, search for ready-made solutions, and tend to satisfice, all of which involve mainly convergent thinking (see also Mayer, 1999). Third, the creative process involves active, attention-demanding processing with multiple cycles of divergent and convergent thought, whereas the standard process proceeds in an additive fashion, with more direct activation, generation, and application. Fourth, in the creative process information from existing category structures is combined or reorganized. In standard problem solving, information is recalled and understood using existing category structures. Thus the core processes of combination and reorganization of category information as well as problem construction differentiate creative and standard problem solving. Within the creative process, different levels of creativity result, in part, from the skill or quality with which each of the involved subprocesses is executed.

### Empirical Evidence

Some recent studies can be highlighted with regard to empirical work on the potentially special nature of the

creative process. Weisberg (1986, 1993), for example, explored the nature of the creative process, drawing on introspective reports, laboratory experiments, and case studies of artists, scientists, and inventors. He found that creative productions can be explained using relatively ordinary cognitive processes, such as analogical thinking. It seems that even great works such as Calder's mobiles, Watson and Crick's discovery of DNA, and the Wright brothers' first airplane involve a series of small steps, none of which require some special process.

In some studies the creative process was observed using specific laboratory tasks. For example, in a study that was briefly mentioned earlier, Getzels and Csikszentmihalyi (1976) observed art students as they made a drawing based on a set of objects that were provided (e.g., a mannequin, a book, a hat, a glass prism). The number of objects manipulated, exploration of the objects, and the unusualness of the objects selected were noted as indexes of the problem-finding process in the predrawing phase of work. Once the drawing began, photographs of the work in progress were taken to determine when the essential structure of the drawing became clear. Changes in the still-life composition and further exploration of the objects were noted. A panel of expert judges rated the originality of the drawings. Originality ratings correlated positively with most of the indexes of problem finding. For example, in the predrawing phase, the number of objects manipulated and the extent to which each object was explored in detail correlated significantly ( $r > .50$ ) with originality. Significant positive correlations were also observed between problem formulation behaviors during the drawing phase and originality of the final product. Given the nature of the drawing task, all the art students had to handle the objects to set up their still-life composition. However, some students manipulated only a few objects and did not examine these in detail, whereas other students explored in detail many of the proposed objects. Furthermore, some students reengaged the problem-finding process after beginning to draw the still-life composition that they had arranged. Thus differences in the quality and quantity of problem finding, as well as when it occurred during the drawing task, influenced originality.

Using a think-aloud methodology, Goor and Sommerfeld (1975) examined differences in the subprocesses used by creative and noncreative students who were preselected based on performance on divergent thinking tasks. The students thought aloud while solving three insight-type problems (making four trian-

gles with six matches, killing a tumor without destroying healthy cells, a problem concerning the selection of colored pebbles by chance). Problem-solving protocols were divided into brief intervals and seven categories of verbal behaviors were noted (e.g., generating new information or hypotheses, self-reference or self-criticism, silence). The highly creative group spent more time than the less creative group on generating new information or hypotheses, working on these hypotheses, and self-reference or self-criticism. There were also some group differences on the sequences of activities. For example, following self-reference or self-criticism, the highly creative group tended to engage in generating new information or developing hypotheses, whereas the less creative group entered a period of silence. Other process-related differences were noted that depended on the specific task. Although the criterion for identifying high and low creative groups as well as the choice of creative performance tasks may be criticized, this study illustrates a direction that further research on the creative process may pursue.

Finally, using an experimental methodology, Lubart (1994b) studied the role of idea evaluation during the creative process. University students composed short stories and made still-life drawings, which were judged for creativity by graduate-level teaching assistants in, respectively, literary composition or studio art. During task production, students were instructed to evaluate their work in progress. The moment when the evaluations occurred, the number of evaluations, and the way that evaluations were prompted were systematically varied. For the writing task, the results showed that participants who evaluated their ideas early in their work tended to have higher mean creativity than those who evaluated relatively later in their work or distributed their evaluations throughout the work. The early-evaluation group showed significantly higher creativity than a control group that was not prompted explicitly to evaluate. These results were replicated, in general, across different instructional methods for prompting evaluation and with a different story composition task. For the drawing task, no clear effect of the timing of evaluations was found. For both tasks, no effect of the quantity of evaluations was observed. Acknowledging that the experimental conditions used in this study may have influenced the creative process, the findings suggest that relatively early autoevaluations of one's story in progress led to higher creativity than did evaluations conducted at other mo-

ments. Thus, the timing of the evaluation subprocess during short-story writing seemed to have an effect on the creativity of the final production.

### Further Questions About the Creative Process

In addition to the questions raised earlier about the basic nature of the creative process, several other questions can be raised. For example, to what extent is the creative process recursive? A number of authors, in both theoretical and empirical reports, have noted that the subprocesses involved in creativity recur over and over in complex sequences (Eindhoven & Vinacke, 1952; Mumford et al., 1991; Runco, 1994). For example, problem definition may occur at the beginning of one's work and recur in the middle of problem solving when inconsistencies in one's problem representation prevent further progress (Dudek & Côté, 1994; Jay & Perkins, 1997). There is potentially an interaction between initial ideas and the developing work that is sometimes referred to as a dynamic, evolving process rather than a static process in which one step follows another toward problem solution. Several authors have also proposed a recursive application of idea generation and idea evaluation in cyclic, dynamic sequences. Assuming that recursion does occur in the creative process, the key question is how exactly this recursion is organized. What provokes recursion? What metacognitive functions control the choice of certain subprocesses and their recursive application? In general, due to the number of subprocesses potentially involved in creative work and the possibility of recursion, existing process models seem underspecified and, hence, difficult to test empirically.

Several other questions concern the generality of the creative process. Does the creative process vary according to the nature of the task? Is there a creative process for work in the visual arts that differs from the creative process involved in literary or scientific work? Some models of the creative process for specific types of work have been formulated. For scientific creativity, Busse and Mansfield (1980) proposed the stages of (a) selecting a problem to solve among several possible problems, (b) engaging in efforts to solve the problem, (c) setting constraints on the problem solution, (d) changing the constraints and restructuring the problem (which if successful leads to an illumination), and (e)

verifying and elaborating the proposed solution. Nemiro (1997) explored the creative process in actors, linking general preparation, rehearsal, and performance activities to the stages described in Amabile's (1996) model. Sapp (1995) proposed a process model for artistic creativity based on the general creative problem-solving model developed by Osborn, Parnes, Isaksen, and Treffinger (see Treffinger, 1995). Some authors have, furthermore, proposed that the nature itself of a given subprocess involved in the creative process may differ according to the domain of work. For example, Dudek and Côté (1994) characterized problem finding in art as an internally oriented effort to come to terms with a topic, express one's emotions, point to a new social reality, or externalize an inner state. Problem finding in science, in contrast, has been characterized as discovering gaps or discrepancies in existing knowledge, sensing difficulties when one's expectations are not met, when observations do not match with an existing mental model of a phenomenon (Ochse, 1990). Thus, the subprocess of problem finding may be quite different depending on the kind of task.

Other differences between tasks may also lead to differences in the creative process. For example, there may be a difference between the creative process involved in online productions, such as acting or playing improvisational jazz, and offline productions, such as writing a script for a play or composing a symphony (see Nemiro, 1997; Sawyer, 1992). There may also be different creative processes for tasks in the same domain of work, such as writing a novel and writing a short story or writing a haiku and writing a sonnet.

Related to the generality of the creative process is the question of whether there is one generic process model that fits everyone. In fact, nearly all the work on the creative process has sought the model, or, a small set of domain-specific models. A growing body of work in cognitive psychology suggests that there are often several valid paths for solving both simple and complex cognitive tasks (Reuchlin, 1999). In this vein, there may be several paths that lead to a creative production. We may find, for example, that an individual could sequence the subprocesses for creativity in several different ways. Certain sequences would lead to a highly creative product. A great number of other possible sequences would lead to less creative or noncreative productions. Thus, we may learn a great deal more about the creative process by studying

intraindividual and interindividual variability in the creative process while holding constant the creative level of the final product.

A final set of questions that could be posed about the creative process concerns the articulation between the sequence of activities that leads to a final product and person-centered or context-centered variables. For example, how does a person's level of perseverance or intrinsic motivation impact on the creative process? Does motivation enhance the use of certain creative subprocesses or influence more fundamentally which subprocesses are used altogether? Does the nature of creative process differ if one is a novice or expert in a task domain? Do contextual variables such as time pressure, external evaluation, or competition lead to modifications in the creative process?

There has been some research on these questions. For example, comparisons between the creative process of artists and nonartists in a painting task indicated quantitative and qualitative differences in some studies, such as artists spending more time on planning their painting than nonartists (Eindhoven & Vinacke, 1952; Patrick, 1935, 1937). In one study, Kay (1991) found that nonartists, semiprofessional artists, and professional artists differed on certain process-related variables such as time spent exploring and arranging elements of artistic puzzle-like tasks. These results suggest that the same task may involve problem-finding processes for some people (semiprofessional artists) and not for others (professionals who have an artistic vision already developed that can be applied to open-ended tasks). A related study by Rostan (1994) suggests that the relation between variables such as the time spent in problem-finding activities and expertise level may vary also with the specific task employed. Finally, Mumford et al. (1991) suggested that the use of subprocesses involved in creativity may be limited by the quality of the information on which these processes can draw. Thus it is clear that the studies of the creative process must take into account the quality of the cognitive raw materials that are available as well as the process itself.

### Conclusion

There has been notable progress during the past half-century in specifying the subprocesses involved in the creative process. However, in terms of a comprehensive understanding of the creative process, there are

good reasons to echo Guilford's (1950) discontent. Theories of the creative process need to specify in much greater detail how the subprocesses can be sequenced to yield creative productions. This issue should be central to any model of the creative process. Furthermore, the ways in which such models account for differences in creativity and distinguish between creative and noncreative work are essential. Variations on a modal creative process depending on the domain of the work or characteristics of the individual need also to be considered in both theoretical and empirical work. A revised, enhanced perspective on the creative process will have implications for practical issues such as creativity training and the identification of creative people. For both of these issues, the subprocesses involved in creativity as well as the ways that these subprocesses can be best used together, which may vary with the nature of the problem-solving task, need to be taken into account. Creativity training or selection procedures may not be effective, according to the current view, if people master specific skills but do not know how to combine these when working on a task.

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