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The Nature of Creativity

Robert J. Sternberg

Tufts University

ABSTRACT: Like E. Paul Torrance, my colleagues and I have tried to understand the nature of creativity, to assess it, and to improve instruction by teaching for creativity as well as teaching students to think creatively. This article reviews our investment theory of creativity, propulsion theory of creative contributions, and some of the data we have collected with regard to creativity. It also describes the propulsion theory of creative contributions. Finally, it draws some conclusions.

The field of creativity as it exists today emerged largely as a result of the pioneering efforts of J. P. Guilford (1950) and E. Paul Torrance (1962, 1974). It is wholly fitting to dedicate a special issue of the *Creativity Research Journal* to Torrance because of his seminal contributions to thinking about creativity. To this day, the Torrance Tests of Creative Thinking (Torrance, 1974) remain the most widely used assessments of creative talent.

Guilford and Torrance had many more agreements than disagreements about the nature of creativity and the ways to measure it. Both were basically psychometric theorists and conceived of and attempted to measure creativity from a psychometric standpoint. However, both were broad thinkers, and their conceptions were much more expansive than the operationalizations of these conceptions through their tests. Both concentrated on divergent thinking as the basis of creativity and devised tests that emphasized the assessment of divergent thinking. Both left behind numerous students and disciples to carry on their pioneering work. Torrance, in particular, was a warm, caring, and positive person. I met him only a few times, but I was enormously impressed with the modesty he displayed, given his preeminence in the field. He showed that the best people in the field have no need

for the pretensions to which less-distinguished academics can be so susceptible.

There are a number of different approaches one can take to understanding creativity. Torrance preferred a psychometric approach to understanding creativity. My colleagues and I (e.g., Sternberg, Kaufman, & Pretz, 2002; Sternberg & Lubart, 1995, 1996) have chosen to use a confluence approach as a basis for our work on creativity. I will discuss two of the theories underlying our work and some of the empirical work we have done to test our ideas. These theories are part of a more general theory—WICS—of wisdom, intelligence, and creativity synthesized (Sternberg, 2003b).

The Investment Theory of Creativity

Our investment theory of creativity (Sternberg & Lubart, 1991, 1995) is a confluence theory according to which creative people are those who are willing and able to “buy low and sell high” in the realm of ideas (see also Rubenson & Runco, 1992, for the use of concepts from economic theory). Buying low means pursuing ideas that are unknown or out of favor but that

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Correspondence and requests for reprints should be sent to Robert J. Sternberg, Dean of the School of Arts and Sciences, Tufts University, Ballou Hall, Medford, MA 02155. E-mail: Robert.sternberg@tufts.edu

have growth potential. Often, when these ideas are first presented, they encounter resistance. The creative individual persists in the face of this resistance and eventually sells high, moving on to the next new or unpopular idea.

Aspects of the Investment Theory

According to the investment theory, creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. Although levels of these resources are sources of individual differences, often the decision to use a resource is a more important source of individual differences. In the following sections, I discuss the resources and the role of decision making in each.

Intellectual skills. Three intellectual skills are particularly important (Sternberg, 1985): (a) the synthetic skill to see problems in new ways and to escape the bounds of conventional thinking, (b) the analytic skill to recognize which of one's ideas are worth pursuing and which are not, and (c) the practical-contextual skill to know how to persuade others of—to sell other people on—the value of one's ideas. The confluence of these three skills is also important. Analytic skills used in the absence of the other two skills results in powerful critical, but not creative, thinking. Synthetic skill used in the absence of the other two skills results in new ideas that are not subjected to the scrutiny required to improve them and make them work. Practical-contextual skill in the absence of the other two skills may result in societal acceptance of ideas not because the ideas are good, but rather, because the ideas have been well and powerfully presented.

We tested the role of creative intelligence in creativity in several studies. In one study, we presented 80 people with novel kinds of reasoning problems that had a single best answer. For example, they might be told that some objects are green and others blue; but still other objects might be *grue*, meaning green until the year 2000 and blue thereafter, or *bleen*, meaning blue until the year 2000 and green thereafter. Or they might be told of four kinds of people on the planet Kyron—*blens*, who are born young and die young; *kwefs*, who are born old and die old; *balts*, who are born young and die old; and *prosses*, who are born old and die young (Sternberg, 1982; Tetewsky & Sternberg, 1986). Their task was to

predict future states from past states, given incomplete information. In another set of studies, 60 people were given more conventional kinds of inductive reasoning problems, such as analogies, series completions, and classifications, but were told to solve them. However, the problems had premises preceding them that were either conventional (dancers wear shoes) or novel (dancers eat shoes). The participants had to solve the problems as though the counterfactuals were true (Sternberg & Gastel, 1989a, 1989b).

In these studies, we found that correlations with conventional kinds of tests depended on how novel or nonentrenched the conventional tests were. The more novel the items, the higher the correlations of our tests with scores on successively more novel conventional tests. Thus, the components isolated for relatively novel items would tend to correlate more highly with more unusual tests of fluid abilities (e.g., that of Cattell & Cattell, 1973) than with tests of crystallized abilities. We also found that when response times on the relatively novel problems were componentially analyzed, some components better measured the creative aspect of intelligence than did others. For example, in the “grue-bleen” task mentioned earlier, the information-processing component requiring people to switch from conventional green-blue thinking to grue-bleen thinking and then back to green-blue thinking again was a particularly good measure of the ability to cope with novelty.

In another study, we looked at predictions for everyday kinds of situations, such as when milk will spoil (Sternberg & Kalmar, 1997). In this study, we looked at both predictions and postdictions (hypotheses about the past where information about the past is unknown) and found that postdictions took longer to make than did predictions. Novel predictions and postdictions are more challenging and time-consuming than simpler ones.

Creativity and simply thinking in novel ways are facilitated when people are willing to put in up-front time to think in new ways. We found that better thinkers tend to spend relatively more time than do poorer reasoners in global, up-front metacomponential planning when they solve difficult, novel-reasoning problems. Poorer reasoners, conversely, tend to spend relatively more time in local planning (Sternberg, 1981). Presumably, the better thinkers recognize that it is better to invest more time up front so as to be able to process a problem more efficiently later on.

Knowledge. On the one hand, one needs to know enough about a field to move it forward. One cannot move beyond where a field is if one does not know where it is. On the other hand, knowledge about a field can result in a closed and entrenched perspective, resulting in a person's not moving beyond the way in which he or she has seen problems in the past. Knowledge thus can help, or it can hinder creativity.

In a study of expert and novice bridge players, for example (Frensch & Sternberg, 1989), we found that experts outperformed novices under regular circumstances. When a superficial change was made in the surface structure of the game, the experts and novices were both hurt slightly in their playing, but they quickly recovered. When a profound, deep-structural change was made in the structure of the game, the experts initially were hurt more than the novices, but the experts later recovered. The reason, presumably, is that experts make more and deeper use of the existing structure and hence have to reformulate their thinking more than novices do when there is a deep-structural change in the rules of the game. Thus, one needs to decide to use one's past knowledge.

Thinking styles. Thinking styles are preferred ways of using one's skills. In essence, they are *decisions* about how to deploy the skills available to a person. With regard to thinking styles, a legislative style is particularly important for creativity (Sternberg, 1988, 1997a), that is, a preference for thinking and a decision to think in new ways. This preference needs to be distinguished from the ability to think creatively: Someone may like to think along new lines, but not think well, or vice versa. It also helps to become a major creative thinker, if one is able to think globally as well as locally, distinguishing the forest from the trees and thereby recognizing which questions are important and which ones are not.

In our research (Sternberg, 1997b; Sternberg & Grigorenko, 1995), we found that legislative people tend to be better students than less legislative people, if the schools in which they study value creativity. If the schools do not value or devalue creativity, they tend to be worse students. Students also were found to receive higher grades from teachers whose own styles of thinking matched their own.

Personality. Numerous research investigations (summarized in Lubart, 1994, and Sternberg & Lubart,

1991, 1995) have supported the importance of certain personality attributes for creative functioning. These attributes include, but are not limited to, willingness to overcome obstacles, willingness to take sensible risks, willingness to tolerate ambiguity, and self-efficacy. In particular, buying low and selling high typically means defying the crowd, so that one has to be willing to stand up to conventions if one wants to think and act in creative ways (Sternberg, 2003a; Sternberg & Lubart, 1995). Often creative people seek opposition; that is, they decide to think in ways that countervail how others think. Note that none of the attributes of creative thinking is fixed. One can *decide* to overcome obstacles, take sensible risks, and so forth.

In one study (Lubart & Sternberg, 1995), we found that greater risk-taking propensity was associated with creativity for artwork but not for essays. When we investigated why this was so, we found that some evaluators tended to mark down essays that took unpopular positions. We learned, therefore, that one of the risks people face when they are creative, even in an experiment on risk taking, is that the evaluators will not appreciate the risks if they go against their own beliefs!

Motivation. Intrinsic, task-focused motivation is also essential to creativity. The research of Amabile (1983) and others has shown the importance of such motivation for creative work and has suggested that people rarely do truly creative work in an area unless they really love what they are doing and focus on the work rather than the potential rewards. Motivation is not something inherent in a person: One *decides* to be motivated by one thing or another. Often, people who need to work in a certain area that does not particularly interest them will decide that, given the need to work in that area, they had better find a way to make it interest them. They will then look for some angle on the work they need to do that makes this work appeal to rather than bore them.

Environment. Finally, one needs an environment that is supportive and rewarding of creative ideas. One could have all of the internal resources needed to think creatively, but without some environmental support (such as a forum for proposing those ideas), the creativity that a person has within him or her might never be displayed.

Environments typically are not fully supportive of the use of one's creativity. The obstacles in a given en-

environment may be minor, as when an individual receives negative feedback on his or her creative thinking, or major, as when one's well-being or even life are threatened if one thinks in a manner that defies convention. The individual therefore must *decide* how to respond in the face of the nearly omnipresent environmental challenges that exist. Some people let unfavorable forces in the environment block their creative output; others do not.

Part of the environment is determined by who is doing the evaluating. In our studies (Lubart & Sternberg, 1995), we had creative products of people of different ages rated for their creativity by raters of different age cohorts. We found informal evidence of cohort matching—that is, raters tended to rate as more creative products of creators of roughly their own age cohort. For example, people will often tend to prefer the popular music of the generation in which they grew up as early adolescents more than the popular music of the generation in which their parents or children grew up. Thus, part of what may determine growth patterns of creativity (Simonton, 1994) is in changing criteria for evaluations of creativity on the part of raters.

Confluence. Concerning the confluence of these six components, creativity is hypothesized to involve more than a simple sum of a person's level on each component. First, there may be thresholds for some components (e.g., knowledge) below which creativity is not possible regardless of the levels on other components. Second, partial compensation may occur in which a strength on one component (e.g., motivation) counteracts a weakness on another component (e.g., environment). Third, interactions may occur between components, such as intelligence and motivation, in which high levels on both components could multiplicatively enhance creativity.

Creative ideas are both novel and valuable. However, they are often rejected when the creative innovator stands up to vested interests and defies the crowd (cf. Csikszentmihalyi, 1988). The crowd does not maliciously or willfully reject creative notions. Rather, it does not realize, and often does not want to realize, that the proposed idea represents a valid and advanced way of thinking. Society often perceives opposition to the status quo as annoying, offensive, and reason enough to ignore innovative ideas.

Evidence abounds that creative ideas are often rejected (Sternberg & Lubart, 1995). Initial reviews of

major works of literature and art are often negative. Toni Morrison's *Tar Baby* received negative reviews when it was first published, as did Sylvia Plath's *The Bell Jar*. The first exhibition in Munich of the work of Norwegian painter Edvard Munch opened and closed the same day because of the strong negative response from the critics. Some of the greatest scientific articles have been rejected not just by one but by several journals before being published. For example, John Garcia, a distinguished biopsychologist, was immediately denounced when he first proposed that a form of learning called classical conditioning could be produced in a single trial of learning (Garcia & Koelling, 1966).

From the investment view, then, the creative person buys low by presenting an idea that initially is not valued and then attempting to convince other people of its value. After convincing others that the idea is valuable, which increases the perceived value of the investment, the creative person sells high by leaving the idea to others and moving on to another idea. People typically want others to love their ideas, but immediate universal applause for an idea often indicates that it is not particularly creative.

The Role of Decision Making

Creativity, according to the investment theory, is in large part a decision. The view of creativity as a decision suggests that creativity can be developed. Simply requesting that students be more creative can render them more creative if they believe that the decision to be creative will be rewarded rather than punished (O'Hara & Sternberg, 2000–2001).

To be creative one must first *decide* to generate new ideas, analyze these ideas, and sell the ideas to others. In other words, a person may have synthetic, analytical, or practical skills but not apply them to problems that potentially involve creativity. For example, one may decide (a) to follow other people's ideas rather than synthesize one's own, (b) not to subject one's ideas to a careful evaluation, or (c) to expect other people to listen to one's ideas and therefore decide not to try to persuade other people of the value of these ideas. The skill is not enough: One first needs to make the decision to use the skill.

For example, ability to switch between conventional and unconventional modes of thinking is important to creativity. One aspect of switching between conventional and unconventional thinking is the decision

that one is willing and able to think in unconventional ways—that one is willing to accept thinking in terms different from those to which one is accustomed and with which one feels comfortable. People show reliable individual differences in willingness to do so (Dweck, 1999). Some people (what Dweck calls “entity theorists”) prefer to operate primarily or even exclusively in domains that are relatively familiar to them. Other people (what Dweck calls “incremental theorists”) seek out new challenges and new conceptual domains within which to work. I have proposed a number of different decisions by which one can develop one’s own creativity as a decision (Sternberg, 2001): (a) redefine problems, (b) question and analyze assumptions, (c) do not assume that creative ideas sell themselves: sell them, (d) encourage the generation of ideas, (e) recognize that knowledge can both help and hinder creativity, (f) identify and surmount obstacles, (g) take sensible risks, (h) tolerate ambiguity, (i) believe in oneself (self-efficacy), (j) find what one loves to do, (k) delay gratification, (l) role-model creativity, (m) cross-fertilize ideas, (n) reward creativity, (o) allow mistakes, (p) encourage collaboration, (q) see things from others’ points of view, (r) take responsibility for successes and failures, (s) maximize person–environment fit, (t) continue to allow intellectual growth.

Evidence Regarding the Investment Theory

Assessment. Research within the investment framework has yielded support for this model (Lubart & Sternberg, 1995). This research has used tasks such as (a) writing short stories using unusual titles (e.g., the octopus’ sneakers), (b) drawing pictures with unusual themes (e.g., the earth from an insect’s point of view), (c) devising creative advertisements for boring products (e.g., cufflinks), and (d) solving unusual scientific problems (e.g., how could we tell if someone had been on the moon within the past month?). Our measures have the same goal as Torrance’s do, but we attempt to use tasks that are more oriented toward what people do in school and in the real world when they think creatively. This research showed creative performance to be moderately domain specific and to be predicted by a combination of certain resources, as described as follows. The exact blend of resources and the success with which these resources are blended may vary from one culture to another. For example, Niu and Sternberg (2001) found that both

American and Chinese evaluators rated two distinct artistic products (collages and science fiction characters) of American college students to be more creative than products of Chinese college students roughly matched for conventional intelligence (Niu & Sternberg, 2001). This finding held up regardless of whether the raters were American or Chinese.

One concern we have is whether creative skills can be measured in a way that is distinct from the way g-based analytical skills are measured, as well as the practical skills that, together with the analytical and creative ones, combine into my theory of successful intelligence.

In one study (Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999), we used the so-called Sternberg Triarchic Abilities Test (STAT; Sternberg, 1993) to investigate the relations among the three abilities. Three hundred twenty-six high school students, primarily from diverse parts of the United States, took the test, which consisted of 12 subtests in all. There were four subtests, each measuring analytical, creative, and practical abilities. For each type of ability, there were three multiple-choice tests and one essay test. The multiple-choice tests, in turn, involved, respectively, verbal, quantitative, and figural content. Consider the content of each test:

1. Analytical–Verbal: Figuring out meanings of neologisms (artificial words) from natural contexts. Students see a novel word embedded in a paragraph and have to infer its meaning from the context.
2. Analytical–Quantitative: Number series. Students have to say what number should come next in a series of numbers.
3. Analytical–Figural: Matrices. Students see a figural matrix with the lower right entry missing. They have to say which of the options fits into the missing space.
4. Practical–Verbal: Everyday reasoning. Students are presented with a set of everyday problems in the life of an adolescent and have to select the option that best solves each problem.
5. Practical–Quantitative: Everyday math. Students are presented with scenarios requiring the use of math in everyday life (e.g., buying tickets for a ballgame) and have to solve math problems based on the scenarios.
6. Practical–Figural: Route planning. Students are presented with a map of an area (e.g., an entertainment

park) and have to answer questions about navigating effectively through the area depicted by the map.

7. Creative–Verbal: Novel analogies. Students are presented with verbal analogies preceded by counterfactual premises (e.g., money falls off trees). They have to solve the analogies as though the counterfactual premises were true.

8. Creative–Quantitative: Novel number operations. Students are presented with rules for novel number operations, for example, “flox,” which involves numerical manipulations that differ as a function of whether the first of two operands is greater than, equal to, or less than the second. Participants have to use the novel number operations to solve presented math problems.

9. Creative–Figural: In each item, participants are first presented with a figural series that involves one or more transformations; they then have to apply the rule of the series to a new figure with a different appearance, and complete the new series.

We found that a confirmatory factor analysis on the data was supportive of the triarchic theory of human intelligence, yielding separate and uncorrelated analytical, creative, and practical factors. The lack of correlation was caused by the inclusion of essay as well as multiple-choice subtests. Although multiple-choice tests tended to correlate substantially with multiple-choice tests, their correlations with essay tests were much weaker. We found the multiple-choice analytical subtest to load most highly on the analytical factor, but the essay creative and performance subtests loaded most highly on their respective factors. Thus, measurement of creative and practical abilities probably should be accomplished with other kinds of testing instruments that complement multiple-choice instruments. In sum, creative skills could be measured separately from analytical and practical ones.

In a second and separate study, conducted with 240 freshman-year high school students in the United States, Finland, and Spain, we used the multiple-choice section of that STAT to compare five alternative models of intelligence, again via confirmatory factor analysis. A model featuring a general factor of intelligence fit the data relatively poorly. The triarchic model, allowing for intercorrelation among the analytic, creative, and practical factors, provided the best fit to the data (Sternberg, Castejón, Prieto, Hautamäki, & Grigorenko, 2001).

In a third study, we tested 511 Russian schoolchildren (ranging in age from 8 to 17 years) as well as 490 mothers and 328 fathers of these children (Grigorenko & Sternberg, 2001). We used entirely distinct measures of analytical, creative, and practical intelligence. Consider, for example, the tests we used for adults. Similar tests were used for children.

We measured fluid intelligence using standard measures. The measure of creative intelligence also consisted of two parts. The first part asked the participants to describe the world through the eyes of insects. The second part asked participants to describe who might live and what might happen on a planet called “Priumliava.” No additional information on the nature of the planet was specified. Each part of the test was scored in three different ways to yield three different scores. The first score was for originality (novelty), the second was for the amount of development in the plot (quality), and the third score was for creative use of prior knowledge in these relatively novel kinds of tasks (sophistication). The measure of practical intelligence was self-report and also comprised two parts. The first part was designed as a 20-item, self-report instrument, assessing practical skills in the social domain (e.g., effective and successful communication with other people), in the family domain (e.g., how to fix household items, how to run the family budget), and in the domain of effective resolution of sudden problems (e.g., organizing something that has become chaotic).

In this study, exploratory principal component analysis for both children and adults yielded very similar factor structures. Both varimax and oblimin rotations yielded clear-cut analytical, creative, and practical factors for the tests. Thus, a sample of a different nationality (Russian), a different set of tests, and a different method of analysis (exploratory rather than confirmatory analysis) again supported the theory of successful intelligence. Now consider in more detail each of three major aspects of successful intelligence: analytical, creative, and practical.

In a recent study, creativity was measured using open-ended, performance-based measures (Sternberg & the Rainbow Project Collaborators, in press) to assess creativity. These performance tasks were expected to tap an important part of creativity that might not be measured using multiple-choice items alone, because open-ended measures require more spontaneous and free-form responses.

For each of the tasks, participants were given a choice of topic or stimuli on which to base their creative stories or cartoon captions. Although these different topics or stimuli varied in terms of their difficulty for inventing creative stories and captions, these differences are accounted for in the derivation of item response theory ability estimates.

Each of the creativity performance tasks were rated on criteria that were determined *a priori* as indicators of creativity.

1. Cartoons. Participants were given five cartoons purchased from the archives of the *New Yorker*; however, the captions were removed. The participants' task was to choose three cartoons and to provide a caption for each cartoon. Two trained judges rated all the cartoons for cleverness, humor, originality, and task appropriateness on 5-point scales. A combined creativity score was formed by summing the individual ratings on each dimension except task appropriateness, which theoretically is not a measure of creativity *per se*.

2. Written stories. Participants were asked to write two stories, spending approximately 15 min on each, choosing from the following titles: "A Fifth Chance," "2983," "Beyond the Edge," "The Octopus's Sneakers," "It's Moving Backwards," and "Not Enough Time" (Lubart & Sternberg, 1995; Sternberg & Lubart, 1995). A team of six judges was trained to rate the stories. Each of six judges rated the stories for originality, complexity, emotional evocativeness, and descriptiveness on 5-point scales.

3. Oral stories. Participants were presented with five sheets of paper, each containing a set of 11 to 13 images linked by a common theme (keys, money, travel, animals playing music, and humans playing music). After choosing one of the pages, the participant was given 15 min to formulate a short story and dictate it into a cassette recorder, which was timed by the proctor for the paper assessments and by the internal computer clock for the computer assessments. There were no restrictions on the minimum or maximum number of images that needed to be incorporated into the stories. As with the written stories, each judge rated the stories for originality, complexity, emotional evocativeness, and descriptiveness on 5-point scales.

In a sample of 793 first-year college students from around the United States, in colleges ranging from not selective at all to very selective, we found that a sepa-

rate creativity factor emerged that separated the creative performance tests from the other tests. We also found that adding our creative measures to analytical as well as practical measures roughly doubled the predictive value of the SAT for our sample in predicting grades for first-year college students (Sternberg & the Rainbow Collaborators, in press). The measures also served to *decrease* ethnic differences between groups.

Creativity is as much a decision about and an attitude toward life as it is a matter of ability. Creativity is often obvious in young children, but it may be harder to find in older children and adults because their creative potential has been suppressed by a society that encourages intellectual conformity.

Instruction. One can teach students to think more creatively (Sternberg & Williams, 1996; Williams, Markle, Brigockas, & Sternberg, 2001). However, the emphasis in our research has been on evaluating our ideas about creativity in the classroom for instruction of conventional subject matter.

In a first set of studies, we explored the question of whether conventional education in school systematically discriminates against children with creative and practical strengths (Sternberg & Clinkenbeard, 1995; Sternberg, Ferrari, Clinkenbeard, & Grigorenko, 1996; Sternberg et al., 1999). Motivating this work was the belief that the systems in most schools strongly tend to favor children with strengths in memory and analytical abilities.

To validate our ideas, we have carried out a number of instructional studies. In one study, we used the STAT (Sternberg, 1993). The test was administered to 326 children around the United States and in some other countries who were identified by their schools as gifted by any standard whatsoever. Children were selected for a Yale summer program in (college-level) psychology if they fell into one of five ability groupings: high analytical, high creative, high practical, high balanced (high in all three abilities), or low balanced (low in all three abilities). Students who came to Yale were then divided into four instructional groups. Students in all four instructional groups used the same introductory psychology textbook (a preliminary version of Sternberg, 1995) and listened to the same psychology lectures. What differed among them was the type of afternoon discussion section to which they were assigned. They were assigned to an instructional condition that emphasized either memory, analytical, creative, or

practical instruction. For example, in the memory condition, they might be asked to describe the main tenets of a major theory of depression. In the analytical condition, they might be asked to compare and contrast two theories of depression. In the creative condition, they might be asked to formulate their own theory of depression. In the practical condition, they might be asked how they could use what they had learned about depression to help a friend who was depressed.

Students in all four instructional conditions were evaluated in terms of their performance on homework, a midterm exam, a final exam, and an independent project. Each type of work was evaluated for memory, analytical, creative, and practical quality. Thus, all students were evaluated in exactly the same way.

First, we observed when the students arrived at Yale, that the students in the high creative and high practical groups were much more diverse in terms of racial, ethnic, socioeconomic, and educational backgrounds than were the students in the high analytical group, suggesting that correlations of measured intelligence with status variables such as these may be reduced by using a broader conception of intelligence. Thus, the kinds of students identified as strong differed in terms of populations from which they were drawn in comparison with students identified as strong solely by analytical measures. More importantly, just by expanding the range of abilities measured, we discovered intellectual strengths that might not have been apparent through a conventional test.

Second, we found that all three ability tests—analytical, creative, and practical—significantly predicted course performance. When multiple regression analysis was used, at least two of these ability measures contributed significantly to the prediction of each of the measures of achievement. Perhaps as a reflection of the difficulty of deemphasizing the analytical way of teaching, one of the significant predictors was always the analytical score.

Third and most importantly, there was an aptitude treatment interaction whereby students who were placed in instructional conditions that better matched their pattern of abilities outperformed students who were mismatched. In other words, when students are taught in a way that fits how they think, they do better in school. Children with creative or practical abilities, who are almost never taught or assessed in a way that matches their pattern of abilities, may be at a disadvantage in course after course, year after year.

A follow-up study (Sternberg, Torff, & Grigorenko, 1998a, 1998b) examined learning of social studies and science by third graders and eighth graders. The 225 third graders were students in a very low-income neighborhood in Raleigh, North Carolina. The 142 eighth graders were students who were largely middle to upper-middle class studying in Baltimore, Maryland, and Fresno, California. In this study, students were assigned to one of three instructional conditions. In the first condition, they were taught the course that basically they would have learned had there been no intervention. The emphasis in the course was on memory. In a second condition, students were taught in a way that emphasized critical (analytical) thinking. In the third condition, they were taught in a way that emphasized analytical, creative, and practical thinking. All students' performance was assessed for memory learning (through multiple-choice assessments) as well as for analytical, creative, and practical learning (through performance assessments).

As expected, students in the analytical, creative, practical combined condition outperformed the other students in terms of the performance assessments. One could argue that this result merely reflected the way they were taught. Nevertheless, the result suggested that teaching for these kinds of thinking succeeded. More important, however, was the result that children in the successful-intelligence condition outperformed the other children, even on the multiple-choice memory tests. In other words, to the extent that one's goal is just to maximize children's memory for information, teaching for creative as well as analytical and practical thinking is still superior. It enables children to capitalize on their strengths and to correct or to compensate for their weaknesses, and it allows children to encode material in a variety of interesting ways.

We have extended these results to reading curricula at the middle and the high school levels. In a study of 871 middle school students and 432 high school students, we taught reading either creatively, analytically, and practically or through the regular curriculum. At the middle school level, reading was taught explicitly. At the high school level, reading was infused into instruction in mathematics, physical sciences, social sciences, English, history, foreign languages, and the arts. In all settings, students who were taught using our expanded model substantially outperformed students who were taught in standard ways (Grigorenko, Jarvin, & Sternberg, 2002).

Thus, the results of three sets of studies suggest that teaching for creative thinking, as well as for analytical and practical thinking, is worthwhile. Some kinds of students do not maximally profit from conventional instruction, but they may profit from the kinds of expanded instruction we can offer. For example, when I took introductory psychology as a freshman, I was a creative learner in a memory course. My grade showed it: Despite my efforts, I got a C in the course.

Kinds of Creative Contributions

Creative contributors make different *decisions* regarding *how* to express their creativity. We proposed a propulsion theory of creative contributions (Sternberg, 1999b; Sternberg, Kaufman, & Pretz, 2001, 2002) that addresses this issue of how people decide to invest their creative resources. The basic idea is that creativity can be of different kinds, depending on how it propels existing ideas forward. When developing creativity, we can develop different kinds of creativity, ranging from minor replications to major redirections in thinking.

Creative contributions differ not only in their amounts but also in the kinds of creativity they represent. For example, both Sigmund Freud and Anna Freud were highly creative psychologists, but the nature of their contributions appears in some way or ways to have been different. Sigmund Freud proposed a radically new theory of human thought and motivation and Anna Freud largely elaborated on and modified Sigmund Freud's theory. How do creative contributions differ in quality and not just in quantity of creativity?

The type of creativity exhibited in a creator's works can have at least as much of an effect on judgments about that person and his or her work as does the amount of creativity exhibited. In many instances, it may have more of an effect on these judgments. For example, a contemporary artist might have thought processes, personality, motivation, and even background variables similar to those of Monet, but that artist, painting today in the style of Monet, probably would not be judged to be creative in the way Monet was judged. He or she was born too late. Artists, including Monet, have experimented with impressionism, and unless the contemporary artist introduced some new twist, he or she might be viewed as imitative rather than creative.

The importance of context is illustrated by the difference, in general, between creative discovery and rediscovery. For example, BACON and related programs of Langley, Simon, Bradshaw, and Zyngow (1987) rediscover important scientific theorems that were judged to be creative discoveries in their time. The processes by which these discoveries are made via computer simulation are presumably not identical to those by which the original discoverers made their discoveries. One difference derives from the fact that contemporary programmers can provide, in their programming of information into computer simulations, representations and particular organizations of data that may not have been available to the original creators. Moreover, the programs solve problems but do not define them. However, putting aside the question of whether the processes are the same, a rediscovery might be judged to be creative with respect to the rediscoverer, but it would not be judged to be creative with respect to the field at the time the rediscovery is made.

Given the importance of purpose, creative contributions must always be defined in some context. If the creativity of an individual is always judged in a context, then it will help to understand how the context interacts with how people are judged. In particular, what are the types of creative contributions a person can make within a given context? Most theories of creativity concentrate on the attributes of the individual (see Sternberg, 1999a; Ward, Smith, & Vaid, 1997). However, to the extent that creativity is in the interaction of person with context, we need to concentrate as well on the attributes of the individual and the individual's work relative to the environmental context.

A taxonomy of creative contributions needs to deal with the question not only of in what domain a contribution is creative but also of what the type of creative contribution is (Gardner, 1993). What makes one work in biology more creative or creative in a different way from another work in biology, or what makes its creative contribution different from that of a work in art? Thus, a taxonomy of domains of work is insufficient to elucidate the nature of creative contributions. A field needs a basis for scaling how creative contributions differ quantitatively and, possibly, qualitatively.

A creative contribution represents an attempt to propel a field from wherever it is to wherever the creator believes the field should go. Thus, creativity is, by its nature, *propulsion*. It moves a field from some point to

another. It also always represents a decision to exercise leadership. The creator tries to bring others to a particular point in the multidimensional creative space. The attempt may or may not succeed. There are different kinds of creative leadership that the creator may attempt to exercise, depending on how he or she decides to be creative.

The propulsion model suggests eight types of contributions that can be made to a field of endeavor at a given time. Although the eight types of contributions may differ in the extent of creative contribution they make, the scale of eight types presented here is intended as closer to a nominal one than to an ordinal one. There is no fixed a priori way of evaluating *amount* of creativity on the basis of the *type* of creativity. Certain types of creative contributions probably tend, on average, to be greater in amounts of novelty than are others. However, creativity also involves quality of work, and the type of creativity does not make any predictions regarding quality of work.

The eight types of creative contributions are divided into three major categories, contributions that accept current paradigms, contributions that reject current paradigms, and paradigms that attempt to integrate multiple current paradigms. There are also subcategories within each of these categories: paradigm-preserving contributions that leave the field where it is (Types 1 and 2), paradigm-preserving contributions that move the field forward in the direction it already is going (Types 3 and 4), paradigm-rejecting contributions that move the field in a new direction from an existing or preexisting starting point (Types 5 and 6), paradigm-rejecting contributions that move the field in a new direction from a new starting point (Type 7), and paradigm-integrating contributions that combine approaches (Type 8).

Thus, Type 1, the limiting case, is not crowd defying at all (unless the results come out the wrong way!). Type 2 may or may not be crowd defying, if the redefinition goes against the field. Type 3 typically leads the crowd. Type 4 goes beyond where the crowd is ready to go and so may well be crowd defying. Types 5 through 8 typically are crowd defying to at least some degree. Obviously, there often is no "crowd" out there just waiting to attack. Rather, there is a field representing people with shared views regarding what is and is not acceptable, and if those views are shaken, the people may not react well.

Types of Creativity That Accept Current Paradigms and Attempt to Extend Them

1. Replication. The contribution is an attempt to show that the field is in the right place. The propulsion keeps the field where it is rather than moving it forward. This type of creativity is represented by stationary motion, as of a wheel that is moving but staying in place.

2. Redefinition. The contribution is an attempt to redefine where the field is. The current status of the field thus is seen from different points of view. The propulsion leads to circular motion, such that the creative work leads back to where the field is but as viewed in a different way.

3. Forward incrementation. The contribution is an attempt to move the field forward in the direction it already is going. The propulsion leads to forward motion.

4. Advance forward incrementation. The contribution is an attempt to move the field forward in the direction it is already going but by moving beyond where others are ready for it to go. The propulsion leads to forward motion that is accelerated beyond the expected rate of forward progression.

Types of Creativity That Reject Current Paradigms and Attempt to Replace Them

5. Redirection. The contribution is an attempt to redirect the field from where it is toward a different direction. The propulsion thus leads to motion in a direction that diverges from the way the field is currently moving.

6. Reconstruction/Redirection. The contribution is an attempt to move the field back to where it once was (a reconstruction of the past) so that it may move onward from that point, but in a direction different from the one it took from that point onward. The propulsion thus leads to motion that is backward and then redirective.

7. Reinitiation. The contribution is an attempt to move the field to a different, as-yet-unreached, starting point and then to move from that point. The propulsion is thus from a new starting point in a direction that is different from that the field previously has pursued.

A Type of Creativity That Synthesizes Current Paradigms

8. Integration. The contribution is an attempt to integrate two formerly diverse ways of thinking about

phenomena into a single way of thinking about a phenomenon. The propulsion thus is a combination of two different approaches that are linked together.

The eight types of creative contributions described above are largely qualitatively distinct. Within each type, however, there can be quantitative differences. For example, a forward incrementation can represent a fairly small step forward or a substantial leap. A reinitiation can restart a subfield (e.g., the work of Leon Festinger on cognitive dissonance) or an entire field (e.g., the work of Einstein on relativity theory). Thus, the theory distinguishes contributions both qualitatively and quantitatively.

Conclusion

In this article, I have reviewed some of the theory and research my collaborators and I have developed in our efforts to understand the nature of creativity. We have not dealt with every question that a complete theory of creativity must answer—far from it. However, we have tried to consider at least a sampling of its aspects. Our fundamental premise is that creativity is in large part a decision that anyone can make but that few people actually do make because they find the costs to be too high. Society can play a role in the development of creativity by increasing the rewards and decreasing the costs. E. Paul Torrance was one of the pioneers in recognizing that creativity can be understood by scientific means. We are proud to follow in his footsteps.

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