Cognition and Creativity

Advanced Organizer
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INTRODUCTION

Cognitive theories focus on thinking skills and intellectual processes. Cognitive perspectives are quite numerous; there may be more cognitive theories of creativity
than any other kind of theory. This may be because there is an intuitive connection between cognition and creativity (and evidence reviewed in this chapter suggests that intuition is a useful source of information), or because cognitive research is often very scientific. In other words, we can study the cognitive bases for creative problem solving, and we can often do so in reasonably valid and reliable ways, in a controlled laboratory setting or with paper-and-pencil tests. Some approaches to creativity do not allow such experimentation and rigorous research.

The approaches to creative cognition are extremely varied. There are bridges between basic cognitive processes (e.g., attention, perception, memory, information processing) and creative problem solving, as well as connections with intelligence, problem solving, language, and other indications of individual differences. The basic processes are generally nomothetic, meaning that they represent universals. These are things shared by all humans. Individual differences represent the dimensions along which people differ. There are both cognitive universals and cognitive individual differences in creativity.

This chapter presents an overview of the available theories of creative cognition. We will begin by examining the relationship between creativity and traditional intelligence and then explore the possibility that creativity can sometimes be a kind of problem solving. We will also review research on the creativity of computers, incubation, insight, and expertise. As we will see, cognition is related to many kinds of creative behavior.

### Universals

Research on universals is sometimes described as nomothetic, but care should be taken when using this term. The word nomothetic is used to describe the kinds of laws that are found in a legal system, and not to laws in the sense that science defines them. Laws in the sciences refer to general rules, so there is a parallel, but it is only a parallel. Strictly speaking, it is best to discuss universals in creativity and avoid the term nomothetic. Similar confusion arises with the complementary term idiographic. An ideograph is a symbol, but idiographic has been used to describe the scientific emphasis on individual differences. This makes sense if you think about the more common term, idiosyncratic. The confusion here, then, is simply spelling (idiographic vs. ideographic). It certainly is useful to distinguish universals from individual differences.

### Creativity and Intelligence

The relationship between IQ and creative potential was quite the controversy 40 or 50 years ago. In fact, the relationship of intelligence and creativity was the key debate when the study of creativity was establishing itself. This debate was key because the field of creativity needed to separate itself from other scientific topics
and interests in the 1950s and 1960s, and this required empirical evidence that creativity was not the same thing as intelligence. It was the demonstrated separation of creativity from traditional intelligence that gave this field its identify and respect.

Some of the earliest research on creativity was designed to test the possibility that creativity was distinct from intelligence. After all, if creativity was dependent on intelligence there would be little reason to study it or encourage it. Intelligence could be studied or encouraged and creativity would follow along. But sure enough, the early research confirmed that creativity (in the research, defined in terms of divergent thinking or some paper-and-pencil measures) was not dependent on traditional intelligence.

The field of creative studies had a shaky start. Getzels and Jackson (1962), for example, reported that creativity was not clearly distinct from intelligence. This conclusion was based on empirical research with a sizeable group of students, each of whom had taken various tests of creative potential, and for whom there was information about traditional intellectual potential. Simplifying some, the measures of creative potential and the indicators of traditional intelligence were correlated. They did not suggest independence.

Wallach and Kogan (1965) questioned that conclusion, and more precisely, questioned the methodology that led to it. They felt that the tests used by Getzels and Jackson (1962) were too diverse and tapped noncreative skills as well as creative talents. Very significantly, they also suggested creativity can easily be stifled in an educational or testing environment. With this in mind, they conducted their own investigation of the Modes of Thinking in Young Children (the title of their book). That investigation relied heavily on tests of divergent thinking. As described in detail later, these contain open-ended questions (e.g., “what things move on wheels?”), and an individual can therefore produce original answers.

Wallach and Kogan (1965) also took great care with the testing environment. They spent a great deal of time in the schools before data were collected, for instance, and built rapport with the students. When the measures of divergent thinking finally were administered, they were described as games rather than tests. Children were told that no grades would be given, that spelling did not matter, that they did not need to think about “correct” answers but could instead list numerous ideas. They were told to have fun, for goodness sakes, and apparently they did. The game-like, or permissive environment, paid off. The children were indeed quite original. They gave many answers to the various divergent thinking games, and those answers reflected a mode or thought that could not be predicted from traditional intelligence. The implication: IQ, GPA, and the convergent thinking that is required by them (see Box 1.1) is independent of divergent and original thinking.

That may sound like a statistical and scientific result—and it is!—but consider what the same conclusion means in the sense of identifying creative children. It means that, if schools care about creativity and give children exercises and tests of creative potential, but if those are given in a test-like academic atmosphere, the same children who always do well on tests will excel, and the children who do moderately or poorly on traditional tests will again do only moderately or poorly.
Box 1.1
Tests of Convergent and Divergent Thinking

Convergent thinking questions always have one (or very few) correct or conventional answers. Here are examples:

Who was the first President of the United States?
How far is it from New York City to London?
How many dimes are in one dollar?
Who won the 1988 World Series?

Divergent thinking requires open-ended questions for which there are multiple answers and solutions. Here are examples from the classic study of Wallach and Kogan (1965):

Instances questions
- Make a list of things that move on wheels.
- List strong things.
- List square things.

Uses questions
- Make a list of the different ways that you can use a brick.
- List uses for a shoe.
- List uses for a coat hanger.

Many other divergent thinking questions and tasks have been used. Wallach and Kogan (1965) themselves had “visual” or figural tests they called Pattern Meanings and Line Meanings (see Chapter 2). More recently, realistic questions have been developed (these are discussed in detail in Chapter 2).

If those same tests were administered in the permissive atmosphere—even a classroom, if it is carefully controlled—children who always do only moderately well or even poorly on academic tests may do exceptionally well. We may find creative children who would otherwise be overlooked.

Wallach and Wing (1969) extended this line of work in an investigation of college students. They, too, administered divergent thinking tests, but unlike the earlier investigation, Wallach and Wing also collected data on the extracurricular activities and accomplishments of the students. This allowed them to examine the predictive validity of the divergent thinking tests. Predictive validity is the label given to tests that provide information about the future, or about performance beyond the testing environment. Very significantly, Wallach and Wing found that divergent thinking tests were moderately correlated with (i.e., predictive of) the extracurricular activities and achievements of the students, whereas the measures of more traditional
intelligence were not. This conclusion has been replicated many times over (Kogan & Pankove 1974; Milgram 1978; Runco 1986). It does apply to some domains of accomplishment more than others, but that is as it should be, given domain differences in creativity (Albert 1980; Gardner 1983; Plucker 1998; Runco 1987). This difference is extremely important. It implies that creative thinking, as estimated from tests of divergent thinking, are more important in the natural environment than are tests of the IQ or academic tests. Consider this: What would you want to be able to predict, GPA or performance in the natural environment? If you had a child, would you prefer that he or she does better in school or in the natural environment?

Numerous other demonstrations of the predictive validity of creativity tests (divergent thinking exams, as well as a variety of others) are described elsewhere in this book. What may be most important here is that creative thinking may be very different from traditional intelligence. When we practice one of them, we may not be improving the other whatsoever.

What is practiced in our educational system? Traditional intelligence, or creative problem solving? The distinction between divergent thinking (generating a number of ideas) and convergent thinking (finding or remembering one correct or conventional answer) helps to answer that: Most educational efforts emphasize convergent thinking, and therefore may do very little, if anything, for creative potentials.

### Examples from the Creative Accomplishment and Achievement Criterion

- How often have you . . .
- Made candles (Craft domain)?
- Written poetry (Writing domain)?
- Designed any sort of experiment (Science domain)?
- Started a club (Social Leadership domain)?

IQ tests do not tell us about much beyond what is sampled by the test. IQ tests can estimate the potential to do well in school, and although that is important in many ways, individuals in the United States are in school for 12 or so years. How long are they outside of school and in the natural environment?

Tests of creative potential no doubt are similarly limited to the skills that may be required by the test in question. Tests are always limited in some ways (see Chapter 6). Examinees may not be interested in the test, and thus not use their full potential. If this occurs the individual will receive a test score that tells us only that the individual was uninterested in applying him- or herself. No wonder no predictions from tests are all that impressive. It is for this reason that it is best to refer to tests as indicators of potential. If the individual does well on the test, he or she may
or may not do well in the natural environment. The test is probably only highly accurate when the individual is both interested in the test (and for that reason puts a great deal of effort into the examination) and interested in doing well in the natural environment.

**Threshold Theory**

Spearman (1927), the statistician who wrote so much about “g” and general ability (the basis for IQ), explicitly refuted the idea of creativity. He felt that all the evidence demonstrated “that no such special creative power exists. All three ‘neo-genetic’ processes described at the beginning of this chapter, are generative of new mental content and of new knowledge; and no other cognitive generation can possibly be attained in any other way whatsoever, not even a Shakespeare, a Napoleon, and a Darwin were rolled into one. That which is usually attributed to such special imaginative or inventive operation can be simply resolved into a correlate eduction combined with mere reproduction. From this analytic standpoint, then, we must predict that all creative power—whether or not it be dubbed imagination—will at any rate involve g” (p. 187). Spearman cited some even older work by Hargreaves from the 1927 *British Journal of Psychological Monograph Supplement*, who found large correlations between tests and general ability and the following: inkblots, free-completion test, unfinished pictures, and unfinished stories. In this particular inkblot test, subjects had four minutes to look at an inkblot and write down all the objects seen in them. Note that it was a timed task, but not unlike a figural divergent thinking test. The free-completion test asked examinees to fill “gaps left in passages of prose” (p. 187). Unfinished pictures told examinees that “an artist had just begun a picture, had left it unfinished; you were to write down all of the things you would put into the picture if you were going to finish it” (p. 127). Unfinished stories gave examinees something like the following: “a small girl, after her first visit to the zoo, had a very strange dream. She dreamt that . . . .” (pp. 187–188). Examinees were given 20 minutes to write a story.

Creative potential and intelligence may not be entirely independent. One very common perspective today is that there is a threshold of intelligence (basically, a minimal level) that is necessary for creative achievement. It is probably more accurate to refer to a threshold of “traditional” intelligence, because intelligence means many things to many different people (see Box 1.3). Some people equate intelligence with academic performance, and others equate it with verbal aptitude or wit. Too often, children who are simply well informed are viewed as intelligent. In and of itself this is not so bad, but the corollary is that children who are not well informed are not intelligent. This is indeed a problem, called *experiential bias* (Runco et al. 2006), for often information is picked up through experience, and thus associating intelligence with information leads directly to biases against children who may be capable but lack critical experiences.

Intelligence most often refers to the IQ or some similar kinds of abilities, yet even here it would be best to refer to a specific test. Different tests assess different
intellectual skills. There is also the possibility that intelligence cannot be captured by a paper and pencil test.

Threshold theory suggests that there is a minimum level of intelligence (the lower threshold) below which the person cannot be creative. Instead of concluding that creativity and intelligence are one and the same, or that creativity and intelligence are entirely distinct, threshold theory describes the possibility that they are related, but only at certain levels of ability. One important implication of threshold theory is that intelligence is necessary but not sufficient for creative achievement. Thus, if an individual is below the threshold, they simply cannot think for themselves well enough to do manifestly creative work. Above the threshold, they have the potential for creativity, but there is no guarantee. They may be creative, but they may not.

A scatterplot suggesting a triangle and lower threshold of intelligence is presented in Figure 1.1. One important implication of this theory is that some persons may have high levels of intelligence but low levels of creative potential. Intelligence and creativity are thus not interdependent. Note also that no one has a low level of intelligence and a high level of creative potential. Finally, note that the data are from tests of creativity and intelligence. This theory is based on tested ability, not on creative or intelligent performances in the natural environment.

FIGURE 1.1 Scatterplot showing that creative potential is more likely to be high with high intelligence.
Box 1.2
Much Ado about Heteroscedasticity

The relationship of creativity with traditional intelligence has been described with the idea of a threshold (e.g., Runco & Albert 1986b) and with triangular theory ( Guilford 1968). The basic idea is that a minimum level of general intelligence is necessary for creative work. Truly creative work cannot be done below the threshold. The triangle is apparent in a scatterplot with intelligence on the abscissa and creativity on the ordinate. Regression analyses using quadratic predictors can be used to test the threshold, but it really is most accurate to describe the creativity-intelligence relationship using the notion of heteroscedasticity. This best describes the data and scatterplots and also captures what is suggested by the entire range of ability. Hollingworth’s (1942) report implies that variability decreases at an IQ of 180, suggesting a second threshold. There was very little creativity in her sample of exceptionally high IQ individuals. Here, the concept of heteroscedasticity defines different levels of variation at different levels of ability. It is consistent with the ideas that no one with an extremely low IQ does highly creative work (low variation, high correlation), but above a moderate level of IQ some individuals are creative but others are not (high variation, low correlation). It also allows for the possibility that at the highest levels of IQ creativity is very difficult or even impossible (low variability, high correlation).

Threshold theory apparently applies to some tests of intelligence better than others (Runco & Albert 1986b; Sligh et al. 2005), but it is logical as well as consistent with the empirical research, and it is consistent as well with the very general principle of creative performances as optimal. As detailed in Chapter 11, most everything about creativity involves an optimum of some sort. There are many influences on creativity, such as divergent thinking, but only so much actually contributes. Beyond some point creative performances start to decline. If asked to name square things, “my dad’s music” is both original and fitting—it is optimally divergent—but “basketball” may be past the optimal level of originality and not fitting, not creative. We will revisit this principle of optima throughout this volume (also see Runco & Sakamoto 1996).

Structure of Intellect The distinction between divergent and convergent thinking was first proposed by J. P. Guilford. He was president of the American Psychological Association and devoted his 1949 Presidential Address to creativity (Guilford 1950). He argued that creativity is a natural resource and suggested that efforts to encourage creativity would pay high dividends to the whole of society. Guilford also suggested
that creativity can be studied objectively. For the next 35 years he attempted to prove exactly this.

Guilford (1968, 1986) eventually identified 180 different aspects of the intellect. His view was, in this sense, about as far away from that of IQ theories as you can get. IQ tests typically assume that there is one general intelligence (or g) that underlies every intelligent act—every single one. Admittedly, Guilford’s Structure of Intellect model was pointedly criticized, mostly because of the statistical methods used to separate the 180 cells (Carroll 1968). Yet even if Guilford’s methods were questionable, his conception of divergent and convergent thinking has proven to be quite useful. Indeed, much of his thinking on creativity was, and remains, remarkably influential (see Runco 1999d).

Divergent thinking is employed when an individual is faced with an open-ended task (examples were given just earlier—“how can a brick be used?”). From this perspective divergent thinking is a kind of problem solving. Unlike convergent thinking, where the individual gives the one correct or conventional response (e.g., “who won the 1988 World Series?”), divergent thinking leads the individual to numerous and varied responses. When used as a test, individual differences may be found in fluency (the number of ideas), originality (the number of unusual or unique ideas), and flexibility (the number of different categories implied by the ideas).

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**Box 1.3 Conceptions of Intelligence**

The term intelligence has changed dramatically over the years. It still is used in a wide variety of ways. The military, for instance, uses it as a synonym for useful information. John Keegan, military historian, for example, recently published a book titled, *Intelligence in War: Knowledge of the Enemy from Napoleon to al-Qaeda* (2003). His premise is that knowledge about one’s enemy is of limited value in war, and that “objective force” is much more critical. For our purposes, his work simply exemplifies the range of definitions of intelligence. Cognitive scientists are more likely to refer to useful knowledge of the sort Keegan describes simply as “knowledge,” but implicit here is the distinction of that knowledge from information. Information is data; knowledge implies understanding (and hence the utility of “useful knowledge”). In that light, “useful knowledge” is a tautology, for knowledge is more than information precisely because it assumes understanding. Do not let this fool you, however, for cognitive scientists are far from agreement about defining intelligence. For the present purposes intelligence is viewed as distinct from creative ability, but even there it is probably best to refer to traditional intelligence. Certain kinds of intelligence are, at certain levels and in particular domains, related to creativity. For this reason many theorists describe “creative intelligence.”
Divergent Thinking before Guilford’s Structure of Intellect

J. P. Guilford usually is given credit for distinguishing between convergent and divergent thinking. A few scientists before Guilford did recognize the value of ideation. Alfred Binet, for example, who developed the first IQ test around the turn of the century, included an open-ended task not unlike those found on modern-day divergent thinking tests (Binet & Simon 1905).

Sample items from Binet’s (1905) first test of intelligence.

1. Unwrapping candy
2. Follow simple directions
3. Name objects
4. Name objects in pictures
5. Compare two weights
6. Compare two lines
7. Vocabulary
8. Repetition of sentences
9. Repetition of digits
10. Identify differences (e.g., fly and butterfly)
11. Identify similarities (e.g., blood and a poppy)
12. Order weights
13. Complete sentences
14. Cut paper
15. Define abstract terms
16. Visual tracking (i.e., follow moving object with head and eyes)
17. Tactile prehension (i.e., pick up particular object)
18. Distinguish edible and inedible objects

Adapted from Willerman, L. (1979). The psychology of individual and group differences. San Francisco, CA: Freeman, pages 85–86.

A Convergence-Divergence Continuum  The distinction between divergent and convergent thinking implies a dichotomy. Very likely, divergent thinking and convergent thinking are actually two ends of a continuum (Eysenck 2003). This may make the most sense, given we know about individual differences (they tend to fall along continua), and it is apparent when various divergent thinking questions are examined. Along the same lines, it is probably most accurate to think about problem solving as involving both divergent and convergent thinking. In the natural environment it is unusual to find a problem that relies completely on one or the other. Most often, both divergent and convergent thinking are useful.

Divergent thinking is not synonymous with creative thinking, but it does tell us something about the cognitive processes that may lead to original ideas and solutions. No wonder divergent thinking tests are the most commonly used estimates of the potential for creative thought. They have a solid theoretical base, in both the
Structure of Intellect model, and in Associative Theory (outlined next), they have reasonable reliability and validity, and there is a vast literature available to assist interpretations. Divergent thinking test are widely modified such that they can be used as exercises, rather than tests, in training studies and programs, in classrooms and in organizations (Runco & Basadur 1993). Chapter 6 presents a large number of exercises and tactics to solve them.

More will be said about the reliability and validity of divergent thinking in Chapter 9, but of more relevance to cognition is the role of associative processes in divergent and creative thinking.

**Associative Theory**

Many theories of creative cognition look to associative processes. Associative theories focus on how ideas are generated and chained together. If you look back on the history of psychology, you will see that the associative view can be traced back hundreds of years, to John Locke, Alexander Bain, David Hume, and others (Marx & Hillix 1987; Roth & Sontag 1988). These theorists typically are described as philosophers, and certainly they were not scientists. They offered hypotheses but did not test them in any modern scientific sense. It was Mednick (1962) that brought the associative view into modern psychology. He proposed the “associative theory of the creative process” and offered several empirical tests of the theory. Perhaps most important was his finding that original ideas tend to be remote. The first things we think of are typically not very original. Instead, original ideas are found usually only after we deplete the most obvious ideas.

A very simple experimental technique for examining remote associates and ideational patterns—one you may chose to try—involves counting an examinee’s responses to an open-ended task (e.g., a divergent thinking test question), and finding the half-way point. If the examinee gave 20 items to the question, “Name all of the things you can think of that are square,” two sets of 10 ideas can be compared in terms of the number of original ideas, and the flexibility of the ideas. Results from several independent projects using this technique suggest that original ideas come later in a set of responses, but ideas are no more flexible and varied in the second half compared to the first (Mednick 1962; Milgram 1978; Runco 1985).

This line of research confirms that ideas can be counted in a reliable and objective fashion, and ideas can be used as an indication of how people generate solutions to solve problems. In fact, the notion that original ideas come late in the associative chain implies that we should take our time when faced with a problem, to insure that we get to those remote ideas. Mednick (1962) proposed that creative individuals are better at finding remote ideas. His device for the assessment of creative thinking was the Remote Associates Test (RAT). The RAT contains analogies with three given elements, and one blank (e.g., River:Blood:Note). Empirical investigations of the RAT indicate that the RAT lacks discriminant validity, with scores that often are moderately correlated with scores from tests of convergent thinking or verbal ability. Still, Mednick’s theory of remote associates is laudable in its offering testable predictions about creative cognition. An example is Mednick’s notion that “the greater the
number of instances in which an individual has solved problems with given materials in a certain manner, the less the likelihood of his attaining a creative solution using these materials” (p. 223).

The RAT presents questions verbally, and the examinee responds verbally. As such it is open to a verbal bias. Earlier experiential biases were defined in the discussion of IQ tests. A *verbal bias* is similar, at least in the sense that the resulting scores are influenced significantly by something (e.g., verbal ability) that is unrelated to the skill targeted by the test (e.g., creativity). Behaviorally, this means that all children with moderate or high verbal abilities will do well on the RAT, and all children with low verbal abilities will do poorly on the RAT, even though the RAT was designed to test associative and creative potential, and not verbal ability.

**ANALOGICAL THINKING AND METAPHOR**

Not everyone agrees that original ideas are found via associative processes. Some theories emphasize analogies and analogical thinking instead (e.g., Gick & Holyoak 1980; Harrington 1981; Hofstadter 1985). There are many examples of analogies being used for discovery (e.g., Velcro and weeds, steam engines and tea kettles), but not all of these are based on fact. Many of these—including the oft-cited case of Kékulé’s discovering the structure of the benzene model, Archimedes, or even the planetary parallel of atoms (Finke 1995; Gruber 1988; Welling, in press)—are based on the inferences of a biographer or the ex post facto introspection of the creator or discoverer him- or herself. In either case there are potential problems of memory, honesty, subjectivity, self-promotion, and bias.

Weisberg (1995a) identified a number of creative ideas and solutions where “information from a previous situation is transferred to the new situation that is analogous to the old” (p. 62). Even Picasso seems to have drawn heavily from previous work, some of which was his own, and some the work of other painters (Miller 1996; Weisberg 1995a, 1995b). Weisberg (1995b) suggested that most insights resulted from either a change in how the initial problem was interpreted, or from the use of an unconventional approach or representation of the problem.

Welling (in press) defined analogical thinking such that it “implies the transposition of a conceptual structure from one habitual context to another innovative context. The abstract relationship between the elements of one situation is similar to those found in the innovative context.”

Dunbar (1995) focused on scientific analogies. He identified three different kinds:

1. Local analogies (one part of one experiment is related to a second experiment).
2. Regional analogies (involving “systems of relationships,” which are applied in one domain but used in a similar domain).
3. Long distance analogies (a system is found in one domain but applied in a different domain). Long distance analogies might explain the benefits of what has also been called *marginality*. Freud, Darwin, and Piaget were each professionally
marginal in the sense of being outside the mainstream. Marginality is discussed in detail in Chapter 7.

Welling (in press) recently compared analogical, associative, and combinatorial thinking with abstraction. In doing so he pointed out that analogies are unique in that “no new cognitive structure is required” (Welling, in press). Some insights are dramatic shifts and explained in terms of cognitive restructuring. A person’s thinking actually changes, and changes quickly, which is why insights may appear to be sudden. We will come back to this point later.

Welling (in press) also distinguished analogical thinking from combinatorial processes. In his words, “combination is the merging of two or more concepts into one new idea. It differs from analogy in the sense that this operation requires the creation of a new conceptual structure. Concepts can be combined either spatially—concepts are applied simultaneously—or temporally in which the combination results from the sequential applications of existing ideas.” He cited Campbell’s (1960) blind variation and selective retention model, Mednick’s (1962) associative theory, Finke et al.’s (1992) genoplore theory, and Koestler’s (1964) bisociation process as examples of combinatorial creative processes. Scott et al. (2005) reported a series of studies on creative combinatorial processes.

Welling (in press) also distinguishes analogical thinking from abstraction. He defined abstraction as “the discovery of any structure, regularity, pattern or organization that is present in a number of different perceptions that can be either physical or mental in nature. From this detection results . . . a conceptual entity, which defines the relationship between the elements it refers to on a lower, more concrete, level of abstraction.” This is not merely the identification of patterns. It is instead the creation of new concepts, new classes, new information. Welling gave Einstein’s ideas of a continuity of space and time as an example of an abstraction. It represents a higher level of abstraction than had existed previously. Abstraction no doubt operates in the arts. Consider the work of Andy Warhol or Roy Lichtenstein, for example, each of

Box 1.4

Metaphorical Thinking and Creativity

Gibbs (1999) suggested that people use approximately four frozen metaphors and two novel metaphors in every minute of discourse. Frozen metaphors are essentially those that are not novel. Novel metaphors of course require some creative thinking. The interesting thing is that, when metaphors are used, something is gained (understanding, insight), but something is lost as well. Information and detail about the original material is always lost (Runco 1991). No doubt the benefits to communication and insight usually outweigh the loss.
whom stood back, so to speak, and asked the viewer to question “what is art?” Is it a tomato soup can, or as simple as a cartoon figure?

There are several issues. First is Welling’s (in press) conclusion that “so-called high creativity is more readily associated with combination and abstraction operations, while everyday creativity is derived primarily from application and analogy operations.” Clearly this is a simplification, but Welling admitted that “some contradictory findings can be explained by the fact that high creativity is often not the result of a single operation but results from a longer period in which several operations are put to use during the discovery process.” The second issue reflects the possibility that “none of the [cognitive] operations generate entirely new knowledge because the result is always dependent on, or constructed with, previous knowledge. It may be tempting to assume that the ideas that result from abstraction are also the ones that are most impressive or revolutionary, but this is not the case.” The more general question about analogical thinking is that of true originality. Is something truly original if it is similar to what came before it? We will return to this question in the last chapter of this volume.

Many theories of creative thinking, including those that describe divergent thinking and associative processes, assume that creative ideas result from problem solving. The creativity is supposedly in the ideas that are given to solve a problem. Is creativity always a kind of problem solving?

PROBLEM SOLVING

Cognitive theories of creativity often focus specifically on the problem-solving process. A problem can be defined as a situation with a goal and an obstacle. The individual wants or needs something (the goal) but must first deal with the obstacle. There are, of course, different kinds of problems. Divergent and convergent thinking were defined earlier, and they are easiest to contrast when you think about the two kinds of problems that elicit them. Open-ended problems allow divergent thinking, and closed-ended problems require convergent thinking. A similar distinction is between ill-defined problems and well-defined problems. Problems may also represent a dilemma, which is a specific kind of, well, problem. If you have ever been “on the horns of a dilemma” (to repeat the old cliché), you know that it has two options (hence the prefix di-), neither of which completely resolves the problem. If you take one option—either one—you lose what the other option offers. Wakefield (1992) and numerous others have put great care into categorizing the many different kinds of problems.

Not everyone believes that creativity is merely a kind of problem solving. Others have taken the opposite point of view and suggested that problem solving is one kind of creativity. From this perspective there are creative acts and performances that are not attempts to solve a problem. It is not clear-cut, however, and it boils down to how “problem” is defined. After all, you might think that artists are not solving problems but are instead expressing themselves. Yet artists sometimes are attempting to find the best way to express themselves—and that implies that they have a
problem. They may also be dealing psychologically with an issue from their past (Csikszentmihalyi 1988; Jones et al. 1997). Csikszentmihalyi referred to this as active catharsis. Creative efforts are often cathartic, meaning that by being involved in the creative effort the individual releases tension.

A great deal depends on how we define problems. Runc (1994b) stated, Creativity is by no means just problem solving. Creative thinking can help when solving problems (and finding and defining them), but there is more to it. Creative art (which is surely a tautology) is often self-expressive, explorative, and aesthetic more than problem solving. Yet the separation of creativity from problem solving depends entirely on how problem is defined. If a problem is defined in terms of an obstacle between one’s self and a goal, then much of activity of artists could be called problem solving. They may be solving the problem of finding a means to best express an idea or refine a technique. No one else would see it as a problem, especially because it is the artist’s preferred activity, and he or she may be smiling and having a grand old time while doing the art. It may not look like an effort; the artist may not appear to have any problems whatsoever. This is the opposite case of what was described in the preceding paragraph. There problems that others saw were not felt as problems by the creator, but here no one sees the problem except the creator! This latter case is often described as problem finding. Problems are all that way; they are all personal interpretations. They are not givens, not objective entities.

This also shows the value of creativity—it is enormously helpful for solving problems, but leaves us with a necessary ambiguity: creativity is sometimes a form of problem solving, but sometimes not.

Guilford (1965) offered a slightly different view: “I have come to the conclusion that wherever there is a genuine problem there is some novel behavior on the part of the problem solver, hence there is some degree of creativity. Thus, I am saying

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**Box 1.5**

**Analogies and Analogical Thinking**

Many creative insights seem to have benefitted from analogical thinking. Here are some examples described in the creativity literature:

Cotton gin (Eli Whitney saw a cat trying to catch a chicken through a fence)

Telegraph (Samuel Morse ostensibly put stations in the telegraph after thinking about stagecoach changing their horses periodically)

Benzene ring (a snake biting its own tail)

Oil pump (brine pump)

Steam engine (tea kettle)

Underwater tunnels (worm tunnels)

Velcro (burs or weeds)

Note: Analogical thinking was not necessarily involved in these ideas and inventions listed above. It is often cited in introspective reports, but these are suspect given their subjectivity. In some instances, the analogical thinking is simply inferred, but again, it may very well be apocryphal.
that all problem solving is creative. I leave the question open as to whether all creative thinking is problem solving . . . ."

It is probably best to accept that not all problem solving requires creativity, and creative performance is not always a solution to a problem. However, the work on problem solving does contribute to our understanding of some creative performances. This is especially true with the recognition that problems may be operationalized as well-defined or ill-defined, with the latter more common in the real world. This simply means that problems in the natural environment are often a bit ambiguous. They are not like problems we encounter in school, for instance, or on a test. Tests usually present problems in a very clear fashion in order to insure that the examinee focuses on the right information. But in the natural environment problems may need to be identified as such, and defined in a workable fashion. Theories of problem finding take identification and definition into account. As we will see, it may be that problem finding can be separated from problem solving, and yet sometimes the quality of solutions depends on the quality of the problem.

**PROBLEM FINDING**

Nearly always, something must occur before a problem is ready to be solved. As was just suggested, sometimes the problem itself must be identified. This may sound silly—I know many of my problems slap me in the face and will not seem to go away!—but at times we may just have a hazy feeling that “something is wrong,” but we do not know what it is. Indeed, anxiety and stress have both been interpreted as indicators that we have problems and concerns, even if we are not thinking about them (May 1996). Other times we think we know what the problem is, but we are wrong. (Why am I thinking of problems that occur in relationships?) We may have defined “the problem” too generally or too specifically, and therefore have not really identified the problem. It is almost as if we have not located it, at least not accurately.

Various problem finding skills have been identified, including problem construction, problem identification (where a task is simply recognized but not manipulated or operationalized), problem definition (where the task is prepared for solution), problem discovery, problem perception, and problem generation (Getzels & Smilansky 1983; Mumford et al., 1991; Runco 1994b). Once again it may be best to use a continuum, with problems that are presented to us at one extreme (no identification or definition required), problems that do require discovery at the other extreme, and various moderate possibilities in between (Runco et al., in press; Wakefield 1992).

A large body of research now indicates that individual differences exist, with some persons exceptionally capable at identifying or defining problems, but perhaps not as good at solving problems. Other people may be very good at solving problems, but the problems need to be given to them in a very unambiguous fashion. Interestingly, most people studying or experiencing problem finding believe that it is more important than problem-solving skill. Getzels (1975), for example, claimed
that the quality of a problem determines the quality of a solution. I did say “studying or experiencing,” for Einstein himself seemed to hold this opinion. He often is quoted as saying: “The formulation of a problem is often more essential than its solution. . . . To raise new questions, new possibilities, to regard old problems from a new angle, requires imagination and marks real advance in science” (Einstein & Infeld 1938, p. 83). Not long after that, Wertheimer (1982) pointed out that “often in great discoveries the most important thing is that a certain question is found. Envisaging, putting the productive question is often a more important, often a greater achievement than the solution of a set question” (p. 123). Guilford (1950) included “sensitivity to problems” in this seminal presidential speech presentation to the APA in 1949, and Torrance (1962) emphasized “the process of sensing gaps or disturbing missing elements and formulating hypotheses” in his definition of creativity (p. 16, emphasis added).

In the arts, problem finding may be problem expression. Here the problem is not extrinsic, but more a matter of finding a way to capture a feeling or need. Recall here the problems (pun intended) involved in defining “a problem.” The example

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**Box 1.6**

**Computers and Creativity**

Computers can solve problems, at least certain problems, quite well. They are fast and hold huge amounts of information. If creativity is simply a kind of problem solving, it would appear that computers can be creative (Simon 1995). Ohm’s Law, Kepler’s Law, and various other laws and discoveries in the hard sciences have been rediscovered by computers, once they are given the task and relevant information. Boden (1999) presented a thoughtful overview of the various computer programs.

One way to understand cognition is to use a metaphorical dichotomy. More specifically, a computer metaphor, with a distinction between hardware and software, can easily be applied. Computer hardware is, of course, the computer itself, including the CPU. Psychologically, hardware can be viewed as the nervous system, and in particular both the central and peripheral systems. Psychological hardware also would include specific receptors and valves, such as the rods and cones of the eyes, and more centrally, neurons. What, then, is psychological software? The answer to this takes us to a definition of cognition. Cognition represents the software of the human brain. It represents the programs, or in cognitive terms, the concepts, scripts, structures, and processes of thinking.

Using this metaphor, individual differences can be taken as indicating that different persons have different programs available to them. Other “metaphors of mind” are given later in this chapter.
given earlier was of an artist who might not be aware of the problem being addressed in his or her artwork. The work itself might seem to be exploratory, self-expression, or an attempt to refine technique. Art is a reflection of the artist, however, and the artist may be searching.

Then again, artists are sometimes well aware that they are pinpointing problems. The novelist Kurt Vonnegut Jr., for example, felt “an urgency to be a good citizen, to draw people's attention to things, to function as a canary in a coal mine (in Ulin, 2005, p. E1)”. Ulin rephrased this and described the “writer’s obligation [is] to make connections, to offer insights, to ask essential questions, even (or especially) if the answer is to remain unknown.” The emphasis is added to that quotation because it confirms the idea that problem finding may be separate from problem solving.

Problem finding has also been cited in the debate about computers and creativity. A number of attempts have been made to program computers to be creative, and in fact they can find the same high-quality solutions as humans (Simon 1988). This may not be truly creative, however, because unlike humans, computers need to be given a problem; they lack problem-finding skills.

Does a creative solution require a creative problem? Problems, in fact, can be evaluated and their quality determined. Some can be evaluated for their originality, just as ideas are evaluated with divergent thinking tasks—in terms of statistical infrequency (Okuda et al. 1991; Runco & Chand 1995). Table 1.1 contains example tasks from the research on problem generation.

Certainly, we can also take the long view, as is often taken in research on famous creators. We can let posterity decide. Einstein seemed to have identified an excellent problem, for instance, as did Picasso, Freud, Frank Lloyd Wright, and other luminaries.
The idea of problem finding implies that creative thinking can be delineated. This is a debatable point, though entirely consistent with various lines of cognitive research (Shepard 1982). The same assumption of delineation led Wallas (1926) long ago to a four-stage description of the creative process. Wallas suggested that the creative process involves “preparation,” “incubation,” “illumination,” and “verification.” The preparation stage would include problem identification and problem definition, as well as information gathering and the like. The inclusion of verification is noteworthy in that it allows the creative individual to test and tinker. With creativity requiring both originality and effectiveness, verification is probably vitally important. It may be that problems are made the most effective during some sort of verification. The more recent applications of this stage model have included recursion, the idea being that the individual may revisit early stages and cycle through the process as much as is needed. It is not a strictly linear affair.

The second stage, incubation, involves the unconscious processing of information. This is a relatively common requirement in models of the creative process (Rothenberg 1990; Smith & Amner 1997). Incubation probably is recognized often because it explains how progress can be made on a task, even if we are not consciously thinking of the problem. It usually is explained such that associative processes are at work and are free from the censorship of the conscious mind.

Incubation is not just respected by psychoanalysts and people who like to take naps. Guilford (1979), a psychometrician, respected incubation. He wrote, “My own hypothesis is aimed at accounting for the actual progress during an apparently inactive incubation interval. It attributes progress of this kind to transformation of information” (p. 2). Guilford felt that incubation allows promising associations to be formed by providing the time necessary for the cognitive transformations. Not surprisingly, then, Guilford directed his empirical efforts at the intervals between ideas given in response to a divergent thinking tasks (Fulgosi & Guilford 1968, 1973).

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**Box 1.7**

**Problem Generation Tasks (Chand & Runco, 1992)**

List different problems in school that are important to you. You may write down problems about the campus itself, classes, professors, policies, classmates, or whatever. Try to be specific, and take your time. Think of as many problems as you can!

Now list problems at work that are important to you. You may write down any problems about your boss, co-workers, clients, policies, or whatever. Be specific, and keep in mind that the more ideas, the better. Take your time!
Smith and Dodds (1999) outlined several explanations for the benefit of incubation:

1. Intermittent conscious work occurs during the incubation problem.
2. Incubation allows for a recovery from fatigue that has resulted from conscious work.
3. Inappropriate mental states are forgotten and therefore no longer interfere with the problem-solving or thinking.
4. Remote associates may be found more easily.
5. An individual is able to find and assimilate chance or serendipitous hints or data during incubation.
6. Associations are broader and more extensive because the conscious mind has relaxed or is being focused elsewhere.

Smith and Dobbs (1999, p. 39) defined incubation as “a stage of creative problem-solving in which a problem is temporarily put aside after a period of initial work on the problem.” The third stage in Wallas’ (1926) model, illumination, is best known because it leads to an “a-ha” experience (Gruber 1981, 1988). Illumination is also known as insight. Very importantly, most often insights are singular. We may have a problem, and one solution pops into our heads, like a light bulb being turned on. In that light (another pun!), insightful thinking is unlike divergent thinking, where various ideas are generated. Insight usually leads to one solution. Take a look at the insight problem from Schilling (in press), given on the next page, the nine dot problem (Fig. 1.4) and the two string problem (Fig. 1.5).

![Lightbulb representing mental illumination.](image)
Example of an Insight Problem (from Schilling, in press)

Two men walking through the desert discover a third man, lying on the sand, dead. The dead man has a small pack that contains fresh food and water, a larger pack on his back, and a large ring on his index finger. Puzzled about the cause of his death, the two men proceed onward. Later, one of the men accidentally drops his handkerchief while mopping his brow, and as it flutters to the earth he suddenly realizes how the man had probably died: his parachute had broken, and he had plummeted to the ground. This example demonstrates how a partial representation with a gap (a dead man with a pack, food, water, and a large ring) may be suddenly filled in a way that completes the coherent structure of the representation (the large pack contained a parachute, and the ring was from its pull cord).

Insight is often contrasted with trial-and-error. Trial-and-error is step-by-step problem solving, where errors are made but corrected in another small step forward, toward the solution. Insight, in contrast, is also sudden, or at least feels that way. That is why a light bulb is the common symbol of an insight. There is a sudden illumination. Yet insight may not actually depend on a discontinuous process. There is some controversy about that. Weisberg (1986), for example, wrote, “there seems very little reason to believe that solutions to novel problems come about in leaps of insight. At every step of the way, the process involves a small movement away from what is known” (p. 50).

It could be that insight just feels sudden because the processing that led up to it is beyond our awareness (Bowers et al. 1995; Runco 2006). Bowers et al. found semantic similarities between guesses and answers themselves, the idea being that on the semantic level, there is continuity. Put differently, the unconscious processing leading up to an insight is smooth rather than discontinuous. The suddenness is just in the awareness of the solution, not in the discovery of it. I recently attempted to describe the possibility that the processes occurring during incubation are simply beyond the comprehension of our conscious mind:

...the unconscious is less prone to censoring, and as such it has a higher likelihood of generating remote associates and original ideas. Another way of describing the benefit is that the use of pre-conscious or unconscious processes allows the individual to utilize different reasoning processes, processes that, by virtue of their being beyond conscious awareness, are able to value and explore those things that allow original thinking. In this light the preconscious and unconscious are not actually irrational; they just have a rationality of their own. (Runco, 2006b, p. 109)

This view would help explain intuition and the “feeling of knowing” that occurs when we know something but not how we know it (Metcalf 1986). We may know something, or have a good idea, but the idea is in a form that is incompatible with conscious conventional logic or rationality. But we do have a good idea and we react emotionally to it, hence the feeling of knowing.
Wertheimer (1991) felt that insight represented a “discovery of the applicability of an existing schema to a new situation” (p. 190). More recently, Schilling (in press) defined insights in terms of “unexpected connection between disparate mental representations.” She identified five explanations for insight, each of which involves some kind unconscious process. Insight might occur in one of the following situations:

(1) A schema is completed. Schema refer to cognitive structures and information that is personally and meaningfully organized.
(2) Visual information is reorganized.
(3) A mental block is overcome.
(4) A “problem analog” is found.
(5) Information is randomly recombined.

The last of these may not seem all that scientific, and it is controversial. Nobel laureate Herbert Simon (1973), for example, suggested that our thinking follows systematic, logical, and rational processes, much like a computer searching all possible combinations. Not surprisingly, Simon was cited earlier in this chapter, on the idea that computers can be creative. The other side of the debate is probably more popular. Campbell’s (1960) theory of blind variation and selective retention, for instance, is widely cited. It assumes that the variations of thought (the options considered) are blindly generated. Many others hold similar views about the random or at least asystematic nature of creative thinking (Simonton 2006). Keep in mind, however, that we are talking about incubation, and not the entire process. Part of the creative thinking process could draw on random subprocesses, whereas other stages might be entirely systematic. Two historical descriptions of thinking are presented in Boxes 1.8 and 1.9.

**Box 1.8**

**William James**

William James (1880), often considered to be America’s first psychologist, foresaw much of modern-day psychology. Here is his description of thinking, which suggests that ideas may come together for unexpected and unconscious reasons:

> Instead of thoughts of concrete things patiently following one another in a beaten track of habitual suggestion, we have the most abrupt cross-cuts and transitions from one idea to another, the most rarefied abstractions and discriminations, the most unheard of combination of elements, the subtlest associations of analogy; in a word, we seem suddenly introduced into a seething cauldron of ideas, where everything is fizzling and bobbling about a state of bewildering activity, where partnerships can be joined or loosened in an instant, treadmill routine is unknown, and the unexpected seems only law. (p. 456)

This is fairly consistent with the view that insights arise when the individual is able to explore various combinations of ideas, perhaps in a random fashion (quoted by Schilling, in press).
Insight is often explained by the concept of restructuring (Ohlsson 1984a, 1984b). This occurs when the individual initially does not understand something because he or she is relying on one representation of the problem, but then the individual changes that representation—restructures it—such that it takes new information into account or in some allows a better understanding and insight. (Representations are the cognitive analogs to understanding. You might say that information or experience is represented in the mind, thus a person has representations.) Suppose you build a model of something out of Tinkertoys. Your model may be a map of some kind, or it may in fact represent something. Suppose further that you discover something new about the place you have mapped or the thing you have represented. You might remove a few Tinkertoys and add a few. You do not need to start from scratch, however, and in fact the restructuring may be fairly quick. Quick but
dramatic changes are possible: Perhaps you built a model of a tall building but then decide it needs to be even taller. You add long legs to the structure. That may require very little work, but the result is dramatically different. The building may double in height. Restructuring is a bit like changing your model, and sometimes fairly quick changes offer a dramatically different representation—an insight.

The idea of restructuring has a long history (e.g., Duncker 1945; Kohler 1925; Wertheimer 1982). The concept is often tied to Gestalt theory. The gestalt term for it is Umstrukurierung. A gestalt is essentially the result; it is a meaningful whole, as in a whole and complete understanding. Gestalt psychology has been used to describe the perceptual process, the key idea being that humans have a tendency to make sense of our experience and can often construct meaning from partial information. We may perceive a few stars, for instance, but impose meaning such that we see a bear, a god, a dipper (big or little!). Our perceptual system completes the gestalt. More clinically oriented gestalt psychologists (Perls 1978) felt that humans have a need for meaning and are unhappy without it. We can, however, impose meaning on our lives—even when there is little to suggest it! A clinician will often help a client or patient find meaning and thereby happiness. This might even require an insight in the same sense that concept is used in the problem solving and creativity literature. The client’s understanding may be obtained quickly but with dramatic results.

An alternative explanation uses information processing theory and the idea of linear search (Newell & Simon 1962; Ohlsson 1984a; Weisberg & Alba 1981). As Ohlsson (p. 65) described this perspective, “to solve a problem is to proceed step-wise through the space of alternatives, until an action sequence is found which leads from the problem to the solution.” Weisberg and Alba (1981) tested subjects with three insight problems—including the famous Nine Dot problem (see Figure 1.4)—and concluded that the “spontaneous reorganization [restructuring or insight] of experience does not occur during problem solving” (p. 326). They rejected the ideas of insight, restructuring, and fixation (where restructuring is difficult because of a difficulty in restructuring).

![Figure 1.4 The Nine Dot insight problem.](image-url)
Ohlsson (1984a, 1984b) suggested that the gestalt and the information processing perspectives are compatible with one another. She acknowledged that the gestalt view is not as testable as it should be, for science, and that it does not really help us to understand individual differences—or as she put it, “good” and “bad” thinking (1984a, p. 72). Individual differences may be explained in terms of previous experience (Epstein 1990).

Schilling (in press) offered a small network explanation for insight. Insight is defined as “a substantive shift or augmentation of a representation due to the addition or changing of either nodes (elements of information, or sets of information) or links (connections or relationships between nodes of information); . . . such a shift may often be the result of forging connections along a path that the individual perceives as atypical; and . . . the perceived significance or magnitude of the shift may be a function of both the unexpectedness of the connection, and the magnitude of change it creates in the network of representations.” Schilling drew from small network theory, which had been around since the 1950s but really came of age in the 1970s (cf. Watts & Strogatz 1998).

Insights seem to be quick and spontaneous. That is one reason the light bulb often is used to characterize an “a-ha” moment: It illuminates quickly, seemingly all at once. Yet the evidence suggests that insights may actually be protracted (Gruber 1981, 1988; Wallace 1991). They are not instantaneous but instead develop over time. Gruber (1981, 1988) found protraction in a number of scientific insights, and Wallace (1991) found much the same in the writing of Dorothy Richardson, one of the writers who developed the “stream of consciousness” style of fiction.

EXPERIENCE, EXPERTISE, INFORMATION, AND INSIGHT

Wish I didn’t know now what I didn’t know then. —Bob Seger, Against the Wind

The protraction of insight intimates that it may depend on information and experience. Then again, insights can be the most difficult when the individual has a

![Figure 1.5](image)

**Figure 1.5** The two-string insight problem.
great deal of experience in the problem domain (Wertheimer 1982). The individual may experience *einstellung* (Luchins 1942), which means there is a kind of mental block to one’s thinking that keeps the individual from finding new and original ideas. It is similar to the functional fixedness that occurs when the individual sticks with previous experience and conventional thinking about the problem or situation at hand (Duncker 1945).

It is a bit puzzling that experts can sometimes understand things that others cannot, but at the same time they may have difficulty thinking in an original fashion. There is a cost to expertise (Rubenson & Runco 1995).

The benefits of expertise usually are explained in terms of knowledge. Experts develop huge knowledge bases, much of it domain-specific knowledge, but at least as important is that they have a larger number of interconnections among their knowledge. Experts’ domain-specific knowledge, apparently, is also automatically activated when solving problems within their domains. The knowledge is probably better organized than that of a novice, perhaps being hierarchical with concrete knowledge at the bottom of the hierarchy and abstract knowledge at the top. Keep in mind (no pun intended this time) that these characteristics of experts’ knowledge are domain specific. Experts tend to outperform novices within their domains but not outside them.

Experts often make assumptions, because they know so much. This can preclude original and creative thinking. For that reason Piaget (Gruber 1996) and Skinner (1956) both recommended that it was wise to read *outside* one’s own area of research. This kind of reading could easily give the individual a fresh perspective on his or her own field, and it could help the expert to avoid the saturation or rigidity that can result from having too much expertise (Martinsen 1995).

Moving from one field to another creates a kind of professional marginality, and many famous creators have done this intentionally. Piaget himself did this, drawing from biology in his work on cognitive development. Freud drew heavily from physiology in his theory of psychoanalysis. Darwin studied geology extensively but contributed the most to evolutionary biology.

Martinsen (1995) and Epstein (1990) both demonstrated that specific experiences and information can either help or hinder insightful thinking. Martinsen’s work suggests that for many of us, there is an optimal level of information that can help us think creatively, but beyond that, our thinking becomes less insightful.

**INTUITION**

No man clearly understands the sources of his own creativity. —Boring 1971, p. 55

I cannot always distinguish my own thoughts from those I read, because what I read becomes the very substance and texture of my mind. —Helen Keller, from Piechowski 1993, p. 467

Intuition is probably the best example of unconscious processing. Anecdotal reports often pointed to intuition in creative insights, and case studies occasionally
mentioned the famous person’s intuitive capacity. In his study of Albert Einstein and Henri Poincare, Miller (1992) concluded that “aesthetics and intuition are notions that can be discussed in a well defined manner and are essential to scientific research as are mental imagery in descriptive and depictive modes.”

**Einstein on Intuition**

Einstein was very clear about the role of intuition and the scientific method. In his words, “from a systematic theoretical point of view, we may imagine the process of evolution of an empirical science to be a continuous process of induction. . . . but this point of view by no means embraces the whole of the actual process; for it slurs over the important part played by intuition and deductive thought in the development of an exact science” (p. 123).

Similar empirical evidence for intuition was provided by Hasenfus, Martindate, & Birnbaum (1983). They demonstrated that college students can infer the similarities among works of music, architecture, and art for different periods of history. Even if a student has not studied art history or the like, he or she will be able to see that Baroque music is related to Baroque architecture and painting, and that Classical art is related to Classical architecture and music. The students do not know how they know, but they do know.

The large body of research on insight is also relevant. Gruber (1988), for example, demonstrated that creative insights frequently are protracted, meaning that they cover a period of time. They are not sudden or immediate and quick. Instead, the creator is working with the problem or issue, albeit often on an unconscious level. As a matter of fact, that is what all of this research suggests—that the unconscious is very actively involved in many expressions of creativity, including those operating on historical and social levels.

Langan-Fox and Shirley (2003) found discussions of intuition throughout history, going back at least to Spinoza, who felt that intuition was “the highest form of knowledge” (Langan-Fox & Shirley, 2003, p. 3). Kant felt that it was an internal process “supplied by the mind itself” (Langan-Fox & Shirley, 2003, p. 3). Bergson contrasted it with intelligence and felt it was more of an expression of instinct (cf. Barron 1995).

Remarkably, intuition can be studied using the experimental method. Bowers et al. (1990) argued that intuition was an example of informed judgment. They described two stages involved in intuition: first is the guiding stage where a coherence or structure is unconsciously recognized and used, and second is an integrative stage where the coherence makes its way to the level of consciousness. The transition between the two stages very frequently leads to the sudden “a-ha” feeling. It may also explain a sudden closure, such as the ones seen in tasks of gestalt perceptions.
Bowers et al. (1990) developed two tasks of intuition. First is the dyads of triads task (DOT). The second is the Waterloo gestalt closure task. A third task is the accumulated clues task or ACT. The ACT contains sixteen items, each with a clue word that is an associate of the solution word. The last measure was a faith in intuition self-report scale. Items on this, as the name implies, tempted to capture an individual's confidence in his or her own feelings and decision making underlying actions. An example item asked about the individual's reliance on "gut feelings." A second example asked individuals to rate how frequently they have a feeling that they are right or wrong even if they can't explain why.

The Myers-Briggs type indicator (MBTI; Myers & McCaulley 1985) was developed from Jung's (1960) work on feeling, thinking, sensing, and intuition. The MBTI asks examinees how they usually act or feel. It often is interpreted as behavioral rather than a cognitive measure of intuition. The MBTI intuition scale assesses the individual's perception of "possibilities, patterns, symbols, and abstractions" (Myers & McCaulley 1985, p. 207).

Briggs (2000) and Holton (1973) imply that intuition plays a strong role in the sciences. They refer to themata, which are essentially subjective themes and guides within the thinking and work of a sciences. Nuances may also play a role in scientific discovery, and they, too, are highly subjective guides, much like a gut feeling. They are not temporary, however, so the creator may experience a stable feeling guiding his or her work (e.g., Darwin, Curie, Telga). Apparently nuances give the individual a basis for judging the worth of new ideas—his or her own, or ideas of another. They are in a sense criteria, and they allow the individual to judge the appropriateness and originality of new ideas (i.e., judge whether or not new ideas extend a line of thought in a worthy direction). These ideas are entirely consistent with the larger cognitive sciences, and in particular with theories of tacit knowledge, implicit theories, Zeitgeist, and "knowing more than we think we know" (Wilson 1975).

**Box 1.10**

**Cognitive Style**

Cognitive style is supposedly independent of cognitive ability. From this perspective, individuals differ in their performances, not because they vary among some continuum reflecting levels of capacity or ability, but instead because of preferences and different cognitive "styles." Individuals will differ, then, not because one is better or worse than someone else, but instead because they are simply different. It is analogous to cross-cultural studies that would suggest that certain behavior patterns are not better or worse than other behavior patterns, but instead they are just different. This perspective implies qualitative individual differences rather than quantitative.
Theories of incubation and intuition suggest that there are benefits to the unconscious. One benefit has not yet been pinpointed, namely the possibility of reconciling opposites, contradictions, and seemingly incompatible ideas. Arieti (1976) referred to this kind of creative thinking as a *magic synthesis*. Similarly, Koestler (1964) felt that creative insights resulted from the bisociative process, the key feature of which is that discrepant ideas are synthesized. Interestingly, Hoppe and Kyle (1990) used this theory to describe why the two hemispheres of the brain are both required for creative thinking. The associative view of creative thinking (Guilford 1979; Mednick 1962) also assumes an operative unconscious (see also Suler 1980 for a review).

The Idea of the Unconscious

The influence of the unconscious was recognized long before Freud. Tolstoy seemed to recognize it in *War and Peace* when he wrote, “a king is history’s slave” (quoted by Boring 1971, p. 55). Boring also cited Francis Galton, Charles Darwin, and Herbert Spencer as recognizing the unconscious (also see *The Unconscious Before Freud* Whyte, 1983). Admittedly, Freud most carefully delineated the unconscious and tested it in his clinical studies.

Rothenberg’s (1990, 1999) research is especially impressive. He has defined and manipulated two relevant processes, one labeled *Janusian*, named after the Roman God Janus, who could look in two directions at once, and the *homospatial* process, whereby two objects occupy one space. Rothenberg’s experimental research demonstrates clear benefits to these processes, as well as individual differences in the capacity for them. Rothenberg cited Existential Philosophy (absurdity of life, but the possibility of happiness) and the Heisenberg Uncertainty Principle (the location and speed of a particle cannot both be determined) as exemplifying insights resulting from a creator’s thinking about contradictions and opposites. I would add that chaos theory also exemplifies this, for chaos is “an orderly disorder” (Gleick 1987, p. 15).

Children are probably unable to employ these processes. They certainly have difficulty with dialectical thought (Smolucha & Smolucha 1986), and it resembles Janusian and homospatial processes in the sense that opposites are considered simultaneously. The dialectical process starts with one perspective (a thesis) and the opposite perspective (an antithesis), and eventually produces a mixture of the two (a synthesis), even though the thesis and antithesis are ostensibly incompatible. That is no easy trick to bring opposites together! It is cognitively demanding, and not
surprisingly, probably not possible until late adolescence (Smolucha & Smolucha 1986).

Componental Theories

Componental theories, like stage theories, delineate creative cognition. Componental theories do not require a stage-by-stage or step-by-step movement, and in general components are not as interdependent as stages. Usually, in stage models the assumption is that one stage must precede the next stage. Componental models allow for interactions but do not require this same kind of linear progression. Amabile (1990), for instance, presented a componental theory containing (a) task motivation, (b) domain-relevant skills, and (c) creativity relevant processes. Motivation is often intrinsic (see Chapter 9), though it is for some people, or some of the time, extrinsic as well. Domain relevant skills are often technical (e.g., knowing how to conduct research, for a scientist). Creativity-relevant skills are fairly general (e.g., a cognitive style that fits with a domain and tolerates originality and exploration).

Sternberg and Lubart (1996) proposed an investment model, with six kinds of resources: intelligence, knowledge, cognitive style, motivation, personality, and envi-
ronmental context. They further defined each of the resources. Intellectual abilities, for example, allow synthesis, analysis, and a practical ability (e.g., selling the new idea).

Woodman and Schoenfeldt (1990) described the creative process as dependent on an interaction between antecedent conditions, personal characteristics, and situational circumstances. This model is described in Chapter 5.

Mumford et al. (1991) described problem construction, information encoding, category search, a specification of the most appropriate categories, combination and recombination of categories, idea evaluation, idea implementation, and process monitoring.

Finke (1997) outlined the geneplore model (gen- from generate and -plore from explore). The first phase generates a preinventive form, which is a kind of loosely formulated initial cognitive structure. These are then evaluated, extended, or elaborated, and tested during the exploration phase.

Runco and Chand (1995) presented a two-tiered componential theory. The first tier contains what might be called influences on the process, namely motivation (intrinsic and extrinsic) and knowledge (declarative/factual/conceptual and procedural). The second tier contains problem-finding skills, ideation, and evaluation.

Each of the components in the two-tiered model can be subdivided. Problem finding, for instance, represents a family of skills, including those mentioned earlier (e.g., problem identification, problem definition). Ideation also represents a family of skills, as is indicated by Guilford’s (1968) and Torrance’s (1995) theories of divergent thinking. Most often ideational fluency, ideational originality, and ideational flexibility are used.

Several aspects of this model should be emphasized. First is that the flexibility that was just mentioned may be particularly useful in creative thinking, given what was said earlier about functional fixity. Flexibility will help the individual avoid ruts and fixity. In addition to ideational flexibility, there is also a benefit to flexibility as manifested in the use of a “wide repertoire of cognitive styles” (Guastello et al. 1998, p. 77). Cognitive styles were defined in Box 1.9.

A second noteworthy aspect of the two-tier model is that it defines information and motivation influences on the creative thinking process. As noted earlier, motivation can be intrinsic (personally meaningful) or extrinsic (e.g., incentives and rewards). The influence of motivation must be recognized, for individuals will not put the effort into solving a problem unless they are somehow motivated to do so.

Information, which may be declarative (conceptual or factual) or procedural, is relevant in many ways (see later), as is implied by the impact of experience on insight and the earlier discussion about experience. At least as important is that information can provide the individual with the know-how to be creative and solve problems in a creative fashion. Know-how seems like a casual term, but it is perfectly apt for procedural information. It reflects knowledge about how to get something done (in this case, how to find original and creative ideas and solutions). Another way to put this is that procedural knowledge provides tactics for creative thinking.
Tactics depend on metacognition. In literal terms, metacognition is cognition about cognition. It reflects the individual’s thinking about his or her own thinking. Metacognition allows the individual to monitor his or her own actions. It reflects the intentional actions taken to enhance one’s own creativity. Tactics are highly practical precisely because they can be intentionally used. In fact, they must be used intentionally. By definition the individual chooses which tactic to employ, and when, if in fact, any is to be employed. Metacognition is, then, the basis for any tactical or strategic creative efforts.

Sticking with the literal approach, “tactics” are short-term procedures or maneuvers that are used to increase the probability of obtaining a goal. They differ from “strategies,” which are more general and long-term. Strategies often lead to specific tactics (see Box 1.10). A number of tactics are presented in Chapter 10, which deals with the enhancement of creativity.

Metacognition develops only in adolescence (Elkind 1981). Children therefore cannot be tactical about their creativity (see Chapter 2). Then again, they do not need to be tactical: they are spontaneous and uninhibited and do not use as many assumptions and routines as adults. Adults rely on routine and may need tactics to solve problems in a creative fashion and to avoid fixity.

**PERCEPTION AND CREATIVITY**

Two very different views of creative cognition have been described. One allows the creator to take intentional control of his or her work, often through tactics, and the other relies more on unintentional and random processes. These views are not incompatible. Part of the creative process could be unconscious and random (or beyond the reasoning of our conscious mind), whereas another stage is intentional and can be controlled. More will be said about the intentional processes in sections devoted to judgment, mindfulness, and personal creativity.

Another view distinguishes between random and unintentional process (“blind variation”) and systematic but unintentional processes. Perceptual processes play a role in certain kinds of creative thought, and they are anything but random. They are not, however, directed by our conscious mind nor in any sense intentional. Consider in this regard the process of percept-genesis. Smith (Smith & Amner 1997) gave this label to the process through which meaning is assigned, in a step-by-step fashion, to the information we perceive. It is similar to the top-down processing model of cognition (Lindsay & Norman, 1977), which describes information processing as guided by one’s thinking and expectations.

Bottom-up cognitive processing starts from experience and the mind reacts to it by determining what the experience means. Bottom-up processing is often a kind of recognition: We perceive something and react to it by searching our memory for similar objects or experiences. We then label the new experience, based on what we found in our long-term memory. Top-down processing, on the other hand, may
Box 1.11
Tactics vs. Strategies

The techniques and procedures used to insure or increase creativity often are described as strategies, but actually it is important to distinguish between tactics and strategies. Chandler (1962) put it this way: “strategy can be defined as the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals” (pp. 15–16). Tactics, on the other hand, are specific processes for dealing with a particular situation or problem. Organizations often have strategies, especially if they are concerned about innovation (Lines & Grohaug, 2004), but individuals may employ specific tactics when, say, faced with an impasse. They may, for instance, “turn the problem on its head” or “put the problem aside for a short period.” These two tactics do not refer to goals and objectives. Of course, organizations or individuals may have both strategies and tactics; it would be inaccurate to assign strategies only to organizations and tactics to individuals.

require less information because the individual is assigning meaning based on expectations. Of course we often find only what we are looking for, which is why top-down processing and a reliance on expectations can cause problems (Rosenthal 1991).

Chapter 6 discusses several problems that may arise when working with creative children (e.g., they may not fit our expectations of ideal children). Smith’s research on percept-genesis is one of the best examples of how the creative process can be empirically examined. Probably most important is that creative individuals assign meaning in a different fashion than less creative persons. Creative individuals tend to use ambiguous stimuli, or stimuli that have not yet been fully revealed. They can construct meaning based on very little information. Creativity here is very literal: It is the creation of meaning. Cupchik (1999) and Runco (2003) went into more detail about the various ways that the human perceptual system may influence creative thinking. Perception represents one of the nomothetic processes mentioned briefly in the introduction to this chapter.

SYNAESTHESIA

Synaesthesia represents another unintentional but systematic perceptual and cognitive process. Synaesthesia occurs when information from one sensory modality (e.g., hearing) is translated to another sensory modality (taste). Domino (1989) found that 23 percent of his sample of 358 fine art students experienced synaesthesia, and
did so consistently and spontaneously. These students apparently associated colors with music, tastes with certain vowels, and colors with numbers. Domino found the individuals who spontaneously experienced synaesthesia had higher scores on four creativity tests than did a control group.

**MINDFULNESS**

Langer (1989) believes that we can take control of our perceptual processes, and thereby fulfill our potential for creativity and even health. She suggested that creativity and health will flourish if we can avoid mindless (automatic) behaviors. We should also avoid relying on past routines and the categories of experience used in our personal pasts. We should instead look closely at new experiences and create new categories for those new experiences. We should also avoid relying on single perspectives and instead be alert to alternative perspectives. The last of these suggestions shows why mindfulness is related to creative behavior. Apparently, mindfulness and creativity are each related to flexibility. Flexibility will, for instance, allow us to avoid relying on routine and assumption and help us to consider various perspectives. Langer (1989) suggested that we remain open to new information, and “openness to experience,” like flexibility, is often related to creative potential (McCrae 1987). Langer has demonstrated the benefits of mindfulness in the classroom (Langer et al. 1989) and various other institutions. Mindfulness can be enhanced, by one’s self or by others (e.g., teachers, supervisors), and has profound effects on creativity and health.

There is no doubt of an optimal level of mindfulness. Indeed, assumption sometimes works well and makes our lives easier. When we make an assumption, we free up resources that can then be allocated to other concerns. Mindfulness is a very good thing, most of the time.

**OVERINCLUSIVE THINKING**

We can explore this idea of optima further, especially if we stand back and examine the concept of categorization. This is one way we structure our thinking and make our lives easier: We classify people, objects, and experiences into categories and other cognitive structures (Piaget 1976). Usually this dramatically improves the efficiency of our thinking. It can be taken too far, however. If we rely on categories, we might err by assuming that each member of a category is identical. This can be seen when we stereotype people or groups and assume that everyone in one group is the same. ("All lawyers are . . . ") We might also err in the manner that Langer (1989) described, in which case we rely too much on categories from our past experiences and do not notice the originality and significance of new experiences.
Box 1.12

Categorical and Hierarchical Thinking

Did you ever wonder how a letter finds its way to its addressee (the recipient)? The answer is probably obvious to you because you have no doubt addressed many a letter. (I know I have written every creditor in the known universe. They all confuse me with my evil twin.) The postal delivery method was, however, not so obvious when the United States was just getting started. The inventor was none other than Ben Franklin. The interesting thing about the postal delivery method is that it is a method. It is not a thing, a product, but is instead a means or procedure. We often do not think of methods as inventions, but they certainly are as creative as products. Consider Henry Ford’s assembly line (and the later methodological changes, mostly in Asia, to make the auto industry more efficient and cost-effective), Thomas Edison’s invention factory, or McDonald’s fast food methods (Bryson 1994).

The other notable thing about the postal delivery method is that it relies on classification and hierarchical thinking. A letter is delivered by first identifying the country, then the state, then the city, and then the street and house number. (Zip codes expedite this process further, but if you just used a zip code, your letter would not be delivered. It is not specific enough.) Categories, sometimes called concepts or classifications, develop as we acquire knowledge. They represent one way that knowledge is structured: the individual puts similar things in one category (cats and dogs are in the animal category), and infers and constructs hierarchies based on super- and subclassifications. Categories make our thinking much more efficient, for we can often judge something based on the general category. (To answer the question, “Do you like Siamese cats?” you do not even need to know anything specific about that breed, if you are allergic to all cats. Siamese cats represent one subclass in the subclass “Cats,” which of course is a subclass of “Animals,” “Mammals,” and so on.) As a matter of fact the taxonomic system (Kingdom, phylum, genus, species) represents another very useful hierarchy.

The up-side of categorical thinking is that our thinking is more efficient, and the down-side is that our thinking is too efficient. It is too efficient when we do not notice details in a mindful manner. This can create problems (yet another pun) for creative thinking; it is really just another way of saying that when we rely on categories we are making assumptions. These problems—making assumptions, not looking at details, and mindless inattention—will each be examined in Chapter 10, for they all get in the way of original ideation and problem solving. In terms of the cognitive bases of creative thinking, the important points are that (a) our thinking is often structured, and often organized in a hierarchical fashion; (b) creative thinking sometimes results when we ignore the “conceptual boundaries” that define categories; and (c) thinking that largely ignores those same boundaries is overinclusive and sometimes related to psychosis (Eyseneck, 1997).
The interesting thing is that another theory of cognition suggests that sometimes categorization errors contribute to creative insights. I am referring to Eysenck’s (1997, 2003) theory of overinclusive thinking. Eysenck claimed that overinclusive thinking supplies the variations and options from which the individual may select useful and creative ideas. A great deal of attention indeed has been given to the production of variations and options (Campbell 1960; Simonton 2006), and no doubt using loose conceptual boundaries, and including things in categories that others may not include, could expand the range of options. There is also a modicum of experimental research that suggests that creative insights sometimes result from a loosening of conceptual boundaries (Martindale 1990).

CONCLUSION

The most fascinating thing about the cognitive research on creativity may be its diversity. It is tempting to borrow Minsky’s (1988) metaphor of a society of mind, for societies are busy and a bit chaotic. Then again, the society metaphor may imply humanity and undue homogeneity. Perhaps an ecosystem of mind is a better metaphor. An ecosystem implies diversity. In the natural world an ecosystem contains flora and fauna, and often extreme heterogeneity of each. And with the diverse species in an ecosystem, actions occur on various levels (from the treetops and sky to deep in the earth), at different speeds, sometimes interactively and systemically, and sometimes independently. An ecosystem contains not just one species and community, but many of them, as well as a physical environment. For creative cognition, the environment is the brain itself, and the mind it generates.

Metaphors of the Mind

Every era seems to borrow from technology for its favored metaphor of the mind. Here are some examples:

- Telegraph
- Switchboard
- Computer
- Society
- Ecosystem

Such cognitive diversity may be difficult to conceive. Yet this is the kind of thing that should be practiced, given messages from the creativity literature. After all, creative thinking sometimes requires an open mind. The reader may need to practice
just that—open-mindedness—while reading about cognition and creativity. Some of the research herein suggests that cognition depends on affect, for example, and the interplay with cognition is not always an easy idea to accept. Many people view cognition as “cold” and independent of emotions (Lazarus 1991). Even more challenging may be the idea of creative cognition sometimes involving a simultaneous consideration of opposites (Arieti 1976; Rothenberg 1997). This sounds a bit like “white is black” or “day is night.” Then there is the idea of the unconscious! It is by definition untestable and many think it unscientific. But without a recognition of the unconscious, it would be very difficult to explain incubation, insight, and the resolution of opposites. The best solution is to realize that the traditional scientific method, with objectivity as its centerpiece, does not apply perfectly to creative studies. By all means we need to be scientific about creativity, but not when extreme objectivity precludes a realistic understanding of the subject matter. It helps to be open-minded.

Clearly there are different ways to be creative and different processes that can result in original and effective insights, ideas, or solutions. Some processes may be unconscious and out of our personal control. Yet others are entirely conscious and can be controlled. One of the best examples of a controllable process is simply knowledge acquisition. Knowledge is often useful for creativity. No wonder there is a ten-year rule for many domains, where contributions to a field are unheard of until the individual has invested 10 years (some say 20,000 hours) to its study. These 10 years allow the individual to master the prerequisite information. They then get to a point where they see the gaps and know what is important; they can then contribute in a meaningful way. There are domain differences in this regard (see Chapter 2) and exceptions—recall here the idea of professional marginality, where an individual from outside a field has an advantage in questioning assumptions and contributing in a creative fashion (Dogan & Pahre 1990; Runco 1994d)—but most of the time, information is helpful. What is most important is that the process of information acquisition is largely under our control. People who invest 20,000 hours mastering a field do so because they are fascinated by it; they are thrilled by it; so they decide to devote themselves to it. They often lose themselves and do not even realize that they are working at it. Time flies, as they say. Or as Thomas Edison put it, “genius is 10% inspiration and 90% perspiration.”

Then there are those processes that are seemingly beyond our control. All we can do with them is allow them to take place. Parnes (1967) suggested that we “let them happen,” perhaps by taking a walk and providing the time and opportunity for incubation. That is, however, itself a tactical decision. Other tactics are more direct. Parnes referred to them as make it happen tactics. These are detailed in Chapter 6. I mention them here because it is very important that tactics for enhancing creative thinking and for fulfilling potentials have strong justification. They are supported by the theories and research findings reported in this chapter and throughout the volume. That connection, between theory or research and a tactic or strategy, validates and justifies the tactics.
There are a number of additional connections between the concepts in the present chapter and those found elsewhere in this volume. Eysenck's (2003) theory of overinclusive thought, for example, is useful for our understanding of psychopathology (see Chapter 4), as is extremely low flexibility (a correlate of suicide ideation). In fact, Langer (1989) also looked at flexibility, and it is also an important part of the personality approach to creativity. Stein (1975), for instance, listed both flexibility and intuitive capacity in his summary of the creative personality. Cognition is also tied to social processes, as is evidenced by the research on brainstorming. These connections suggest a consensus about certain aspects of the creativity syndrome. We will explore these points of agreement, and various themes in the research, in the conclusion to this volume.