Epilogue: Putting insight into perspective

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Epilogue: Putting Insight into Perspective

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Insight invites metaphors. In this book alone, insight elicited comparisons with evolutionary theory, both Darwinian (Simonton, chapter 14) and punctuated equilibrium (Perkins, chapter 15); gold mining (Perkins, chapter 15); spinning wheels in the mud (Smith, chapter 7); perceptual gap filling (Gruber, chapter 12); the noncontinuous growth of babies (Gruber, chapter 12); humor (Gick & Lockhart, chapter 6); investment theory (Sternberg & Lubart, chapter 16); the interpsychic and intrapsychic dimension (Csikszentmihalyi & Sawyer, chapter 10); and the kinematic theory of gases (Poincaré, cited in Simonton, chapter 14, and others). There are many possible reasons for this plethora of metaphors. A positive view would be to observe, as have many in this text, that insight solutions often follow from analogies (e.g., Davidson, chapter 14; Dunbar, chapter 11; Finke, chapter 8; Gick & Lockhart, chapter 6; Isaak & Just, chapter 9; Mayer, chapter 1). Thus, discussants of insight would be remiss not to draw on the device that they argue is of such value. From a more skeptical perspective, the multitude of analogies to insight may result from a fundamental lack of agreement regarding what insight is and how it works (e.g., Weisberg, chapter 5). Somewhere between these two views lies the suggestion that insight requires multiple analogies to illuminate its multifaceted nature. As Gruber observes, "A single metaphor is always imperfect, but a set of metaphors all almost converging on the same target do illuminate and define it" or, to use an analogy, a single metaphor may shine a spotlight whereas many metaphors can light up the stage. Toeing this middle line, we will draw liberally on various metaphors of insight in order to clarify and highlight a number of central issues surrounding insight's definition, mechanisms, and relationship to other types of thought.

THE DEFINITION OF INSIGHT

After reading this book, one may be a bit perplexed about exactly what *insight* means. Although most usages of the term *insight* incorporate the suggestion that it involves the sudden unexpected solution to a problem, many different, sometimes contradictory characterizations of the term appear throughout these chapters. Traditionally speaking, there are two rather different possible usages of the concept of insight. As Smith notes in chapter 7, insight can be used to represent a state of understanding—that is, to gain insight into something. However, insight also can be described as an experience involving "the sudden emergence of an idea into conscious awareness." Although the difference between these two meanings of *insight* appears substantial, they sometimes are treated as if interchangeable. For example, Csikszentmihalyi and Sawyer (chapter 10) discuss insight both with respect to "seeing inside" and "a moment of realization," and their interviews with creative individuals do not always clearly distinguish between these two formulations.

Even when insight is discussed with respect to its more common psychological usage as an *insight experience*, the components of that experience are not always characterized in the same way. For example, Gick and Lockhart (chapter 6) suggest that the sudden affective "Aha!" experience is a defining component of the insight experience, whereas cognitive restructuring (constructing a new problem representation) is a common but not necessary component of insight. In contrast, Weisberg (chapter 5) uses restructuring as the sole defining criterion for insight and suggests that the "Aha!" experience may not be a criterion. Ippolito and Tweney (chapter 13) seem to ignore both the "Aha!" and the restructuring components of insight and instead characterize it as a special form of perception requiring "the ability to recreate the workings of a selected aspect of the physical world, independent of sensory receptor input."

To confuse matters further, a central theme running through a number of chapters is that insight is associated with a disparate set of processes that can be elicited by distinctly different types of problems. Weisberg (chapter 5), for example, posits three types of problems: change in initial representation, change in goal, and language interpretation problems. Dominowski and Dallob (chapter 2) address spatial, verbal, and object use problems, whereas Gick and Lockhart (chapter 6) distinguish between novel representation and conceptual access problems. Davidson (chapter 4) divides insight problems according to whether they require selective encoding, selective comparison, or selective combination, while Mayer (chapter 1) talks about schema completion, visual reorganization, reformulation, mental block, and analogy problems. We should note also that although many researchers propose different types of problems that elicit certain types of insight processes, they also acknowledge that different problem solvers may answer the same problem by drawing on very different processes (e.g., Davidson, chapter 4; Perkins, chapter 15). Indeed, Davidson and Gick and Lockhart (chapter 6) suggest that certain people need not even employ insight processes to solve insight problems correctly.

In addition to the complications associated with multiple types of insight problems, processes, and problem solvers, a number of researchers observe that there is no commonly agreed-on operational definition by which insight problems may be identified (e.g., Dominowski & Dallob, chapter 2; Weisberg, chapter 5). In light of the current absence of a clear theory of what constitutes an insight problem, Weisberg proposes that "a moratorium should be placed on theorizing about the mechanisms underlying restructuring and insight."

To salvage the general concept of insight from these complexities, it is useful to distinguish between the *explanation* of insight and the *event* of insight. If insight is defined with respect to its explanation, then, given the variety of elements that have been postulated to be involved in insight, we might reasonably question whether they all deserve to be classified under the same heading. If, however, insight is defined as an event and, in particular, a transitional event in which the solver moves from an impasse state to a solution state, then it becomes more sensible to consider it as a single construct. To use another metaphor, consider an explosion (the possible parallels between insight and explosionlike conditions have been proposed before; see Metcalfe's

[1986] depiction of insight as a catastrophic process and, in this volume, Perkins's characterization of insight as a generative breakthrough event). Clearly, there are many different and distinct processes that can lead to an explosion. Nevertheless, these processes all are united in that they lead to a sudden violent dispersal that results in the transition to a state very different from that preceding the explosion. Similarly, although many different processes may lead to an insight, these all can be united by the insight event that results in the transition of the solver to a solution state very different from the nonsolution state that preceded the insight.

The characterization of insight as a transition event in which "a problem solver suddenly moves from a state of not knowing how to solve a problem to a state of knowing how to solve it" (Mayer, chapter 1) provides an operational definition that can be measured empirically. Specifically, Metcalfe's (1986) warmth rating paradigm, in which subjects provide frequent estimates of their nearness to a solution (see Davidson, chapter 4, this book) is able reliably to reveal whether a problem-solving procedure leads to a sudden transition to a solution. This approach seems to provide a clear definition for what might otherwise be a murky construct, but Weisberg (chapter 5) raises two criticisms concerning the use of the warmth rating paradigm for operationally defining *insight*. First, Weisberg notes that such a definition allows only post hoc classifications and thus does not provide a theoretical basis on which to define insight. Second, he argues that using the warmth rating paradigm to identify insight results in a circular argument because "warmth data cannot be used both as the basis for a problem classification and support for that classification."

Weisberg's difficulty with the warmth-rating operationalization of insight seems to stem from his desire to connect the definition of the insight event itself with an explanation for that event. Weisberg specifically suggests that the definition of *insight* should be made in the context of a theory or explanation of insight. Though such a goal sounds lofty, a strong case can be made that the operational definition of the insight event should be *independent* of the theories used to explain that event. Again, the metaphor of explosions may be of value. One might have a theory for what leads to certain types of explosions, but ultimately the definition of an explosion is not whether a certain set of theoretically explosive conditions exists but, rather, whether an explosion actually occurs. To mix metaphors (we couldn't resist), the poof is in the pudding. So, too, no matter how sophisticated our theories of insight, we must have a strict operational definition of what constitutes the occurrence of an insight event in order to test those theories. If the insight event occurs in a situation that the theory does not predict, we should modify the theory, *not* the definition of the event; otherwise, the theory will never be falsifiable. In short, we will be able to advance, compare, and select our theories of insight only if we are able to use a definition of *insight* that is not inherently tied to any one particular theoretical perspective and that allows independent verification of insight through empirical means. Problem situations that result in a sudden transition from a nonsolution state to a solution state, as indicated by warmth ratings or other empirical measures, represent a definition of *insight* that fits with the preceding constraints as well as corresponds to our commonly shared understanding of the term.

Although defining *insight* using an atheoretical operationalization helps us find common ground and provides an empirical basis for determining when insights have occurred, such a definition, by its very nature, cannot provide a theoretical understanding of the basis for insight. As Mayer observes, "Providing a name for this process does not substitute for providing an explanation" (chapter 1). Nevertheless, the claim that insight involves the sudden shift from a nonsolution state to a solution state offers a starting point on which explanations of insight can be based. First, the absence of perceived progress to the solution prior to the insight suggests that would-be solvers are at an impasse. Thus, the questions raised by the preceding definition include: What causes the impasses that keep the solver in a nonsolution state prior to the insight? What conditions enable the solver to overcome the impasse? Why does the overcoming of an impasse lead to a sudden solution? To provide a conceptual scaffolding for considering these questions, we first review the frequently made analogies between insight and two basic everyday experiences—perception and searching physical space.

TWO COMMON METAPHORS OF INSIGHT

The Vision Metaphor

Characterization of the experience of insight as comparable to an object suddenly becoming visible permeates both our folk conceptions of insight and psychological insight theories. The term in*sight* itself emphasizes its parallels with vision, and other common language characterizations of insight similarly invoke visual qualities. Insights often are described as "a sudden flash," "a moment of illumination," or "seeing the light." Pictorial representations of insight (e.g., comics) also reflect the visual quality of this experience, using the characterization of a light bulb appearing over someone's head. The analogy of perception guided early Gestalt theorists, who characterized the processes of insight in terms of many of the same principles of good form, such as closure, used to account for perception. The Gestaltists' perceptual characterization of insight remains considerably influential to this day. For example, Ellen (1982) suggests that insight is akin to Gestalt classic figure ground reversals (e.g., the necker cube) and, in this book, Gruber (chapter 12) hypothesizes that a process comparable to perceptual gap filling (equivalent to the Gestalt notion of closure) may play an important role in insight. Other approaches too have emphasized the parallels between insight and vision. For example, Ohlsson (1984) discusses the discovery of insight solutions as occurring when the solution is in "the horizon of mental lookahead." In this text, Ippolito and Tweney (chapter 13) explicitly characterize "insight as a special form of perception" and Simonton (chapter 14) suggests that discoveries are associated with situations in which consciousness is able to "suddenly change focus, and spotlight the discovery."

The Problem Space Metaphor

A second metaphor that is associated with discussions of insight is the notion that thought is equivalent to moving through physical space. As Roediger (1980, p. 232) notes, "In thinking of consciousness, or more broadly, of mind, we usually resort to a metaphor of an actual physical space, with memories and ideas as objects in the space." Psychologists and nonpsychologists alike describe processes related to insight using such phrases as *searching one's mind, changing the direction of thought, approaching the problem from a different angle, thoughts in the back of one's mind,* and *finding the solution.* In the domain of problem solving, the mental space metaphor has been merged with a computer metaphor (e.g., Newell & Simon, 1972), in which the problem solver moves through a problem space from subgoal to subgoal in order to reach the final goal. The movement through the problem space requires the use of operators, which are actions (e.g., multiply, move, etc.) that fulfill certain subgoals, thereby moving the solver to a new problem state. Although the potential range of operators and problem space routes available to problem solvers is virtually infinite, the limited processing capacity of humans substantially constrains the number of operators that are used and the routes that are explored (Newell & Simon, 1972).

The physical space metaphor of thought provides a number of ways to characterize insight problems. From the standpoint of the searcher, as Isaak and Just (chapter 9) suggest, the problem space characterization of insight leads to the possibility that one may define the boundaries of the problem space so as to preclude finding the solution. From the standpoint of the problem, as Perkins (chapter 15) notes, some problems will offer more clues regarding where one is than others. Thus, by Perkins's account, insight problems may be characterized as corresponding to physical spaces, such as those involved in gold mining, in which one has little idea of progress and then suddenly hits the mother lode.

Combining the Vision and Spatial Metaphors

Although frequently discussed independently, the vision and spatial metaphors of thinking complement one another well. To move through a physical space, it helps to be able to see where to go next. Similarly, in problem solving, the movement from one state to the next requires some assessment of what operators are available. Thus we can readily combine the vision and physical space metaphors of problem solving by proposing a two-process model: (1) a pattern recognition process comparable to vision that surveys the possible directions in which to move (i.e., identifies the potentially applicable operators) and (2) a reasoning process that decides between the potential directions (selects a set of operators) and moves forward (executes the operators). With respect to insight, this characterization is particularly useful because it suggests that multiple factors may contribute to an impasse. One may have a fine vantage point yet still fail to see the goal. In such cases, the problem is one of recognition. Alternatively, one may be heading in the wrong direction and need to determine a way to move to a location that affords a better view. In this latter case, the impasse involves both reasoning (finding and following a route to a better view) and recognition (identifying what one sees when the view is improved). With this analogy in mind, we now consider some of the sources of impasses to insight.

THE CAUSES OF IMPASSES

Recognition Failure

Many discussions of the impasses to insight suggest that the difficulty is simply one of perspective: All the information needed to solve the problem is at hand, but one simply is not looking at it from the right angle. In classic Gestalt discussions of the impasses to insight, this type of impasse was compared to figure-ground illusions, in which the perceptual definition of what is figure and what is ground determines what is seen. From the perspective of the visual–physical space analogy, one has a clear view of the goal but simply fails to recognize it. We turn now to a discussion of two sources for such recognition failures—the overemphasis of irrelevant cues and the underemphasis of relevant cues.

The Overemphasis of Irrelevant Cues

One well-documented reason for people's failure to recognize solutions when they are at hand is that the problem solvers focus excessively on particular sources of information and consequently fail to see the big picture. The excessive focus on inappropriate or irrelevant cues is discussed by a number of contributors to this book. According to Isaak and Just, "Insight problems often contain information that lead subjects to incorrectly accept additional operator constraints not mandated by the problem" (chapter 9). To support this claim, Isaak and Just identify the unnecessary problem constraints elicited by a number of classic insight problems. For example, in functional fixedness problems, the solver is distracted by an object's standard function, which results in failure to recognize that the object can be used for other purposes.

Evidence for impasses resulting from excessive emphasis on irrelevant cues comes from other sources as well. For example, Smith (chapter 7) reports that inventors have great difficulty ignoring dysfunctional design elements involved in prior designs. Smith also finds that providing subjects with misleading hints can interfere temporarily with subjects' ability to solve puzzle problems. Finke (chapter 8) reports that the creativity of subjects' visual imagery inventions is reduced when their images are initially constrained to a particular category. Gick and Lockhart (chapter 6) suggest that many puzzle problems are effective because they invoke ambiguous interpretations (i.e., multiple meanings are potentially available) but the dominant interpretation is inappropriate for solving the problem.

To make matters worse, as individuals continue to work on a problem from the wrong perspective, they may increase the salience of the inappropriate problem elements by perseverating on them, further reducing the likelihood of shifting perspective. To use Smith's (chapter 7) analogy, the more they spin their wheels, the deeper the rut. Empirical evidence for this intuitive claim is suggested by Lockhart, Lamon, and Gick (1988), who found that the vast majority of solutions to insight puzzle problems occur in the first minute of problem solving. One reasonable interpretation of this finding is that with increased activation of the wrong perspective, the problem solver becomes less and less able to switch perspectives. Additional evidence for the suggestion that working on a problem from the wrong perspective can interfere with one's ability to recognize alternative interpretations that are seemingly obvious comes from research on the recognition of out-of-focus pictures. Bruner and Potter (1964) observed that exposure to extremely out-of-focus pictures impairs subjects' ability to recognize moderately out-of-focus versions of the same picture. Bruner and Potter (1964) proposed that this suggests that ill-fated attempts to recognize extremely out-of-focus pictures cause subjects to formulate hypotheses and adopt perspectives which then interfere with the subjects' ability to recognize the correct interpretation when it becomes more available.

The Underemphasis of Relevant Cues

Reconsider the previously cited situation of recognizing out-of-focus pictures. The subjects' emphasis on inappropriate perspectives generated while attempting to recognize very out-of-focus pictures interfered with their ability to attend to the relevant information presented in the successively more focused pictures, which would have enabled a correct identification. A number of chapters in this book advance the theme that impasses can result from the inability to recognize the relevance of available cues. For example, Gick and Lockhart (chapter 6) observe that for many insight problems, "the source of difficulty ... is one of conceptual access ... involving capacity of problem content to cue the appropriate concept." Davidson (chapter 4) observes that lower-intelligence subjects' difficulty with insight problems often occurs because they fail to engage in selective comparison—that is, to recognize relationships between certain features of the problem and information acquired in the past. Similarly, a number of researchers report that the manner in which relevant prior information is encoded can determine whether it is retrieved and used to recognize the solution (see Dominowski & Dallob, chapter 2; Lockhart et al., 1988). In these cases, the would-be solvers are in a state in which they "possess all the knowledge necessary for producing a solution" (Dominowski & Dallob). They simply fail to recognize the correspondence between what they are currently encountering and what they already know.

Searching the Wrong Space

Although some impasses may be associated with situations in which the solver fails to see the solution despite being poised to do so, other impasses require the solver to move to a completely different vantage point. Such a situation is equivalent to being lost in Perkins's (chapter 15) ill-defined Klondike space, far away from any useful vein of gold. In such situations, no form of perspective shifting will be sufficient to allow one to see the solution; rather, the would-be-solver must actively move to new vantage points," avoiding redundant coverage of the same regions, searching for new regions altogether" (Perkins, chapter 15). Examples of such situations include the manner in which subjects must solve the mutilated checkerboard problem described by Gick and Lockhart (chapter 6) and Kaplan and Simon (1990). As Gick and Lockhart suggest, the solution of such problems, unlike those that are constrained simply by conceptual access, requires the would-be problem solver to engage in the active construction of a new problem representation. Many impasses to scientific insights may similarly occur because the investigators simply are not in a place to see the solution. Thus, Simonton's observation (see chapter 14) that important scientific discoveries require at least 10 years of intensive learning in a domain suggests that prior to that time, the researcher simply has not moved into a location in the problem space where insightful solutions may be visible.

HOW IMPASSES ARE OVERCOME

The suggestion that the impasses to insight result either from recognition failure or from being in the wrong place implies that techniques for overcoming impasses should facilitate the recognition process or assist the would-be solver in moving to a more suitable vantage point. In fact, considerable evidence is provided in this book that both of these general approaches can facilitate the overcoming of impasses.

Improving Solving Recognition

Techniques for overcoming impasses that result from a failure to recognize the solutions that are seemingly obvious rely on reversing the processes that cause such oversights. Thus, one general approach for reversing such impasses is to find ways of reducing the salience of inappropriate cues, and the other is to increase the salience of appropriate cues.

Deemphasizing Inappropriate Problem Elements

If seeing the solution is hindered as a result of a focus on distracting problem elements, then techniques that reduce the salience of such elements will increase the likelihood that a more useful perspective is adopted.

Forgetting The passage of time appears to be one of the best remedies for overcoming the salience of inappropriate cues. If one assumes that the activation of inappropriate problem elements increases as one continues to work on the problem, then a delay during which this activation can decay may increase the likelihood that one may take a more suitable perspective. In effect, a delay gives the person the opportunity to take a fresh look at the problem. The suggestion of forgetting as a mechanism for overcoming impasses dates back to Woodworth (1938) and has been reintroduced by a variety of other theorists (e.g., Anderson, 1981; Simon, 1966). In this book, Smith (chapter 7) describes research demonstrating that the negative effects of misleading hints on various problem-solving activities attenuates with the passage of time and suggests that the passage of time facilitates the overcoming of impasses by helping one "escape from the mental ruts that block insight."

Changing context A related technique for reducing the salience of inappropriate problem elements may be to consider the problem in a different physical or psychological context. Specifically, a variety of work suggests that reinstating the context of prior situations, either physically (e.g., Smith, Glenberg & Bjork, 1978) or psychologically (e.g., Bower, 1981; Malpass & Devine, 1981), can increase subjects' access to the information associated with that situation. By the same token, shifting physical or psychological contexts may be helpful by reducing the degree to which the reinstatement of inappropriate problem elements occurs. To our knowledge, there have not been any experimental studies of this hypothesis, but anecdotal reports offer considerable evidence. For instance, there is the classic case of Poincaré experiencing his insights while on vacation (producing changes in psychological as well as physical context). Also, Csikszentmihalyi and Sawyer (chapter 10) report that many individuals experienced insights while engaging in everyday routines outside the context of their work, and it is common folk knowledge that insights often occur in the shower. Accordingly, thinking about a problem in a new physical or psychological context that is not, in itself, too resource demanding may reduce the salience of previously emphasized inappropriate problem elements, thereby providing a fresh perspective.

Accessing Appropriate Problem Elements

In addition to deemphasizing the inappropriate aspects of a problem, changes in perspective leading to recognition of problem solutions can also be elicited by the access of problem-relevant information. In the case of perception, an out-of-focus picture can be entirely reconfigured simply by introducing a single word describing its content. Similarly, in the case of riddles, the punch line provides the listener with an instantaneously new view of the riddle (see Gick & Lockhart, chapter 6). So too, the simple encounter of a cue in the environment, or the spontaneous surfacing into consciousness of some relevant bit of information, can trigger the recognition of an insight solution. We will review briefly these two sources of accessing appropriate problem elements.

Cues in the environment The value of encountering information that can suddenly enable one to recognize the solution to a problem is suggested by both historical and experimental discussions of insight. For example, Seifert, Meyer, Davidson, Patalano, and Yaniv (chapter 3) describe how the physicist, Richard Feynman, on hearing a single phrase about the possible nature of neutron decay, leaped up and exclaimed, "Then I understand EVVVVVERYTHING." Like the viewer who has just been given the name for an out-of-focus picture, or a listener who has just heard the punch line to a joke, Feynman instantly saw the whole picture. Seifert and coauthors propose a compelling explanation for how the environment can prompt such sudden revelations. According to these researchers, when faced with a problem that cannot be solved, individuals store memory traces or "failure indices" of the impasse that "help guide the problem solver back to the problem when relevant new information is later encountered." Seifert's group provides evidence for these failure indices from two diverse paradigms. In a tip-of-the-tongue study, subjects benefited from prior exposure to target items only when those items corresponded to definitions they had failed to produce in an earlier tip-of-the-tongue test. In a memory-for-problems paradigm, subjects showed superior memory for unsolved problems as compared with solved problems only when they had been allowed to reach an impasse on those problems (the classic Zeigarnik effect). These authors concluded that impasses create special mental markers (failure indices) that keep the mind ever vigilant for the sought-after information. When the critical information is found, the partial picture suddenly becomes complete and the solution is recognized (see also Langley & Jones, 1988, and Perkins's discussion of their work in this book).

Unconscious retrieval Cues that may prompt the spontaneous recognition of a problem solution may also surface from the unconscious. For example, a number of researchers have speculated that problem solving may initiate the spread of activation to concepts related to the problem elements. With sufficient activation, critical operators may rise above the threshold of awareness and become available to the problem solver. Such unconscious spreading activation mechanisms have been incorporated into a number of theories of insight (e.g., Bowers, Regehr, Balthazard & Parker, 1990; Langley & Jones, 1988; Ohlsson, 1992; Yaniv & Meyer, 1987; see also Isaak & Just in this book). In addition, unconscious search mechanisms are included in a variety of the discussions in this book, although Seifert and coauthors (chapter 3) present evidence refuting this view. Csikszentmihalyi and Sawyer (chapter 10) observe, "The paradox for the creative individual is to somehow 'direct' this undirectable subconscious process so that useful insights result." Perkins (chapter 15) suggests, "Once set up by deliberate effort with a problem, those unconscious mechanisms basically constitute another mechanism of search operative even though the person may not be concentrating on the problem consciously." According to these views, when the products of these unconscious searches are brought into conscious awareness, the solver's perspective on the problem is spontaneously altered and the solution is seen. As Simonton (chapter 14) observes, "When the succession of subconscious images chances upon a bona fide insight, core consciousness will suddenly change focus and spotlight the discovery."

In some situations, access to the critical information that can prompt sudden recognition of a problem solution may result from a combination of environmental cues and unconscious retrieval processes. A number of studies suggest that environmental cues that are not recognized when encountered can nevertheless subsequently facilitate insights. For example, Maier (1931) observed that subjects frequently solved the two-string problem after one of the strings was accidentally brushed by the experimenter, even though the subjects were not explicitly aware of the hint (see Mayer, chapter 1). Dunbar (chapter 11) and Schunn (1990) found that subjects' problem solving benefited from prior exposure to analogically similar problems even though their retrospective reports showed no evidence that the subjects recognized the relevant similarities between the two problems. In recent research in our laboratory (Schooler & Melcher, 1993), we have found that subjects can benefit from one-word hints to puzzle problems, even when they do not recognize the hints as such. These findings suggest that the environment may set into action unconscious retrieval processes that ultimately can bring to consciousness a cue that can prompt recognition of the solution.

Searching for a New Problem Representation

When the difficulty in solving a problem is simply that one lacks the proper perspective then, as indicated earlier, recognition of the solution can be prompted by passive processes involving the apprehension of new information or unconscious memory retrieval. If, however, the problem solver is not poised to recognize the solution, then more active processes must be engaged to overcome the impasse. We now review briefly some of the considerations involved in actively finding a new problem space.

Recognizing that One is Lost

The recognition that one is at an impasse may be an important first step in encouraging individuals to search actively for a new problem space. For example, Dunbar (chapter 11) observed that when researchers accepted that an unexpected finding was valid and concluded that their existing theory was mistaken, significant conceptual advancement frequently followed. Csikszentmihalyi and Sawyer's interviews of creative individuals (see chapter 10) suggest that the most important insights result from problem finding, in which individuals identify a current impasse and then devote significant effort to resolving it.

A common explanation for the ability of recognition of an impasse to facilitate its being overcome is that recognizing an impasse forces the individual to take stock of his or her problem-solving status and to consider ways of fundamentally redefining the problem. For example, Kaplan and Simon (1990) and Gick and Lockhart (chapter 6) suggest that encountering impasses may cause subjects to search for alternative problem spaces by adopting metastrategies such as noticing invariants of their previous failed solution attempts. In chapter 11, Dunbar suggests that the social pressure of conceding an impasse in the context of laboratory meetings forces scientists actively to consider alternative approaches, thereby leading to insights. Dunbar also reports that subjects in a laboratory experiment who conceded that their initial hypothesis was not succeeding in accounting for the data were forced to search for alternative interpretations and were consequently much more likely to move to a new approach that could lead to a solution. Discussions of historical examples of insights similarly suggest that the recognition of an impasse can lead individuals to attempt to search for new problem approaches. For example, Gruber (chapter 12) reports that Einstein's development of the fundamentally new approach to physics grew out of "his struggle to free himself from the assumption of absolute time."

Attributes Associated with the Ability to Find Alternative Approaches

Recognition that one needs to find a new way to approach a problem may be an important first step in the search for a new problem space, but one still needs to determine the alternative direction in which to progress. Unfortunately, the types of problems that elicit this kind of impasse are also the types of problems that provide few cues regarding which way to go (see Perkins, chapter 15). Accordingly, success in actively searching for a viable alternative approach requires would-be solvers to draw on a number of different attributes.

Perseverance One critical attribute involved in actively finding an alternative approach is simple perseverance. As Edison is often quoted as saying (Csikszentmihalyi & Sawyer, chapter 10), "Creativity is 99% perspiration and 1% inspiration." Many of the authors in this book note that finding the correct approach to a problem often involves simply trying out as many approaches as possible. In short, because the direction in which one needs to go is unclear, one may have to search a long time before getting anywhere. Consequently, as Simonton (chapter 14) observes, the individuals with the most creative contributions are also the ones who are the most productive: "The more shots at the target, the more bulls-eyes." Csikszentmihalyi and Sawyer (chapter 10) make a similar observation in their interviews of creative individuals. For example, one chemist remarked, "'You have lots of ideas, and throw away the bad ones'".

Risk taking As Simonton (chapter 14) observes, "For the kinds of problems on which historic creators stake their reputations, the possibilities seem endless, and the odds of attaining the solution appear nearly hopeless." Given that the odds for the big discoveries are always long shots, as Sternberg and Lubart (Chapter 16) note, important insights, like investments, may require a willingness to take risks. As Dunbar (chapter 11) observes, successful research laboratories often maintain a combination of low-risk and high-risk ventures, thereby enabling them to maintain some balance.

Playfulness A third attribute mentioned by a number of authors as necessary for finding alternative approaches to problems is an ability to toy with different options. For example, Finke (chapter 8) reports that creative inventions often result from subjects "manipulating the [preinventive] forms in playful ways." Isaak and Just (chapter 9) suggest that inventors' search for alternative operators for generating designs often requires "deliberate analogical and combinatory play," and Simonton concurs, stating, "Those people who make their minds accessible to the chaotic combinatory play will equally make their senses more open to the influx of fortuitous events in the outside world." Similarly, Ippolito and Tweney (chapter 13) report that Einstein considered combinatory play of selected sensory experiences to be "an essential feature in productive thought."

Broad knowledge In addition to having knowledge in one's own area of expertise, a number of researchers suggest it is important to have knowledge of a broad variety of areas, thereby enabling one to make connections that others might have missed (see Simonton, chapter 14; Dunbar, chapter 11; Sternberg & Lubart, chapter 16).

The ability to recognize analogies Finally, and perhaps most importantly, the ability to find alternative problem approaches requires the ability to recognize analogies. As virtually all the contributors to this book observe, analogies represent one of the central sources of insight. From the perspective of the present discussion, the value of analogy is that it may enable the individual to conceptualize better the ill-defined problem space in which he or she is working by relating it to some other problem space that is better defined.

The ability to recognize analogies draws on many of the attributes listed previously. In addition, it seems likely to depend critically on the individual's skill at extracting the basic elements of a problem at a sufficient level of abstraction to enable the recognition of the problem's similarity to domains that superficially appear to have little in common with it (see Lee, 1991).

The Flash of Insight: Overcoming an Impasse and Sudden Solution

Having reviewed the mechanisms underlying the formation and overcoming of the impasses to insight, we now must confront the central question of insight (at least, when it is defined as the sudden shift from an impasse state to a solution state): How is it that the solver moves so suddenly from an impasse to a solution state? We share the view that the sources of the suddenness of insight are closely aligned with those associated with the suddenness of various perceptual processes. Throughout our previous discussion of the causes and techniques for overcoming impasses, we have attempted to draw parallels between the processes of insight and those of perception. As noted, these parallels permeate psychological theories as well as our everyday vocabulary and expressions. Nevertheless, some researchers remain skeptical about the parallels between the suddenness of insight and perception (e.g., Weisberg, 1986). We offer here some new evidence demonstrating these parallels and then explore their possible sources.

Further Evidence for the Perceptual Nature of Insight
We have used throughout our discussion the analogy relating insight to recognizing out-of-focus pictures. Like insights, recognition of out-of-focus pictures can be hampered by mental set (e.g., Bruner & Potter, 1964) and facilitated by a simple cue. Moreover, apprehension of the contents of an out-of-focus picture typically is experienced as a sudden shift from an absence of any sense of what is depicted to a full identification of the picture's contents and configural properties. Given these parallels, we wondered whether insight and recognition of out-of-focus pictures might actually draw on some shared cognitive processes. To test this theory, Schooler, McCleod, Brooks, and Melcher (1993; for discussion, see Schooler & Melcher, in press) conducted an individual-difference study, correlating subjects' performance on eight standard insight problems with their performance on a variety of cognitive measures including vocabulary, Scholastic Aptitude Test math and verbal tests, embedded figures, need for cognition, anagrams, remote associates, categorization speed, mental rotation, noninsight problem solving, and, most importantly, recognizing out-of-focus pictures. Of all these measures, recognizing out-of-focus pictures was the single best predictor of insight performance, with a correlation coefficient of 0.45 ($p < .001$). Thus, it appears that the suddenness of insight and perception may be associated with some shared cognitive processes.

Potential Shared Sources of Suddenness in Perception and Insight
Having, we hope, persuaded the reader that parallels between the suddenness of perception and insight are worthy of consideration, let us now explore what some of the mutual sources of suddenness might be.

Not consciously mediated As Gruber (chapter 12) notes in drawing his analogy between insight and perceptual gap filling, both visual recognition and sudden insight share a "non-mediated quality.... That is, no intermediate process is detectable in conscious experience." The nonmediated quality of sudden insights is also a component of other researchers' characterizations. For example, Gick and Lockhart (chapter 6) discuss the final recognition of insight solutions as drawing on automatic, nonconscious processes. According to these authors, a "characteristic of insight is a transition to a solution state at least part of which does not involve conscious step-by-step reasoning." Similarly, Simon (1986) suggests that the suddenness of insight is comparable to the nonconsciously mediated process of recognition. Metcalfe's (1986) and Davidson's (chapter 4) results on the low warmth ratings preceding insight solutions further support the notion that subjects are not aware of the processes that induce insights. Additional empirical evidence for the nonmediated quality of many insights is suggested by a recent protocol analysis conducted by Schooler and Melcher (in press). In this study, we found that whereas a variety of elements of subjects' verbal protocols were predictive of noninsight problem-solving success, there was very little in the contents of subjects' insight problem-solving protocols that heralded success, suggesting that the critical processes were not reportable. The precise nature of the nonmediated recognition processes that lead to insight still need to be specified but, given the strong correlation between visual recognition abilities and insight recognition, it seems likely that pattern recognition processes may be involved in each. As our understanding of visual recognition mechanisms has become more highly advanced (e.g., Hopfield, 1982; Marr, 1982), it might be profitable to explore their applicability to the recognition of insight solutions.

Coherence A second quality that characterizes the suddenness of both visual recognition and insight solutions is the seeming nonambiguity of the recognized product. When an out-of-focus picture is identified, it is with a strong sense of certainty. The experience is "Oh, of course, it is a__________." Similarly with many insight problems, when a solution becomes apparent, it seems clear that it is correct. In both cases, the source of the nonambiguity may result from certain distinctive properties of the situations that elicit sudden recognition. Specifically, the recognition of both insight solutions and out-of-focus pictures frequently share two qualities: First, prior to the solution, there are a number of problem elements that are presented together but lack coherence; second, when the solution is found, distinct coherence in the relationship between the problem elements is perceived. In the case of the out-of-focus picture, suddenly all the disparate shadings and features congeal to produce a single coherent image. Similarly with insight, when the solution is seen, all the parts suddenly seem to fit together. This analysis suggests that suddenness of both insight and visual recognition may be associated with situations for which there exists a potential source of coherence that can unite a seemingly disparate set of elements. Alternatively, rather than replacing a sense of noncoherence, as in the case of recognizing out-of-focus pictures or Feynman's making order out of chaos, insights may be associated with situations in which one coherent pattern can substitute for another. Such coherence substitutions may be comparable to reversible perceptual images such as necker cubes, in which "elements at one moment are seen as one unity; at the next moment, another unity appears with the same elements" (Ellen, 1982, p. 324). Many insight problems and riddles (e.g., Gick & Lockhart, chapter 6) may be associated with situations in which one constructs a coherent representation and then suddenly shifts to an alternative coherent representation.

The Gestalt psychologists referred to this coherence as the *gestalt*, a view that some have criticized owing to the lack of precision with which *gestalt* was defined (e.g., Weisberg & Alba, 1982). We suggest that the notion of gestalt or problem coherence simply be equated with the basic constructs of pattern recognition. In short, our cognitive information-processing systems may be structured to recognize coherent patterns of information in the environment in a manner comparable to that by which the visual system determines invariances in the visual world and uses its knowledge of those invariances to classify what it encounters. This view is supported by the work of Anderson and L. Schooler (1991), which suggests that memory is remarkably attuned to patterns of information in the environment in a manner comparable to that with which perception is sensitive to the invariances in the physical world (see also, Gibson, 1979; Marr, 1982).

RELATING INSIGHT TO OTHER TYPES OF THOUGHT

The question of the relationship of insight to other types of problem solving has been a source of some controversy. At one end of the spectrum is the suggestion that insight processes are outside the purview of cognitive science (e.g., Wertheimer, 1985). At the other end is the suggestion that insight is indistinguishable from other types of problem solving (e.g., Weisberg, 1986). However, the view represented by the majority of contributors to this book is that insight can be characterized within the framework of standard cognitive psychological constructs while at the same time being distinguished from other types of problem solving. Having already reviewed how insight may be conceptualized within the context of standard cognitive constructs, we now turn to how it may be distinguished from other types of problem solving.

Noninsight Problem Solving

A number of researchers have distinguished insight problem solving, which involves a sudden discovery of a solution, from noninsight problem solving, in which the would-be solver engages in a series of incremental arguments, each building on the past and leading gradually to a solution (e.g., Davidson, chapter 4; Metcalfe & Wiebe, 1987). Understanding the reason for this difference between insight and noninsight problem solving may be best accomplished by considering the respective sources of their difficulty. As suggested earlier, the fundamental difficulty for solving insight problems may be recognizing an approach that will lead to the solution. As we have argued, once the approach is recognized, the solution may be immediately apparent (but see discussion under the heading, Hybrid Problem Solving). Thus, the processes involved in insight problem solving are likely to be associated in large part with what we term *approach-recognition*, which entails identifying the possible operators that are available. In contrast, with noninsight problem solving, the correct approach to the problem may be recognized at the outset; however, the difficulty for solving these types of problems may be successfully executing the operators necessary to fulfill that approach. Thus, the processes involved in noninsight problem solving are likely to be associated in large part with what we term *approach-execution*, which involves successfully deciding among and executing the identified operators. In terms of the visual-spatial metaphor, the constraint for insight problem solving is to see where to go, whereas the constraint for noninsight problem solving is to move oneself successfully to the readily perceived destination.

This characterization of the differences between insight and noninsight problem solving suggests that the two types of problem solving should differentially rely on various skills. Insight problem solving should rely relatively more on pattern-recognition processes, whereas noninsight problem solving should rely more on reasoning skills and the ability to maintain a representation of where one is and where one is going. Recent findings in our laboratory support these predictions. In an individual-difference study we found that, although the recognition of out-of-focus pictures is highly correlated with insight problem solving, it is not significantly correlated with noninsight problem solving, which supports the notion that insight problem solving may rely particularly on the ability to recognize an effective approach, given seemingly disparate information. Evidence for the unique demands of noninsight problem solving was provided in our recent protocol analysis. Specifically, we found that, whereas the use of logical arguments was not predictive of successful insight problem solving, it was highly predictive of noninsight problem solving, which supports the notion that noninsight problem solving relies particularly on the ability to reason through a set of arguments. In addition, we found that frequently rereading the problem was negatively correlated with noninsight but not insight problem solving. This suggests that compared to insight problem solving, noninsight problem solving may place greater demands on the solvers' ability to maintain a representation of the problem conditions (where one started) and the goal conditions (where one needs to end up).

Hybrid Problem Solving

Insight problems may tend particularly to tap approach-recognition skills and noninsight problems approach-execution skills, but many problems may tap both types of skills. For example, although Davidson (chapter 4) found that her selective comparison and selective encoding problems behaved like typical insight problems with respect to warmth ratings (i.e., abrupt increase of warmth at the time of solution), her selective combination problems showed characteristics of both insight and noninsight problems. These elicited an initial abrupt increase in warmth ratings followed by a further gradual increase as the solution was approached. Such a pattern of results suggests that selective combination problems elicit the initial constraint of finding the correct problem approach but that once that approach is recognized, a number of operators still must be executed before the solution is found. As Davidson (chapter 4) notes, "Once they have an insight about how to reach a solution, subjects must still work out the details."

The alternation between the approach-recognition skills required for insight and the approach-execution skills required for noninsight problems seems to characterize most real-world types of problem solving. As many authors note, moments of inspiration (or approach-recognition) are typically intermingled with periods of fleshing out the inspiration. For example, Gruber (chapter 12) and Csikszentmihalyi and Sawyer (chapter 10) illustrate how inspirations typically occur within the context of a larger step-by-step analysis of a problem. Isaak and Just (chapter 9) suggest that inventions require the alternation between the generation of possible approaches to the problem and the subsequent analysis of the viability of those approaches. Finke (chapter 8) similarly suggests that invention may involve successive iterations of generation and exploration. In short, many creative endeavors may follow a cyclical process involving viewing the problem to determine where to go, implementing a set of procedures to get to the viewed destination, reviewing the problem from the new vantage point to determine the next step, and so on.

USING THE WRONG PROCESS AT THE WRONG TIME

The notion that creative thought can require alternations between approach-recognition and approach-execution raises the prospect that one might be led to engage in the wrong process at the wrong time. In fact, in a recent series of experiments, Schooler, Ohlsson, and Brooks (1993) found evidence suggesting that the use of language, while suitable for the problem execution demands of noninsight problems, may lead subjects to fail to apply the nonreportable approach-recognition processes required by insight problems.

Over the past several years, our laboratory staff has been documenting the disruption that can ensue when subjects are asked to verbalize tasks associated with nonreportable processes. For example, in a number of studies, we have found that verbally describing a previously seen face can interfere with subjects' subsequent ability to recognize that face (e.g., Schooler & Engstler-Schooler, 1990; Fallshore & Schooler, submitted). Our interpretation of this result, termed *verbal overshadowing*, is that verbalization may emphasize verbalizable processes at the expense of nonverbalizable ones. Consistent with this view, we have found that verbalization disrupts a wide variety of tasks hypothesized to involve nonreportable processes, including color recognition (Schooler & Engstler-Schooler, 1990), taste judgments (Wilson & Schooler, 1991), aesthetic evaluations (Wilson, Lisle, Schooler, Hodges, Klaaren & Lafleur, 1993), visual imagery (Brandimonte, Hitch & Bishop, 1992; Brandimonte, Schooler & Gabbino, 1993), and implicit learning (Fallshore & Schooler, 1993). In contrast, verbalizalion does not seem to impair tasks that involve more readily verbalizable attributes, including statement-recognition (Schooler & Engstler-Schooler, 1990) and face-recognition situations that elicit consideration of relatively verbalizable individual features as opposed to the relatively nonverbalizable configural properties (Fallshore & Schooler, submitted).

Given that insight problem solving often is associated with nonreportable processes (including processes potentially highly comparable to perceptual recognition), Schooler, Ohlsson, and Brooks (1993) speculated that insight might also be vulnerable to verbalization. To explore this hypothesis, Schooler and colleaques had subjects engage in verbalization (thinking aloud) while solving insight and noninsight problems. Compared to the silent control subjects, subjects who verbalized were substantially less likely to solve the insight problems but exhibited no decrement on the noninsight problems. Schooler and colleagues' interpretation of this finding was that verbalization may have caused subjects to focus on the reportable reasoning process associated with noninsight problem solving, thereby interfering with the nonreportable approach-recognition processes required by insight problems.

CONCLUSION

The notion that verbalization may interfere with insight takes on particularly troubling dimensions in the context of a book on insight. Just as explaining a joke can cause it to lose its humor, discussants of insight may find it challenging to be insightful. Although the basic mechanisms of insight lend themselves to scientific scrutiny, we may still feel, when all is said and done, that something is missing. It seems likely that our understanding of the insight processes discussed in this book (such as forgetting, operator selection, representation construction, and perceptual pattern recognition) ultimately may be sufficient to characterize the basic aspects of insight such that we can program a computer to elicit insightful behavior (see Simon, 1986). However, even that level of explanation may still feel incomplete. Indeed, while we may be able to explain the source of the affective component of insight (for example, as resulting from the discovery of an unexpected coherence between seemingly disparate items), we may never be able to explain the feeling itself. One might approach a description of the feeling of insight through metaphor: For example, insight feels the way a blind person might after suddenly acquiring sight. However, in using metaphor, we must be ever cautious not to confuse the metaphor with the object being discussed. The feeling of insight may be similar to gaining sight, but it is not identical. The process of insight may mimic visual pattern recognition, but they remain distinct. So, too, insights may only resemble the insightful computer outputs to which scientific analyses such as those in this book may someday lead. The inability of any single metaphor to illuminate all of the facets of insight suggests that we should remain ever on the look out for alternative ways of viewing insight.

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