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Chapter 5

The Ineffability of Insight

Jonathan W. Schooler and Joseph Melcher

Language can become a screen that stands between the thinker and reality. That is the reason why true creativity often starts where language ends.
Arthur Koestler, *The Act of Creation*.

We often cannot say from where a creative idea came. Such insights can seem to pop into mind, as if from nowhere. This ineffable quality of creativity has frequently elicited mystical views. The ancient Greeks believed that creativity occurred only by the grace of the muses, and to this day many people attribute their creative inspiration to religious or mystical sources. Scientific reactions to the phenomenologically elusive character of creativity have taken two general forms. Many theorists developed approaches to creativity that rely heavily on unconscious processes (Koestler 1964; Simonton 1988). Others attempted to dismiss the elusiveness of creativity altogether and suggested that creative processes are fully accessible and not qualitatively different from other forms of reasoning (Perkins 1981; Weisberg 1986). Researchers who dismiss the importance of the nonreportable aspects of creativity seem to feel that accepting such processes promotes the enigma of creativity and interferes with the successful investigation of the basic cognitive processes on which creativity must be based (Weisberg 1986).

Far from closing the door on creativity, the hypothesis that creativity involves nonreportable processes leads to a number of fruitful research pursuits. First, the nonreportability of creative processes suggests a rather intriguing hypothesis about the possible effects of language on creativity: if certain creative processes cannot be adequately captured in words, then attempting to articulate such processes may actually be disruptive. In fact, recently Schooler, Ohlsson, and Brooks (1993) have produced evidence supporting this claim. Second, although the suggestion that some creative processes cannot be articulated necessarily constrains the informativeness of self-reports, it does not eliminate their value. Comparing self-reports of tasks that vary in their hypothesized use of creative nonreportable components may be helpful specifically because they can help to reveal what is absent from the self-reports of creative processes. Finally, the suggestion that creative processes cannot be fully articulated does not imply that they must remain mysterious. Indeed, there are other nonreportable processes, such as those associated with perception and memory retrieval, that are accepted components of modern theories of cognition (e.g., pattern recognition, spreading activation). One way to examine the role of such processes is to use an individual differences approach to determine the correlation between performance on tasks requiring creativity and tasks involving the nonreportable processes hypothesized to be associated with creativity. Using these approaches, we can begin to confront the enigma of creativity scientifically without denying its phenomenological ineffability.

In our view, many discussions of creativity have been hampered not only because their subject matter is so elusive but also because the domain of creativity is conceived so broadly. Virtually any thought activity can in principle involve components that could be described as creative. Discovering an important new mathematical theorem certainly requires creativity, but so may figuring out where you left your keys this morning. It seems clear that the processes that contribute to these two examples of creativity differ markedly. Rather than considering the entire spectrum of creative processes, we focus on one of its components, insight, defined as the sudden solution to a problem that one has been working on without any sense of progress. The relationship between insight and creativity has been of some contention. Some argue that insight is the central component of creativity (Taylor 1988), while others suggest that it has no importance (Weisberg 1986). However, as Tardif and Sternberg (1988) note, "The majority view falls somewhere in between with 'flashes of insight' discussed as a small but necessary component of the creative process" (p. 430). If insight represents only a small portion of the full creative process, it nevertheless constitutes one of the major sources of ineffability with which discussions of creativity have grappled. Thus, if we want to explore the unreportable aspects of creativity, it makes sense to begin with insight.

Theoretical Characterizations of Insight

Over the years, there have been many records of individuals' experiencing sudden and profound realizations about problems for which they perceived themselves to be at an impasse. Readers familiar with

the creativity literature have probably read (ad nauseam) tales of Archimedes sitting down in his bath and suddenly realizing water displacement as a technique for measuring the volume of the king's crown and Poincaré stepping on a bus and abruptly recognizing the relationship between Fuchian functions and non-Euclidian geometry.

To add a fresh anecdote to the list, a front-page article in the *New York Times* on February 18, 1993, reported a medical student's (Yung Kang Chow) account of how he came to invent a technique that appears to be the first successful method for eliminating the AIDS virus from human cells in the test tube and also preventing the infection of healthy cells. Chow challenged the medical dogma that the treatment value of combining drugs is due to the fact that each drug attacks the disease at a different stage in the life cycle. His insight was that multiple drugs might work together at a single stage of the virus's life cycle.[1] This insight occurred to him as he reflected on his adviser's query about why patients could develop a resistance to each of two drugs and yet still benefit from their combination. Chow conveys the exhilarating surprise he experienced when he suddenly realized the misdirection of medical dogma and the implications of his alternative perspective: "I was reading during dinner, which is a bad thing to do . . . but I had to because I had so much to do that evening. I was thinking of ways to explain the phenomenon, and the idea just came to me in an instant. It was an inspiration, almost like 'Eureka', I was ecstatic jumping up and down and telling my wife that I think this was the most exciting thing I ever came up with because right away I realized the implications of the work."

This example has many of the classic qualities of insight discoveries. First, an impasse in solving the problem is produced because of the existence of unwarranted assumptions. A second quality, not necessary for insight solutions but often postulated to be helpful, is that the solver has sufficient but not excessive experience with the problem, thereby being less entrenched in the unwarranted assumption (Ellen 1982; Luchins 1942). Chow speculated, "Perhaps by virtue of being a graduate student and not having learned much medicine yet, I had much more naive insight into the problem." Finally, the solution appeared suddenly with no warning, instantly transforming Chow from worriedly eating his dinner to jumping up and down ecstatically. The suddenness of anecdotal insights may in some cases be exaggerated (Perkins 1981) but their persistent recurrence makes them difficult to dismiss. Moreover, researchers have also developed laboratory analogues of these discoveries using puzzle problems that elicit solutions possessing the same suddenness as that reported in the anecdotes of creative discoveries (Metcalfe and Wiebe 1987).

The suddenness of insight solutions has prompted many theorists to postulate a role of unconscious, and hence unreportable, processes. Accordingly, dismissing the possibility that the solutions truly come out of nowhere (as is often the phenomenological experience) means that the critical processes leading to insights are outside awareness. Many speculations regarding the nature of these unreportable processes were developed prior to the cognitive era of psychology and thus included terms and constructs that can seem rather imprecise to those steeped in the cognitive tradition. Indeed, the obscure quality of early approaches to insight may in part account for why some cognitive theorists have attempted to dismiss prior claims that insight relies on important nonreportable processes. Cognitive theorists who have considered the nonreportable aspects of insight as an issue worthy of explanation have sought to avoid the vagueness that plagued their predecessors by defining the issue using basic cognitive constructs. In so doing, these approaches have recast the valuable ideas of past approaches. Generally modern approaches have been largely successful in adopting the useful elements from past approaches. However, at least one useful idea from the past seems not to have made the cut: some insight processes, by virtue of their nonreportability, may actually be disrupted by language. We now turn to a brief review of past and current approaches to insight and then discuss our attempts to salvage this abandoned notion of the potential negative effects of language on insight.

Pre–Information Processing Approaches

Pre–information processing approaches to insight explored a number of overlapping elements of insight: the notions of restructuring, context-induced mental set, unconscious idea recombination, and the suggestion that more than merely inconsequential to insight, language, and logic might actually impair the insight process.

Restructuring Gestalt theorists argued that insights often involve restructuring the problem in a manner similar to the classic perceptual figure-ground reversals (such as the Necker cube or the vase-face illusion) (for a review see Ohlsson 1984). Restructuring was conceived of as involving a global shift in one's perspective of the problem, such that the solver initially sees the problem one way but in an entirely different light the next moment. Drawing parallels between problem solving and perception, the Gestaltists further suggested that such restructurings or perspective shifts followed principles comparable to the notions of "good form" used to account for perceptual organization. The unsolved problem was seen as creating unacceptable gaps that the brain naturally tried to close by restructuring processes (Wertheimer 1959). Although the Gestalt tradition never adequately articulated the precise mechanisms by which restructuring occurred, they did note a number of conditions that they viewed as most likely to lead to restructuring. First, it was critical that the problem solver devote sufficient concentration to the problem to enable a holistic representation whereby the problematic gaps would emerge. Second, although effort was required to establish the perception of gaps that lead to restructuring, the actual restructuring process itself was believed to be passive and nonconscious, thus accounting for the surprise quality of the insight.

Context-Induced Mental Set A related theme in historical treatments of insight that also emerged from the Gestalt tradition was the view that the context of a problem could fixate subjects into adhering to particular unwarranted assumptions, thereby preventing the consideration of alternative approaches. Duncker (1945) used the term *functional fixedness* to convey the idea that when people perceived objects in the context of their standard functions, they assumed the objects must be used in their usual manner. Fixedness thereby made individuals unable to consider an atypical application of the object, for example, using a tool as ballast for a pendulum in order to tie two strings together. Discussions of the mechanisms involved in producing the insight that can occur when subjects overcome such context-induced fixations often emphasized the importance of nonreportable components. For example, Maier (1931) asked subjects to report retrospectively their solutions to the two-string problem in which they had been given a seemingly accidental hint by the experimenter. Subjects who could report the stepwise construction of the solution also reported the hint and its effect on their problem solution, but subjects who reported the solution as having arrived in a flash of insight gave no evidence of being aware of the hint. Others, such as Koestler (1964), Poincaré (1952), and Wallas (1926), suggested that new approaches could result from an incubation period in which the subconscious searched for new combinations of ideas. It should be noted, however, that not all of the precognitive theorists claimed that putting a problem aside necessarily elicited complex, unconscious processes. Some suggested that a break simply facilitated the forgetting of inappropriate approaches (Woodworth 1938).

Unconscious Idea Recombination A third component of a number of the original approaches to insight followed from anecdotal reports of important scientific and mathematical discoveries involving the sudden connection of diverse ideas. Such claims led theorists to speculate that the unconscious may combine and recombine previously unrelated ideas. Poincaré (cited by Koestler 1964) expressed this view using the analogy of ideas as atoms hooked to a wall, some of which become loosened when individuals initially think about a problem. During incubation, these loosened ideas become detached and recombine: "During a period of apparent rest and unconscious work certain of them are detached from the wall and put into motion. They flash in every direction through space . . . like the molecules of gas in the kinematic theory of gases. Then their mutual impacts may produce new combinations" (p. 165). Poincaré observed that such combinations typically would be of no value but occasionally would produce fruitful results whose aesthetic quality would be appreciated by the unconscious and therefore delivered to consciousness. Similar theories of unconscious idea recombination were proposed by Wallas (1926), Hadamard (1954), Koestler (1964), and others, all sharing the basic view that insight results from the sudden appearance in consciousness of ideas that had been recombined in the unconscious. These theories differed primarily with respect to the specific mechanisms of recombination and in particular the degree to which the unconscious was guided by intelligent versus random processes.

The Constraint of Language on Insight The suggestion that insight does not rely on the language and logic that mediates conscious thought led some of the original insight theorists to speculate that these elements of consciousness might in fact impede insight. For example, Koestler (1964) suggested that language and logic served as "constraints which are necessary to maintain the discipline of routine thoughts but may become an impediment to the creative leap" (p. 169). With respect to language he further noted that "words are a blessing which can turn into a curse. They crystallize thought; they give articulation and precision to vague images and hazy intuitions. But a crystal is no longer fluid" (p. 173). Koestler argued that the price of language's ability to crystallize thought is that it can prevent distant connections. The remedy for this constraint of language is the unconscious, in which "more primitive levels of mental organization are brought into activity" (p. 169). According to Koestler, by ignoring the laws of logic and language that constrain conscious thought, the unconscious is capable of bringing together thoughts that would be too rigidly distinct to be connected consciously. Similar views regarding the constraints of language were also noted by others. For example, Hadamard (1954) vehemently asserted, "I insist that words are totally absent from my mind when I really think . . . and I fully agree with Schopenhauer

when he writes, 'thoughts die the moment they are embodied in words'" (p. 75). While these authors' discussions of the nonlanguage-based process that leads to insights may seem imprecise in the context of modern information processing views, the basic premise that conscious thought, and in particular language, may restrict creative leaps represents a hypothesis of some merit. Nevertheless, perhaps because this view was often tied to some of the most fanciful discussions of insight (Koestler 1964) it was left out of many of the subsequent information processing views of insight.

Information Processing Views of Insight

The enigmatic unconscious processes that have historically been proposed to account for insight may have discouraged serious information processing theorists from tackling this sticky issue. In addition to its historical association with questionable theories of the unconscious, as Ohlsson (1993) observed, the construct of insight is also somewhat of a challenge to the information processing view that problem solving represents the stepwise implementation of symbol manipulation. In the light of these difficulties, a number of the initial information processing examinations of insight were conducted in an effort to dismiss all of its alleged elusive qualities. We briefly review these information processing repudiations of insight and then consider cognitive approaches that have taken a more sympathetic view of insight.

The Dismissal of Insight Weisberg (1986) and Perkins (1981) provide forceful arguments for dismissing the view that insight is distinguished from other types of problem solving by its sudden appearance and reliance on nonreportable processes. Weisberg rejects the involvement of unreportable cognitive processes in creativity by challenging the anecdotal evidence on which the early claims of such processes were based. Drawing on evidence that providing subjects with hints to the solution to so-called insight problems does not bring about immediate success, he further denounces the suggestion that insight involves global and sudden shifts in perspectives and argues that insight problem solving encompasses the same incremental steps used in other types of problems. He concludes that "there seems to be 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).

Perkins (1981) shares Weisberg's skepticism that insight problem solving differs from other types of problem solving and further advocates the view that elements of insight problem solving are readily reportable. He based his conclusion in part on an analysis of subjects' retrospective reports of how they solved an insight puzzle problems (specifically problem C used in our studies, see box 5.1 later in this chapter). Perkins observed that whereas some subjects retrospectively reported leaplike experiences, the majority reported solving the problems in a more piecemeal, stepwise fashion. Because these verbal reports reflect subjects' underlying processes, Perkins further suggests, there should be no concern that language might interfere with the solving of so-called insight problems.

Reconceptualizing Insight Constructs Using Current Theories of Cognition
Although a number of information processing approaches have sought to dismiss insight as a distinct type of problem solving, other approaches manage to reconceptualize many of the earlier aspects of insight theorizing within a modern cognitive framework.

Restructuring. Current conceptualizations of problem restructuring focus on the notion that insight solutions may require shifting to a new problem space (Ohlsson 1984). In other words, the difficulty in many insight problems is to find a representation of the problem that enables it to be readily solved. Using protocol analysis for an extremely difficult insight problem (the mutilated checkerboard), Kaplan and Simon (1990) found evidence that subjects spent most of their time searching for an appropriate way to represent the problem. Once the correct representation was found, the solution followed quickly.

With respect to the mechanisms involved in restructuring, Kaplan and Simon suggest that the re-representation of problems involves a memory search for a new problem space comparable to that involved in searching within a problem space. Others, however, recovered the Gestalt view of the importance of perception. For example, Ellen (1982) suggests that the suddenness of insights makes them especially akin to figure-ground reversals in which "elements at one moment are seen as one unity, at the next moment, another unity appears with the same elements" (p. 324). Still others, such as Ohlsson, propose that either memory search or perceptual reencoding may be involved, depending on the problem.

Context-induced mental set. The notion that the context of a problem can cause subjects to adhere to false assumptions has also been incorporated into current cognitive conceptualizations of insight. In modern terms, fixedness is conceptualized as excessive activation of inappropriate operators—that is, the knowledge and actions that one attempts to use to solve the problem (Ohlsson 1993). From this perspective, one benefit of an incubation period is that it enables the activation to dampen, thereby increasing the likelihood that other, more useful

operators will be accessed on subsequent attempts (Simon 1986; Smith and Vela 1991). Empirical support for this view was recently provided by Smith and Blankenship (1989) using a paradigm in which subjects were given insightlike problems with either helpful or misleading hints. Smith observed a benefit of incubation only for subjects who received the misleading hints, suggesting that the main benefit of the incubation period was to enable the decay of activation of the misleading hint.

Unconscious idea recombination. Even the suggestion that insight may entail unconscious search processes for new combinations has made its way into some of the current cognitive conceptualizations. In this case, unconscious search and combinations are viewed as consequences of spreading activation. Accordingly, activation of ideas during problem solving may spread to related concepts. With sufficient activation, critical operators may rise above the threshold of awareness and become available to solve the problem. Such unconscious spreading activation mechanisms have been incorporated into a number of theories of insight (Langley and Jones 1988; Ohlsson 1993; Yaniv and Meyer 1987) and have even received some empirical support. For example, Bowers and associates (1990) and Bowers (1991) looked at the attempted responses provided by subjects who were unable to generate the correct solution to "insight-like" problems such as recognizing distant semantic associates (e.g., What word relates to both *arsenic* and *shoe*?) and solving anagrams. Bowers observed that incorrect guesses often had some semantic relationship to the correct solution, indicating that solution-relevant information was being activated and implying that this subawareness activation may have contributed to the solving of the problem. Bowers and associates concluded, "The suddenness with which insights sometimes occur thus represents an abrupt awareness of a mental product or end state generated by more continuous, sub rosa cognitive processes" (p. 95).

Constraints of language. Although there is debate about the role of nonreportable processes in current conceptualizations of insight, nonreportable processes are centrally involved in a number of current theories. Moreover, even some of the theorists who reject the possibility of nonreportable search mechanisms acknowledge that nonreportable processes may play an important role in insight. As Simon (1966) observed, "The subconscious plays a major role in modern theories of motivation, emotion and psychopathology. There is no a priori reason, then, to assign the problem-solving process to the conscious rather than the unconscious" (p. 30). Despite current theorists' advancement of previous claims that insight may involve nonreportable processes, they generally have not taken their predecessors' further step of suggesting that language might actually interfere with insight. For example, Simon, one of the central architects of cognitive approaches to problem solving, acknowledges a role of subconscious processes in insight. Nevertheless, in other writings, he strongly asserts that verbal reports, when properly elicited, should not impair performance other than possibly slowing it down slightly (Ericsson and Simon 1984). As we shall see, current faith in the nonreactivity of language is open to question, which in turn reopens the door for earlier suggestions that language may disrupt insight.

Empirical Demonstrations of the Disruptive Effects of Language

Recently, we and others have been finding evidence that verbalization can interfere with a variety of tasks hypothesized to involve nonreportable processes.

A natural starting place for examining nonverbal thought is face recognition. As the philosopher Polanyi (1967) noted: "I shall reconsider human knowledge by starting from the fact that we can know more than we can tell. . . . Take an example. We know a person's face, and can recognize it among a thousand, indeed a million. Yet we usually cannot tell how we recognize a face. So most of this knowledge cannot be put into words" (p. 4). The clear nonreportability of much of the information involved in recognizing faces suggests that if verbalization can disrupt nonreportable processes, then face recognition is a sensible place to look for evidence for such verbal disruption. Consistent with this view, Schooler and Engstler-Schooler (1990) observed that verbalizing the appearance of a previously seen face markedly interfered with subjects' ability to recognize that face from an array of similar ones. Additional studies supported the interpretation that verbalization may emphasize verbalizable attributes of the stimulus while overshadowing the critical nonreportable information necessary for optimum performance. For example, visualization was found to have no negative effects on face recognition; however, verbalization was found to disrupt the recall of other nonreportable stimuli (color) while marginally improving performance on a readily reportable stimulus (a spoken statement). Similar disruptive effects of verbalization have been observed in a variety of other domains hypothesized to rely on nonreportable processes or information, including taste judgments (Wilson and Schooler 1991), aesthetic evaluations (Wilson et al. 1993), visual imagery (Brandimonte, Hitch, and Bishop 1992), and implicit learning (Fallshore and Schooler 1993). Of greatest relevance here are a recent series of studies examining the effects of verbalization on insight problem solving.

Schooler, Ohlsson, and Brooks (1993) compared the effects of concurrent, nondirected verbalization on subjects' ability to solve insight and noninsight problems. The insight problems were comparable to the "aha" type of problems used by other investigators of insight (see table 5.1). The noninsight problems were comparable to the logic problems used in the analytic section of the Graduate Record Examination and used by other researchers comparing insight to noninsight problems (Metcalfe and Wiebe 1987). (For ease of reference we will henceforth refer to these noninsight problems as analytic problems.) The main result of this series of studies was that concurrent verbalization markedly impaired insight problem solving while having no effect on the solving of analytic problems of comparable difficulty.

A number of possible interpretations of the disruptive effects of verbalization on insight were considered. For example, verbalization might consume processing resources that otherwise would have been available for the problem-solving effort (Russo et al. 1989). This explanation predicts that performance on noninsight problems of comparable difficulty should also be reduced by verbalization, a prediction that turned out to be unfounded. A related alternative explanation for the effect of concurrent verbalization is that it slows problem solving without qualitatively altering it. However, there was no difference between the solution times of insight problems in the verbalization and control conditions. A final possibility was that subjects, when thinking aloud, were reluctant to reveal to the experimenter that they perceived themselves to be on the wrong track and hence continued with the wrong approach in order to avoid the appearance of seeming inconsistent or scattered. To investigate this possibility, subjects in one of the experiments were given a hint that described the "mindsets" associated with insight problems. These subjects were advised that some of the problems were of this nature and suggested that when they felt they were working on such problems they should try approaching the problem from a new perspective. Two minutes into each problem, the experimenter reminded them of this hint. Even with this strong encouragement to consider alternative approaches, the negative effect of concurrent verbalization was maintained, suggesting that subjects were not simply sticking with the inappropriate approach in order to follow the potential implicit demand to maintain a consistent approach to the problem.

In the absence of a compelling alternative explanation and in the light of the variety of other demonstrations that nonreportable processes can be vulnerable to verbalization, these findings were interpreted as being most compatible with the hypothesis, first suggested by the early insight theorists, that language can disrupt nonreportable processes that are critical to achieving insight solutions. It must be conceded, however, that this study did not report any direct evidence that insight problem solving involved nonreportable processes, other than the fact that the insight problems were uniquely susceptible to verbalization. Since the publication of this study, we have uncovered additional direct evidence supporting the suggestion that our subjects were more reliant on nonreportable processes when they solved insight as compared to analytic problems. This evidence emerged from careful examination of the contents of subjects' protocols.

A Comparison of Insight and Analytic Problem-Solving Protocols

Readers may wonder what we might expect to find in the protocols of subjects' solving insight problems if, as we claim, the processes leading to insight are truly nonreportable. Nevertheless, even if the processes associated with insight problem solving are nonreportable, we still may be able to see by-products of these processes in subjects' self-reports. More important, if protocols of insight problem solving differ from those associated with analytic problems with respect to the degree to which they provide information about the steps subjects used to reach their solutions, then this observation in itself would provide evidence that insight problems do not rely on the reportable processes associated with other types of problems.

Our specific predictions regarding differences between insight and analytic problem-solving protocols were based on some of the previously mentioned characterizations of the difference between these two types of problems. To recap, insight and analytic problem solving can be conceptualized as differing with respect to the degree to which their solutions rely on a stepwise set of logical arguments. According to this view, analytic problems entail a series of incremental arguments, each building on the previous one and leading ultimately to a solution. In contrast, insight problems elicit an initial impasse in which subjects are unaware of making any progress as they struggle simply to determine the right approach to tackle the problem. Ultimately, we hypothesize that nonreportable memory and perceptual processes provide a new view of the problem that leads to sudden solutions. This characterization makes some rather specific predictions about differences between the two sets of protocols. Analytic problems would be expected to involve greater use of logical arguments, the bricks and mortar on which solutions to these problems are built. Insight problem solving's greater reliance on nonreportable processes

suggests that subjects should be more likely to pause while trying to solve insight as compared to analytic problems. Insight problems would also be expected to contain more metacognitions, reflecting subjects' struggle to find the right general approach for solving the problem.

In addition to differences in the overall frequency of different types of problem-solving components, our characterization also suggests predictions about the correspondence of protocol elements with actual performance. If, for example, the use of logical argumentation is critical for analytic but not insight problem solving, then argument usage should be relatively more predictive of success on analytic as compared to insight problems. Additionally, if the critical components to the solution of insight problems are nonreportable, then there should be little in the contents of subjects' reports that will predict their success. Indeed, the one attribute that might be predictive of success on insight problems is the frequency with which subjects stopped verbalizing and allowed the nonreportable process to proceed unhampered.

Method/Coding Scheme

In order to test these predictions, we transcribed the "think-aloud" protocols of the 40 verbalization subjects who participated in experiment 4 of Schooler, Ohlsson, and Brooks (1993).[2] The six problems that subjects attempted to solve (three insight and three analytic) are presented in box 5.1. Each transcript was exhaustively coded according to a set of categories whose development was guided by the literatures on protocol analysis (Chi 1992; Ericsson and Simon 1984; Ohlsson 1990), noninsight problem solving (Chi et al. 1989; Chi and VanLehn 1991; Voss et al. 1983), insight problem solving (Ohlsson 1993), and mental modeling (Collins and Gentner 1987). The coded segments were defined as thought units—the smallest coherent or complete statements (whole or partial sentences). Definitions for the final set of coding categories are presented in box 5.2. The first section of the table defines the three categories that we predicted would distinguish insight from analytic problems; we had no particular predictions for the other categories.

Three persons coded the 40 protocols in a consistent two-step process. First, the raters worked through two protocols together. Second, the raters separately coded a third protocol, exhaustively compared their codings, and resolved discrepancies through discussion. Step 2 was repeated once again, by which time the prediscussion interrater agreement had reached 85 percent. (This value is likely to be a conservative estimation for the remaining protocols because we later collapsed a number of the more subtle category distinctions.)

Box 5.1
Insight and Analytic Problems used in Experiments 3 and 4

Insight problems

A. Show how you can make the triangle point downward by moving only three of the circles:

Solution:

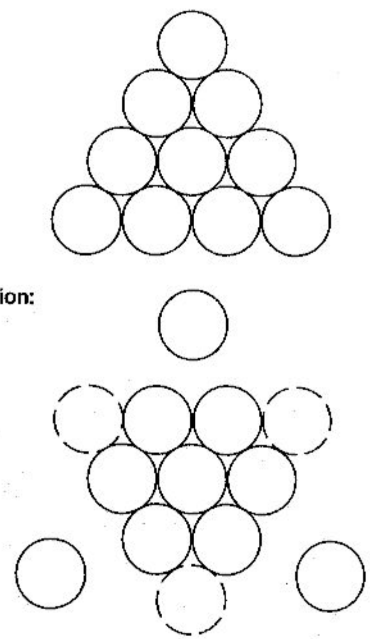

Figure 5.1
Diagram and solution for the "triangle" problem

B. A prisoner was attempting to escape from a tower. He found in his cell a rope that was half long enough to permit him to reach the ground safely. He divided the rope in half and tied the two parts together and escaped. How could he have done this?

C. A dealer in antique coins got an offer to buy a beautiful bronze coin. The coin had an emperor's head on one side and the date 544 B.C. stamped on the other. The dealer examined the coin, but instead of buying it, he called the police. Why?

Analytic problems

D. Three cards from an ordinary deck are lying on a table, face down. The following information (for some peculiar reason) is known about those three cards (all the information refers to the same three cards):

Box 5.1
(continued)

To the left of a Queen, there is a Jack
To the left of a Spade, there is a Diamond
To the right of a Heart, there is a King
To the right of a King, there is a Spade

Can you assign the proper suit to each card?

E. The police were convinced that A, B, C, or D had committed a crime. Each of the suspects made a statement, but only one of the statements was true:

A said, "I didn't do it."
B said, "A is lying."
C said, "B is lying."
D said, "B did it."

Who is telling the truth? Who committed the crime?

F. There are four coins—two heavier coins of equal weight and two lighter coins of equal weight—all distinguishable in appearance or by touch (you cannot tell them apart by looking at them or holding them). How can you tell which coins are the heavy ones and which coins are the light ones in two weighings on a balance scale? (You may use the scale only twice.)

Using Fisher's (1991) computer program we obtained the frequency of category occurrence for each subject by problem type. The statement frequencies of each subject's insight and analytic protocols were then converted into a percentage of the total number of coded elements that each subject's protocol contained for that problem type. So, for example, a subject who made 12 MOVE statements during the course of 240 coded statements would have 5 percent MOVEs for the particular type of problem.

Table 5.1 shows the percentages for each problem-solving category. Comparison of the relative preponderance of different categories in the insight and analytic problems, collapsed across hint conditions, revealed a number of differences consistent with our predictions. Before discussing these differences, however, we should note that in many respects the usages were quite similar for insight and analytic problems. The rank orders of elements were very similar for the two problem types as indicated by a Spearman rank order correlation of .95 between insight and analytic problems. The absence of relative rank order differences for these various statement elements suggests that there are certain basic problem-solving characteristics that generalize between insight and analytic problems. Nevertheless, exami-

Box 5.2
Definitions of Protocol Coding Categories

Categories predicted to distinguish the two types of problems

ARGUMENT: Any kind of reasoning, logic, propositional (e.g., if-then statements), or means-ends analysis.
METACOGNITION: Self-reflective comments about the subject's problem-solving progress, technique, perspective, impasses, etc.
PAUSE: Breaks in verbalization lasting between 5 and 15 seconds (after 15 seconds, the experimenter prompted subjects to continue verbalizing their thoughts).

Other statement elements

REREAD: Verbatim rereading of all or a part of the problem, there were two types:

1. Reread premise: Reread a single problem premise, constraint, or goal.
2. Reread entire: Reread the entire problem.

REHEARSE: Any attempt to state, draw, rehearse, etc., some aspect of the problem or its status, a large proportion of rehearses were paraphrases of the problem elements or their premises.
MOVE: To assign a new physical position or categorical name to a problem element. Subjects often prefaced moves with "maybe" or "you could" or "assume that." Also, to state hypotheticals for the purpose of argumentation.
RECALL: To retrieve relevant world knowledge from memory.
QUESTION: To ask a question other than the nominal problem question. There were two types:

1. Asking oneself a question.
2. Asking the experimenter a question.

SOLUTION: The actual or presumed solution. The subject had to announce it as such unless it was clear from the context. There were three types:

1. Correct solutions.
2. Incorrect solutions (including partial solutions).
3. Solve-not (subject failed to solve a problem during the allotted time of 6 minutes).

FEEDBACK (from the experimenter): To inform subjects of incorrect solutions (often noting the reason the proffered solution was incorrect) or the need to adhere to problem constraints. Feedback was also given in response to direct questions from the subject.
MISCELLANEOUS: Otherwise uncodable fragments, such as inaudible statements, mumbling, or incomplete fragments of thought.

Table 5.1
Percentages of Protocol Problem-Solving Elements with Predicted Differences

	Insight Problems	Analytic Problems
ARGUMENT	12.05	19.85
METACOGNITION	8.09	2.89
PAUSE	4.70	2.58
Other elements		
REREAD	14.93	29.97
REHEARSE	19.27	17.93
MOVE	8.89	5.88
RECALL	1.03	0.04
QUESTION-SELF	2.11	0.97
QUESTION-EXPERIMENTER	4.48	2.04
SOLUTION-INCORRECT	5.08	2.92
FEEDBACK	11.38	7.25
MISCELLANEOUS	5.82	4.40
Totals[a]	97.83	96.72
Total elements	3,333.00	4,668.00

a. Totals are less than 100 percent because they do not include the terminal states (correct solutions, failure-to-solve, or, in the HINT condition, the "hints").

nation of the relative usage of specific statement elements that we hypothesized differentiate these two types of problems provides compelling evidence that despite a superficial similarity in approaches, insight and analytic problem solving also differ in significant ways.

Differences between the Statement Elements of Insight and Analytic Problems
With respect to the elements that characterize analytic problems, we had one central prediction: that these problems, by virtue of their reliance on a step-by-step logical solutions, would include a greater incidence of logical arguments than insight problems. Consistent with this prediction, we found that analytic protocols contained a significantly greater proportion of arguments (logic, or means-ends analysis) as compared to insight protocols ($t(39) = -4.50$, $p < .001$).[3]

A second characteristic of analytic problem protocols also points to the step-by-step structure and solution process associated with these problems. Compared to insight protocols, the analytic protocols were associated with a significantly greater proportion of statement elements involving rereading the problem ($t(39) = -8.73$, $p < .01$). Although we had not explicitly predicted this difference, this finding is consistent with the suggestion that analytic problems are distinguished from insight problems with respect to their requirement to be solved in a series of steps. Accordingly, after subjects solved one step in an analytical problem, they may have needed to reread the problem in order to help determine the next step. In the case of insight problems, a step-by-step strategy may have been less appropriate, and so such solve-and-review strategies occurred less often.

We had two predictions regarding the types of statement elements that would characterize insight problem solving. First, because insight problems are hypothesized to involve a greater reliance on nonreportable processes, we predicted that they would be more likely to elicit pauses. Comparison of the relative incidence of pauses for the two types of problems supported this prediction. Subjects paused more while solving insight problems than during analytic problems. A paired t-test showed that the difference was significant ($t(39) = 2.91$, $p < .01$). Our second prediction was that insight problems, by virtue of the nonreportability of their processes, their likelihood to induce impasses, and their requirement to shift perspectives, would be more likely than analytic problems to elicit metacognitive statements. As with pauses, we found a significant difference in the predicted direction, with metacognition means of 8.09 percent and 2.89 percent for insight and analytic problems, respectively ($t(39) = 5.41$, $p < .01$).[4]

In order to get a deeper understanding of the nature of the differential probability of reporting metacognitive statements, we further divided the metacognitive statements into six subcategories (box 5.3).[5] The results of this analysis were generally consistent with our predictions. Insight subjects were more likely to indicate that they were at

Box 5.3
Definitions for Metacognition Subcategories

IMPASSE: Subject specifically states that he or she is unable to make further progress.

STRATEGY DESCRIPTION: Subject states what strategy he or she was using or had tried to use.

PERSPECTIVE SHIFT: Subject explicitly notes that he or she is exploring a different approach.

NONREPORTABILITY: Subject states that it is difficult or impossible to verbalize what he or she is thinking.

COMPETENCE: Subject evaluates his or her ability to solve (or not solve) the problem.

OTHER: Otherwise unclassifiable metacognitions.

an impasse with metacognitions such as "I just can't imagine . . . ," "I don't think I can solve it at all, no matter how much time I had," and "I am just wondering where to go from here." There were an average of 1.8 impasse statements per subject during insight problems as compared to just 0.3 during analytic problems ($t(19) = -3.71$, $p < .0001$). Also consistent with our predictions, insight protocols tended to be more likely to contain nonreportability statements, that is, reports that subjects were having difficulty articulating their thoughts. For example, one subject exclaimed while working on an insight problem, "there is nothing that's going through my mind that's really in any kind of—that's in a verbal fashion. Another subject noted, "There is not a whole lot I can say about this while I'm trying to figure it out." Still another subject exclaimed, "I know I am supposed to keep talking but I don't know what I am thinking." There were an average of only .05 nonreportability statements per subject in the analytic protocols as compared to .70 such statements for insight problems. A paired t-test indicated that the difference was significant ($t(19) = -2.02$, $p = < .03$, one tailed).

We had also predicted that while solving insight problems, subjects would be more likely to mention their attempts to shift perspectives as, for example, a subject who said, "I could look at it from different angles"; another volunteered "OK, I'm going to look at it a different way then." Although these occurred numerically more often in the insight condition, the respective frequencies were too low (four for insight, two for analytic) to be significant.

Statement Elements as Predictors of Success

Although comparing the overall frequency of different types of statement elements helps to characterize the differences between the approaches that subjects take to solving insight and analytic problems, such a comparison has a fundamental limitation. The fact that subjects incorporated particular statement elements in their protocols does not in itself indicate that those elements necessarily contributed to their problem solutions. Indeed, it is our contention that little of what subjects said in the case of the insight problems had anything to do with the actual processes that elicited the solutions. To get at the actual utility of different statement elements, it is helpful to examine the degree to which the existence of these elements was predictive of successful problem solving. Accordingly, if a particular type of problem element is useful for a particular type of problem, then subjects who are more likely to use that problem element should tend to be more successful.

Before discussing this analysis, we briefly review our predictions. With respect to analytic problems, given our contention that the key to their solutions lies in progressive processes of logical reasoning, it follows that the frequent use of logical arguments should be predictive of successful solutions. In the case of insight problems, the claim that verbalization has little to do with solving these problems predicts that there should be very little in the content of these problems that would be predictive. One element that might be predictive, however, is the frequency of pauses, with subjects who were more likely to pause potentially being more likely to concentrate on, or otherwise to access more effectively, nonreportable processes.

Our results (table 5.2) were generally in keeping with the predictions. In the case of analytic problems, the percentage of subjects' statement elements that were coded as arguments was strongly correlated with the number of problems that they solved ($r = .57$, $p < .01$). In contrast, in the case of insight problems, there was no correlation between arguments and problem success ($r = .08$, $p > .60$).

A second unique predictor of analytic problems was percentage of reread statements. The percentage of rereading was inversely predictive of subjects' success on analytic problems ($r = -.44$, $p < .01$). In other words, the more successful subjects spent a lower percentage of effort on rereading premises, suggesting that subjects who were able to maintain the premises of a problem in working memory may have been less likely to confuse the steps involved in analytic problems. For insight, there was a much lower, nonsignificant correlation between rereading and performance ($r = -.13$, $p > .40$).

Table 5.2
Correlations (Pearson's r) between Selected Protocol Categories and Number of Correct Solutions

	Problem Type	
	Analytic N = 40)	Insight (N = 39)
ARGUMENT	.57**	.08
METACOGNITION	−.09	.01
PAUSES	−.04	.20
REREADS	−.44**	.13
REHEARSE	.09	−.18
MOVE	.17	.38*a
MISCELLANEOUS	−.35*	−.05

a. $r = .20$ ($p > .05$) when the triangle problem is omitted from this analysis.
* $p < .05$.
** $p < .01$.

In the case of insight problems, our prediction that very little in the protocols would be diagnostic of success was borne out by the dearth of significant predictors. There was a slight trend for subjects who paused more tending to be more successful ($r = .20$, $p < .11$, one-tailed), with not even a hint of this trend for analytic problem solving ($r = -.04$). There was an unexpected correlation between performance and the number of MOVEs that subjects used on average to solve insight problems ($r = .37$). However, examination of the incidence of MOVE statements for insight problems indicated that virtually all of the MOVE statements were associated with the triangle problem in which subjects had to reconfigure the circles in a triangle (see problem A in box 5.1). Because this problem can be solved by trial and error, it seems likely that making more moves may have simply increased subjects' likelihood of stumbling onto the solution. Indeed, when this problem was omitted from the analysis, MOVEs were no longer predictive of insight solution success (table 5.2).

Although these findings are generally consistent with the claim that the useful elements of analytic problem solving are not of value for insight problems, there is a possible alternative interpretation: subjects solving insight problems do in fact use the same processes as those used by analytic problems, but the time course of the application of those processes is simply too fast to be revealed in concurrent verbalization protocols. Using retrospective reports, Perkins (1981) suggested that subjects solving insight problems engaged in series of logical steps, each happening so quickly that they may seem to occur as a single leap (Ohlsson 1993). Although retrospective reports are somewhat suspect because subjects may have inferred post hoc steps that they did not actually take, this speeded reasoning view might be used to dismiss some of our findings. Accordingly, if the critical logical steps in insight problem solutions happen too quickly to be reported, then our assessment of the actual number of logical steps used by insight subjects may not be accurate, and consequently, it is not surprising that we found no correlation between the frequency of logical arguments and insight solutions. This reasoning, although potentially sound, implies a prediction that was not supported by the data. Specifically, if we assume that insight and analytical problem solving involve comparable logical reasoning processes—that are more quickly implemented during insight problems—then it follows that subjects' logical reasoning with analytic problems should be predictive of their performance with the insight problems. Because subjects in our experiment solved both types of problems, it was possible to address this question. As it turned out, their use of logical arguments while solving analytic problems was not at all correlated with their performance on the insight problems (r = .07), even though this argumentation was highly correlated with analytic problem solving (r = .57). The lack of a correlation between argument usage for analytic problems and success with insight problems is particularly interesting in view of the overall correlation between success on the two types of problem ($r = .45$, $p < .01$). It would seem the successful subjects effectively drew on distinctly different processing strategies for insight versus analytic problems: argumentation for analytic and some other nonreported process for insight problems. We will return to the possible factors that may account for individual differences in insight and analytic problem solving.

Summary

In short, our protocol analysis suggests that the factor that distinguishes whether problems are vulnerable to verbalization is whether they elicit straightforward and logical problem-solving strategies. When subjects are faced with problems that they can solve logically, as in the case of the standard analytic problem, they can verbally report the stepwise arguments necessary to solve the problem, and they are unimpaired by verbalization. In contrast, when solving insight problems, subjects are less likely to draw on logical arguments and more likely to attempt to make metacognitions reflecting their inability to progress following standard logical means. This relative lack of reliance on reportable processes may therefore make them vulnerable to verbalization.

The analysis provides direct evidence for the logical processes used by analytic problem solvers and the lack of such processes in insight problem solving. By inference, these findings support the importance of nonreportable processes for solving insight problems; however, they are less revealing regarding the precise nature of those unreportable processes. The protocol analysis suggested that metacognitive considerations such as overcoming impasses were important. However, the manner in which such impasses are overcome was not clear. In the following section, we report a preliminary study that attempted to explore these hypothesized nonreportable processes.

Individual Differences and Insight

An individual-differences approach can often offer a first step in establishing the component processes involved in a skill. The basic logic of this approach is that if process A is involved in a particular skill B, then performance on tasks involving process A should be predictive of tasks requiring skill B. There have been countless applications of

the individual-differences approach in identifying the processes associated with intelligence (Hunt, Lunneborg, and Lewis, 1975); however, relatively little research has used this approach to identify the processes associated with insight problem solving.

There have been a few examinations of the factors that correlate with insight, but the conclusions that can be drawn from these are quite limited. A number of researchers failed to find any correlates with insight performance (Burke and Maier 1965; Maier and Burke 1966; Raaheim and Kaufmann 1972). However, these researchers used only a single insight problem (Maier's 1945 hat rack problem), thereby greatly attenuating their statistical sensitivity, not to mention constraining the generalizability of any results. Other researchers have found reliable predictors of insight, although again the implications of these findings are limited. For example, Jacobs and Dominowski (1981) observed significant correlations between performance on different insight problems and further found that performance on insight problems was correlated with performance on the Gestalt Transformation Test (a measure of subjects' ability to figure out unusual uses for objects). Although this finding provides some validity to the notion that insight may tap a measurable skill, it does not do much to explain that skill since the items on the task are themselves quite similar to insight problems. For example, one of the items asks subjects to decide which of the following objects would be most appropriate to use in lubricating a friction point: water, pencil, bottle of ink, eraser, or dictionary. The answer is the pencil (graphite can be used as a lubricant).

In addition to these difficulties, the past published studies of the correlates of insight problem solving have typically omitted a critical control, the inclusion of analytic problems. In the absence of an analytic problem control, a correlation between insight problem solving and other individual-differences measures may suggest a factor that is unique to insight problem solving, or it may simply correspond to a general problem-solving skill. In order to determine the processes that are unique to insight, it is necessary to examine the relationship between individual-differences measures and both insight and analytic problem-solving ability.

In the following study, we (Schooler, McCleod, Brooks, and Melcher 1993) examined the correlation between a variety of different measures and both insight and analytic problem solving in an effort to illuminate the nonreportable processes that appear to mediate insight problem solving. As a starting place, we considered the three elements of insight that have repeatedly appeared in both the early and recent discussion of insight: restructuring, context-induced fixedness, and unconscious search.

The basic premise of the Gestalt approach to restructuring was that insight involves a process, analogous to perceptual pattern recognition, whereby individuals find a new, more complete representation of the problem. The measure that taps this characterization was not immediately obvious. After some reflection, we opted for the task of recognizing out-of-focus pictures (Bruner and Potter 1964). This task requires pattern recognition, and it also elicits the phenomenological experience of a sudden shift in perspective; one moment you have no idea what the object is, and the next moment it is obvious.

Recognizing out-of-focus pictures also provided us with the opportunity to test a second element of many theories of insight: the notion that insight problems require one to overcome a set produced by the context of the problem. Bruner and Potter (1964) observed that exposure to extremely out-of-focus pictures impairs subjects' ability to recognize mildly out-of-focus versions of the same picture. The interpretation of this result is that viewing a very blurred picture causes subjects to adopt inaccurate interpretations (comparable to a false set), which can then interfere with their later recognition of the picture. In our study, we attempted to examine the role of this induced set by generating a difference measure corresponding to the difference between subjects' recognition of moderately out-of-focus pictures that were presented either in isolation (single presentation) or preceded by very out-of-focus versions of the same picture (serial presentation). If the set hypothesized to be elicited by seeing very out-of-focus pictures corresponds to a general susceptibility to context-induced set and if insight solutions are hampered by a similar process, then the difference between subjects' identification of singly and serially presented pictures may be predictive of insight performance. That a susceptibility to context-induced set might hamper insight problem solving also suggested the applicability of one of the most widely used individual difference constructs: field dependence. Measures of field dependence, most notably the embedded-figures test and the rod and frame test, have been shown, under a large number of different situations, to reveal the degree to which an individual's judgment is influenced by context (for a review see Witkin et al. 1962). Indeed, some unpublished research suggests that it may be correlated with performance on at least one insight problem (Harris, cited by Witkin 1971). If insight problems require subjects to ignore the implicit context of a problem and seek out some alternative perspective, then field dependence might well prove a reliable predictor of the ability to solve various insight problems.

If, as many theories have suggested, insight draws on the process of extensive unconscious memory search, then one might expect that memory search ability might be correlated with insight problem-solving performance. In order to explore this hypothesis we used the following measures that require extensive memory search:

1. Remote associates: This measure gives individuals three distant associates, such as *salt, deep, foam,* and requires them to retrieve a fourth word that relates to all three words (*sea*).
2. Category instance generation: This speeded task requires subjects to generate an instance of a category given only the first letter (e.g., fruit—*P*).
3. Anagrams; This task requires subjects to search for a word that corresponds to a rearrangement of the presented words (e.g., *mhnua = human*).

In addition to these three measures of abilities hypothesized to be associated with insight, we also included some more general measures of intellectual ability, including mathematical ability (Math SAT), verbal ability (Verbal SAT, Vocabulary), spatial ability (mental rotation task), and general intellectual curiosity (need for cognition). These measures enabled us to distinguish general intellectual abilities from those hypothesized to be more specifically required for insight problem solving.

Method

Fifty-one subjects were given a battery of measures during 2-hour sessions. Subjects were run in groups ranging from one to eight individuals. The measures were 8 insight problems, 8 analytic problems, and out-of-focus picture identification task of 10 out-of-focus pictures presented with slide projector (5 pictures were presented singly and 5 were preceded by very out-of-focus versions of the same picture), the Group Embedded Figures Test (Witkin et al. 1971), a standard vocabulary test, 40 single-solution anagrams drawn from two sources (Gilhooly and Johnson 1978; Tresselt and Mayzner 1966), 32 remote associates problems drawn from Bowers and associates (1990), 40 category completion items modeled after Freedman and Loftus (1971), a mental rotation test (Hunt, Davidson, and Lansman 1981), and the need-for-cognition scale (Cacioppo and Petty 1982). Subjects were given a consent form asking their permission for us to obtain their SAT information.

Results and Discussion

The correlation matrix of all measures are presented in table 5.3. Because our central interest was to determine the factors that distin-

Table 5.3
Individual Difference Correlates of Insight and Analytic Problem Solving

	INS	ANAL	PIC	PICDIF	EMB	CAT	ANAG	REM	VOC	ROT	NEED	SATV	SATM
Problem-Solving type													
Insight (INS)	**1.00**												
Analytic (ANAL)	**.36***	**1.00**											
Restructuring													
Out-of-focus pictures (PIC)	**.45****	**.21**	1.00										
Context-induced set													
Out-of-focus difference (PICDIF)	**.14**	**.02**	.18	1.00									
Embedded figures (EMB)	**.41****	**.18**	.35*	.14	1.00								
Memory retrieval													
Categorization (CAT)	**.25**	**.38***	.29	.11	.360	1.00							
Anagrams (ANAG)	**.25**	**.40***	.33*	.23	.46**	.54**	1.00						
Remote associates solved (REM)	**.37***	**.54****	.24	−.03	.46**	.49**	.55**	1.00					
General abilities													
Vocabulary (VOC)	**.36***	**.36***	.39*	−.11	.19	.53**	.47**	.55**	1.00				
Mental rotation (ROT)	**.26**	**.13**	.19	.16	.10	−.16	.09	.01	−.14	1.00			
Need for cognition (NEED)	**.21**	**.14**	.23	.02	.37*	.22	.29	.43*	.36*	−.18	1.00		
Verbal SAT[a] (SATV)	**.17**	**.24**	.36*	−.01	.06	.46*	.26	.52**	.84**	−.01	.42**	1.00	
Math SAT[a] (SATM)	**.20**	**.36***	.10	.09	.16	.44**	.27	.35*	.50**	.13	.26	.61**	1.00

Note: Correlations are based on $N = 51$.
The first two columns are presented in boldface in order to draw attention to the most important correlations—those between the various individual difference measures and the Insight and Analytical problem types.
a. Correlations are based on $N = 40$.
*$p < .05$.
**$p < .01$

guish insight and analytic problem solving, we consider correlates of these two abilities in turn.

Predictors of Insight Problem Solving Although the patterns that emerged were somewhat complex, at least some measures associated with all three of the hypothesized components of insight proved to be predictive of insight performance.

Our first predicted element of insight performance was perceptual restructuring, which we measured by examining subjects' ability to recognize out-of-focus pictures. This ability turned out to be the single best predictor of insight performance (table 5.6), suggesting that restructuring may play an important role in insight problem solving.

The second element of insight problem solving investigated was overcoming context-induced set. We used two measures to examine this construct: the difference between sequentially and singularly presented pictures, and field dependence. With respect to the former measure, we replicated earlier findings that moderately out-of-focus pictures preceded by very out-of-focus versions were more difficult to recognize than moderately out-of-focus pictures that were presented alone. Mean performance scores for sequential and single picture recognition were 1.59 and 2.77, respectively ($t(50) = -5.786, p < .01$). This suggests that the sequence manipulation did produce some type of disruptive set; however, when we took the difference between scores on these two versions of the task in order to derive a measure of "susceptibility to set," we found that performance on this value was not correlated with insight performance. While this may serve as some evidence against the hypothesis that context-induced set constrains insight, we must be cautious in interpreting this null result, particularly because this measure also proved to be uncorrelated with all other measures. Indeed when insight performance was correlated with a validated measure of sensitivity to context (field dependence), a strong positive correlation emerged (the greater the score on the embedded figure test, the lesser one's degree of field dependence). Thus, the hypothesis that insight requires overcoming context-induced set garnered some support.

The third element of insight examined was memory retrieval—the ability to engage in extensive memory search. Consistent with our predictions, subjects' ability to find remote associates was correlated with their insight performance. However, the other two measures of memory search (category instance generation and anagrams) proved to be unpredictive. Indeed all three of these measures turned out to be more predictive of analytic performance than insight performance. Although the findings provide only minimal evidence for the memory search component of insight, we note in hindsight that we may not have used measures that fully capture the memory search requirements of insight problems.

Of the general measures of intellectual ability, only vocabulary was significantly correlated with insight problem solving. This finding suggests that whereas some general knowledge may be useful for insight solutions, insight problem solving is distinct from general intellectual functioning. It is also of interest that insight was only marginally correlated with spatial ability. One less interesting interpretation of the results could follow from the fact that a few of the insight problems involved diagrams and thus had spatial characteristics. Accordingly, it could be that the spatial ability required by a few of the insight problems could have been responsible for the correlations between insight and the embedded figures and out-of focus picture recognition tasks, both of which also involve spatial information. However, the fact that these factors were predictive of insight performance even when spatial ability was partialed out (r = .37 and .42, respectively) argues against this interpretation.

Predictors of Analytic Problem Solving While there was a significant correlation between insight and analytic problem solving, it is quite notable that the factors that predicted performance on the two types of problems were generally different. Embedded figures and out-of-focus pictures, the two measures that were most strongly correlated with insight problem solving, were not significantly correlated with analytic problems. Moreover, anagrams, categorization, and Math SAT scores, which were not significantly correlated with the insight problems, were significantly correlated with the analytic problems. This differential pattern of findings suggests once again that the two types of problems draw on qualitatively different processes. Some of the factors that were uniquely predictive of analytic problem solving follow directly from our previous characterization. For example, performance on the math SAT requires the same type of logical step-by-step process that we associated with analytic problems. Other factors that we did not predict to correlate with analytic problem solving nevertheless make some sense in hindsight. The three memory retrieval measures all correlated quite highly with noninsight problem-solving performance as well as with each other. It thus seems quite reasonable to speculate that these three measures all tap some general ability to retrieve verbal information. The previous protocol analysis suggested that analytic problems put a sizable demand on subjects' ability to maintain verbal information. This was indicated both by the high frequency with which subjects needed to reread the problems and by the negative correlation between rereading the problem and successful solutions. It thus seems reasonable to speculate that the sizable correlation between the various memory retrieval measures and analytic problem solving reflected the role of verbal working memory skills (Daneman and Carpenter 1980; Just and Carpenter 1992) required for maintaining the verbal information necessary for solving analytic problems.

The suggestion that analytic problems put unique demands on verbal working memory raises the possibility that the verbal memory measures used in this study may have correlated with insight and analytic problems for different reasons. Insight problems may correlate with verbal memory measures because of their demand for real-world knowledge. In contrast, analytic problem solving may correlate with verbal memory measures because such measures also tap the verbal working memory abilities necessary to maintain and manipulate information. This speculative characterization could be empirically tested by examining the correlation of working memory measures with insight and noninsight problem solving. If analytic problem solving particularly draws on verbal working memory, then verbal working memory measures should correlate more with analytic problem solving than insight problem solving. Such a hypothesis must be considered merely speculative at this time, but it might be well worth exploring.

Summary

This individual-differences analysis provided some hints as to the nonreportable processes associated with insight. Both perceptual restructuring, as measured by the ability to recognize out-of-focus pictures, and the ability to overcome context-induced set, as measured by performance on the embedded-figures task, were highly correlated with insight performance but insignificantly correlated with analytic performance. In contrast, analytic problem solving was particularly correlated with other tasks that can be solved in a step-by-step manner (e.g., math SAT and anagrams) as well as verbal memory measures that may reflect the potentially unique working memory demands of analytic problems.

Conclusions

Our empirical investigations provide some support for a number of historical speculations about the ineffable nature of insight. Research investigating the effects of verbalization on insight and analytic processes (Schooler, Ohlsson, and Brooks 1993) suggests that there is some truth to past suggestions that insight may be hampered by language. Analysis of the protocols generated in that study supported the historic view that verbalizable logical thinking, so central to analytic problem solving, is of relatively little use in achieving insights. Finally, our individual-differences study provided evidence for at least two of the three nonreportable processes identified in historical discussions of insight: restructuring process comparable to perceptual pattern recognition and avoiding context-induced mental sets. Furthermore, the fact that the two measures most correlated with insight performance were perceptual in nature provides some support for early Gestalt claims that the nonreportable processes involved in insight may be analogous in some respects to those involved in perception.

Although this work is generally consistent with the view that insight involves unique nonreportable processes, it also suggests that insight and analytic problems share significant qualities. The verbalization research indicated that although insight and analytic problems are differentially vulnerable to verbalization under normal conditions, the analytic problems can become impaired by verbalization when subjects are encouraged to think of them as potential insight problems. The protocol analysis showed that although the two problem types differ in the frequency with which they elicit different types of statement elements, most statement elements were applied to both types of problems. Finally, the individual-differences study suggested that although insight and analytic problems are differentially correlated with a number of variables, they also share correlations with other variables and indeed are somewhat correlated with each other. Thus, it seems inappropriate to conclude that insight and analytic problems involve an entirely distinct set of mental processes. Rather, it seems more reasonable to suggest that they may share some processes but not others. Indeed, the semioverlapping nature of the processes involved in insight and analytic problems may help to explain some of the difficulties that subjects can have solving these problems. For example, the demand to think out loud may induce subjects to draw on analytic problems-solving processes such as explicit logical argumentation, even if such elements are not useful, simply because they are readily verbalized. A misapplication of metacognitive processes required for insight to analytic problems may similarly account for the disruptive effects of the "insight hint" on analytic problems (see 2–4). In short, insight and analytic problem solving may overlap relatively more with respect to the types of processes that subjects attempt to use and relatively less with respect to the processes that ultimately end up being useful.

The research discussed in this chapter suggests that the nonreportability of insight need not impede efforts to begin to characterize the processes that distinguish insight from analytic problem solving. In closing, we briefly speculate about worthwhile directions for future research on this topic. With respect to the disruptive effects of verbalization on insight, it would be quite useful to manipulate the insight problems components systematically in order to isolate the elements of insight problem solving that are disrupted by verbalization. For example, it may be that verbalization primarily disrupts the search for alternative problem approaches (restructuring). Alternatively, verbalization may prevent subjects from disregarding the initial context-induced approach (overcoming set). These alternatives might be teased out by identifying problems that differentially elicit these hypothesized problem components, and examining their relative vulnerability to verbalization. With respect to the protocol analysis research, it may be helpful to compare in more detail the specific reasoning used in individual problems. We took the approach of exhaustively coding and quantifying all statement elements at a relatively coarse level of analysis. This quantitative approach helped to demonstrate the generality of the basic factors that distinguish the two types of problems but at the expense of more qualitative analyses of a few protocols. Such qualitative analyses can be quite informative (Chi and VanLehn 1991) by leading to inferences about complex reasoning operations. For example, it is possible that a very fine grained analysis of analytic problems could reveal that they may sometimes require little insights in order to move from one step to the next, thus helping to account for the overlapping nature of the two types of problems. With respect to the individual-differences approach to characterizing the two types of problems, we suggest that future research might try more sophisticated measures for revealing the search component hypothesized to be associated with insight. Langley and Jones (1988) suggest that memory "indexing" is a critical component of the memory search required by insight problem solving. Memory indexing involves relating the elements of a problem to existing knowledge structures in a manner that optimizes the likelihood that activation can spread in useful directions. It seems likely that simple semantic searches that were required by our measures did not tap memory indexing ability and therefore may not have reflected this critical component of the memory search required for insight problems. Future research might profitably explore the relationship between memory indexing and insight performance by examining the correlation between insight problem solving and other measures that more directly draw on memory indexing ability, such as the ability to recognize analogies between the deep structure of two superficially different problems (Gick and Holyoak 1980).

In addition to pursuing the specific approaches documented here, future insight research might also begin to apply recent advances in other domains that examine nonreportable cognitive processes. For example, research on dissociating conscious from automatic processes (Jacoby, Ste Marie, and Toth in press), subliminal perception (Merikle and Reingold 1990), implicit learning (Reber 1989), and implicit memory (Schacter 1987) may offer other paradigms by which to study insight. Neuropsychological developments in localizing brain function may also prove useful. For example, a recent priming study using brief stimulus presentations to the right and left visual fields suggests that activation in the right hemisphere may spread more broadly than in the left, that is, to more distant associates (Beeman et al. in press). This finding raises the possibility that the spreading activation to divergent concepts, which has been hypothesized to be involved in insight problem solving, may be localized to the right hemisphere. Since the right hemisphere is also associated with a number of other properties related to insight, including nonverbal cognition (Milner 1971), visual-spatial processing (Kosslyn 1987), appreciating humor (Foldi, Cicone, and Gardner 1983), and recognizing the multiple interpretations of metaphor (Winner and Garnder 1977), empirical investigations of the relationship between hemispheric function and insight and analytic problem solving seem worthwhile.

We endorse future efforts to uncover the ineffable elements of insight while acknowledging a concern that naturally arises from the implications of our endeavor. In analyzing insight, are we in effect attempting to pin down verbally the very process that we have shown to be hampered by verbal analysis? Might our effort to understand insight require the specific operations that hinder it? We cannot rule out the possibility that, by becoming excessively analytic about the insight process, we may have limited ourselves in a manner comparable to what verbalization did to the subjects in our study. We note, however, that our approach to studying insight involved a relatively straightforward logical analysis, drawing on the type of reasoning that readily lends itself to verbalization. While this analytical approach has allowed us to make real progress on the topic, we must concede that there is little in this chapter that can be characterized as a true insight about insight. Toward this goal, we might profitably draw on Poincaré's advice that "to invent, one must think aside." Insight may be like a faint star, best seen when kept slightly away from the center of focus. While definite progress can be made when insight is examined directly, perhaps the true insights about insight will occur if, as we

study other aspects of human cognition, we keep insight in the corner of our eyes.

Notes

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1. Since we wrote this chapter, more recent reports suggest that Chow's original study contained some flaws that bring into question its conclusions. Nevertheless, after some deliberation we opted to keep this example; even if it ultimately turns out not to be valid, it remains a fine instance of an insight in the sense that it suggested a highly plausible alternative view that had not been previously considered. In addition, while there has yet to be a fully successful implementation of Chow's basic insight—that multiple drugs may operate by targeting the same, as opposed to different stages in a diseases' growth cycle—this alternative approach has also yet to be ruled out completely.
2. In this experiment half of the subjects received a "mind-set hint" describing insight problems and suggesting that such problems might require them to overcome a "mind-set" and find an alternative approach. This hint had no effect on insight problem solving (replicating Olton and Johnson 1976) but reduced verbalization subjects' performance on the noninsight problems. In interpreting this unexpected result, Schooler, Ohlsson, and Brooks (1993) speculated that the hint manipulation may have caused subjects to treat analytic problems more like insight problems, thereby increasing their vulnerability to verbalization. This hypothesis was reflected by some mild differences in the analytic problem protocols of hint and no-hint subjects. However, because the effects of insight hints on noninsight problem solving is not the focus of our concern, we will limit to a few brief notes our discussion of the mild effects of these hints on subjects' protocols.
3. Arguments constituted 23.26 percent of analytic problem statements in the no-hint condition as compared to 16.44 percent in the hint condition ($t(38) = 1.63$, $p < .06$, one-tailed). This marginally significant difference is consistent with the suggestion that the insight hint caused subjects to treat analytic problems more like insight problems.
4. Metacognitions constituted 2.19 percent of analytic problem statements in the no-hint condition as compared to 3.60 percent in the hint condition ($t(38) = 1.63$, $p < .06$, one-tailed). This marginally significant finding is also consistent with the suggestion that the insight hint caused subjects to treat analytic problems more like insight problems. Additional evidence that subjects in the hint condition were treating analytic problems as if they were insight problems is suggested by the content of their metacognitions. For example, one subject speculated, "But I might be in a mind-set, I don't know." Another exclaimed, "I'm in a mind-set," while rapping the table. Still another said, "All right, all right. The first thing I'm thinking is that—this is what it is—an insight question."

5. Because of the influence of the hint on subjects' metacognition, we limited the analysis of metacognitions to the 20 no-hint protocols.

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