

Thoughts Beyond Words: When Language Overshadows Insight

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Four experiments examined whether verbalization can interfere with insight problem solving. In Experiment 1, Ss were interrupted during problem solving and asked either to verbalize their strategies (retrospective verbalization) or engage in an unrelated activity (control). Ss in the retrospective verbalization condition were significantly less successful than control subjects at solving the problems. Experiment 2 replicated the finding of Experiment 1 and demonstrated that the control Ss' advantage was not due to any beneficial effect of the interruption. In Experiment 3, concurrent, nondirective verbalization impaired the solving of insight problems but had no effect on noninsight problems. In Experiment 4, the effect of concurrent verbalization on insight was maintained even when Ss were encouraged to consider alternative approaches. Together, these findings are consistent with the hypothesis that verbalization can result in the disruption of nonreportable processes that are critical to achieving insight solutions.

Although thought processes often closely correspond to the contents of inner speech (e.g., Ericsson & Simon, 1980, 1984; Sokolov, 1972; Vygotsky, 1934/1989), certain thoughts have a distinctly nonverbal character. A long tradition of scholars have suggested that creative thoughts, and in particular "insights" (problem solutions that occur unexpectedly following an impasse), are distinct from language processes (e.g., Bergson, 1902; Bruner, 1966; Ghiselin, 1952; Hadamard, 1954; Koestler, 1964; Maier, 1931; Poincaré, 1952; Polanyi, 1967; Wallas, 1926; Wertheimer, 1959). One of the most eloquent spokespersons for the nonverbal characteristics of certain thoughts is William James (1890), who noted that many important insights are reported to have occurred in the absence of words: "Great thinkers have vast premonitory glimpses of schemes of relations between terms, which hardly even as verbal images enter the mind, so rapid is the whole process" (p. 255). Albert Einstein (cited in Schlipp, 1949) later provided eloquent support for James's claim that creative insights often precede their translation into language, noting that "These thoughts did not come in any verbal formulation. I very rarely think in words at all. A thought comes, and I may try to express it in words afterwards" (p. 228). In addition to the anecdotal reports of great thinkers, empirical research, to be discussed shortly, has also provided evidence for nonreportable insight processes (e.g., Bowers, 1991; Bowers, Regehr, Balthazard, & Parker, 1990; Durkin, 1937; Metcalfe, 1986a, 1986b; Metcalfe & Wiebe, 1987).

If insights are in some sense distinct from language, then this raises the question, What is the relationship between language and insight? One way to empirically address this question is to examine the effect of attempting to put insight processes into words. If insight processes are either completely dependent or independent of the language system, then trying to articulate these processes should be of little consequence. If, however, insight processes are both distinct from language and at the same time influenced by it, then verbalization might well interact with insight. Specifically, attempts to translate insight problem solving into words might promote a reliance on verbalizable processes while disrupting the use of the hypothetical nonreportable components of insight. In this article we explore this possibility by examining the potential interference that may result from articulating insight processes.

The Effects of Verbalization on Cognition

A number of recent studies have indicated that verbalization of nonverbal tasks can interfere with successful performance (e.g., Fallshore & Schooler, 1993; Schooler & Engstler-Schooler, 1990; Schooler, Ryan, & Reder, 1991; Wilson et al., in press; Wilson & Schooler, 1991). For example, Schooler and Engstler-Schooler (1990) examined the effects of verbalization on the primarily nonreportable process of face recognition. Face recognition requires considerable information that cannot be adequately verbalized; that is, people are remarkable in their ability to recognize faces yet they have great difficulty describing the basis for their recognition judgments (Ellis, 1984; Polanyi, 1967; Schooler, 1989). Schooler and Engstler-Schooler observed that when subjects attempted to describe a previously seen face, their subsequent recognition was substantially reduced compared with subjects who did not describe the face. Schooler and Engstler-Schooler called this interference *verbal overshadowing* because of the evidence that verbalization focuses subjects on the verbally relevant information and thereby overshadows information that is not readily verbalized. For

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example, the effects of verbalization were found to depend on the verbalizability of the stimulus; verbalization impaired memory for both faces and colors while marginally improving memory for a verbal stimulus (a spoken statement). Further support for the overshadowing nature of the verbalization came from the observation that when subjects' recognition time was limited, the negative effects of condition were attenuated. Presumably, limiting the recognition time reduced subjects' opportunity to retrieve the verbalizable information and thereby prevented that information from overshadowing the original visual memory trace.

A recent study by Wilson and Schooler (1991) provided further evidence that verbalization can increase the salience of the verbalizable attributes of a stimulus and thereby overshadow the nonverbalizable attributes. Wilson and Schooler examined the effects of verbalizing affective judgments, which is another domain for which subjects are unable to fully articulate their thought processes (Nisbett & Wilson, 1977). For example, in one study, subjects were asked to evaluate different brands of strawberry jams. Control subjects tasted the jams and then rated them, and verbalization subjects tasted the jams and then wrote the reasons for their preferences prior to rating them. When subjects' ratings were compared with those of taste experts from *Consumer Reports*, it was found that the control subjects agreed quite well with the experts, whereas verbalization subjects showed little agreement. Wilson and Schooler concluded that verbalization causes subjects to base their evaluations on the reportable aspects of their taste experience and to ignore those aspects that cannot be adequately expressed in words. In support of this hypothesis, it was observed that the attitudes implied by subjects' written evaluations of the jams strongly correlated with their ultimate ratings.

Although potentially relevant to the many discussions of when language does and does not mediate thought (for a recent review see Hunt & Agnoli, 1991), most studies that have examined the effects of articulating thought processes have been primarily motivated by methodological concerns regarding the use of "think-aloud" protocols. For example, Ericsson and Simon (1980, 1984) supported their conclusion that think-aloud protocols can be used as a valid source of data with an extensive review indicating that under most circumstances verbalizing cognitive processes has little or no effect on performance. Although Ericsson and Simon suggested that verbalization is typically benign, they did identify one situation in which it may be reactive, namely, when subjects attempted to articulate information that would not otherwise have been heeded. Although this constraint on the benign properties of verbalization is consistent with the verbal overshadowing approach outlined above, Ericsson and Simon concluded that recoding of nonverbal processes into verbal form does not cause subjects to alter the information that they consider. Rather, in their view, recoding introduces an extra step and thereby slows down, but does not qualitatively alter, cognitive processing (see Ericsson & Simon, 1984, p. 79). According to Ericsson and Simon, qualitative effects on cognitive processing do not result from verbalizing particular types of processes, but rather are created by particular types of verbalization instructions. Ericsson and

Crutcher (1991) gave the following summary of Ericsson and Simon's (1980, 1984) review:

They [Ericsson & Simon] found that think-aloud and retrospective reports yield valid data on cognitive processes without interfering with the normal course of thought sequences. They also found that reactive effects and poor validity of verbal reports were inevitably due to other types of verbal report procedures that attempted to obtain more information than subjects spontaneously report: for example, instructing subjects to give reasons for generated thoughts. (p. 66)

There are a number of possible reasons for the differences between the conclusions of the verbal overshadowing approach as outlined by Schooler and Engstler-Schooler (1990) and Ericsson and Simon's (1980, 1984) suggestion that verbal recoding of nonverbal processes should not qualitatively alter those processes. This disparity may be due to differences in the type of cognitive processes that were evaluated. For example, Schooler and Engstler-Schooler considered recognition of visual stimuli and Wilson and Schooler (1991) considered affective judgments. In contrast, Ericsson and Simon focused more on higher order cognitive processes such as reasoning and problem solving. It may be that the hypothesized verbal overshadowing resulting from verbalization only occurs for very basic processes and that as Ericsson and Simon suggest, recoding does not substantially interfere with nonreportable processes associated with higher order tasks such as problem solving.

Differences between the conclusions of the two approaches may also be due to the fact that the verbalization used by Schooler and colleagues differs in significant ways from the type of verbalization that Ericsson and Simon (1980, 1984) suggested is nonreactive. Ericsson and Simon argued that verbalization should not affect performance when it is nondirected and done during the cognitive activity (concurrent). However, Schooler and Engstler-Schooler (1990) asked subjects to describe the appearance of a face that was previously seen (retrospective verbalization). In addition, they specifically directed subjects to describe the appearance of the face, which may not be equivalent to expressing naturally occurring thoughts. Wilson and Schooler (1991) asked subjects to verbally justify the basis for their decisions and, thus, their instructions not only elicited verbalization but also focused subjects on particular types of thoughts, that is, reasons for and inferences about their decision process.

In short, the question remains open whether the verbal overshadowing that has been hypothesized to result from verbalization of basic cognitive processes such as perception, recognition, and affective responses can generalize to higher order processes such as problem solving. Moreover, if verbal overshadowing does generalize to higher order domains, it is not clear whether it would occur if subject's directions were nondirective and their verbalization concurrent. To address this issue, it is first necessary to identify a higher order cognitive activity that involves considerable nonreportable processing and then examine the effects of verbalization on this activity.

Evidence That Insight Problem Solving Involves Nonreportable Processes

One higher order cognitive activity that has frequently been hypothesized to involve nonreportable processes is insight problem solving. Although it is difficult to study the nonreportable processes hypothesized to be associated with the thinking of creative geniuses, examination of insight puzzle problem solving in the laboratory may serve as a model for more important creative insight. By an insight problem we mean a problem that (a) is well within the competence of the average subject; (b) has a high probability of leading to an impasse, that is, a state in which the subject does not know what to do next; and (c) has a high probability of rewarding sustained effort with an "Aha" experience in which the impasse is suddenly broken and insight into the solution is rapidly attained. The impasse-insight sequence was first observed by Gestalt psychologists (Duncker, 1945; Kohler, 1921; Wertheimer, 1959) who invented and studied a number of such problems (see Ohlsson, 1984a, for a review of the Gestalt work).

Many discussions of insight processes have proposed the existence of nonreportable or unconscious processes (e.g., Bergson, 1902; Bruner, 1966; Ghiselin, 1952; Hadamard, 1954; Koestler, 1964; Maier, 1931; Poincaré, 1952; Polanyi, 1967; Wallas, 1926; Wertheimer, 1959). Evidence of the nonreportable qualities of insight processes comes from a variety of sources. As mentioned earlier, one type of source is the anecdotal reports of scientists and other creative individuals who report experiencing their discoveries as occurring in wordless thoughts. Similar types of experiences have also been observed with the more mundane discoveries of solutions to laboratory insight problems. For example, Durkin (1937) observed that problem solvers typically grow silent immediately before an insight. She asked subjects to verbalize their thought processes while attempting to solve insight problems. Durkin observed that the solutions to these problems involved "sudden reorganization" (p. 80). Durkin further noted that these sudden reorganizations were typically preceded by an inability to verbalize thoughts: "Usually a rather short very quiet pause occurs just preceding the sudden reorganization" (p. 80). More recent discussion of protocols associated with insight problem solving have also noted the degree to which the critical steps in the insight solution are not reported (e.g., Ericsson & Simon, 1984; C. A. Kaplan & Simon, 1990).

Further evidence for the nonreportable processes associated with insight comes from analyses of subjects' ability to anticipate their nearness to insight solutions. For example, Metcalfe and Wiebe (1987) found that subjects know when they are on the verge of solving analytic problems (such as those found in standardized tests), as evidenced by accurate ratings of closeness to solution. However, subjects had little ability to rate their closeness to solutions to insight problems, supporting the hypothesis that the processes that prepare for insights are inaccessible. Finally, Maier (1931) asked subjects to retrospectively report their solutions to an insight problem for 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.

Early accounts of the mechanisms underlying unconscious production of insight solutions suggested that elaborate unconscious inference processes produced insight solutions. More recent explanations of insight have focused instead on nonreportable memory and perceptual processes and in particular on spreading activation (Bowers, 1991; Bowers et al., 1990; Langley & Jones, 1988; Ohlsson, 1984b, 1992). For example, Ohlsson (1992) describes an information processing model of insight problem solving in which inappropriate perception of a problem causes subjects to focus on solution approaches that do not directly activate the memory entries that are needed to solve the problem. At the same time, however, subawareness activation may accumulate on knowledge structures that are critical to the correct solution. For example, consider the following problem: A man and his son are in a serious car accident. The father is killed and the son is rushed to the emergency room. Upon arrival, the attending doctor looks at the child and gasps, "This child is my son!" Who is the doctor? Of course the answer is "The doctor is the mother." However, failure to solve this problem may result if subjects fail to retrieve into consciousness the critical memory element that "Doctors can be mothers." Although unable to retrieve the "mother" memory entry, activation to that element may accumulate at a subawareness level.

Over time, a variety of processes may contribute to the subawareness activation of these critical entries, including elaboration, reencoding, and constraint relaxation. *Elaboration* involves adding information to a problem representation, perhaps by closer scrutiny of the problem situation. *Reencoding* involves changing the perceptual interpretation of the situation, for example, by changing figure-ground relations. *Constraint relaxation* involves rejecting features of the solution that were previously thought necessary. When the mental representation of the problem is changed in any of these ways, activation will spread down alternative pathways in memory, raising the level of activation of relevant memory entries. As soon as the activation to the critical memory causes it to enter into awareness, the crucial element necessary for the solution to the problem is retrieved, thereby resulting in the suddenness of the insight experience. Accordingly, in the previous example, when the activation to the construct of "mother" or the fact that "Doctors can be mothers" reaches the level of awareness, a sudden solution is reached.

Further empirical evidence for subawareness activation of elements critical to insight puzzle problem solving has come from research examining subawareness activation in tasks that are similar to insight problems. Bowers et al. (1990) and Bowers (1991) looked at the attempted responses provided by subjects who were unable to generate the correct solution to "insightlike" 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 have some semantic relationship to the correct solution, indicating that solution-relevant information was

being activated and implying that this subawareness activation may ultimately contribute to the solving of the problem. Bowers et al. concluded that "The suddenness with which insights sometimes occur thus represents an abrupt awareness of a mental product or end stage generated by more continuous, sub rosa cognitive processes" (p. 95).

Another result that has been suggested to imply the possibility of subawareness activation of insight solutions is priming effects resulting from tip-of-the-tongue states. Yaniv and Meyer (1987) observed that even when subjects were unable to retrieve answers to factual questions (e.g., What is a 16th-century navigational instrument?), those answers were nevertheless more quickly responded to in a subsequent lexical decision task. Yaniv and Meyer concluded that the solutions, though not retrieved, were still activated at a subawareness threshold, and they suggested that analogous processes may occur during insight problem solving.

In sum, there seems to be considerable evidence that processes associated with insight problem solving are not available to verbal report. The nature of these nonreportable insight processes is somewhat less clear. There is, however, accumulating evidence for the key role of spreading activation to knowledge structures that were not originally perceived to be relevant to the problem solution.

Could Verbalization Impair Insight Problem Solving?

The characterization of insight problem solving as involving nonreportable information processing components, in conjunction with the suggestion that verbalization can overshadow difficult-to-report perceptual and memory processes, suggests that requests to verbalize attempted solutions to insight problems may interfere with successful problem solving. Problem solving requires both the search for relevant information and also the manipulation of that information. As Ericsson and Simon (1984) noted, people cannot verbalize the memory retrieval process itself but only the product of a memory search. At the same time, people are quite adept at articulating the manner in which they manipulate information that is already in working memory. If verbalization causes subjects to neglect those processes that are not readily verbalized, then verbalization during problem solving may cause subjects to favor working memory manipulation over long-term memory retrieval. If insight problem solving requires the retrieval of nonobvious memory elements, then a reduced emphasis on long-term memory retrieval processes is likely to lower the probability of attaining insight. Metaphorically speaking, verbalization may cause such a ruckus in the "front" of one's mind that one is unable to attend to the new approaches that may be emerging in the "back" of one's mind.

Although there are theoretical reasons to believe that verbalization might disrupt insight problem solving, relatively little research has directly addressed this issue. In their review of the effects of verbalization, Ericsson and Simon (1984) cited two studies (Bullbrook, 1932; Weisberg & Suls, 1973) that they viewed as evidence that verbalization does not affect insight problem solving. Careful examination of these studies, however, indicates that they are not really in-

consistent with the prediction that verbalization can impair performance on insight problems. Bullbrook (1932) compared the solution strategies of individual subjects who thought aloud while solving insight problems with the retrospective reports of subjects who solved insight problems in groups. Bullbrook noted that subjects reported similar strategies in the two conditions. However, Bullbrook did not provide the frequency of successful solutions in the two conditions, making it impossible to determine the effects of verbalization on performance.

In a more recent study, Weisberg and Suls (1973) reported performance levels of subjects who solved insight problems under both think-aloud and silent conditions. Although Weisberg and Suls, as well as Ericsson and Simon (1984), viewed the results of these experiments as indicating that verbalization had no effect on insight problem solving, in fact, the frequency of successful insight solutions was numerically lower in the think-aloud experiment than in the silent experiment (24% vs. 44%). Given that these results were observed in different experiments that varied in other respects besides verbalization, comparison of these means is not strictly appropriate. Nevertheless, if anything, they hint at the possibility that verbalization may impair the successful solution of insight problems. Thus, the effects of verbalization on insight problem solving are still an open issue.

In this study, we assessed the applicability of the verbal overshadowing approach to higher order cognitive processes by conducting a systematic examination of the possible disruptive effects of verbalization on the solving of insight problems. In Experiments 1 and 2, we examined whether verbalization would disrupt insight problem solving under conditions as comparable as possible to those in previous verbal overshadowing experiments (e.g., Schooler & Engstler-Schooler, 1990). Specifically, we examined the effects of directed retrospective verbalization, using a paradigm in which subjects were interrupted while solving insight problems and then probed regarding the strategies that they were using. In Experiments 3 and 4 we examined whether verbalization would affect insight problem solving under conditions suggested to be the least likely to produce reactive effects, that is, nondirected concurrent verbalization (Ericsson & Simon, 1984). If verbalization reliably impairs insight solutions under conditions comparable to both the verbal overshadowing paradigm and the standard think-aloud paradigm, such a finding would provide at least preliminary evidence that some component of insight problem solving may be overshadowed by language.

Experiment 1

Experiment 1 examined whether retrospective verbalization would disrupt insight problem solving under conditions as comparable as possible to those in previous verbal overshadowing experiments (e.g., Fallshore & Schooler, 1993; Schooler & Engstler-Schooler, 1990). In the standard retrospective verbalization paradigm, the verbalization occurs after the completion of the primary task (e.g., Russo, Johnson, & Stephens, 1989); thus, by the time subjects verbalize about a problem they have already completed it. However, in pre-

vious verbal overshadowing experiments, subjects verbalize about stimuli that they have encountered but for which they have not yet been tested. To maximize the comparability of the present study to previous verbal overshadowing experiments we modified the standard retrospective verbalization procedure to enable subjects to reflect on a problem before they had finished working on it. Specifically, in Experiment 1, subjects were interrupted one third of the way through their allotted time for solving each problem and were asked to articulate what strategies they had been using. As a control for the effects of interruption, the verbalization condition was compared with a condition in which subjects were interrupted and engaged in an unrelated activity. If subjects in the retrospective verbalization condition performed significantly worse than control subjects, this would provide evidence that the verbal disruption observed in previous verbal overshadowing studies may generalize to insight problem solving.

Method

Subjects

Subjects were 86 undergraduates from the University of Pittsburgh who received course credit for their participation. Subjects were run in groups of up to 4 at a time. Four subjects were eliminated from the analysis because they were familiar with one or more of the stimulus problems.

Materials

Pilot research was conducted using a pool of insight problems obtained from previous research on insight (e.g., Davidson & Sternberg, 1984; Metcalfe & Wiebe, 1987). Out of 10 problems, 6 were chosen for which mean pilot performance was closest to 50%. In the midst of the study, one of the problems had to be removed from the problem set because of its use in a lecture attended by the subject pool. This problem was replaced with one for which pilot performance was comparable. All seven problems used are reproduced in Appendix A.

Procedure

Each group of subjects was randomly assigned to one of two conditions: verbalization or unrelated interruption. At the beginning of each session, subjects were fully informed of the procedure of the experiment and the instructions they would be expected to follow. In each session, there were six trials involving six different insight problems. The problems were presented in written form, one at a time. Problem order was counterbalanced to control for order and position effects. Subjects were instructed to show all solutions to the experimenter immediately. When subjects believed they had a correct solution, they informed the experimenter, who then checked it. If correct, subjects were given an unrelated task to complete for the remainder of the time allotted to the problem. If incorrect, subjects were encouraged to continue with the problem.

In both conditions, subjects were interrupted after 2 min of working on each problem. The interruption lasted 1.5 min. During that time, those in the verbalization condition were instructed to write out all relevant thoughts that had occurred during the first 2 min of solving the problem. The exact instructions were: "Please stop working on the problem now and write down, in as much detail as possible, everything you can remember about how you have been

trying to solve the problem. Give information about your approach, strategies, any solutions you tried, and so on." Subjects in the unrelated interruption condition spent the interruption time working on a standard crossword puzzle. At the end of the 1.5 min, subjects in both conditions were instructed to resume working on the problem. All subjects had 7.5 min to solve each problem (6 min of problem-solving time and 1.5 min on the control or experimental activity). Subjects worked on each problem until they arrived at a correct solution or until 7.5 min had passed.

Results

Accuracy

Overall. The dependent measure of accuracy was the total number of problems solved correctly in the allotted time for each subject. Subjects in the verbalization condition solved significantly fewer problems in the allotted time than subjects in the unrelated interruption condition, $t(74) = 2.126$, $p < .05$. Mean percentages correct were 35.6% for verbalization and 45.8% for unrelated interruption.

Relative to the interruption. Overall, there was no significant difference between performance before and after the interruption, $F(1, 74) = 1.179$, $p > .05$. There was also no interaction between the effects of retrospective verbalization and the number of problems solved before and after interruption, $F(1, 74) < 1$. This latter finding indicates that the magnitude of the difference between the percentage of problems solved by subjects in the verbalization and unrelated interruption conditions prior to the interruption (15.3% vs. 21.7%) was comparable to the difference between these two conditions after the interruption (20.3% vs. 24.1%). It should be noted, however, that neither of these differences was significant alone ($p > .05$, simple effects test).

Item and serial position effects. Some items were more difficult than others. $F(5, 370) = 25.805$, $p < .0001$. However, there was no interaction between item and condition, $F(10, 370) < 1$. An analysis of variance (ANOVA) yielded no evidence of a serial position effect, $F(5, 370) = 1.362$, $p > .05$, and no interaction between serial position and verbalization, $F(5, 370) = 1.604$, $p > .05$.

Time

There was no significant difference in the amount of time taken to correctly solve the problems in the unrelated interruption and verbalization conditions, with means of 168.46 s and 191.21 s, respectively, $t(70) = 1.274$, $p > .05$.

Discussion

In Experiment 1, subjects who attempted to verbalize how they had been trying to solve insight problems solved significantly fewer problems than control subjects who engaged in an unrelated activity for an equivalent period of time. Thus, Experiment 1 provides support for the hypothesis that verbalization interferes with the processes associated with insight in a manner comparable to that observed for other difficult-to-report stimuli (e.g., Schooler & Engstler-Schooler, 1990; Wilson & Schooler, 1991).

Previous discussions of the effects of verbalization have made a distinction between effects that result in qualitative differences in the course and structure of a problem solving effort and effects, such as time to solution, that cause changes in quantitative aspects (Ericsson & Simon, 1984; Russo et al., 1989). A possible explanation of the result of Experiment 1 is that verbalization caused subjects to take more time to solve the experimental problems, perhaps because they were aware that they would have to report their strategies. Because the time allotted for each problem was restricted, a manipulation that increased the time needed to solve a problem would cause fewer problems to be solved. However, if the verbalization request slowed down problem solving, then it would be expected that correctly solved problems should have taken longer in the verbalization condition. However, there was no significant difference between the times required by subjects in each condition to solve the problem. Moreover, when problems were solved, the mean time required was well under the time limit (2.5 min less than 45% of the allotted time). Even if subjects were slowed down by verbalization, they still would have had time to solve the problem. Thus, the slowing down hypothesis does not account for our results.

One possible concern raised by the results of Experiment 1 is that the effects of the instructions to verbalize were comparable in magnitude before and after the explicit act of verbalization. Although the effects of the verbalization instructions prior to the interruption were not statistically significant, the comparable difference between the unrelated interruption and verbalization conditions before and after the interruption suggests the possibility that subjects were affected by the knowledge that they would have to verbalize their strategies. In fact, a similar effect of retrospective verbalization was recently reported by Russo et al. (1989), who found that in many cases the effects of instructing subjects to verbalize their strategies after they had completed solving a problem (retrospective verbalization) were comparable to the effects of verbalization during problem solving (concurrent verbalization). Russo et al. similarly suggested that subjects in the retrospective condition were presumably influenced by the knowledge that they would have to verbalize. It seems likely, for example, that the expectation of having to verbalize one's problem-solving strategies may elicit internalized verbalizations during problem solving. We will return to the issue of possible effects of concurrent verbalization in Experiment 3.

A second possible concern about the results of Experiment 1 relates to the rather moderate size of the effect. Although the difference between subjects' performance in the verbalization and unrelated interruption conditions was statistically significant, the absolute difference in percentage of problems solved in the two conditions was relatively small (approximately 10%) and might not be considered conceptually significant. However, there are two reasons to consider this difference important. First, because of the overall low levels of performance, relatively speaking, unrelated interruption subjects solved approximately 30% more problems than verbalization subjects. Second, verbalization subjects performed less well than unrelated interruption subjects despite

the fact that they were actually given more time to think about the experimental problems. The unrelated interruption subjects spent the interruption period engaged in an unrelated activity, but the verbalization subjects spent the corresponding amount of time thinking about the problem. Verbalization subjects spent approximately 1.5 min more on each problem than did unrelated interruption subjects, biasing the experiment against the observed outcome.

Although the additional time allotted to verbalization subjects increases the conceptual significance of their poorer performance, it also introduces a possible alternative explanation. The difference between the two conditions might be due not to impairment in the verbalization condition, but rather to facilitation in the unrelated interruption condition resulting from incubation (Wallas, 1926). Experiment 2 addressed this issue.

Experiment 2

The first goal of Experiment 2 was to replicate the findings of Experiment 1. The second goal was to determine more precisely the cause of the differences between the two conditions in Experiment 1 (assuming that the difference was replicated). The results of Experiment 1 were consistent with the hypothesis that verbalization impairs performance on insight problems, but the experiment is open to the alternative interpretation that the control activity improved performance. The interruption might have served as an incubation period and thus increased the probability of insight solutions in the control group.

Incubation can be defined as an increase in the probability of finding the solution to a problem after a pause, as compared with after continued problem solving. Wallas (1926) proposed that all creative problem solving follows a sequence of four stages that he called *preparation*, *incubation*, *illumination*, and *verification*. In a recent review of the laboratory evidence regarding incubation, C. A. Kaplan (1989) discussed 18 studies. Twelve of these studies found evidence for incubation, two failed to find an incubation effect, and the remaining four studies were difficult to interpret because of their nonstandard definition of incubation. In addition, Kaplan reported three new experiments that strongly supported the reality of incubation effects.

The plausibility of the incubation phenomenon has also increased with the formulation of precise theories of the mechanisms that might be responsible for the beneficial effects. The concept of memory decay is central to such explanations. Although the possible role of memory decay was suggested by Woodworth (1938), more sophisticated decay theories of incubation awaited the information processing approach to problem solving. For example, Simon (1986) suggested that different kinds of information about a problem decay at different rates. During a pause in problem solving, information about previous approaches to the problem 2 decay faster than information about the problem itself. After a pause, the information about previous solution attempts will have decayed, increasing the probability that some alternative approach will come to mind. Similar decay-based mechanisms of incubation have been proposed by

Anderson (1981) and recently supported by Smith and Vela (1991).

In Experiment 2 we sought to distinguish between the incubation and verbal interference explanations of Experiment 1 by introducing a third condition in which subjects worked on the problem for the full duration without interruption. If the results from Experiment 1 are due to incubation, then the subjects in the no interruption condition should perform similarly to the subjects in the verbalization condition. If, on the other hand, Experiment 1 reflected a disruptive effect of verbalization on insight, then the subjects in the no interruption condition should perform as well as the subjects in the unrelated interruption condition.

Method

Subjects

Subjects were 123 undergraduates from the University of Pittsburgh who received course credit for their participation. Subjects were run in groups of up to 4 at a time.

Materials

Materials included the first six problems used in Experiment 1, reproduced in Appendix A.

Procedure

The procedure for Experiment 2 was replicated with the addition of a third condition in which subjects were not given an interruption activity. Subjects in this no interruption condition worked on each problem without interruption for a maximum of 6 min. As in Experiment 1, subjects in the verbalization and unrelated interruption conditions also spent up to 6 min on each problem with an additional 1.5 min devoted to the interruption activity (i.e., verbalization or crossword puzzle) after the 2-min mark.

Results

Accuracy

Overall. An analysis of variance (ANOVA) revealed a main effect for condition, $F(2, 120) = 3.958, p < .05$. Mean percentages correct for the no interruption, unrelated interruption, and verbalization conditions were 51.2%, 47.5%, and 37.3%, respectively. There was a replication of the effect of verbalization observed in Experiment 1, with subjects in the unrelated interruption condition performing significantly better than subjects in the verbalization condition ($p < .05$, simple effects test). Subjects in the unrelated interruption condition similarly outperformed subjects in the verbalization condition ($p < .05$, simple effects test). There was, however, no significant difference between performance in the unrelated interruption and no interruption conditions ($p > .05$, simple effects test).

Relative to the 2-min mark. Overall, significantly more problems were solved after the first 2 min of problem solving, $F(1, 120) = 7.58, p < .01$. However, there was no in-

teraction between the number of problems solved before and after the 2-min mark and condition, $F(2, 120) < 1$. Again, this latter finding indicates that the magnitude of the difference between the percentage of problems solved by subjects in the verbalization, unrelated interruption, and no interruption conditions prior to the interruption (15.85%, 19.52%, and 21.95%, respectively) was comparable with the difference between these two conditions after the interruption (21.55%, 28.05%, and 29.26%, respectively).

Item and serial position effects. As in Experiment 1, there was a strong item effect indicating variation in item difficulty, $F(5, 600) = 43.29, p < .0001$. Item analysis also revealed a significant interaction between problem and condition, $F(10, 600) = 2.263, p < .05$. This interaction occurred because of performance on one particular problem (the pyramid problem, see Appendix A), for which subjects appeared not to have recognized the solution even when they reached it. On this problem, it was discovered after the completion of the experiment that a few subjects in the verbalization condition had written the solutions in their verbalizations without recognizing that they had the correct answer. It seems likely that subjects in the other two conditions may have similarly considered the correct solution, but because they did not have the opportunity to report the dismissed solution, they simply did not state it. When the correct solutions that were only mentioned in the verbalizations are not included, the item interaction disappears, $F(10, 600) = 1.5, p > .05$. Moreover, when this problem is not included in the analysis, the interaction between condition and problem is also not observed, $F(8, 480) = 1.43, p > .05$. An ANOVA revealed no evidence of a position effect, $F(5, 600) < 1$, and no interaction between position and condition, $F(10, 600) < 1$.

Time

For those problems that were correctly solved, there was no significant difference between conditions in time required to reach the solution, $F(2, 120) < 1$. The mean times spent on correctly solved problems in the no interruption, unrelated interruption, and verbalization conditions were 181.3, 179.9, and 183.4 s, respectively.

Discussion

Experiment 2 successfully replicated the findings of Experiment 1: Subjects were less successful when interrupted to verbalize their strategies than when interrupted to perform an unrelated activity. Experiment 2 extended the findings of Experiment 1 by demonstrating that the difference between the verbalization and unrelated interruption conditions was not due to benefits of the unrelated interruption. If participation in the unrelated interruption condition had actually improved performance, then subjects in this condition would have been expected to perform better than the no interruption subjects. The similar performance of subjects in these two conditions indicates that the difference between the verbalization condition and the unrelated interruption condition

cannot be attributed to an improvement resulting from incubation, but rather must reflect impairment caused by the effort to verbalize insight processes.

Although the lack of a beneficial effect of the unrelated interruption provides no support for the reality of incubation effects, this result should not be taken as strong evidence against the existence of incubation effects under other circumstances. Studies that have observed benefits of unrelated interruption have typically been associated with problem-solving attempts of longer duration and longer incubation periods. The present study may not have provided sufficient time for incubation effects to appear. The outcome of Experiment 2 only shows that the incubation hypothesis cannot account for the observed difference in performance between the verbalization condition and the unrelated interruption conditions in these two experiments.

Another possible explanation for the differential performance of subjects in the verbalization and unrelated interruption conditions of Experiments 1 and 2 involves the specific verbalization procedure used. Both Experiments 1 and 2 used a modified retrospective verbalization technique designed to be as comparable as possible to previous verbal overshadowing experiments (e.g., Schooler Engstler-Schooler, 1990). This technique requires that subjects access a memory trace of what they were doing while they were solving the problem. Also, our instructions explicitly asked the subjects to write down their strategies, thus encouraging them to theorize about the reasons and causes of their own problem-solving behavior. Ericsson and Simon (1980, 1984) pointed out that directed retrospective verbalization requests are very different from requests for concurrent verbalization, which does not specify a particular category of information to be verbalized. Directed retrospective verbalizations may be biased both because they rely on memory and because subjects' theories about their own behavior may influence what they say. If directed retrospective reports are more likely than nondirected concurrent reports to be biased, then it seems reasonable, as Ericsson and Simon (1984) suggested, that they would also be more likely to have reactive effects on performance. This analysis thus raises the question of whether the effects observed in Experiments 1 and 2 were due to the directed retrospective nature of the verbalization or whether they were a more general consequence of any effort to verbalize insight problem solving, retrospectively or otherwise. In short, the question remains whether the impairment observed in the previous Experiments was caused by the act of retrieving strategies and problem-solving steps from memory or by the act of clothing the problem solving in words. Experiments 3 and 4 explored this issue.

Experiment 3

In their review of the effects of verbalization, Ericsson and Simon (1980, 1984) concluded that concurrent verbalization, which does not require the subject to retrieve past memory traces and which does not request that subjects explain their strategies, should not cause a disruption of primary task performance. However, Ericsson and Simon based this conclusions on two assumptions that may not apply to insight

problem-solving situations. First, they assumed that efforts to solve problems typically yield reportable products that are heeded in the normal course of problem solving. Although this claim may often be true, current theories of insight claim that insight solutions require a number of processes, such as spread of activation, that are not easily verbalized (Ohlsson, 1992). Second, Ericsson and Simon assumed that when no reportable products are produced subjects simply fall silent. However, although subjects solving insight problems often fall silent prior to solutions (Durkin, 1937), it is quite possible that many of the subjects who fail to solve insight problems under talk-aloud conditions may have performed suboptimally because they continued talking. Specifically, this on-line verbalization may highlight reportable aspects of the task and overshadow critical information and processes that are not readily verbalized. If so, then requests to verbalize might interfere with solutions to insight problems, even if the verbalization is concurrent rather than retrospective, and even if the subject is not requested to theorize about his or her own behavior or to verbalize some particular category of information. To explore this possibility, Experiment 3 examined the effects of nondirective concurrent verbalization on insight processes.

A second issue addressed by Experiment 3 was whether verbalization differentially affects performance on insight and noninsight problems. If, as suggested, verbalization impairs performance on insight problems because of the non-reportable processes associated with insight, then it should be expected that verbalization should not affect problem solving that is hypothesized to have little reliance on non-reportable processes. Most characterizations of solving standard analytic noninsight problems have indicated little reliance on nonreportable processes (e.g., Metcalfe & Wiebe, 1987). Rather, these problems appear to be solved by an incremental series of steps, each producing a reportable product (Ericsson & Simon, 1984). Thus, if the negative effects of verbalization are associated specifically with nonreportable processes, then it would be expected that verbalization should have little effect on noninsight analytic problems. Alternatively, if the effects of verbalization are due to some other mechanism, then negative effects on matched noninsight problems might also be expected. For example, Russo et al. (1989) suggested that when subjects are engaged in difficult problems, attention devoted to verbalization could drain the resources available for solving the problem. Competition for scarce processing resources would presumably impair the solution of any type of problem, but the effect would be stronger the more difficult the problem (Kahneman, 1973). Hence, if scarce resources were the cause of the effects of verbalization, then verbalization should also affect noninsight problems that are comparable in difficulty to the insight problems. The same prediction follows if the effect of verbalization is due to such factors as additional stress (Zajonc, 1965), motivational shifts (Wilder & Harvey, 1971), or increased sense of accountability (Tetlock & Kim, 1987). To address these issues, Experiment 3 examined the effects of concurrent verbalization on insight and noninsight problems that were matched for difficulty.

Method

Subjects

Subjects were 41 undergraduates from the University of Pittsburgh who received course credits for their participation. All subjects were run individually. The data of one subject were eliminated because of familiarity with one of the problems.

Materials

Seven problems were used; three were insight problems and four were noninsight problems (including one practice problem). The insight problems were those problems from Experiments 1 and 2 that showed the strongest verbalization effect. The noninsight problems were comparable to the incremental problems used by Metcalfe and Wiebe (1987) and were drawn from a variety of sources including Grosswirth and Salny (1983) and P. Kaplan (1964). These problems can be solved in a logical, incremental fashion and do not require any nonobvious approaches to reach the correct solution. From a pilot study involving 10 of these noninsight problems, 3 problems were chosen, for which mean performance was similar to that of the insight problems (approximately 50% accuracy). A fourth problem (for which performance was considerably higher) was used as a practice problem (see Appendix B). In problem presentation, the practice problem always appeared first. The insight and noninsight problems were always blocked. Position of problems within each group was randomized, and the order in which the two groups occurred was counterbalanced across subjects.

Procedure

Each subject was randomly assigned to either the no verbalization or verbalization conditions. All subjects were run individually and were given a maximum of 6 min to solve each of the seven problems. When subjects believed they had a correct solution, they informed the experimenter, who then checked it. If correct, subjects were given the next problem. If incorrect, subjects were encouraged to continue with the problem. In the verbalization condition, subjects were additionally instructed to think aloud while solving each problem. The exact instructions given were as follows:

While you work on each problem, I want you to think aloud. That is, verbalize any thoughts you have while trying to solve the problem; that means any information you are thinking about, anything you read, questions you ask yourself and so forth. Whatever crosses your mind as you work on the problems should be said aloud. Try not to plan what to say or come up with ideas that sound good. Just allow your thoughts to come out in words as naturally as possible.

As dictated by standard think-aloud procedures (Ericsson & Simon, 1984), verbalization subjects were also prompted to continue verbalizing whenever there was a period of silence exceeding 15 s. Verbal protocols were audiotaped with each subjects' full consent. Subjects in the no verbalization group were instructed to work on each problem until it was solved or until the allotted time was up.

Results

Accuracy

As can be seen in Figure 1, the performance of verbalization subjects was substantially lower than that of the no verbalization subjects for insight problems; however, for the noninsight problems, the performance of the two groups was

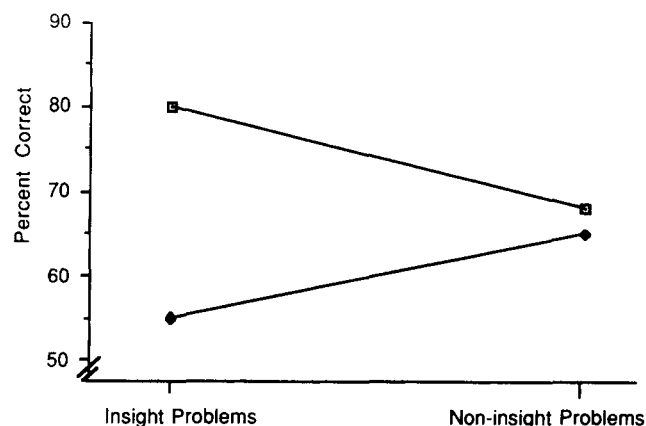


Figure 1. Mean percentage of correctly solved insight and noninsight problems in Experiment 3. (Open symbols indicate no verbalization; solid symbols indicate verbalization.)

approximately equal. An ANOVA revealed a significant interaction between verbalization and type of problem, $F(1, 38) = 5.221, p < .05$. This interaction reflects the observation that verbalization impaired performance on the insight problems but had no effect on performance on noninsight problems.

Item Effects

Separate item analyses were conducted for the insight and noninsight problems. For the insight problems there was a significant item effect indicating that some items were more difficult than others, $F(2, 76) = 7.053, p < .01$. However, there was no interaction between item and condition, $F(2, 76) = 1.0, p > .05$, indicating that verbalization did not differentially affect the three insight problems. For the noninsight problems, there was no significant effect of item, $F(2, 76) = 1.72, p > .05$, nor any interaction between items and verbalization, $F(2, 76) = 1.96, p > .05$. Because of the randomization of problem order, it was not possible to determine order effects.

Time

The mean durations required to solve the insight and noninsight problems are shown in Figure 2. An analysis of time spent on those problems that were correctly solved revealed no main effect for condition, $F(1, 34) < 1$, and no interaction between condition and type of problem (insight or noninsight), $F(1, 34) < 1$. There was, however, a main effect for type of problem, $F(1, 34) = 47.55, p < .001$. Overall, the noninsight problems required more time than the insight problems.

Discussion

In Experiment 3 concurrent verbalization impaired the solution of insight problems while having virtually no effect on the solution of noninsight problems. This finding suggests that the disruptive effects of verbalization observed in Ex-

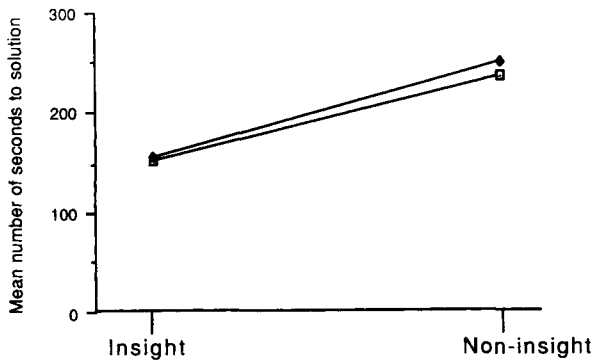


Figure 2. Mean time taken to correctly solve insight and noninsight problems in Experiment 3. (Open symbols indicate no verbalization; solid symbols indicate verbalization.)

periments 1 and 2 were not artifacts of the retrospective paradigm; that is, they were not simply the result of informal theorizing on the part of the subjects about their own behavior. Rather, it appears that the disruption observed in the previous experiments was directly associated with the efforts to verbalize insight processes.

The results of Experiment 3 further support our hypothesis that verbalization disrupts critical nonreportable processes by providing evidence against some alternative explanations for the disruptive effects of verbalization on insight problem solving. The hypothesis that verbalization reduces the resources available for the primary task predicts greater impairment for more difficult problems (Kahneman, 1973). However, the performance of the no verbalization subjects shows that the noninsight problems were, if anything, more difficult than the insight problems and therefore should have shown at least as great an effect of divided resources. The lack of an effect on the matched noninsight problems also argues against other explanations that do not differentiate between insight and noninsight problems. For example, verbalization in the presence of an experimenter might increase arousal, which could impair performance. However, this hypothesis, too, would predict that equally difficult tasks would show similar impairment (Zajonc, 1965), which is not what we observed.

The aforementioned comparisons suggest that verbalization disrupts some process or processes that are unique to insight problems. We have suggested that these unique processes may involve nonreportable components, such as spreading activation, that ultimately allow subjects to retrieve critical memory elements necessary for insight problem solving. An alternative reason why subjects may be unable to retrieve the critical elements necessary for insight solutions is that the act of verbalization may produce a "demand" to stay in the originally defined problem space. Experiment 4 explored this issue.

Experiment 4

It is well established that experimental situations can introduce demands on subjects that may profoundly influence their performance (Orne, 1962). Problem solving is not im-

mune from influences of experimenter demands. For example, Wilder and Harvey (1971) observed that having an experimenter present reduced the number of moves necessary to solve a move problem. Russo et al. (1989) suggested that verbalization improved subjects' performance in deciding between two gambles by increasing their motivation to use a more effortful strategy (mental multiplication). In a personality prediction task, Tetlock and Kim (1987) observed that subjects who believed they were publicly accountable for their decisions used more complex processes and showed greater predictive accuracy than subjects who did not believe.

Verbalizing one's strategies in the presence of an experimenter clearly presents the possibility for various perceived demands. In Experiment 3, all subjects were tested individually with the experimenter attentively nearby to minimize differences between the demands in the no verbalization and verbalization conditions. However, there is one type of demand that might be particularly disruptive for insight problem solving. Specifically, verbalization may produce an experimental demand to continue with the approach that has been verbalized, because changing one's approach is to admit failure, which might be socially embarrassing for some subjects. Insight problems are characterized precisely by the necessity to reject the initial, obvious approach in order to find the solution, whereas noninsight problems can be solved by pursuing the obvious approach. Hence, a reluctance to admit failure and search for a different approach would affect insight problems more than noninsight problems.

To counteract this hypothesized demand to avoid considering alternative approaches, we replicated the procedure of Experiment 3 and introduced a new condition aimed at providing the opposite demand, that is, a demand to consider new problem approaches. Specifically, we used a set-breaking hint (Olton & Johnson, 1976) that described what a mental set is, that provided an example of an insight problem with a set and how it was broken, and that encouraged subjects to search for alternative approaches if they believed that they were stuck in an inappropriate approach. It is reasonable to assume that this procedure would counteract any perceived demand to stick with a single approach even when stuck, so if the effect of verbalization results from an implicit demand to that effect, then such a hint should attenuate the impairment. If, however, verbalization prevents subjects from using the nonreportable perception and memory processes necessary to find the appropriate approach, then the set-breaking hint should have little effect on subjects' performance in solving the insight problems.

With respect to solving noninsight problems, a priori it is difficult to anticipate the effect of providing a hint to consider alternative approaches. On the one hand, because the issue of "mind-set" is less relevant to noninsight problems, subjects in both conditions might simply ignore the hint while solving the noninsight problems. On the other hand, if the mind-set hint makes subjects process noninsight problems more like insight problems (i.e., by using memory retrieval processes to search for alternative approaches), then it is possible that verbalization might also disrupt noninsight problems when they are accompanied with the mind-set hint.

Method

Subjects

Subjects were 83 undergraduates from the University of Pittsburgh who received \$5 for their participation. All subjects were run individually. Three subjects were eliminated because of familiarity with one of the problems.

Materials

The problems used in Experiment 4 were identical to those used in Experiment 3.

Procedure

The procedure for Experiment 4 replicated Experiment 3, with the addition of a hint condition in which subjects were told that they would be working on both insight and noninsight problems and were given information about the general nature of these two types of problems. Noninsight problems were described as involving conventional, step-by-step, logical thinking. In contrast, insight problems were described as typically leading one to get stuck on a problem-solving approach that does not work. Solving this type of problem was suggested to require considering it from a new perspective. To illustrate this point, subjects were shown a sample insight problem and were given an explanation of the process of insight as it related to the problem. Hint subjects were advised that if they felt they were stuck on a problem that they should consider the possibility that they were in a mind-set and should try an alternative approach. Subjects were further reminded that not all of the problems were insight problems and that some of them could be solved in a conventional, logical way. After hint subjects worked on a problem for approximately 2 min, they were again reminded that if they felt stuck on a problem, then it might be an insight problem and they might be caught in a mind-set.

Results

Accuracy

The mean number of problems solved in the various conditions of Experiment 4 are presented in Figure 3.

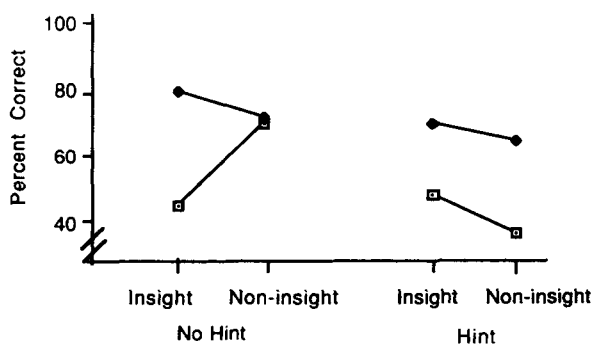


Figure 3. Mean percentage of correctly solved insight and non-insight problems in Experiment 4. (Solid symbols indicate no verbalization; open symbols indicate verbalization.)

Effects of verbalization. Overall, subjects in the verbalization conditions solved significantly fewer problems than those in the no verbalization (control) conditions, $F(1, 76) = 12.482, p < .001$. There was also a trend toward an interaction between verbalization and type of problem, in which verbalization caused greater impairment for insight problems than for noninsight problems, $F(1, 76) = 3.017, p < .09$. This trend is better understood in light of the significant three-way interaction between verbalization, hint, and type of problem, $F(1, 76) = 6.789, p < .05$. This interaction reflects differences in the interaction between verbalization and type of problem in the hint and no hint condition. In the no hint condition, which involved the identical procedure as used in Experiment 3, there was an interaction between verbalization and type of problem, $F(1, 76) = 9.434, p < .01$. This interaction represents a replication of the observation in Experiment 3 that verbalization subjects performed markedly less well than no verbalization subjects on insight problems (a 35% difference), whereas there was virtually no difference between the performance of these two conditions on noninsight problems (less than 2%). In the hint condition, there was a main effect of verbalization, $F(1, 76) = 8.309, p < .01$, but no interaction between verbalization and type of problems, $F(1, 76) < 1$, indicating that verbalization subjects performed less well than no verbalization subjects on both insight problems (a 22% difference) and noninsight problems (a 29% difference).

Effects of the hint. Overall, subjects who received hints solved fewer problems than those who did not receive hints, though this difference only approached significance, $F(1, 76) = 3.619, p < .06$. The hint and type of problem variables yielded a significant interaction, $F(1, 76) = 4.715, p < .05$. This interaction reflects the finding that the hint manipulation caused impairment on noninsight problems but had no effect on insight problems.

Item effects. Separate item analyses were conducted for the insight and noninsight problems. For the insight problems there was a significant item effect indicating that some items were more difficult than others, $F(2, 152) = 4.62, p < .05$. However, there was no significant interaction between items and verbalization, $F(2, 152) = 2.7, p > .05$; between items and hint, $F(2, 152) = 1.157, p > .05$; nor among items, hint, and verbalization, $F(2, 152) < 1$. For the noninsight problems, there was no significant effect of item, $F(2, 152) = 2.21, p > .05$, and no significant interactions between items and verbalization, $F(2, 152) < 1$; between items and hint, $F(2, 152) < 1$; nor among items, hint, and verbalization, $F(2, 152) < 1$. Because of the randomization of problem order, it was not possible to determine order effects.

Time

The mean time to correctly solve the insight and noninsight problems is presented in Figure 4. As in the earlier experiments, subjects took significantly longer to solve the noninsight problems than the insight problems, $F(1, 60) = 101.48, p < .001$. There was no main effect on solution time of either verbalization or hint, $F(1, 60) < 1$, in both cases. There was also no significant interaction between verbalization and

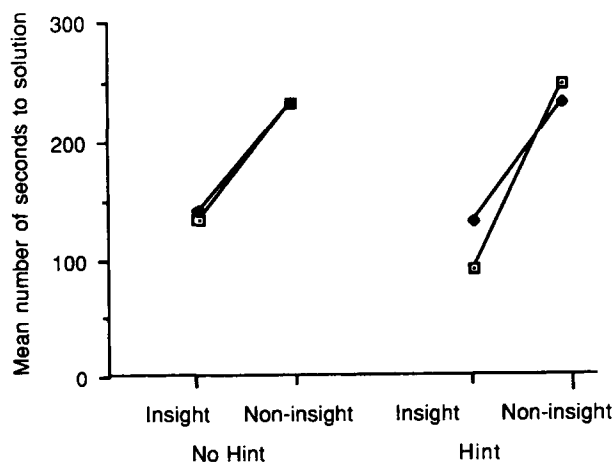


Figure 4. Mean time taken to correctly solve insight and noninsight problems in Experiment 4. (Solid symbols indicate no verbalization; open symbols indicate verbalization.)

hint, $F(1, 60) < 1$; between verbalization and type of problem, $F(1, 60) = 2.02, p > .05$; between type of problem and hints, $F(1, 60) = 2.25, p > .05$; nor among type of problem, hint, and verbalization, $F(1, 60) = 1.05, p > .05$.

Discussion

The results of Experiment 4 replicate the findings from Experiment 3. In the absence of the set-breaking hint, concurrent verbalization impaired performance on insight problems but had little effect on noninsight problems. The performance of subjects who received the set-breaking hint offers further evidence against the suggestion that the verbal impairment is due to an implicit demand to continue with one's initial approach. Even when the experimenter gave explicit instructions to consider alternative approaches, subjects' verbalization performance on the insight problems was impaired. Thus, the effect observed in Experiments 3 and 4 cannot be explained as a result of implicit demands to continue with one's initial approach.

One might have expected the hint to improve performance. C. A. Kaplan and Simon (1990) found that one important step in the solution of insight problems is the realization that the present approach is not working, and therefore, that one should search for alternative approaches. A set-breaking hint might have increased subjects' awareness that they needed to search for alternative approaches. However, Olton and Johnson (1976) also failed to find an effect of a set-breaking hint. The failure of the hint to improve performance may be indirectly related to the reasons why verbalization impairs performance: The critical processes are outside of awareness and therefore are not only difficult to verbalize, but difficult to control voluntarily. Without volitional control over the critical processes, the subjects cannot act on the advice in the hint.

Although the hint did not improve performance, it nevertheless proved to be a powerful manipulation. Although having virtually no effect on subjects' performance in the no verbalization condition nor on verbalization subjects' per-

formance on insight problems, the hint markedly impaired verbalization subjects' ability to solve noninsight problems. Although we did not have a strong a priori prediction of this particular finding, one reasonable interpretation is that the hint caused subjects to process noninsight problems as if they were insight problems. It seems plausible that when subjects work on noninsight problems that offer a straightforward solution approach, they do not give much consideration to whether they are on the right track. However, when given the hint, subjects who are solving noninsight problems may begin to treat the problems as if they may be insight problems. For example, they may attempt to use memory retrieval processes to determine whether there is "something they are missing." Because this type of memory retrieval is likely to be difficult to verbalize, it follows that noninsight problems, when treated as if they may be insight problems, might also be expected to be impaired by verbalization. In short, although noninsight problems typically do not appear to elicit processes that are vulnerable to verbalization, it seems that the critical factor in whether verbalization disrupts problem solving is not simply the nature of the problem per se. Rather, what seems to be most important is the nature of the processes that subjects bring to bear on the problem.

General Discussion

Summary

The hypothesis underlying this series of studies is that a request for verbalization interferes with the successful solution of insight problems because it interferes with the successful application of the nonreportable processes hypothesized to be associated with such problems. The present series of studies documents the predicted effect of verbalization on insight and argues against a number of alternative interpretations.

In Experiment 1, subjects who were interrupted while solving insight problems and asked to retrospectively verbalize their strategies performed less well than no verbalization subjects who were interrupted and engaged in an activity unrelated to their problem-solving effort. Although this result is consistent with the hypothesized disruptive effects of verbalization on insight, it might have been due to the beneficial effects of taking a pause and engaging in an unrelated activity. However, Experiment 2 ruled out this latter possibility by demonstrating that interruption alone has no effect on performance in the present paradigm. We conclude that pausing and verbalizing one's problem-solving strategies impairs performance on insight problems.

In Experiments 3 and 4 we studied concurrent verbalization in which subjects were given standard think-aloud instructions. The instructions encouraged the subjects to verbalize their thoughts as they occurred and did not direct them toward a particular category of information. Experiment 3 compared concurrent verbalization with silent problem solving and found higher performance in the silent condition. Significantly, this difference was observed for insight problems but not for noninsight problems. In Experiment 4, the negative effects of verbalization on insight problem solving

were shown to hold even when the subjects were given a hint that they might be in a mind-set and might need to change their view of the problem.

Alternative Explanations for the Current Findings

We believe that a likely explanation for the present results is that verbalization disrupts the nonreportable processes associated with insight problem solving. Before further explicating this hypothesized mechanism, we briefly consider a variety of alternative explanations.

One possible interpretation of the present findings is that verbalization can consume general processing resources that otherwise would have been available for the problem-solving effort (e.g., Russo et al., 1989). Although verbalization may influence the manner in which resources are allocated (i.e., emphasizing reportable processes and information at the expense of nonreportable ones), the present findings argue against the suggestion that verbalization reduces the general resources available for problem solving. Specifically, the general resource consumption explanation predicts that verbalization should interfere with noninsight problems of comparable difficulty, which was not the case in Experiment 3 nor in the no hint condition of Experiment 4. The differential effect of verbalization on insight and noninsight problems similarly argues against a variety of other explanations, such as task arousal (Zajonc, 1965), which assumes that verbalization adds an element of difficulty to the problem-solving effort.

A related alternative explanation for the effect of concurrent verbalization is that it slows down problem solving without qualitatively altering it. Ericsson and Simon (1980, 1984) proposed that this is to be expected when the verbalized information is heeded, but not in verbal form, and thus in need of recoding. Because our subjects were given a limited time for each problem, increasing the time to solution would result in a reduced number of solved problems. However, we found no evidence that verbalization slowed down performance on insight problem solving. If verbalization slowed down performance, then it would be expected that the peak frequency of insight solutions would occur later in the verbalization condition compared with the nonverbalization condition. However, there was no evidence in any of the four experiments that verbalization increased the time taken to solve the insight problems. It appears that in the case of insight problems, you either get them or you do not, and if you are verbalizing you are simply less likely to get them.

It was also possible that the observed effects of verbalization were due to an interaction between the demand characteristics of the verbalization situation and problem type. If subjects are reluctant to reveal to the experimenter that they are on the wrong track, then the think-aloud instruction might create a strong tendency to continue with the current approach. This tendency would be expected to affect insight problems, in which finding the right view of the problem is the crucial step, more than noninsight problems, in which the main difficulty is to execute or carry out the obvious approach. However, in Experiment 4 subjects were given a hint by the experimenter that they might be in a mind-set and that

they might need to consider alternative views of the problem. This hint should have created a demand characteristic in favor of considering alternative approaches. Nevertheless, the results from Experiment 3 were replicated: Verbalization still impaired insight problems more than noninsight problems even when subjects were encouraged to consider alternative approaches. Thus, an explanation in terms of demand characteristics is also insufficient to explain our results.

The Mechanism of Interference

The mechanism underlying the disruptive effects of verbalizing insight problem solving seems likely to be related to the negative effects of verbalizing other activities that involve critical difficult-to-report components. As previously mentioned, recently there has been growing evidence that verbalization may cause nonreportable aspects of a task to become overshadowed by those that are more readily reported (e.g., Brandimonte, Hitch, & Bishop, 1992; Fallshore & Schooler, 1993; Schooler & Engstler-Schooler, 1990; Wilson & Schooler, 1991). Our explanation for the effect of verbalization on insight is that a request for verbalization may similarly cause the verbalizable task components to overshadow those that are less readily verbalized. In the case of noninsight problems, verbalization would not be expected to produce much disruption because these problems involve a series of incremental steps, each of which is separately reportable (e.g., Newell & Simon, 1972). In contrast, the solutions to insight problems occur suddenly (Durkin, 1937; Metcalfe & Wiebe, 1987), thus suggesting that the critical steps leading to the solution are unavailable for conscious inspection. Despite the opaqueness of insight processes, subjects are nevertheless quite willing to think aloud while attempting to solve insight problems. It seems that the reportable processes are simply not the ones that will lead to a correct solution. Consistent with this suggestion is Metcalfe's (1986b) observation that subjects' belief that they are close to a solution is actually predictive of a *failure* to solve the problem. Metcalfe suggested that subjects who believe that a solution is imminent are engaging in a "gradual rationalization process" (p. 623) that focuses them on an inaccurate yet reportable approach. It seems likely that a similar process may occur in the case of verbalization, namely that the gradual reportable processes elicited by verbalization may overshadow the critical nonreportable processes necessary for successful solutions.

Although the present findings are consistent with the suggestion that verbalization overshadows critical difficult-to-report insight processes, the nature of these processes remains to be specified. One likely nonreportable component of insight is memory retrieval, and in particular spreading activation processes (e.g., Bowers et al., 1990; Langley & Jones, 1988; Ohlsson, 1992). Inspection of the insight and noninsight problems in the Appendixes indicates that the noninsight problems are relatively self-contained, that is, subjects do not need to draw on any additional world knowledge to solve them. Rather, the difficulty of noninsight problems typically lies in correctly sequencing and executing the operators necessary to solve the problem. In contrast, insight

problems require identifying an alternative approach to the problem, which often requires retrieving world knowledge. For example, in the case of the problem of identifying how a dealer knows that a bronze coin marked 544 B.C. is a fraud (see Appendix A), subjects must retrieve the fact that B.C. corresponds to "before Christ" and the implications of that fact.

A related insight process that may be disrupted by verbalization is constraint relaxation (Ohlsson, 1992). In many insight problems, the initial representation is likely to be unnecessarily constrained by false assumptions, often referred to as an incorrect mind-set or *Einstellung* (Luchins, 1942). For example, in the previously discussed problem of determining the parental identity of a surgeon, it may be falsely assumed that the solution can only be fulfilled by a man. Verbalization may interfere with the ability to overcome such unnecessary constraints both by strengthening the activation of the incorrect assumption(s) and by interfering with the retrieval of the necessary counterinformation (e.g., that women can be surgeons).

Another nonverbalizable insight process that may also be disrupted by verbalization is perceptual reorganization (Ohlsson, 1992). In some insight problems, critical shifts in defining the problem space may arise from perceptual remapping of the objects involved (e.g., the Necker cube phenomenon). Given the nonverbal characteristic of such perceptual processes, it seems quite possible that verbalization may disrupt these processes as well. Although a disruption in perceptual reorganization might account for reduced performance on some of the insight problems (e.g., the triangle coin problem in Appendix A), it is important to note that verbalization equally affected the insight problems that did not include perceptual components.

Future research will be necessary to isolate the mechanism by which verbalization focuses subjects on reportable processes at the expense of nonreportable ones. It seems likely, however, that because the distinction between reportable and nonreportable cognition is often mapped onto the distinction between automatic and controlled processes (e.g., Jacoby, Ste-Marie, & Toth, in press; Schneider, Dumais, & Shiffrin, 1984), verbal overshadowing of nonreportable processes may be comparable to situations in which "the attentive system overrides the automatic" (Eriksen, Webb, & Fournier, 1990, p. 486). Specifically, a number of researchers have suggested that automatic processes may be disrupted when attention is directed toward automatized tasks (Eriksen et al., 1990; Kimble & Perlmuter, 1970; Langer & Imber, 1979; Norman & Shallice, 1986). In the present study, the nonreportable insight processes, such as spreading activation, that we suggest may be disrupted by verbalization are typically characterized as being automatic (e.g., Bowers et al., 1990). Moreover, subjects' inability to benefit from instructions to consider alternative approaches in Experiment 4 suggests that this critical step to successful insight solutions is not under volitional control and therefore involves automatic processes. It thus remains an intriguing possibility that verbalization may, in some sense, increase the brightness of the attentional spotlight and thereby overshadow the automatic processes necessary for insight problem solving.

Implications for the Study of Insight

Some researchers have suggested that insight processes reduce to the same conscious processes that are associated with other types of problem solving (Perkins, 1981; Weisberg, 1986; Weisberg & Alba, 1982). The present series of experiments presents some difficulty for such a view. The differential effect of the verbalization request on subjects' performance on insight and noninsight problems is strong evidence that the underlying processes are not identical. The present results thus extend Metcalfe's (1986a) and Metcalfe and Wiebe's (1987) observation that people can accurately report their distance from the solutions to noninsight problems but are unable to report their nearness to insight solutions. These results are consistent with the present view that processes leading to insight solutions differ from those leading to noninsight solutions in that they are not available for conscious inspection and therefore leave few hints as to their progress. Thus, a strong argument for the existence of distinct insight processes is that they readily account for qualitative differences between insight and noninsight problems observed in two different paradigms.

Methodological Implications and the Generality of Verbalization Effects

The use of verbal protocols is now a widely used method for studying cognitive processes in large part because of Ericsson and Simon's (1980, 1984) theory suggesting that verbal protocols when properly collected are both valid and nonreactive. Our research is in agreement with Ericsson and Simon's general theoretical assumption that verbalization will primarily interfere with performance when subjects attempt to verbalize information that is not normally heeded. However, the present research suggests that Ericsson and Simon may have underestimated the situations under which verbalization may cause normally unheeded information to be considered. Specifically, Ericsson and Simon suggested that verbalization only qualitatively alters cognitive processes when subjects are explicitly directed to verbalize information that they would not otherwise consider (e.g., when asked to engage in retrospective verbalization about the strategies that they used). However, the present findings suggest that tasks that involve a considerable amount of nonreportable processing may be disrupted by verbalization, even if subjects are given concurrent, non-directive, think-aloud instructions.

The disruptive effects observed in the present study are particularly notable because they were incurred with problem solving, which represents the most common application of think-aloud procedures. In the past, although there were many examinations of the effects of verbalization on higher order processes such as reasoning and problem solving, as Ericsson and Simon (1980, 1984) noted, there was little evidence that nondirective think-aloud procedures could disrupt such performance in a manner other than simply slowing performance or increasing arithmetic slips (Russo et al., 1989). The present research indicates that it is not only perceptionlike nonreportable processes that can be disrupted by

verbalization. Rather, more generally, any cognitive activity that relies primarily on nonreportable processes and information may be vulnerable to verbalization, including creativity (Finke, 1990; Koestler, 1964), implicit concept learning (Reber, 1989), implicit memory (Schacter, 1987), and automated complex motor skills (Norman & Shallice, 1986). The potential breadth of cognitive tasks that may be vulnerable to verbalization strongly suggests that all researchers using think-aloud procedures should, at a minimum, consider the degree to which the cognitive processes they wish to examine are likely to involve nonreportable components. However, because we do not at present have an adequate theory for identifying whether a task involves nonreportable components (although this is clearly an important area for future theory and research), researchers using think-aloud techniques should seriously consider including silent control groups to determine whether verbalization is influencing performance (c.f. Russo et al., 1989).

Language and Thought

The finding that verbalization disrupts insight processes suggests two implications for the age-old issue of the relationship between language and thought (for a recent review, see Hunt & Agnoli, 1991). First, the finding that subjects are less effective at solving insight problems when they are compelled to put their thoughts into words provides additional support for the claim that insight involves processes that are distinct from language. Second, the observation that verbalization qualitatively alters performance suggests one situation in which insight problem solving may become increasingly influenced by language, namely when subjects attempt to articulate their thoughts. In short, the present research suggests that the relationship between language and thought is not always symbiotic. Rather, in some situations, language may interfere with thought.

The claim that verbalization impairs thinking contradicts the common wisdom of the benefits of "talking through" a problem. This notion has received some support from a number of studies showing that verbalization can improve problem solving (e.g., Ahlum-Heath & Di-Vesta, 1986; Davis, Carey, Foxman, & Tarr, 1968; Gagne & Smith, 1962; Wilder & Harvey, 1971). However, all of these studies used non-insight step-by-step problems with a limited number of options at each step, and they did not require the retrieval of nonobvious operators. As long as a problem is reasonably straightforward, it appears that verbalization should be, at a minimum, benign and that verbalization sometimes may even help by highlighting useful information. However, when the basic difficulty is that the obvious approach is the wrong approach and the crucial step is to retrieve information that will help to change one's view about the problem, then talking through the problem appears not to be an effective tactic. At least in the case of insight problems it may be better to "think before you speak."

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Appendix A

Insight Problems

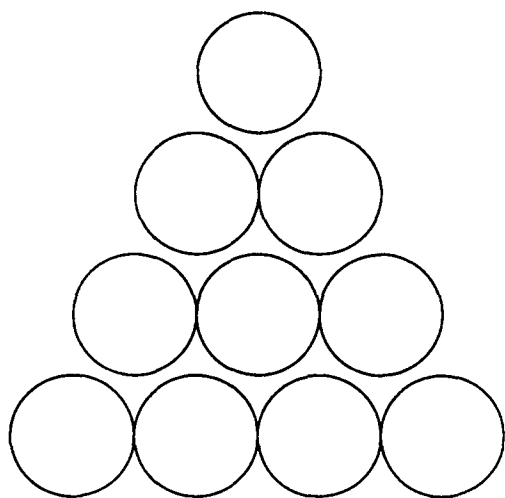
1. (Experiments 1–4) Show how you can make the triangle below point downward by moving only three of the circles. [see Figure A1.]

2. (Experiments 1–4) 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 ground safely. He divided the rope in half, tied the two parts together, and escaped. How could he have done this?

Solution: He unraveled the rope and tied the two pieces together.

3. (Experiments 1–4) 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?



Solution:

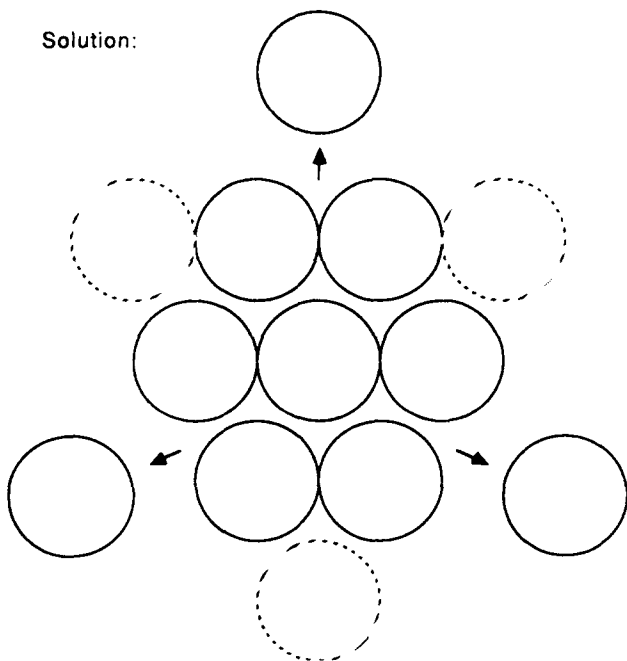
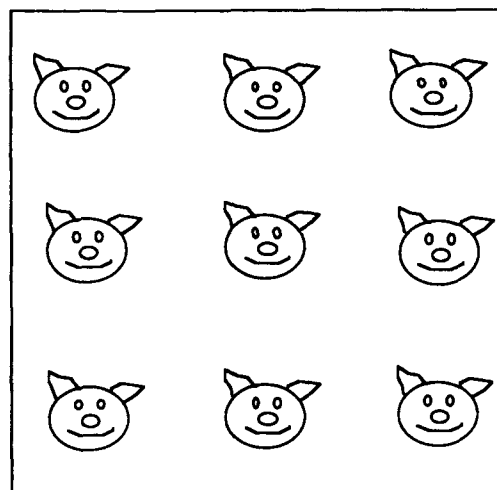


Figure A1. Diagram and solution for the "Triangle" problem.



Solution:

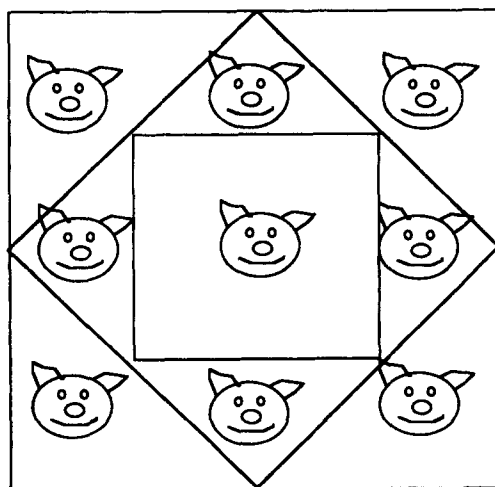


Figure A2. Diagram and solution for the "Pigs in a pen" problem.

Solution: In 544 B.C. Christ had not been born, so a coin from that time would not be marked "B.C." (before Christ).

4. (Experiments 1 and 2) Nine pigs are kept in a square pen. Build two more square enclosures that would put each pig in a pen by itself [See Figure A2.]

5. (Experiments 1 and 2) Describe how to cut a hole in a 3- \times -5-in. card that is big enough for you to put your head through.

Solution: First cut a spiral path from the outside of the card to the inside. Then cut a long slit down the middle of the spiral strip leaving the ends of the strip intact. A number of similar variations to this solution were also accepted.

6. (Experiments 1 and 2) A giant inverted steel pyramid is perfectly balanced on its point. Any movement of the pyramid will cause it to topple over. Underneath the pyramid is a \$100 bill. How would you remove the bill without disturbing the pyramid?

Solution: Burn or tear the dollar bill.

7. (Experiment 1 only) Water lilies double in area every 24 hr. At the beginning of the summer, there is one water lily on the lake. It takes 60 days for the lake to become completely covered with water lilies. On which day is the lake half-covered?

Solution: The lake is half-covered on the 59th day.

Appendix B

Noninsight Problems Used in Experiments 3 and 4

1. (Practice) Mary won't eat fish or spinach, Sally won't eat fish or green beans, Steve won't eat shrimp or potatoes, Alice won't eat beef or tomatoes, and Jim won't eat fish or tomatoes. If you are willing to give such a bunch of fussy eaters a dinner party, which items from the following list can you serve: green beans, creamed codfish, roast beef, roast chicken, celery, and lettuce.

Solution: roast chicken, celery, and lettuce.

2. 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 below refers to the same three cards):

- 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 picture card?

Solution: jack of hearts, king of diamonds, queen of spades.

3. The police were convinced that either A, B, C, or D had committed a crime. Each of the suspects, in turn, made a statement, but only one of the four 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? and Who committed the crime?

Solution: B is telling the truth, and A committed the crime.

4. There are four coins—two heavier coins of equal weight and two lighter coins of equal weight, all of which are indistinguishable 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 only use the scale twice.)

Solution: Begin by placing one coin on each side of the scale. If they do not balance, then you have already identified one heavy and one light coin. Repeating the procedure with the remaining two coins will identify the other light and heavy coins. If the initial two coins balance, simply remove one of the coins and replace it with one of the remaining coins. This weighing will provide the remaining information needed to determine which coins are heavy and which are light.

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