Using Sentence and Picture Clues to Solve Verbal Insight Problems

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Abstract
Pictures and sentences, designed to be equivalent in information content, were compared as clues for solving verbal insight problems. Solving insight problems may require creative thinking because a novel approach is required for their solution. A 2 (test condition: informed, uninformed) x 3 (clue type: picture, sentence, unrelated) between and within-subjects design was used. Participants (N=144) completed in order: an information acquisition task, verbal insight problems, a free recall task, and a questionnaire. This methodology extended prior research by comparing picture and sentence clues in the same experiment. There was no reliable difference in solution rates for problems associated with picture clues versus sentence clues. Problems associated with sentence clues were solved more quickly. Recall rates were higher for picture clues. One explanation consistent with these findings is that sentence clues, which have similar surface features to the problems, are used automatically to predispose problem solvers to initially represent the problem in a way that makes it solvable. Picture clues, which are more memorable and subjective, are more functional to enable a problem solver at impasse, who is aware of the connection between the pictures and the problems, to re-represent the problem so that it is solvable.
Using Sentence and Picture Clues to Solve Verbal Insight Problems

A creative approach is often required to solve problems that are ill-defined or for which the path to solution is unclear (Finke, Ward & Smith, 1992). All creativity does not involve problem solving and all problem solving is not creative problem solving, but when a novel or original solution to a problem is discovered creative thinking has occurred (Guilford, 1950). The transition from not knowing how to solve a problem to suddenly knowing how to solve it is referred to as insight (Mayer, 1995). What is insightful for one individual may not be insightful for another (Davidson, 1995). A problem that is solved creatively by one person may be solved more routinely by another if the problem solver has had experience with similar problems in the past (Davidson, 1995; Dominowski, 1992; Nickerson, 1999). The role of creativity and insight in solving problems is dependent on the cognitive processes used by the problem solver rather than characteristics of the problem or the problem solution (Davidson, 2003; Finke et al., 1992).

Insight is a process sometimes associated with creative thinking but also a specific type of problem solving. Insight problems require the problem solver to depart from the familiar to make sense of what often seems unsolvable. The nonroutine, often confusing, characteristics of insight problems sometimes make it difficult to access and use prior knowledge that is relevant to the solution. Such is the case with verbal insight problems, often referred to as brainteasers or riddles. These problems create ambiguity that leads the reader to plausible but inappropriate assumptions when interpreting the problems. Multiple interpretations are possible but only one interpretation, usually the nondominant one, renders the problem solvable. Nevertheless, most problem solvers have the requisite knowledge to solve these problems easily once they represent them properly (Dominowski, 1992; Lockhart, Lamon, & Gick, 1988).
Numerous studies have found that, unless they have been specifically informed of the connection, people often have difficulty transferring previously acquired information to cue solutions in subsequent problem-solving tasks (Adams, Kasserman, Yearwood, Perfetto, Bransford, & Franks, 1988; Bowden, 1985; Gick & Holyoak, 1980; Lockhart et al., 1988; Perfetto, Bransford, & Franks, 1983; Ross, Ryan, & Tenpenny, 1989; Weisberg, DiCamillo, & Phillips, 1978). The literature documents that problem solving performance with a clue is better than performance without a clue (Bowden, 1985; Lockhart et al., 1988; Perfetto et al., 1983; Ross et al., 1989). When a clue is provided, performance is better when problem solvers are specifically informed of the connection between the clue and the problem than when they are uninformed (Bowden, 1985; Perfetto et al., 1983; Ross et al., 1989; Weisberg et al., 1978). However, even blatant clues are sometimes surprisingly little help. For example in Perfetto et al. (1983, Experiment 1), with blatant clues and verbal insight problems, solution rates were 19%, 29% and 54% without a clue, uninformed with a clue, and informed with a clue, respectively.

Although many studies of information transfer in a problem solving context have been done, few have used pictures in the incidental learning or acquisition task (Chen, 1995; Dreistadt, 1969; Stein, Brock, Ballard & Vye, 1987). This is surprising for two reasons. First, the picture superiority effect findings indicate that pictures are remembered more easily than words (Berry, Banbury, & Henry, 1997; Madigan, 1983; Paivio, 1978; Paivio, Philipchalk & Rowe, 1975; Paivio, Rogers & Smythe, 1968; Rajaram & Roediger, 1993; Weldon & Roediger, 1987) and provide access to semantic memory more readily than words (Banks & Flora, 1977; Glaser, 1992; Nelson, 1979; Paivio, 1975; 1978; 1986; Potter & Faulconer, 1975; Seifert, 1997; Smith & Magee, 1980). Second, solving insight problems is often considered a creative thinking task and anecdotal and empirical evidence abound to suggest that images are associated with creative
thought (e.g., Daniels-McGhee & Davis, 1994; Durndell & Wetherick, 1977; Finke et al., 1992; Forisha 1978a, 1978b; Gardner, 1982, 1993; Hadamard, 1945; Koestler, 1964; LeBoutillier & Marks, 2003; Paivio, 1971, 1978, 1986; Shaw & Belmore, 1982; Shaw & DeMers, 1986; Wallace & Gruber, 1989; West, 1997). Given the memorability of pictures and the importance of images for many creative thinkers, it is logical to explore pictures as clues for solving insight problems.

In this study, relevant information was presented to participants in two forms, pictures and sentences, during an information acquisition task. It was during this task that participants attended to and encoded features of the stimuli. The clues were designed to provide equivalent information, however, they were not equivalent in form. A direct comparison will inform whether sentences or pictures have more functional utility as clues when solving verbal insight problems. The results will enhance understanding of how previously acquired information is used in problem solving and the cognitive effectiveness of clues presented in diverse forms.

Clues and Transfer

The literature establishes that, although receiving a clue in no way guarantees a correct solution, verbal insight problem solving performance with a clue is superior to performance with no clue (Bowden, 1985; Lockhart et al., 1988; Perfetto et al., 1983; Ross et al., 1989). From an information processing perspective of insight, the mental representation of a problem acts as a memory probe to retrieve problem solving knowledge operators from memory (Ohlsson, 1992). The ambiguous language of verbal insight problems makes it difficult to formulate a mental representation that is a useful memory probe to retrieve the knowledge operator needed to solve the problem. When the mental representation does not activate the relevant knowledge operator, the problem solver faces an impasse. Only by changing the problem representation can new
memory probes be created that activate different knowledge operators from memory (Knoblich, Ohlsson, & Raney, 2001). If the relevant operator is so activated, the impasse is broken and the problem is solvable. Clues may help the problem solver interpret the problem in a way that the solution is understood, resolve an ambiguous word or phrase by accessing a non-dominant meaning, or avoid fixation on an incorrect interpretation.

When clues do not help, the lack of information transfer to facilitate problem solving may occur because problem solvers fail to access the information contained in the clue, represent the problem in a way that excludes the solution, or overemphasize unrelated aspects of the problem or the clue. Alternatively, problem solvers may access information contained in the clue but, because they do not make the connection between that information and the problem, fail to apply it. Comparing the performance of problem solvers who are informed of the connection between the clue and the problem with problem solvers who are not informed provides a methodology to distinguish between failure of access and failure of application. For uninformed problem solvers transfer requires successful access and application of the clue. For informed problem solvers only successful application is required (Bassok, 2003).

**Surface and Structural Similarity**

Previous research has shown that similar surface features facilitated transfer between a source analog and the subsequent problem (Chen, 1995; Gick & Holyoak, 1983; Holyoak & Koh, 1987; Novick, 1988). Consistent with Stein & Hedgecough (1983, Experiment 2), verbal similarity in this experiment was operationalized as the use of two or more identical content words in the sentence clue and the insight problem. Thus, sentence clues had surface similarity to the problems. This similarity may remind the problem solver of the clue, and thus provide a
mechanism for retrieving information contained in the clue. Surface similarity between the clue and the problem should give sentence clues an advantage over picture clues.

Consistent with Chen (1995), pictorial similarity in this experiment was operationalized as a picture that contained representations of objects mentioned in the corresponding insight problem. The pictures used in this experiment were black and white drawings that depicted a scene that conveyed a concept or situation relevant to solving the problem. Nevertheless, problem solvers must infer the concept a picture represents. Unlike the information presented in sentence form, the information the problem solver ‘sees’ in a picture is subjective. The downside is that the researcher cannot control whether the problem solver does indeed recognize and encode the intended concept from a picture. The upside of this subjectivity is that picture meanings are less constrained. Shephard (1978) posited that concrete visual imagery encompasses details that may not be adequately contained in a verbal image.

Picture clues do not have surface similarity to the problems as do sentence clues. From this perspective, picture clues should be at a disadvantage relative to sentence clues. However, because pictures are typically more memorable than words (Nelson, 1979; Paivio, 1978; Paivio et al., 1975; Paivio et al., 1968; Rajaram & Roediger, 1993; Weldon & Roediger, 1987), problem solvers may be more likely to remember a picture clue than a sentence clue. Having the clue in memory should make the information it contains available for use in problem solving. Assuming the problem solver does access the picture clue, its inherent subjectivity may allow characteristics of the picture to activate memory structures that were not previously triggered by the problem but are necessary to solve the problem. In this way picture clues may be more apt to stimulate re-representation of an incorrect problem representation. As Richardson (1969) explained, controlled imagery might facilitate problem solving by providing an alternative to
verbal thought and facilitate restructuring of a problem by disrupting an unproductive mental set. Thus, memorability and subjectivity should give picture clues an advantage over sentence clues.

*Processing Time*

Time was included as a dependent variable labeled “seconds to solution” in this experiment. A comparison of processing time for problems associated with sentences and pictures informed the efficiency of clues presented in diverse forms. Bowden (1985) found informed and uninformed participants produced most of their problem solutions within one and two minutes respectively. He tested participants in small groups. The experimenter prompted participants to draw a line across the paper every 20 seconds and to write their solution beneath the most recent line. Time to solution was reported in 20-second intervals. Lockhart et al. (1988, Experiment 2) found that most solutions to insight problems occurred in the first minute of problem solving. Participants were tested individually, signaled the experimenter as they began to read the problem, and again when they had written down an answer. The experimenter measured response time in seconds using a stopwatch.

In an attempt to improve the precision of the timing procedures used in previous studies, participants in this experiment timed themselves using a stopwatch. Participants were tested in small groups of 2 to 10. They were instructed to start their stopwatch before they read the problem and stop it before they wrote down the answer. Because problem representation is crucial to solving verbal insight problems, cognitive processing begins as soon as the problem solver begins to read the problem. Presumably a problem solver has formulated a solution before beginning to write it down, so the time it takes to record the answer is not included in seconds to solution. More specific information about the timing procedure is included in the method section.
Previous research has found significant individual differences that could impact problem solving performance. These factors include IQ (Davidson, 1986; Davidson & Sternberg, 1986; Sternberg & Davidson, 1982), the ability to self-monitor problem solving progress (Davidson, 1995), expertise (Klein & Hoffman, 1993; Novick, 1988; Rabinowitz & Glaser, 1985), memory organization (Siefert, Meyer, Davidson, Patalano, & Yaniv, 1995), attentional resources (Ansburg & Hill, 2003), apprehending relations and generating and testing numerous possible solutions (Ansburg, 2000), perceptual restructuring and ability to break context (Schooler & Melcher, 1995). It could be argued that vocabulary ability might impact problem solving performance by influencing problem representation as well as encoding of clue sentences. It could also be argued that imaging ability might affect problem solving performance for two reasons. First, imaging ability might influence encoding of pictures. Second, because insightful problem solving is often considered a creative task and some creative thinkers are prone to think in images, high imagers might have an advantage over low imagers in solving the problems. In this study, the number of participants was sufficiently large that it was reasonable to assume the above-mentioned variables, as well as other possible individual difference variables, did not systematically influence the results. Each subject received problems associated with each clue type, which further controlled for individual difference variables.

Predictions

First, consistent with the findings of prior studies discussed above (Bowden, 1985; Lockhart et al., 1988; Perfetto et al., 1983; Ross et al., 1989), clues are expected to facilitate problem solving. Problems for which there is a related clue should have higher solution rates and faster solution times than problems for which there is not a clue. Second, consistent with the literature previously discussed (Bowden, 1985; Perfetto et al., 1983; Ross et al., 1989), a priori
information about clue relevance is expected to improve problem solving performance. Problem solvers who are informed that the sentences and pictures presented in the acquisition task are clues to solve the problems should perform better than problem solvers who are not informed. Third, sentence clues have the advantage of surface similarity to the problems. Picture clues have the advantage of memorability and subjectivity. Given these competing characteristics, no specific prediction regarding relative clue utility is made.

**Method**

*Choosing Clues*

Given the design of this experiment, it was crucial that the sentences and pictures were equivalently relevant and effective as clues to avoid any ex ante performance bias. A pilot study (N=20), using 20 potential verbal insight problems with associated sentence and picture clues, was conducted to choose problems to use in the experimental tasks. Each problem was presented already paired with a relevant clue. No information transfer was required.

Four selection criteria were used: (1) at least 80% of participants solved the problem correctly; (2) a solution rate difference of 10% or less for a problem paired with its associated picture clue versus its sentence clue; (3) for each picture and sentence the difference in clue “helpfulness” as determined by mean ranking on a scale from 1 (not at all helpful) to 5 (extremely helpful) was not statistically significant; (4) if problems required the same trick to disambiguate meaning, only the one that best met criteria 1 through 3 was chosen. The 20 problems were ranked and the 12 problems that best met the criteria were selected. (See the Appendix for a sample problem with associated picture and sentence.)
Participants

One hundred forty four undergraduates from SUNY Brockport (57 women, 19 men), St. John Fisher College (42 women, 11 men), and SUNY Geneseo (11 women, 4 men) participated in this experiment for extra credit.

Design, Procedure, and Materials

A 2 x 3 mixed factorial design was used, with test condition (informed, uninformed) as a between-group factor, and clue type (picture, sentence, unrelated) as a within-group factor. Participants were alternately assigned to the two test conditions. Participant 1 was assigned to the informed group, participant 2 to the uninformed group, participant 3 to the informed group, and so forth. Participants were tested in small groups of 2 to 10. They completed in order: an information acquisition task, verbal insight problems, free recall of clues. Participants turned in each completed task booklet before receiving the next one. After completing all three experimental tasks, each subject answered a questionnaire. The tasks and procedure were the same for all participants regardless of test condition. Only the written directions for the problem solving task distinguished the test conditions. Each participant was given a stopwatch to use during the problem solving task, instructed on how to use it, and given a few minutes to practice before beginning the experiment.

Information acquisition task. Each of the 12 insight problems had an associated picture clue and an associated sentence clue. Problems were randomly assigned to three problem sets (i.e., four problems per set) balanced for difficulty using the rankings from the pilot study. For Task 1 each participant received sentence clues associated with one problem set, picture clues associated with a second problem set, and two unrelated sentences and two unrelated pictures with the third problem set. The unrelated sentences and pictures were associated with problems
in the pilot study that were not chosen to include in the main experiment. Thus they were similar in format to the sentence and picture clues but they bore no connection to any of the problems participants were asked to solve. There is precedent for this in Perfetto et al. (1983), Bowden (1985), and Ross et al. (1989) who used “filler” sentences, which bore no connection to any of the subsequent problems, in their acquisition tasks. The same unrelated sentences and pictures were used for all participants. As in Bowden (1997), unrelated sentences and pictures provided a baseline or control condition for problem solving without a clue and were analyzed as such. The clue/problem pairings were rotated so that after three participants each problem had been paired once with each clue type.

Each participant received a booklet containing six sentence clue pages (i.e., one for each of four sentence clues and the two unrelated sentences) and six picture clue pages (i.e., one for each of four picture clues and the two unrelated pictures) in random order. One clue was presented on each 8½ x 11in. (22 x 28 cm) page. To encourage participants to think carefully about the clue, each page also contained the question: “How easy is it to understand the meaning of the above sentence?” on sentence clue pages and “How easy is it to understand the meaning of the above picture?” on picture clue pages with a ranked scale from 1 (not at all easy) to 5 (extremely easy) to respond. Written directions, which were given on the first page of each booklet, were the same for all participants. The experimenter timed this task, prompting participants to turn to the next page at 20-second intervals.

Problem solving task. For Task 2 each participant received a booklet with all twelve verbal insight problems in random order. Written directions, which varied depending on test condition, were given on the first page of each booklet. Directions received by participants in the informed group contained the following additional sentence: “The first task you completed -- the
rating of sentences and pictures -- contained information that may help you solve some of the problems.” Directions received by participants in the uninformed group did not contain this sentence. Therefore, uninformed group participants were never explicitly told that the information acquisition task had any relevance to the problem solving task.

The directions included a numbered sequence of steps to follow for solving and timing each problem as follows: (1) Start your stopwatch (push the blue button), before you read the problem; (2) Read the problem; (3) Solve the problem in your mind; (4) When you think you know the answer, stop your stopwatch (push the blue button); (5) Write down the time shown on the stopwatch; (6) Now write down the answer to the problem; (7) Rate your confidence in your answer on the scale provided; (8) Reset your stopwatch to zero (push the far left gray button); (9) Turn the page and follow the same procedure for the next problem; Remember, note the time when you know the answer to the problem, but before you write down the answer.

Each booklet page was printed on an 8 ½ x 11in. (22 x 28 cm) sheet of paper and contained prompts to reinforce the above direction procedure. The top of each page contained the prompt, “START YOUR STOPWATCH NOW,” followed by the problem. Below the problem was the prompt, “When you know the answer, stop your stopwatch, and note the time here” followed by the instruction “Now write down your answer in the space below.” A reminder to “RESET YOUR STOPWATCH TO ZERO” was included at the bottom of each page. Consistent with this timing procedure, the time variable included the time to read and solve the problem but not the time to write down the answer. To gather information for a subsequent study, the question “How confident are you that your answer is correct?” was asked on each page with a ranked scale from 1 (not at all confident) to 5 (extremely confident) to respond. This task was
self-paced. Participants timed themselves using the stopwatch they each received at the beginning of the experimental session.

*Free recall task.* Materials for Task 3 consisted of two sheets of 8 ½ x 11 in. (22 x 28 cm) paper. Directions given on the top of the first page included the following instruction: “Please write down as many sentences as you can recall from the sentences you rated at the beginning of this experimental session. Also, please draw or describe as best you can as many pictures as you can recall from the pictures you rated at the beginning of this experimental session. The sentences and pictures do not have to be in the order they were presented to you. Just do the best you can to remember as much as you can about as many of the sentences and pictures as you can.” This task was self-paced with no time limit.

*Post-experiment questionnaire.* After completing the three experimental tasks, each participant completed a questionnaire. One purpose was to determine if they were familiar with any of the problems prior to the experiment. Other questions asked about problem solving strategies and if the participant was aware of the specific connection between the information acquisition task and the problem solving task.

**Results and Discussion**

Consistent with other transfer experiments (Bowden, 1985; Perfetto et al., 1983; Ross et al., 1989), data from participants who had familiarity with two or more problems as self-reported on the questionnaire were dropped from the analysis. Data from participants who did not follow directions or did not complete one or more of the task booklets were also dropped. Based on these criteria, data from 11 informed participants and 13 uninformed participants were not used in the analysis. Additional subjects were tested to bring the total to 72 in each test condition.
Two trained independent raters scored all task booklets. Inter-rater reliability, as measured by Cohen’s kappa, was 100%.

A note about degrees of freedom is necessary. To effectively analyze the data by test condition and/or clue type, each data point represents a particular participant/problem pairing. Collapsing within-subject data to a single data point would prelude analysis of clue type performance, which is central to the hypothesis comparing sentence and picture utility. Therefore, for each participant there are 12 distinct data points (i.e., one for each problem) rather than a single summary data point. For analyses that include all participants and all problems there are a maximum of 1,728 data points (144 participants X 12 problems) and degrees of freedom of 1 and 1,726. Degrees of freedom change depending on the constraints of the analysis (e.g., solved problems, informed participants, picture clues, etc.).

The dependent variable measuring performance was whether a problem was solved correctly. An answer was scored correct if it was consistent with information provided in the clue and the problem. Consistent was defined as ‘not contradictory.’ The dependent variable measuring processing time was seconds to solution. The time variable frequency distribution was positively skewed (skewness = 3.32, SE = .06). A transformation to natural logarithmic scale resulted in a more symmetric distribution (skewness = .204, SE = .06). To meet normalcy assumptions, all analyses comparing means, and tests of significance, were done using natural logarithms of raw time data [i.e., ln(time)]. In reporting results, the actual time in seconds was also included to give the reader a sense of the average time participants spent on problems. Actual time included the label “s” to distinguish it from ln(time) data.

The dependent variable to measure accessibility of information was free recall of clues. No predictions specific to recall were proposed, nevertheless, when recall results informed
performance and processing findings they were reported. The criterion to determine if a clue was recalled correctly was whether information in the sentence or picture, as written or drawn by the subject, was isomorphic with critical information needed to solve the problem, which is the information that was presented to the participant in the information acquisition task.

Table 1 shows solution rates, and mean time to solution for correctly solved problems by clue type. Table 2 shows clue free recall results for problems not solved and for solved problems. Results are given for all participants and also segmented by informed and uninformed participants.

The results supported the prediction that clues facilitate problem solving. The percentage of problems solved correctly was reliably higher for problems associated with clues than for problems associated with unrelated sentences and pictures (48% v. 32%) \[ F (1, 1726) = 39.18, p < .001, r^2 = .022 \]. Between-group analysis showed similar results for the informed test condition (52% v. 31%) \[ F (1, 862) = 36.18, p < .001, r^2 = .04 \] and uninformed test condition (43% v. 33%) \[ F (1, 862) = 8.17, p < .004, r^2 = .009 \]. Performance for problems associated with sentence clues was reliably better than performance for problems associated with unrelated sentences and pictures for both the informed test condition \[ F (1, 574) = 29.68, p < .001, r^2 = .049 \] and the uninformed test condition \[ F (1, 574) = 11.74, p < .001, r^2 = .02 \]. Performance for problems associated with picture clues was reliably better than performance for problems associated with unrelated sentences and pictures for the informed test condition \[ F (1, 574) = 26.00, p < .001, r^2 = .043 \]. For the uninformed test condition solution rates were higher for problems associated with picture clues but the difference did not reach statistical significance. Mean time to solution for problems associated with clues (18.4 s) was 17% faster [i.e., ln (time)] than mean time to solution for problems associated with unrelated sentences and pictures.
(20.6 s) $[F(1, 733) = 8.74, p = .003, r^2 = .012]$. Mean time to solution for the informed test condition was 21% faster for problems associated with clues than for problems associated with unrelated sentences and pictures $[F(1, 387) = 7.1, p = .008, r^2 = .018]$. For the uninformed test condition, mean time to solution was 12% faster but the difference was not reliable.

The results also supported the prediction that a priori knowledge about clue relevance improves problem solving performance. Informed and uninformed participants solved 45%, and 40% of the problems respectively. This translates to a reliable advantage for informed problem solvers over uninformed problem solvers $[F(1, 1726) = 4.38, p = .036, r^2 = .003]$. The performance advantage of informed participants is due to superior performance on problems associated with picture clues $[F(1, 574) = 8.18, p = .004, r^2 = .014]$. The performance difference for sentence clues and unrelated sentences and pictures did not reach significance. A priori knowledge of clue relevance also resulted in faster solution times. Mean time to solution for informed participants (17.8 s) was 10% faster than for uninformed participants (20.2 s) $[F(1, 733) = 4.01, p = .046, r^2 = .005]$. Informed participants showed faster times for all clue types although the differences were not reliable.

The results regarding the comparison of sentences and pictures for functional utility indicated that sentences and pictures were equally effective as clues. Overall the percentage of problems solved correctly was higher for problems associated with sentence clues (50%) than picture clues (46%) but this difference in solution rates was not reliable. A between-group analysis yielded the same results. The percentage of problems solved correctly for both the informed and uninformed test conditions was higher for problems associated with sentence clues than for problems associated with picture clues but the difference in solution rates was not reliable. Mean time to solution for problems associated with sentence clues was 13% faster than
for problems associated with picture clues \( F(1, 548) = 4.73, p = .03, r^2 = .009 \). Participants in both the informed and uninformed test conditions solved problems associated with sentence clues faster but at significance levels of .12 and .11 respectively.

More problems were solved correctly with recall (60%) than without recall (37%) \( F(1, 1150) = 64.18, p < .001, r^2 = .053 \). Between-group analysis showed similar results for the informed test condition \( F(1, 574) = 34.73, p < .001, r^2 = .057 \) and uninformed test condition \( F(1, 574) = 27.5, p < .001, r^2 = .046 \). Recall of picture clues (65%) was significantly higher than recall of sentence clues (32%) \( F(1, 1150) = 149.01, p < .001, r^2 = .115 \). Picture clues were more readily recalled for both the informed test condition (68% v. 34%) \( F(1, 574) = 77.0, p < .001, r^2 = .118 \) and the uninformed test condition (63% v. 29%) \( F(1, 574) = 72.32, p < .001, r^2 = .112 \). The data in Table 2 indicate that, for correctly solved problems, recall of picture clues was significantly higher than recall of sentence clues \( F(1, 548) = 70.65, p < .001, r^2 = .114 \).

Between-group analysis showed similar results for both the informed test condition \( F(1, 298) = 44.91, p < .001, r^2 = .131 \) and the uninformed test condition \( F(1, 248) = 25.85, p < .001, r^2 = .094 \).

Two additional findings are worth reporting. First, higher confidence ratings as self-reported on the ranked scale, were associated with higher solution rates \( F(1, 1706) = 865.37, p < .0001, r^2 = .337 \), faster solution times \( F(1, 1706) = 475.18, p < .001, r^2 = .218 \) and more recalled clues \( F(1, 1706) = 32.72, p < .001, r^2 = .018 \).

Second, although there was no difference in solution rates or times as a function of understanding the clues, as self-reported on the ranked scale in the information acquisition task, participants were significantly more likely to recall clues to which they gave low scores on the
“understanding” scale \[ F(1, 1725) = 4.43, p = .035, r^2 = .003 \]. That is, the least understandable clues were the most readily recalled.

**General Discussion**

As expected, the results showed that clues facilitated problem solving. Solution rates were higher and solution times were faster with clues. A priori knowledge of clue relevance was an advantage, but only for informed participants for problems associated with picture clues. There was no reliable difference in solution rates for problems associated with picture clues versus sentence clues.

More problems were solved with clue recall. Recall data must be interpreted carefully. One interpretation is that the ability to recall clues, as evidenced by the recall data, facilitated solving the problems. Because the recall task was administered after the problem solving task, an alternative explanation is that solving the problem made recalling the clue easier so more clues were recalled when problems were solved. Direction of the effect cannot be determined from the data as collected. Recall rates were higher for picture clues than for sentence clues. The impressive recall of picture clues is intriguing given that pictures were no more functional than sentences at facilitating problem solving. Problem solvers did not apply the relevant information contained in pictures to assist them in solving problems proportionate to their ability to remember them.

Confidence in answers was associated with better performance. This may be because participants had self-awareness of whether or not they had solved a problem correctly. They developed confidence as a result of solving the problems. An alternate explanation is that their confidence influenced their problem solving effectiveness. Further study using a different experimental design is needed to distinguish the direction of effect.
An interesting finding was that poorly understood clues were more readily recalled. This may be because participants allocated more thought to clues they had difficulty understanding. An alternative explanation is that difficult to understand clues were more novel and hence more memorable. A different methodology is needed to explore these and other alternative explanations.

Taken together the results suggest that sentence and picture clues, although equally effective, might facilitate solving verbal insight problems in different ways. One explanation of the data is that sentences are more likely to prime an appropriate initial problem representation and picture clues are more functional as a catalyst for the problem re-representation necessary to resolve the impasse that occurs when a problem is initially misrepresented.

The between-group performance results support this explanation (Figure 1). For problems associated with sentence clues, there was no reliable performance difference between informed and uninformed problem solvers. Even though uninformed participants had no specific direction linking the clues and the problems, solution rates were not reliably different from informed participants. A logical explanation for this finding is that problem solvers in both groups readily made the connection between the sentence clue and the problem and benefited from the helpful information contained in the clue. Surface similarity between the sentences and the problems likely contributed to problem solvers automatically using the information contained in sentence clues. Additionally, the within-group analysis showed that performance for problems associated with sentence clues was reliably better than performance for problems associated with unrelated sentences and pictures for both informed participants and uninformed participants. That is, performance improved as a function of prior exposure to relevant information provided in sentence clues for all problem solvers. By
definition, priming is an automatic process that results in improved performance as a consequence of prior exposure to information, often without conscious use of that information. The findings evidence that performance improved as a function of prior exposure to relevant information contained in sentence clues and that use of that information was automatic, which makes it reasonable to conclude that sentences functioned as primes.

For problems associated with picture clues, there was a reliable performance difference between informed and uninformed participants. Informed problem solvers, who were explicitly told the pictures might be helpful, used them reliably more than uninformed problem solvers. Therefore, it is reasonable to conclude that picture use was not automatic. The memorability and subjectivity of pictures likely contributed to their use in a more deliberate and controlled way, perhaps to resolve a problem solving impasse.

The time data are consistent with the explanation that sentences are used automatically and pictures are used more intentionally. Priming, which results in the appropriate interpretation of the problem on the initial reading, involves fewer cognitive processing steps than impasse resolution, which requires re-representation of the problem subsequent to an initial inappropriate interpretation. Since cognitive processing takes time, a mechanism that consists of more processing steps should take longer to complete than a mechanism with fewer steps. Therefore, time to solution might provide a measurable variable for underlying cognitive mechanisms. For correctly solved problems, rapid problem solution might be considered evidence of solution via priming. The more time a problem solver spends working on a problem the more likely an impasse has been reached and must be broken for the problem to be solved. Therefore, slower problem solution might be considered evidence of solution via impasse resolution. Recall that mean time to solution for problems associated with sentence clues was 13% faster than mean
time to solution for problems associated with picture clues. Therefore, the time results lend support to the explanation that sentences prime and pictures are more useful for resolving an impasse. However, a plausible alternative explanation is that it takes longer to process the information contained in a picture clue than a sentence clue which increases processing time. More research and a method to measure processing time with significantly more precision than the one used here, and in previous experiments, is needed to fully understand processing time and draw valid conclusions from time to solution differences for sentences and picture clues.

Free recall data support the conclusion that sentence use was relatively more automatic and picture use was relatively more intentional. For correctly solved problems, the free recall rate of picture clues was reliably higher than the free recall rate of sentence clues for both informed and uninformed problem solvers. It is reasonable to expect that clues that were used deliberately would be remembered better than clues that were used automatically. There is empirical evidence that subjects may spontaneously access and use information in problem solving without being aware that they are doing so and, therefore, be unable to explicitly recall it. For example, Maier’s (1931) “two string” problem involved putting a subject in a room with two strings hanging from the ceiling far enough away from each other so that when holding onto one string it was not possible to reach the other string. Also in the room were other objects such as a pole, an extension cord, and a pair of pliers. The task given the participant was to tie the two strings together. The solution was to tie the pliers to the end of one string and set it in motion like a pendulum. While holding the other string, the swinging string could be caught on the upswing and the two strings could then be tied together. Problem solvers rarely thought of this pendulum solution. When the problem solver was at an impasse, Maier would enter the room and brush into one string setting it in motion. Shortly afterwards, participants tended to produce the pendulum
solution. However, they reported not having noticed the hint of the swinging string. The relevant information was presumably accessed and used to solve the problem without the subject being aware (Eysenck & Keane, 1995; Schooler et al., 1995; Simonton, 1995).

The recall data must be interpreted carefully, however, because one anticipated advantage of picture clues was based on the expectation that pictures would be more memorable than sentences. The data in Table 2 showed that the pattern of recall for pictures and sentences differed for problems that were solved compared to problems that were not solved. The difference between informed and uniformed recall was 5.5% for sentence clues associated with problems that were not solved and converged to 1.3% for correctly solved problems. There was no apparent advantage to being an informed participant. The difference between informed and uniformed recall was 1.1% for picture clues associated with problems that were not solved and diverged to 5.8% for correctly solved problems. There was a clear advantage to being informed for recall of picture clues, consistent with the argument that picture use is more intentional. These differences were not statistically significant and no interaction effects were found. A replication study is needed to clarify if the superior free recall of picture clues over sentence clues supports the explanation that they result in different cognitive mechanisms to disambiguate meaning in verbal insight problems, or if the difference in recall is simply the well-documented picture superiority effect.

Future Research

In addition to a replication study to clarify the time and recall data, the results suggest questions for future research. Given the surface similarity between the sentence clues and problems, why weren’t sentences even more effective? Recall that only 50% of problems associated with sentence clues were correctly solved. One explanation is that the number of
problems and clues exceeded the cognitive limits of participants to maintain sufficient
connection between the stimuli. By the time participants got to the final insight problems, the
ability of sentences to prime may have been diminished. Further study is needed to determine if
with fewer problems, and therefore fewer clues, sentences will prime more solutions.

The performance data support the conclusion that sentence and picture clues are used
differently. Specifically, informed problem solvers used picture clues more effectively than
uninformed problem solvers. To further clarify this disassociation, problem solvers could be
given another chance to solve problems they did not solve after a time delay. If the premise that
the memorability and subjectivity of picture clues makes them more available to problem solvers
to resolve impasse is correct, more problems associated with picture clues than sentence clues
should be solved after this incubation period.

High imagers may have an advantage in using picture clues to solve problems because
anecdotal and empirical evidence suggest that images are associated with creative thought and
insightful problem solving is often considered a creative thinking task. Further study using
results from a standard creativity test such as the Vividness of Visual Imagery Questionnaire
(VVIQ) or the Visual Memory Test as an independent variable would increase understanding of
the role of imagery in solving insight problems associated with picture clues.

To summarize, the performance results of this experiment suggest that sentences and
pictures, designed to be equivalent in informational content, are equally effective conveyors of
information transfer when solving verbal insight problems, but they may function in cognitively
different ways. One explanation consistent with the data is that sentences clues, which have
similar surface features to the problems, were used equally by informed and uninformed problem
solvers to predispose them to initially represent the problem in a way that made it solvable.
Pictures, which are more memorable and subjective, were more functional to enable a problem solver at impasse, who was aware of the connection between the pictures and the problems, to re-represent the problem in a way that made it solvable.
References


[Reprinted by Lawrence Erlbaum Associates, Inc. in 1979].


Appendix

Sample verbal insight problem with associated picture clue, sentence clue, and answer.

A man was caught in the rain with no hat or umbrella. There was nothing over his head and his
clothes got soaked, but not a hair on his head got wet. How is this possible?

Sentence clue: A bald man has no hair to get wet in the rain.

Answer: The man was bald.
Table 1

*Summary Data for Solution Rates and Time by Test Condition and Clue Type*

<table>
<thead>
<tr>
<th>Clue Type</th>
<th>Total ((N = 144))</th>
<th>Informed Participants ((n = 72))</th>
<th>Uninformed Participants ((n = 72))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrelated</td>
<td>32.1% (46.7)</td>
<td>30.9% (46.3)</td>
<td>33.3% (47.2)</td>
</tr>
<tr>
<td>Sentence</td>
<td>50.0% (50.0)</td>
<td>52.8% (50.0)</td>
<td>47.2% (50.0)</td>
</tr>
<tr>
<td>Picture</td>
<td>45.5% (49.8)</td>
<td>51.4% (50.0)</td>
<td>39.6% (49.0)</td>
</tr>
</tbody>
</table>

Mean Seconds to Solution for Correctly Solved Problems

<table>
<thead>
<tr>
<th>Clue Type</th>
<th>Unrelated ((n = 72))</th>
<th>Sentence ((n = 72))</th>
<th>Picture ((n = 72))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrelated</td>
<td>20.6 (14.6)</td>
<td>17.3 (16.1)</td>
<td>19.5 (17.3)</td>
</tr>
<tr>
<td>Sentence</td>
<td>19.9 (13.2)</td>
<td>15.9 (13.7)</td>
<td>18.5 (17.1)</td>
</tr>
<tr>
<td>Picture</td>
<td>21.2 (15.8)</td>
<td>19.0 (18.2)</td>
<td>20.8 (17.4)</td>
</tr>
</tbody>
</table>

*Note:* Standard deviations are in parentheses under the mean estimates.
Table 2

*Summary Data for Free Recall by Test Condition and Clue Type*

<table>
<thead>
<tr>
<th>Clue Type</th>
<th>Total (N = 144)</th>
<th>Informed Participants (n = 72)</th>
<th>Uninformed Participants (n = 72)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Problem Not Solved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrelated</td>
<td>28.1% (45.0)</td>
<td>28.6% (45.3)</td>
<td>27.6% (44.8)</td>
</tr>
<tr>
<td>Sentence</td>
<td>18.4% (38.8)</td>
<td>21.3% (41.1)</td>
<td>15.8% (36.6)</td>
</tr>
<tr>
<td>Picture</td>
<td>55.1% (49.2)</td>
<td>55.7% (49.9)</td>
<td>54.6% (50.0)</td>
</tr>
<tr>
<td></td>
<td>Problem Solved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrelated</td>
<td>29.2% (45.6)</td>
<td>31.5% (46.7)</td>
<td>27.1% (44.70</td>
</tr>
<tr>
<td>Sentence</td>
<td>44.8% (49.8)</td>
<td>45.4% (50.0)</td>
<td>44.1% (49.8)</td>
</tr>
<tr>
<td>Picture</td>
<td>77.9% (41.6)</td>
<td>80.4% (39.8)</td>
<td>74.6% (43.7)</td>
</tr>
</tbody>
</table>

*Note:* Standard deviations are in parentheses under the mean estimates.
Figure Captions

Figure 1. Percentage of problems solved correctly as a function of clue type for informed (n = 72) and uninformed (n = 72) test conditions.

Figure A1. Picture clue: Bald man in the rain.