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Teaching Students to Solve Insight Problems: Evidence for Domain Specificity in Creativity Training

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ABSTRACT: The purpose of this research was to investigate whether insight problem solving depends on domain-specific or domain-general problem-solving skills, that is, whether people think in terms of conceptually different types of insight problems. In Study 1, participants sorted insight problems into categories. A cluster analysis revealed 4 main categories of insight problems: verbal, mathematical, spatial, and a combination of verbal or spatial. In Studies 2 and 3, participants received training in how to solve verbal, spatial, or mathematical problems, or all 3 types. They were taught that solutions to verbal insight problems lie in defining and analyzing the terms in the problem, solutions to mathematical insight problems lie in a novel approach to numbers, or solutions to spatial insight problems lie in removing a self-imposed constraint. In both studies, the spatial trained group performed better than the verbal trained group on spatial problems but not on other types of problems. These findings are consistent with the idea that people mentally separate insight problems into distinct types. Implications for instruction in insight problem solving are discussed.

How can we help students to solve insight problems such as shown in Figure 1? Are insight problems a coherent class of problems, or are there conceptually important subcategories of insight problems? These are the questions that motivate our investigation. To answer these questions, we examine the nature of insight problem solving, theories of insight problem solving, and research on teaching students how to solve insight problems.

Nature of Insight Problem Solving

Creative thinking occurs when a problem solver invents or discovers a novel solution to a problem (Guilford, 1950) and insight is the process of moving from not knowing how to solve a problem to knowing how to solve a problem (Mayer, 1995). It is customary in the problem solving literature to distinguish between routine and nonroutine problems (Mayer, 1992, 1995, 1999). For routine problems, the problem solver immediately recognizes a solution method that he or she already knows. For example, for most adults, the problem 563 × 143 is a routine problem because they immediately know how to apply the procedure for long multiplication. For nonroutine problems, the problem solver does not already know an appropriate solution method and therefore must invent one. For example, for most adults who are not fans of solving puzzles, the problems listed in Figure 1 are nonroutine problems. Creative thinking and insight are involved in nonroutine problems but are not involved in routine problems.

Insight problems may be seen as a special type of nonroutine problems in which the problem primes an inappropriate solution procedure that is familiar to the problem solver. In insight problems the problem solver must overcome the familiar way of looking at the problem and invent a novel approach. Examples include

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Examples of a Verbal Insight Problem

Is it legal for a man to marry his widow's sister? Why or why not?

Examples of a Mathematical Insight Problem

If you have black socks and brown socks in your drawer, mixed in a ratio of 4 to 5, how many socks will you have to take out to make sure that you have a pair the same color?

Examples of a Spatial Insight Problem

Without lifting your pencil from the paper, show how you could join all 4 dots with 2 straight lines.

Figure 1. *Three types of insight problems.*

classic insight problems such as Duncker's (1945) tumor problem, Kohler's (1925) banana problem, Wertheimer's (1959) parallelogram problem, and Duncker's (1945) candle problem. In addition, Metcalfe (1986; Metcalfe & Wiebe, 1987) found that people used different strategies for solving insight problems and noninsight problems, such as being able to tell how far they are from solving a noninsight problem but not being able to tell how far they are from solving an insight problem.

Domain-General Versus Domain-Specific Theories of Insight Problem Solving

The major new issue addressed in this investigation concerns people's conceptions of the structure of insight problems. According to the domain-general theory, insight problems are thought of as a single class of problems that all require the same general problem-solving strategy. According to the domain-specific theory, insight problems can be broken down into coherent subcategories such as verbal, mathematical, and spatial insight problems, each requiring a different kind of problem-solving strategy. We chose to focus on these three categories because there is ample evidence in the psychometric literature of differences among verbal, spatial, and mathematical ability (Carroll, 1993; Sternberg, 2000) and because most of the problems we identified in our search of typical insight problems fell into one of these three categories.

Consider a situation in which we ask students to sort a deck of insight problems into categories. According to the domain-general theory, this should be a difficult task that is performed differently by different students, and which yields no clear categorical substructure. According to the domain-specific theory, students should show a high level of agreement in their sorting of the problems into subcategories such as spatial, verbal, and mathematical types. We examined these predictions in Study 1.

Consider a situation in which we teach students how to solve one type of insight problem—such as spatial problems or verbal problems—and then test them on all types. According to the domain-general theory, training on solving one type of insight problem should transfer to solving all types of insight problems. According to the domain-specific theory, problem-solving training in one type of insight problem should result in increased performance on problems of that same type but not on other types of insight problems. We examined these predictions in Studies 2 and 3.

Study 1

Study 1 was a preliminary nonexperimental study in which students were asked to sort 67 insight problems into self-defined categories.

Method

Participants and design. The participants were 22 undergraduate students enrolled in an introductory psychology course at the University of California, Santa Barbara. Eleven participants served in the solution group, and 11 served in the nonsolution group. The students fulfilled a course requirement by participating in the study and were naive to the experimental hypothesis. The mean age was 19.18 years (*SD* = 1.22), the percentage of men was 36%, and the mean SAT score was 1,237.65 (*SD* = 99.97).

Materials. The materials included a background questionnaire, instruction sheets, two forms of an insight problem packet, and two forms of insight problem cards.[1] The background questionnaire, the instruction sheets, and the two forms of insight problem packets were presented on 8½- × 11-in. sheets of paper.

The background questionnaire contained questions concerning the participant's age, gender, year in college, and SAT scores as well as a questionnaire concerning the participant's experience with riddles. The first instruction sheet (which accompanied the packet of insight problems) stated that the participants were to read each problem carefully and specify whether they were familiar with it by checking "Yes" or "No" in the column to the left. The second instruction sheet (which accompanied the deck of insight problems) asked participants to sort the cards into smaller stacks based on the similarity of problems.

The solution version of the insight problem packet consisted of a list of 67 insight problems along with their solutions; the nonsolution version of the insight problem packet was identical, except solutions were not included. The problems were gathered from various published sources including research publications, riddle books (i.e., recreational books containing riddles for people to solve), textbooks, and Internet sites. The list of insight problems contained 39 verbal insight problems, 11 mathematical insight problems, and 17 spatial insight problems. Example problems are given in Figure 1 and a complete list is presented in Appendix A. The distinguishing feature of a verbal insight problem is that it contains a word or phrase that must be interpreted in an unobvious way. The verbal insight problems described a situation that did not have an obvious solution because one of the words or phrases primed an inappropriate approach. Once the student correctly understood the tricky word, the solution became apparent. For example, in Problem 21 in Appendix A, the trick word is "starts" (i.e., the problem solver must realize that the score of a game before it starts is 0 to 0). The distinguishing feature of a mathematical insight problem is that it looks like an arithmetic word problem but it is not solved by simple computation. The mathematical insight problems contained situations that had no obvious solutions, because their format primed a strategy of making numerical calculations. Once the student recognized that the problem called for deeper understanding of the situation rather than carrying out computations, the solution followed. For example, in Problem 3 in Appendix A, the task is not to multiply numbers but rather to recognize that the day before the 60th day the lake will be half covered. The distinguishing feature of spatial insight problems is that they imply a constraint that is really not part of the problem. The spatial insight problems described situations with no obvious solution, because they encouraged students to impose an unnecessary constraint. Once the students ignored the self-imposed constraint, they were able to solve the problem. For example, in Problem 16 in Appendix A, problem solvers may believe that the solution must take place in two dimensions when in fact the correct solution requires using three dimensions.

The solution version of the deck of insight problem cards contained 67 3 × 5 in. index cards with one problem and its solution on each card; the nonsolution version was identical except no solution was included.

Procedure. Participants were tested individually with up to 5 participants being tested concurrently per session. Each participant sat in an individual cubicle with a restricted view of the other participants and each participant did not interact with other participants. Each participant was randomly assigned to either a solution group or a nonsolution treatment group. First, participants were given the background questionnaire. On completion of the background questionnaire the experimenter gave a verbal outline of the three stages of the experiment. In Stage 1, the participants were given the first instruction sheet and the packet of insight problems. The solution group received the solution version of the insight problem packet and the nonsolution group received the nonsolution version of the packet. Participants read through all of the insight problems and indicated whether or not they were familiar with each one. The goal of Stage 1 was to provide the experimenter with information regarding the participants' prior experience with the insight problems and to allow the participants to preview the insight problems to be sorted in the second stage. Each participant was allowed to read and respond at his or her own pace. On completion each participant was given the second instruction sheet and the deck of insight problems. The deck of insight problems was in a random order such that the verbal, mathematical, and spatial insight problems were presented randomly. Each participant received the same random order. The

[1]The materials and procedure included a further step in which participants were asked to express the strength of membership of each problem in the catergory, but the resulting data were not used.

solution group received the solution version of the deck and the nonsolution group received the nonsolution version of the deck. Participants were instructed to sort the deck of insight problems into smaller categories based on the similarity of the problems. The participants were informed that there was no correct number of categories, so the number of categories created was at each participant's discretion. Again the participants set their own pace. On completion, the participants were thanked, debriefed, and allowed to ask any questions regarding the experiment.

Results and Discussion

Scoring. Each participant received a score of 0 or 1 for each possible pair of insight problems: If the participant placed two problems in the same insight category, a score of 1 was given for that pair; if the participant placed two problems in different categories, a score of 0 was given for that pair. For example, if insight problem Number 7 was placed in the same category as insight problem Number 9, then the 7–9 pair would receive a pairing rating of 1. If 10 participants placed insight problem Number 7 into the same category as insight problem Number 9 then the 7–9 pair would receive a group score of 10. With 11 participants in each group the possible range of scores for each pairing was from 0 to 11.

A correlation analysis was computed for all the possible pairings of the insight problems between the solution group and the nonsolution group, and revealed that the pairings of the insight problems for the solution group and the nonsolution group were moderately strongly correlated (r =.48, p < .01). In addition, the cluster structures based on hierarchical cluster analyses were similar for the solution and nonsolution groups. Therefore, the subsequent analyses reported in this paper are based on the combined data with a sample size of 22 and a possible score of 0 to 22 for each pairing.

Categorical structure of insight problems. The goal of this study was to investigate whether students conceived of insight problems as a unitary, domain-general category or a collection of domain-specific categories. We hypothesized that insight problems are domain specific, specifically that there are three main domains: verbal, spatial, and mathematical. We conducted a hierarchical cluster analysis on the group pairing data (i.e., total number of times each pair of problems had been placed in the same category out of 22 possible). As can be seen from the resulting dendogram in Figure 2, four main clusters emerged: a spatial cluster containing 10 spatial and 2 verbal problems, a verbal cluster containing 25 verbal and 1 spatial problem, a mathematical cluster containing 11 mathematical and 8 verbal problems, and a mixed spatial-verbal cluster containing 6 spatial and 4 verbal problems. Of the 39 verbal insight problems 64% fell within the same category. Of the 17 spatial insight problems 59% fell within the same category. Of the 11 mathematical insight problems 100% fell within the same category. Based on a Fisher Exact Test this pattern (i.e., 46 of 67 problems correctly categorized) is significant at the .05 level.

The results are consistent with the idea that students conceived of insight problems as a collection of domain-specific problems. Although the four categories in Figure 1 did not match perfectly with our a priori categorization, many of the discrepancies are interpretable. The spatial cluster contained two verbal problems—one based on rearranging letters (i.e., flymia) and one based on deciphering (i.e., solve "r|e|a|d|i|n|g"), so the spatial and verbal insight problems in this category appeared to be nonverbal in presentation. The verbal cluster contained one spatial problem (i.e., the tumor problem), but it is possible that the tumor problem was placed with the verbal insight problems because its mode of presentation is mainly in words. The mathematical cluster contained 8 verbal problems, but all of these verbal problems had a numerical component such as inquiring about a quantity or total amount (e.g., "*How many cubic centimeters of dirt are in a hole 6 meters long, 2 meters wide and one meter deep?*"). The mixed cluster contained both spatial and verbal problems, but the verbal insight problems involved considering a spatial arrangement (e.g., "Two mothers and two daughters were fishing. They managed to catch one big fish, one small fish, and one fat fish. Since only three fish were caught how is it possible that each woman had her own fish?"). Although this is a verbal problem, problem solvers might believe that they need to know a spatial arrangement of the family members in a family tree diagram rather than realizing that one mother is also a daughter (i.e., one grandmother, one mother, one daughter). The spatial insight problems that were categorized with these ver-

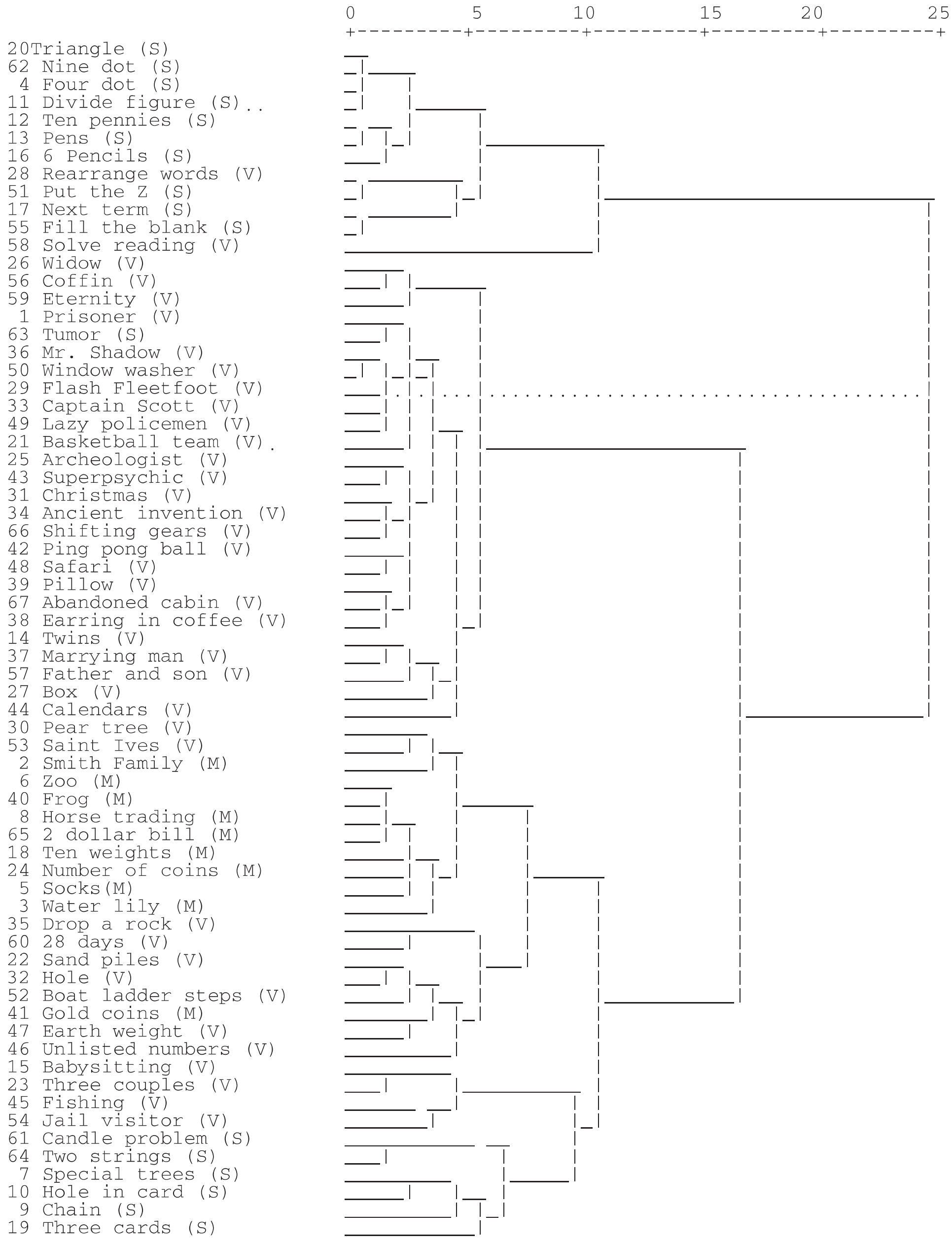

Figure 2. *Cluster analysis of 67 insight problems—Preliminary study. V = verbal, M = mathematical, S = spatial.*

bal insight problems can be separated from "pure spatial insight" problems that tend to be nonverbal in presentation (Wiesberg, 1995) and are not presented in a word problem format. As previously stated, the pure spatial insight problems all fell within the first cluster.

These results provide preliminary evidence that participants seem to be aware of the different domains of insight problems, which provides support for the domain specificity of insight problem solving. However, hierarchical cluster analysis is an exploratory procedure (Marcoulides & Hershberger, 1997), so we investigated the results of this preliminary study in two experiments involving transfer of problem-solving training—namely Studies 1 and 2.

Study 2

Study 2 was a between-subjects experiment aimed at determining if training to solve one kind of insight problem (e.g., spatial, verbal, or mathematical) would transfer to solving other kinds of insight problems.

Method

Participants and design. The participants were 63 undergraduate students from the University of California, Santa Barbara. The average age of the participants was 19.14 years (*SD* = 1.0), the percentage of men was 32%, and the mean SAT score was 1,169.50 (*SD* = 141.83). Thirteen participants served in the verbal training group, 13 participants served in the mathematical training group, 18 participants served in the spatial training group, and 19 participants served in the combined training group. All participants were tested on verbal, mathematical, and spatial insight problems.

Materials. The materials consisted of the same background questionnaire as used in the preliminary Study, 2 versions of a 3-page verbal insight problem training packet, 2 versions of a 3-page mathematical insight problem training packet, 2 versions of a 3-page spatial insight problem training packet, 2 versions of a 3-page combined insight problem training packet, and 2 versions of the 9-item problem-solving test.

The verbal insight problem training packet consisted of three worked-out verbal insight problems, each on typed on a separate 8½- × 11-in. sheet of paper. Each sheet began with a statement that verbal insight problems were solved by noticing "one of the words is a trick or play on words." This was followed by a description of a three-step procedure for how to solve verbal insight problems—namely, defining, analyzing, and concluding. Next, a verbal insight problem was presented, such as the widow problem, which states "Is it legal for a man to marry his widow's sister?" Then, each of the three steps was demonstrated. In the first step, labeled *defining*, each of the main words was listed along with its definition. For example the word *legal* was defined as "allowed by law"; the word *man* was defined as "a male human, in this case a potential husband"; the word *marry* was defined as "to wed another person"; the word *widow* was defined as "a woman who's husband died"; and the word *sister* was defined as "a female sibling." In the second step, labeled *analyzing*, each definition was assessed through a question. For example one question was, "Can a widow have a sister?" and printed response was, "Yes." Another question was "Can a widow have a living husband?" which had the answer, "No." A third question was, "Can a woman marry a dead man?" with the response being, "No." In the third step, labeled *concluding*, the following statement was printed: "It is **not** legal for a man to marry his widow's sister because he would be dead." On each training sheet participants also were given a "common mistake made" presented in a box in the right side of the page. The common mistake made with widow problem is "not realizing that the husband is dead."

The mathematical insight problem training packet consisted of three worked-out mathematical insight problems, each on typed on a separate 8½- × 11-in. sheet of paper. Each sheet began with a statement that mathematical insight problems were solved by finding "a novel approach to the problem rather than only carrying out mathematical computations." This was followed by a description of a three-step procedure—namely, finding principle, implement principle, and concluding. Next, a mathematical insight problem was presented, such as the lily problem, which states "Water lilies double in area every 24 hours. At the beginning of 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?" Then, each of the three steps was demonstrated. The first step, labeled *finding principle*, contained the phrase "Doubling means increasing size twofold." The second step, labeled *implementing principle*, contained the phrase "If an object doubles with each step then on the previous step it would have been half its current size." The third step, labeled *concluding*, stated "Therefore, the water lily will cover half of the lake on the 59th day." To the right was a box stating: "A common mistake is trying to solve by dividing 60 by 2 resulting in an incorrect answer of 30 days."

The spatial insight problem training packet consisted of three worked-out spatial insight problems, each on typed on a separate 8½- × 11-in. sheet of paper. Each sheet began with a statement that spatial insight problems were solved by "ignoring a self-imposed constraint (or block) rather than trying various actions." This was followed by a description of a three-step procedure for how to solve spatial insight problems—namely, finding constraint, constraint removal, and conclusion. Next, a spatial insight problem was presented, such as the line problem: “Without lifting your pencil from the paper, show how you could join all 4 dots with two continuous straight lines” (along with a picture of four dots such that no three of them were on the same horizontal or vertical line). Then, each of the three steps was demonstrated. In the first step, labeled *finding constraint*, the sheet stated: “Do I need to stop at each dot or can I draw through it and keep going?” (along with a picture showing a line from one dot to another and then another). In the second step, labeled *constraint removal*, the sheet said: “Draw through the dots.” In the third step, labeled *conclusion*, there was a picture showing one line through two of the dots and another line through the other two dots with the lines meeting at a point outside the dots. To the right was a box stating “A common mistake is to stop at each dot.” An example is shown in Appendix B.

The combined insight problem training package consisting of one verbal, one mathematical, and one spatial sheet, as described previously.

The problem solving test consisted of three spatial insight problems, three mathematical insight problems, and three verbal insight problems, each typed on an 8½- × 5½-in. sheet of paper. Based on pilot testing, the three insight problems used in testing for each category were matched on difficultly with three insight problems used in training. Insight problems used in training and testing were counterbalanced, so there were two versions of the problem solving test and of each training packet.

Procedure. Participants were tested individually with up to 5 participants tested concurrently per session. Each participant was randomly assigned to the verbal, mathematical, spatial, or combined group. They sat in the same cubicles, as described in the preliminary study, and completed the background questionnaire. Participants were then given their assigned insight problem training packet and were given 15 min to read the three training sheets. After completing training all of the participants were given the insight problem test. Participants were given 3 min to solve each of the nine insight problems. If the participants finished an insight problem within 3 min, they were instructed to wait the full 3 min before proceeding on to the next one. Participants were instructed to work through the insight problems sequentially and not to skip ahead or return to any insight problems.

Results and Discussion

According to the domain-specific theory participants should perform well on the type of insight problem they were trained to solve but not on other types. According to the domain-general theory there should be no difference in problem-solving performance as a result of training group. Table 1 shows the mean number correct (and standard deviation) for each of the four training groups on each of the three types of problems. For each type of problem, we conducted a one-way analysis of variance (ANOVA), with training group as the between subjects factor and number of insight problems solved (out of three) as the dependent variable. There was no significant difference among the training groups on problem-solving scores for verbal insight problems, $F(3, 59) = .43$, $MSE = .25$, $p = .73$, and for mathematical insight problems, $F(3, 59) = .59$, $MSE = .51$, $p = .62$, but there was a significant difference among the groups in performance for spatial insight problems, $F(3, 59) = 4.32$, $MSE = 2.75$, $p < .01$. Based on Tukey post hoc tests (with $\alpha = .05$), the spatial training group scored significantly greater on solv-

Table 1. *Mean Problem Solving Score and Standard Deviation for Four Training Groups on Three Types of Insight Problems—Study 2*

	Insight Problem Type					
	Verbal		Mathematical		Spatial	
Training Type	***M***	***SD***	***M***	***SD***	***M***	***SD***
Verbal training	2.08	.64	2.07	.76	.62	.69
Mathematical training	2.15	.80	1.62	.87	.69	.85
Spatial training	2.22	.81	1.78	1.00	1.50	.99
Combined training	1.95	.78	1.74	.99	.79	.63

ing spatial insight problems than did the verbal training group (*HSD* = 1.03, $p < .05$) and the mathematical training group (*HSD* =.94, $p < .05$); no other pairwise differences were statistically significant.

The results provide partial support for the domain-specific theory. Consistent with the predictions of the domain-specific theory, participants in the spatial training group exhibited a greater success rate on spatial insight problems than did participants in the verbal or mathematical training groups. On the other hand, training in verbal insight problems did not differentially improve verbal insight problem rates and training in mathematical insight problems did not differentially improve mathematical problem solving rates. In short, the verbal training and mathematical training did not work. The apparent ineffectiveness of verbal training and mathematical training could be attributed to the participants' previous experience with math and verbal problems or to poor training materials. Past general educational experience may have provided students with frequent exposure to mathematical and verbal problems. Because spatial problems are traditionally encountered less frequently in the general educational curriculum (Kelly, 1996) the participants may have been more influenced by the spatial training learned during the experiment. The lack of difference between the spatial and combined groups on spatial insight problems suggests that students were able to learn the spatial strategy from a single spatial training sheet within the combined insight problem training treatment. Importantly, Study 2 did not directly address the issue of whether insight training produced improvements in students' problem solving performance because Study 2 did not include a control group that received no training. This shortcoming was addressed in Study 3, which included a baseline control group that received no training. However, it should be noted that in Study 2 the various training groups also served as controls for each other (i.e., we were mainly interested in comparing the spatial, verbal, and mathematical training groups against each other on the spatial, verbal, and mathematical test items).

Study 3

Another way to examine relations among problem types is by examining the amount of transfer among problems. In Study 3, we further investigated this issue by giving students verbal insight problem training, spatial insight problem training, or no training in a between-subjects experiment and then testing them on verbal and spatial insight problems. We dropped the mathematical insight training and mathematical insight problems used in Study 2 in order to simplify the study and allow for a simple test of the domain specificity hypothesis. We focused on verbal and spatial insight problems because cognitive science research has demonstrated major differences in verbal and spatial processing (Sternberg, 2000).

Method

Participants and design. The participants were 71 undergraduate students from the University of California, Santa Barbara. The average age of the participants was 18.68 years (*SD* = 2.31), the percentage of men was 30%, and the mean SAT score was 1,190.50 (*SD* = 134.82). Twenty-three participants served in the verbal training group, 24 participants served in the spatial training group, and 24 participants served in the control group. All participants took tests of verbal and spatial insight problem solving.

Materials. The materials consisted of the same background questionnaire used in Study 2, the same verbal and spatial training packets used in Study 2, and the same problem-solving test used in Study 2 (except that the three mathematical problems were not included).

Procedure. The participants completed the background questionnaire and were randomly assigned to one of three groups. Participants in the verbal group and the spatial group received the same training procedures used in Study 2. The third group served as a control and received no training. All groups took the problem-solving test as in Study 2 except that no mathematical problems were included.

Results and Discussion

According to the domain-specific theory participants in the verbal training group should outperform both the spatial and control group on verbal insight problems and participants in the spatial group should outperform both the verbal and control group on spa-

Table 2. *Mean Problem Solving Score and Standard Deviation for Three Training Groups on Two Types of Insight Problems—Study 3*

	Insight Problem Type			
	Verbal		Spatial	
Training Type	*M*	*SD*	*M*	*SD*
Verbal training	1.70	.93	.48	.67
Spatial training	1.83	.70	.96	.55
No training (control)	1.54	.98	.67	.76

tial insight problems. According to the domain-general theory there should be no differences between the spatial and verbal groups in problem solving performance. Table 2 shows the mean problem-solving score for each of the three groups on verbal problems and on spatial problems. We conducted a one-way ANOVA with training group as a between subjects factor of group (verbal, spatial, or control) and verbal problem-solving score as the dependent measure, and an identical ANOVA with spatial problem-solving score as the dependent measure. No significant differences were found among the training groups on solving verbal insight problems, $F(2, 68) = .67$, $MSE = .77$, $p = .52$, but there was a significant difference among the training groups on solving spatial insight problems, $F(2, 68) = 3.13$, $MSE = .1.38$, $p = .05$. Based on Tukey post hoc tests (with $\alpha = .05$), the mean of the spatial training group was significantly greater than that of the verbal training group ($HSD = .47$, $p < .05$) but not the control group ($HSD = .29$, $p > .05$). There was no significant difference found between the verbal training group and the control group ($HSD = .19$, $p > .05$) for spatial insight problem solving.

The results of Study 3 tend to replicate the results of Study 2, and thus to lend additional support to some of the predictions of the domain-specific theory. In both experiments, training in how to solve spatial insight problems did not transfer to solving other types of insight problems.

General Discussion

This set of studies provides some evidence consistent with the domain-specific theory of insight problem solving, namely, the idea that insight problems are not a unitary general category but rather should be thought of as a collection of distinct types of problems. The main evidence for this conclusion is as follows: (a) Students tended to sort insight problems into verbal, mathematical, and spatial subcategories (as found in the preliminary study); (b) the spatial trained group performed better than the verbal and mathematical trained groups on spatial problems but not on other types of problems in Study 2; (c) the spatial trained group performed better than the verbal trained group on spatial problems but not on other types of problems in Study 3.

Theoretical Implications

What is learned when someone learns how to solve spatial insight problems? Our research suggests that students learn a general strategy that applies only to a subcategory of insight problems—that is, learning to overcome self-imposed constraints in solving spatial insight problems. We propose that insight problems should not be thought of as a unitary category of problems, but rather as a collection of distinct problem types. The distinguishing feature of each problem type is the general strategy that can be used to solve it. Consistent with theories of transfer based on specific transfer of general strategies (Mayer, 2002; Singley & Anderson, 1989), when one learns how to solve spatial insight problems one learns a general strategy that applies to other spatial insight problems but not to mathematical or verbal problems. What enables transfer is that the to-be-solved problem requires the same general solution strategy as a source problem that the learner already knows how to solve.

Practical Implications

Training of creative problem solving has a somewhat disappointing history, because learning to solve one kind of problem rarely supports solving of other types of problems (Chase & Simon, 1973; Chi, 1978; Mayer, 1996, 2002; Ripple, 1999; Thorndike, 1906). When the goal is to teach students to improve their creative problem-solving skills, it is worthwhile to focus on a collection of general strategies that each apply to a specific problem type. Students need practice both in recognizing problem types and in adapting appropriate strategies to novel problems within each type. Instead of trying to improve creative problem in general, creativity training should focus on helping students learn a collection of general strategies and know when to use them.

Limitations and Future Directions

Our conclusions are limited by the short-term nature of our treatments, our focusing on college students in a nonschool setting, and the fact that only the spatial insight problem training had an effect on learners. Future research is needed to further discriminate the types of insight problems and their underlying solution strategies. Overall, this research contributes to cognitive theories of transfer and to the design of creativity training programs.

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Appendix A
Sixty-Seven Insight Problems Used in Study 1

1. Prisoner (V): A prisoner was attempting to escape from a tower. He found in his cell a rope, which was half long enough to permit him to reach the ground safely. He divided the rope in half and tied the two parts together and escaped. How could he have done this?

2. Smith family (M): In the Smith family, there are 7 sisters and each sister has 1 brother. If you count Mr. Smith, how many males are there in the Smith family?

3. Water lily (M): Water lilies double in area every 24 hours. At the beginning of 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?

4. Four dot (S): Without lifting your pencil from the paper, show how you could join all 4 dots with 2 straight lines

5. Socks (M): If you have black socks and brown socks in your drawer, mixed in a ratio of 4 to 5, how many socks will you have to take out to make sure that you have a pair the same color?

6. Zoo (M): Yesterday I went to the zoo and saw the giraffes and ostriches. Altogether they had 30 eyes and 44 legs. How many animals were there?

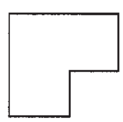
7. Special trees (S): A landscaper is given instructions to plant four special trees so that each one is exactly the same distance from each of the others. How is he able to do it?

8. Horse trading (M): A man bought a horse for $60 and sold it for $70. Then he bought it back for $80 and sold it for $90. How much did he make or lose in the horse trading business?

9. Chain (S): A woman has four pieces of chain. Each piece is made up of three links. She wants to join the pieces into a single closed loop of chain. To open a link costs 2 cents and to close a link costs 3 cents. She only has 15 cents. How does she do it?

10. Hole in card (S): How can you cut a hole in a 3 × 5 card that is big enough for you to put your head through?

11. Divide figure (S): Show how you can divide this figure into four equal parts that are the same size and shape



12. Ten pennies (S): Show how you can arrange 10 pennies so that you have 5 rows (lines) of 4 pennies in each row.

13. Pens (S): Describe how to put 27 animals in 4 pens in such a way that there is an even of number of animals in each pen.

14. Twins (V): Marsha and Marjorie were born on the same day of the same month of the same year to the same mother and the same father—yet they are not twins. How is that possible?

15. Babysitting (V): Three women—Joan, Dana, and Sandy—have among them three children—Sam, Traci, and David. Sam likes to play with Dana's son. Sandy occasionally baby-sits for Joan's children. Who is Traci's mother?

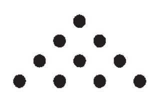
16. 6 Pencils (S): How can you arrange 6 identical pencils in such as way as to form 4 identical triangles whose sides area are all equal, without modifying the pencils in any way?

17. Next term (S): Identify the next term in the series: 88 … 64 … 24 …

18. Ten weights (M): There are ten bags, each containing ten weights, all of which look identical. In nine of the bags each weight is 16 ounces, but in one of the bags the weights are actually 17 ounces each. How is it possible, in a single weighing on an accurate weighing scale, to determine which bag contains the 17-ounce weights?

19. Three cards (S): Three cards lie face down on a table, arranged in a row from left to right. We have the following information about them. a. The Jack is to the left of the Queen b. The Diamond is to the left of the Spade c. The King is to the right of the Heart d. The Spade is to the right of the King. Which card—by face and suit—occupies each position?

20. Triangle (S): The triangle shown below points to the top of the page. Show how you can move three circles to get the triangle to point to the bottom of the page.



21. Basketball team (V): Our basketball team won a game last week by the score of 73–49, and yet not even one man on our team scored as much as a single point. How is that possible?

22. Sand piles (V): A child playing on the beach has 6 sand piles in one area and 3 in another. If he put them all together, how many sand piles would he have?

23. Three couples (V): Three couples went together to a party. One woman was dressed in red, one in green, and one in blue. Each man was wearing one of these colors. When all three couples were dancing, the man in red was dancing with the woman in blue. "Isn't it funny Christine, not one of us is dancing with a partner dressed in the same color." Think about the man

who is dancing with the woman in red. What color is he wearing?

24. Number of coins (M): What is the minimum number of coins you need to be able to pay the exact price of any item costing anywhere from one cent up to one dollar? The coins are pennies (1 cent), nickels (5 cents), dimes (10 cents), quarters (25 cents) and half dollars (50 cents)?

25. Archaeologist (V): One archaeologist reported finding a Roman coin with Julius Caesar's image on it, dated 21 B.C. Another archaeologist correctly asserted that the find was a fraud. Why?

26. Widow (V): Is it legal for a man to marry his widow's sister? Why or why not?

27. Box (V): What was Lewis Carroll talking about in this poem? John gave his brother James a box: About it there were many locks. James woke and said it gave him pain; So he gave it back to John again. The box was not with lid supplied, Yet caused two lids to open wide. And all these locks had never a key - What kind of box, then, could it be?

28. Rearrange words (V): Rearrange the following patterns to make familiar words:

runghy
flymia
mulcica
dornev
lendraca

29. Flash Fleetfoot (V): The legendary runner Flash Fleetfoot was so fast that his friends said he could turn off the light switch and jump into bed before the room got dark. On one occasion Flash proved he could do it. How?

30. Pear tree (V): A farmer in California owns a beautiful pear tree. He supplies the fruit to a nearby grocery store. The store owner has called the farmer to see how much fruit is available for him to purchase. The farmer knows that the main trunk has 24 branches. Each branch has exactly 6 twigs. Since each twig bears one piece of fruit, how many plums will the farmer be able to deliver?

31. Christmas (V): In what year did Christmas and New Year's fall in the same year?

32. Hole (V): How many cubic centimeters of dirt are in a hole 6 meters long, 2 meters wide and one meter deep?

33. Captain Scott (V): Captain Scott was out for a walk when it started to rain. He did not have an umbrella and he wasn't wearing a hat. His clothes were soaked yet not a hair on his head got wet. How could this happen?

34. Ancient invention (V): There is an ancient invention still used in parts of the worlds today that allows people to see through walls. What is it?

35. Drop a rock (V): If you drop a rock, would it fall more rapidly through water at 40 degrees Fahrenheit or 20 degrees Fahrenheit? Why?

36. Mr Shadow (V): Mr Shadow opened the door to Dr Apple's office and surveyed the scene. Dr Apple's head lay on her desk in a pool of blood. On the floor to her right lay a gun. There were powder burns on her right temple indicating that she was shot at close range. On her desk was a suicide note and in her right hand the pen that had written it. Mr. Shadow noted that death had occurred in the past hour. He also realized that it had not been a suicide but a clear case of murder. How does Mr. Shadow know?

37. Marrying man (V): A man who lived in a small town in the United States married 20 different women of the same town. All are still living and he never divorced any of them. In this town polygamy is unlawful; yet he has broken no law. How is this possible?

38. Earring in coffee (V): One morning a woman's earring fell into a cup that was filled with coffee, yet her earring did not get wet. How could this be?

39. Pillow (V): Paul is carrying a pillow case full of feathers. Aaron is carrying three pillow cases the same size as Paul's, yet Aaron load is lighter. How can this be?

40. Frog (M): A frog fell into a well thirty-two feet deep. Each day he jumped two feet up the wall and slid back down one foot each night. How many days did it take him to jump out of the well?

41. Gold coins (M): Which would be worth more, a pound of $10 pure gold coins or half a pound of $20 pure gold coins; or would they be worth the same? Explain your answer.

42. Ping pong ball (V): A magician claimed to be able to throw a ping pong ball so that is would go a short distance, come to a dead stop, and then reverse itself. He also added that he would not bounce the ball against any object or tie anything to it. How could he perform this feat?

43. Superpsychic (V): A famous superpsychic could tell the score of any baseball game before it starts. What was his secret?

44. Calendars (V): Calendars made in England do not show Lincoln's birthday. Do these calendars show the fourth of July? Explain.

45. Fishing (V): Two mothers and two daughters were fishing. They managed to catch one big fish, one small fish, and one fat fish. Since only three fish were caught how is it possible that each woman had her own fish?

46. Unlisted numbers (V): There is a town in Northern Ontario where 5% of all the people living in the town have unlisted phone numbers. If you selected 100 names at random from the town's phone directory, on average, how many of these people selected would have unlisted phone numbers?

47. Earth weight (M): It is estimated that the earth weighs 6 sextillion tons. How much more would the earth weigh if 1 sextillion tons of concrete and stone were used to build a wall?

48. Safari (V): While on safari in the wild jungles of Africa, Professor White woke one morning and felt something in the back pocket of her shorts. It had a head and a tail but no legs. When White got up she could feel it move inside her pocket. White however showed little concern and went about her morning rituals. Why such a casual attitude toward the thing in her pocket?

49. (V) Professor Bumble, who is getting on in years is growing absent minded. On the way to a lecture one day he went through a red light and turned down a one way street in the wrong direction. A policeman observed the entire scene but did nothing about it. How could Professor Bumble get away with such behavior?

50. Window washer (V): A window washer was cleaning the windows of a high rise building when he slipped and fell off a sixty-foot ladder onto the concrete sidewalk below. Incredibly he did not injure himself in any way. How was this possible?

51. Put the Z (S): Can you figure out where to put the letter Z, top or bottom line and Why?

A EF HI KLMN T VWXY

BCD G J OPQRS U

52. Boat ladder steps (V): If a boat, at low tide, has 6 of it's 12 ladder steps in the water. How many ladder steps will be in the water a high tide?

53. Saint Ives (V): While I was traveling to Saint Ives, I met a man with 7 wives, the 7 wives had 7 sacks, and the 7 sacks had 7 cats, the 7 cats had 7 kittens. Kittens, Cats, Sacks, Wives, how many were going to Saint Ives?

54. Jail visitor (V): A man goes to visit another man in jail, the guard tells the visitor that only family members are allowed to visit inmates, the visitor declares " brothers, sisters I have none, but that man's father is my father's son." Who is the visitor?

55. Fill in the blank (S): Fill in the blank: 2, 4, 6, 30, 32, 34, 36, 40, 42, 44, 46, 50, 52, 54, 56, 60, 62, 64, 66, ___?

56. Doesn't want it (V) Whoever makes it doesn't use it, whoever buys it doesn't want it and whoever uses it doesn't know it?

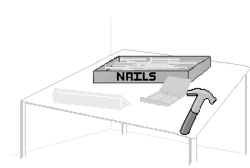
57. Father and son (V): A father and his son get in a car accident. The father is sent to one hospital, and the son is sent to another. When the doctor comes in to operate on the son, the doctor says, "I cannot operate on him. He is my son." How can that be?

58. Solve reading (V): Solve: |r|e|a|d|i|n|g|

59. Eternity (V): What is at the beginning of eternity, the end of time and space. The beginning of every end, the end of every place.

60. 28 days (V): How many months have twenty-eight days in them?

61. Candle problem (S) Given the material below how can you attach the candle to the wall above the table so that the wax does not drip on the table?

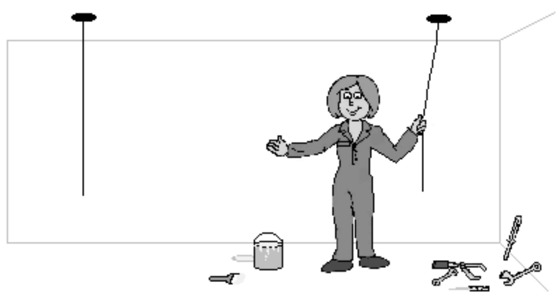


62. Nine dot (S): Draw four continuous straight lines, connecting all the dots without lifting your pencil from the paper.

63. Tumor (S): Imagine you are a doctor treating a patient with a malignant stomach tumor. You cannot operate but you must destroy the tumor. You could use high intensity X rays to destroy the tumor but unfortunately the intensity of the X rays needed to destroy the

tumor also will destroy healthy tissue through which the X rays must pass. Less power full X rays will spare the healthy tissue but will not be strong enough to destroy the tumor. How can you destroy the tumor without damaging the healthy tissue?

64. Two strings (S): There are two strings hanging from the ceiling in the room below. The woman cannot reach both. How can she tie the two strings together?



65. 2 dollar bill (M): A man had a 2 dollar bill and wanted to buy a train ticket that cost 3 dollars. He took the 2 dollar bill to a pawn shop where he pawned it for $1.50. On the way to the train station, he met a friend to whom he sold the pawn ticket for $1.50. He then had 3 dollars with which to buy his ticket. Who was out the extra dollar?

66. Shifting gears (V): Professor Carney was driving along in her old car when suddenly it shifted gears by itself. She paid no attention and kept on driving. Why wasn't she concerned?

67. Abandoned cabin (V): Erin stumbles across an abandoned cabin one cold, dark and snowy night. Inside the cabin is a kerosene lantern, a candle, and wood in a fireplace. She only has *one* match. What should she light first?

Appendix B
Spatial Insight Problem Training Sheet Used in Studies 2 and 3

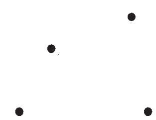
Definition of spatial insight problems: Solutions are found by ignoring a self-imposed constraint (or block) rather then trying various actions.

There are 3 steps to solving spatial insight problems:

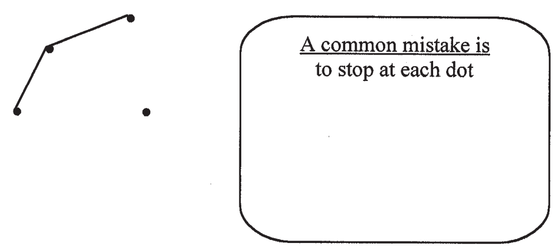
1. Finding a constraint or block
2. Removing a constraint
3. Concluding

Here is a spatial insight problem:

Without lifting your pencil from the paper, show how you could join all 4 dots with 2 continuous straight lines.



1. **Finding constraint**
   Do I need to STOP at each dot or can I draw through it and keep going?



2. **Constraint removal**

   Draw through the dots.

3. **Conclusion**