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Feeling of Knowing in Memory and Problem Solving

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This study investigates feelings of knowing for problem solving and memory. In Experiment 1 subjects judged their feelings of knowing to trivia questions they had been unable to answer, then performed a multiple-choice recognition test. In a second task, subjects gave feeling-of-knowing judgments for "insight" problems to which they did not immediately know the answers. Later, they were given 5 min to solve each problem. In contrast to the positive correlation found in the memory task, the feeling-of-knowing rank ordering of insight problems did not relate to problem solution. Experiment 2 provided a replication of Experiment 1 with a generation memory technique rather than a multiple-choice recognition test. Both experiments showed that although people could predict memory performance reasonably well, predictive metacognitions were nonexistent for the problems. The data are interpreted as implying that insight problems do involve a sudden illumination, and that illumination cannot be predicted in advance.

When people tackle a difficult problem they usually have metacognitions about the problem: how easy or difficult it is, how likely they will be to solve it. People might manifest feelings that they will know the solutions to problems, just as they demonstrate feelings of knowing in memory tasks. Whether or not they can do so accurately is an important question to ask in the context of the debate on whether problems may be solved by sudden insights or by more gradual accrual of information. If problem solutions come by insight, then people should not be able to give reliable predictions about future solutions. If, on the other hand, people solve problems by accrual of partial information, then feeling of knowing in problem solving might resemble those judgments in memory tasks.

In a memory feeling-of-knowing task, subjects are asked to assess future ability to remember an item that, at the time of judgment, is not available to consciousness. Although most commonly investigated with recognition, feelings of knowing have been studied with a wide variety of episodic memory tasks (Blake, 1973; Hart, 1967; Nelson, 1984; Schacter, 1983) including perceptual identification (Nelson, Gerler, & Narens, 1984) and overlearning (Nelson, Leonesio, Shimamura, Landwehr, & Narens, 1982), with subject populations ranging from children (Wellman, 1977) through undergraduates (Gruneberg & Monks, 1974; Nelson & Narens, 1980a) to older adults (Lachman, Lachman, & Thronesbury, 1979), and with many diverse types of materials. The near universal finding in these studies is that subjects are able to reliably, though not perfectly, predict memory performance on a future test even when they fail on a prior test. This result obtains even though they are tested only on items that, at the time of making the prediction, they are unable to recall. Nelson et al. (1984) have reviewed many of the mechanisms that have been proposed to account for the accuracy of feeling-of-knowing judgments in memory. They note that feelings of knowing may result because a person knows something about the topic in question, a partial label, some image, or some dimensions of the target but not enough to give the answer. In addition, people may show feelings of knowing on topics in which they are experts, because the cue is recognized easily, or because they have access to related episodic information. Most of the explanations reviewed by Nelson et al. (1984) implicate partial information (of various sorts) as the basis of accurate feeling-of-knowing judgments.

There are some similarities between memory tasks and insight problem-solving tasks. Weisberg and Alba (1981a, 1981b, 1982; and see also Weisberg, 1980; Weisberg, DiCamillo, & Phillips, 1978; Weisberg & Suls, 1973) favor a retrieval framework as an explanation for how "insight" problems are solved. They stress the importance of recalling past experiences of problems similar to those one is trying to solve. Bowers (1985) proposes a similar formulation. "This viewpoint argues that presentation of a problem serves as a cue to retrieve relevant information from memory. Any information that is retrieved then serves as the basis for solution attempts" (Weisberg & Alba, 1981a, p. 171). They describe the process of problem solving as follows: "Restructuring of a problem comes about as a result of further searches of memory, cued by new information accrued as the subject works through the problem. This is in contrast to the Gestalt view that restructuration is spontaneous" (Weisberg & Alba, 1982, p. 328). Presumably this partial information may be similar to that retrieved in attempting to answer general information memory questions. In addition, problem solving is frequently described

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in the same sort of terms—usually of searching through the appropriate pathways (see Newell & Simon, 1972; Simon & Reed, 1979)—as memory retrieval. If task-specific past knowledge is important in problem solving and if the processes involved in solving insight problems are basically like those used in other areas of cognition such as memory, then we might expect to find subjects' metacognitions on problem solving reflecting the positive correlational pattern found with memory questions.

On the other hand, solving certain kinds of problems may involve insight (see Dominowski, 1981; Ellen, 1982). Maier (1930, p. 116) describes the process of problem solving as follows:

> First one has one or no gestalt, then suddenly a new or different gestalt is formed out of the old elements. The sudden appearance of the new gestalt, that is, the solution, is the process of reasoning. How and why it comes is not explained. It is like perception: certain elements which one minute are one unity suddenly become an altogether different unity.

If the solution to insight problems involves a radical transformation in the gestalt, then there is no reason to expect that subjects, before solving the problems, have diagnostic partial information accessible to consciousness. Consequently, they should not have accurate feelings of knowing about the solutions. As several researchers have pointed out (Norman, 1983; Weisberg & Alba, 1981a), there is very little experimental research bearing on the question of whether there is such a process as insight.

In Experiment 1, subjects were asked to give feeling-of-knowing judgments about a number of problems that they would later have the opportunity to solve. In addition, subjects performed a memory feeling-of-knowing task. The question of main interest was whether there would be accurate feeling-of-knowing effects in problem solving, as there are in memory.

Experiment 1

Method

Subjects. The participants were 44 undergraduate students in Introductory Psychology at the University of British Columbia. Subjects were tested individually and each received a bonus credit in return for participation.

Procedure. Upon arriving for the experiment, subjects were asked to answer a series of trivia questions which were taken from the feeling-of-knowing norms of Nelson and Narens (1980b). The flash cards on which the questions were typed were reshuffled for each subject. The initial recall task, in which subjects simply answered the questions if they could, was subject paced and continued until a total of five mistakes were made. Subjects were allowed about 5 s to come up with answers to questions before the experimenter suggested that they should put it aside to return to in the multiple-choice test. If the subject felt that the answer was *on the tip of the tongue* the experimenter allowed the subject to dictate when he wanted to put the question aside to return to later. The five no-response or error cards were shuffled and arranged in a circle. The subjects were asked to rearrange the cards in a line going from left to right: The leftmost card contained the question that the answer was least likely to be correctly recognized later; the rightmost card contained the question that the answer was most likely to be recognized later; and the intermediate cards indicated intermediate feelings of knowing. After the subject had arranged the cards, the experimenter checked the order with the subject in a pairwise fashion, recorded the order in which the cards had been placed, and then reshuffled the five cards. Next, the experimenter asked the subject to make an absolute judgment about the likelihood of recognizing the answer for each question on a scale from *definitely will not get the answer* (0) to *definitely will get the answer* (10). The cards were reshuffled and the experimenter gave the subject an eight-alternative forced-choice recognition test for each of the five questions, and recorded whether the subject was right or wrong on each question. After completing the recognition test, subjects were told the correct answers. This procedure is similar to the version of the feeling-of-knowing memory procedure advocated by Nelson and Narens (1980a).

In the second phase of the experiment, subjects were given a series of problems to read and to solve if the solutions were immediately obvious. Because the pool of problems was limited, subjects were given problems until they made five mistakes or reached the end of the problem set, whichever came sooner. The problem set included only six insight problems, and these were chosen to be problems that were uncommon and that were not included in subjects' textbooks. Most of the subjects had not seen the problems before testing, and as a result, they were unable to solve more than one of them just by reading them and thinking for a few seconds. The mean number of problems used in the experiment was 4.84, because a few subjects were problem aficionados who had seen two of the problems before or who had solved the problems immediately. No subject had fewer than four problems, however. Subjects were given about 5 s to think about each problem. If they did not know the answer immediately, they were reminded that they would have time later to try to solve the problems. The cards containing the problems were then reshuffled and arranged in a circle. Next, the subjects were asked to rank order the cards from left to right in terms of those problems they would be least likely to solve in five minutes, to those they would be most likely to solve in the same span. After subjects had ranked the problems, they gave absolute ratings, on a scale from 0 to 10, to indicate how certain they felt that they would be able to later solve each problem. Five minutes were allowed for attempted solution of each of the problems. In the course of solving, subjects gave warmth ratings every 15 s on a scale from 0 to 10 indicating how near they were to solving the problem. These ratings are not relevant to the present research and will not be described further in this article. At the conclusion of the session, subjects were told the answers to the problems and were thanked for participating.

Materials. The trivia questions were taken from Nelson and Narens (1980b). The insight problems were taken from deBono (1967, 1969). The problems are reproduced in the Appendix. The horse trading problem (#3) has also been studied by Maier and Burke (1967).

Results and Discussion

The correspondence between feeling of knowing and actual knowing was computed by calculating, for each subject, a Goodman-Kruskal gamma score (see Nelson, 1984) based on the rank ordering of the trivia questions and the answers (correct or incorrect) on the recognition test. The scores potentially range from 1 to −1, with zero indicating that there was no relation between the feeling of knowing and performance on the recognition test. Similarly, for problem solving, a gamma score was computed for each subject by taking the rank ordering of the problems against whether the problem was answered correctly or not in the 5-min solution interval. Any subject who got all of the questions wrong, or all of the questions right, on either task, was eliminated from the analysis comparing the gamma scores, because the gamma statistic is undefined under these circumstances. This left 28 subjects in the analysis.

The average gamma score for the memory feeling-of-knowing was .45. This score indicates that subjects were able to predict reliably how well they would be able to remember later. The magnitude of this score is similar to that found in other studies with undergraduates as subjects and similar materials. The average gamma score for the problem solving task was .10, which was not significantly different from zero. Scores on the two tasks were significantly different, $t(27) = 3.22$, $p < .01$. The standard deviations of the probability correct scores based on all 44 subjects were similar: .23 for recognition and .18 for problem solving. (The means were .28 and .28.) Thus, the difference in the gammas is probably not attributable to more constrained variance in accuracy with the problems. The variance in the ranking is meaningless because subjects were required to rank order all five items in both conditions. The mean number of problems attempted was 4.84 (97%), as compared with 5 for the memory part of the experiment. The difference in gammas is probably not due to a difference in the absolute number of items ranked.

A second index of subjects' metaknowledge in the two tasks was available via the absolute judgments of likelihood of success. Gamma scores were recomputed using the absolute probability estimations. These gamma scores and the rank ordering gamma scores are shown in Table 1. Once again the gamma correlations for memory (.48) and for problem solving (.08) differed from one another, $t(27) = 2.23$, $p = .03$. The difference in the rank ordering gammas and the gammas based on absolute scores results because (a) there was some inconsistency between the two rankings and (b) the latter gammas allow for ties, whereas the former do not. However, the correlations between the gamma scores, although not perfect, were quite high. For recognition, the correlation between gammas taken from the two different tests of the feeling of knowing, based on all 34 subjects who had usable data on the recognition test, was .75, whereas for problem solving, based on 36 subjects, it was .87. Thus the main finding of interest—the positive feeling of knowing correlation in the memory condition and the zero correlation in the problem solving condition—is probably not attributable to selective test–retest unreliability in the problem-solving condition. Subjects did not vacillate more in their feelings of knowing to the problems than to the trivia questions. These results indicate that subjects had fairly accurate metacognitions about the memory task but nonpredictive metacognitions about the problem-solving task.

The mean estimations given by subjects as absolute scores for each memory question and problem were also treated as probability predictions to indicate how likely it was that the person felt he or she would be able to solve the problems. To convert these scores to probability estimations, the mean ratings were simply divided by 10 to yield a score ranging from 0 to 1. The mean was taken over the five scores given to result in a mean expectation score. On the memory task there was a positive correlation between expectation and performance, $r = .31$, $p < .05$, but no correlation was found for the problem solving task, $r = -.06$. Thus, in this experiment, subjects who thought they would do well on the memory task tended to do well (see Sherman, Skov, Hervitz, & Stock, 1981), whereas expectation did not predict performance on the problem-solving task.

The mean probability estimates were compared with the actual probability of correct responses on each of the two tasks by means of an analysis of variance (ANOVA). In accord with many studies investigating people's calibration of probability estimations as compared with performance (see Lichtenstein, Fischhoff, & Phillips, 1982, for a review), subjects in this study overestimated the likelihood that they would be successful at the tasks, $F(1, 43) = 87.23$, $MS_e = .039$, $p < .001$. Although the proportion of correct performance was .28, mean estimation of performance was .56. This overestimation was especially pronounced for the problem-solving task and less prominent for the memory task, $F(1, 43) = 14.07$, $MS_e = .016$, $p < .001$. Interestingly, subjects were less confident about getting the correct solutions to the memory questions than to the problems even though the chance of getting a memory question right by guessing randomly was .125, whereas this probability was .00 for the problems. Subjects knew, at time of making the judgment, that the memory test would be eight-alternative forced choice. Thus, the finding of more overconfidence in problem solving than memory is all the more impressive; if subjects had made this judgment only on the basis of the guessing probabilities, the effect would have been in the opposite direction, that is, in favor of the memory condition. Lichtenstein et al. (1982) have pointed out that overestimation seems to be especially exacerbated by difficult tasks. However, differences in task difficulty, at least as measured by the probability correct scores on the two tasks, cannot account for the difference in overestimation. It seems that insight problems appear to be simple to subjects. But the kinds of partial information or feelings of familiarity that cause the high probability estimations are not diagnostic for problem solution.

The results of Experiment 1 suggest that the metacognitions involved in solving insight problems may differ in fundamental ways from those involved in memory. The relation between feeling of knowing and later knowing was accurate, though not perfect, for the memory task whether that feeling was measured in terms of the rank ordering or in terms of probability estimations. The feeling of knowing for the problems, however, had no predictive value for problem solution. In addition, subjects overestimated the probability of success on the problems by more than a 2:1 ratio. They were more calibrated on the memory task. These results suggest that solving insight problems may be different in fundamental ways from memory retrieval. In particular, the processes involved in solving insight problems do not appear to be open to accurate metacognitions.

Table 1
Experiments 1 and 2: Gamma Correlations for Memory and Problem Solving

Task	Gammas computed on: Ranking	Probability estimation
Experiment 1		
Memory	.45	.48
Problem solving	.10	.08
Experiment 2		
Memory	.52	.52
Problem solving	−.25	−.32

Experiment 2

Before reaching any strong conclusions from Experiment 1, a second experiment is presented that investigates certain problems in the first experiment. The second experiment equates the nature of the tasks to a greater extent than did the first—both the problem solving and the memory tasks are 5-minute generate tasks. The order of task is treated as a factor. Subjects are asked explicitly to give probability estimations, rather than rating the likelihood of success on a 10-point scale. No warmth ratings are taken during the course of problem solving. The second experiment thus provides a replication, with certain modifications, of the first experiment.

Method

Some pilot work was undertaken before this experiment was conducted. Initial testing with the full set of trivia questions (Nelson & Narens, 1980b) revealed that almost no subjects were able to come up with the answers to the initially failed questions. To make it possible for subjects to get some of the initially failed questions correct after thinking about them for 5 min, many of the exceedingly difficult questions were pruned from the pool of to-be-answered trivia questions. Thus, the trivia materials used in Experiment 2 contained a disproportionate number of easy questions, and also most of the Americana questions were omitted. The relatively easy question set provided the added advantage of making the experiment, which was extraordinarily difficult for subjects, a little easier in at least one phase. Based on the normative data collected by Nelson and Narens (1980b) with an American subject population, the average likelihood of generated solution to the questions that were selected for this experiment was .451 with a standard deviation of .278. The probability of success ranged from .937 (What was the name of Tarzan's girlfriend?) to .008 (What was the name of the villainous people who lived underground in H. G. Wells's book *The Time Machine*?)

Procedure. All subjects participated in both the trivia and the problem-solving tasks. They were randomly assigned to be in either the problems or the trivia questions part of the experiment first. Upon arriving for the experiment, subjects were told that they would be shown a series of problems (or trivia questions) and if they knew the answer right away, they should give it. If not, they should pass and there would be time later to come back to think about (or solve) the problem. They were told that they would be given problems (questions) until there were a total of six that they could not answer, or until the end of the deck was reached. Once there were six problems that the subject could not immediately answer, the cards were arranged in a circle and the subjects ranked them and made probability estimations of how likely they felt they would be to answer (correctly) each of the questions. The experimenter explained what a probability estimation is. A few subjects gave these judgments as percentages. In this case, the numbers were converted into probabilities by the experimenter. Once the probability estimations had been made, the cards were reshuffled, and subjects were allowed to work on each of the problems for 5 min or until they believed they had the solution. Subjects were allowed to use pencil and paper during the problem solving.

Having completed the first half of the experiment on problem solving (or trivia questions), the subject was then given the other materials, and the procedure was repeated. No online warmth ratings were taken during the course of trivia retrieval or problem solving, because it is possible (though unlikely) that this procedure in Experiment 1 altered the results.

Subjects were tested individually in 1-hr sessions.

Materials. The trivia questions were taken from Nelson and Narens (1980b) but were selected as indicated earlier.

The problems were taken from deBono (1967, 1969), as in Experiment 1. Several new problems (from Fixx, 1972; and one given by L. Ross, personal communication, 1985) were added because some of the problems from Experiment 1 had become known around campus by the time the second experiment was conducted. A variant of Problem 11 (see the Appendix for problems used in this experiment) has been studied by Sternberg and Davidson (1982).

Subjects. Sixty Introductory Psychology students at the University of British Columbia received a small bonus course credit for participating in the experiment.

Results and Discussion

As had been the case in Experiment 1, the correspondence between feeling of knowing and knowing was computed by calculating gamma scores for the two tasks. It was necessary that subjects get at least one answer correct in each of the problem solving and the trivia tasks, in order to be able to compute correspondences. In this experiment 34 subjects provided usable data. Ten subjects got no answers correct on the memory part of the experiment, 14 subjects were unable to solve any of the problems, and 2 subjects got no problems or memory questions correct. An ANOVA was computed on the gamma scores including the order of presentation of tasks (either memory task first or problem solving task first, between subjects) and task (either memory, or problem solving, within subjects) as factors. The order of tasks was not significant, nor did order of task interact with task.

As was the case in the first experiment there was a significant difference between the tasks on the gamma scores, $F(1, 32) = 39.05$, $MS_e = .254$, $p < .001$. The mean gamma on the memory trivia questions was .52, and on the problem-solving task, it was −.25. This effect does not appear to be attributable to subject selection, because the mean values of the gammas are .53 (SD = .60) for the trivia questions and −.23 (SD = .56) for problem solving when all subjects who had gamma scores on either task were included in the calculation. Over subjects, the scores ranged from 1 to −1 for both tasks. The standard deviations on the accuracy scores were the same in the two conditions: .19 for memory and .18 for problem solving. Thus the difference is probably not due to constrained variance on the probability of correct problem solutions. The mean accuracy scores were .23 for memory and .22 for problem solving.

The analysis was repeated using the probability estimates rather than the rank orderings to compute the gammas. One subject gave the same probability estimation for all of the problems, making it impossible to compute a gamma correlation on those data. Thus this analysis applies to only 33 rather than 34 subjects. As before, neither the order of task nor the interaction between order of task and task was significant. As before, there was a significant difference between predicted and actual performance on the memory as compared with the problem solving task, $F(1, 31) = 37.13$, $MS_e = .308$, $p < .001$. The mean gammas were .52 for memory and −.32 for problem solving. These results are presented in Table 1. Because the absolute rankings were given while the questions were still in their ranked order, the correlation between absolute and ranked gamma scores does not provide a measure of test–retest reliability, as it did in the first experiment in which the absolute scores were given in a separate test. Thus, the retest correlation was not computed in this experiment.

The negative correlations in the problem-solving condition computed both from the rank orderings and from the probability estimations were significantly different from zero, $t(33) = 2.49$, $p = .01$, and $t(32) = 2.82$, $p = .008$, respectively. I thought that these negative correlations might be primarily attributable to one problem (Problem 7 in the Appendix) because many subjects had stated that this problem did not evoke an *aha* response upon solution and so did not seem to be an insight problem. It was also a relatively easy problem. Thus, I recomputed the analyses on the gamma scores excluding this problem. On the ranked data the mean gamma was .52 for memory and −.15 for problems, $t(24) = 4.13$, $p < .001$. Thus the effect of interest held up even without this problem and with the smaller number of subjects resulting when this problem was eliminated. The mean of the problem condition was not significantly different from zero, $t(24) = 1.21$, $p = .23$. When the gammas were computed on the probability estimates, the means were .54 for memory and −.18 for problem solving, $t(23) = 4.37$, $p < .001$. Again, the negative correlation in problem solving was not significantly different from zero, $t(23) = 1.42$, $p = .16$.

Additional analyses were conducted on the probability estimations given initially to indicate expected success as compared with actual performance on the tasks. All 60 subjects were included in these analyses. There was a small but significant positive correlation between high probability estimations and high performance, in both tasks. People who thought they would do well, as indicated by their high mean probability estimations, tended to do slightly better then people who thought they would do poorly ($r = .29$ for memory trivia, and $r = .23$ for problem solving, $p < .05$). An ANOVA comparing expected probability of success with actual success rate, over the two tasks, revealed that in both tasks, people overestimated the likelihood that they would get the questions right, $F(1, 59) = 105.44$, $MS_e = .07$, $p < .001$. However, people overestimated more on the problems than on the trivia questions, $F(1, 59) = 14.51$, $MS_e = .08$, $p < .001$. The data for this selective overestimation effect are given in Table 2. Although the mean performance did not differ between tasks, subjects expected that they would do about twice as well as they actually did on the problems, and 1½ times as well as they did on the trivia. Thus, not only do subjects not know which problems they will be able to solve, but they also radically overestimate the chances that they will be able to solve insight problems. Their estimations of success, although still optimistic, were closer to reality on the memory task.

Conclusion

These experiments showed that although subjects have accurate feelings of knowing about whether they will be able to remember certain items of information in a memory test, the feelings of knowing for insight-type problems have no predictive value concerning the chance that those problems will be solvable later. If it were the case that solving insight problems involved the gradual accrual of information from memory, then it seems reasonable to suppose that feeling-of-knowing ratings should have had some predictive validity. The fact that these ratings did not show the slightest tendency to discriminate solvable from unsolvable problems is consistent with the *insight* view of problem solving.

In addition to the lack of correspondence between feeling of knowing and knowing in the problem-solving task, subjects also greatly overestimated the likelihood of success on the problems. The information that was given in the statement of the problem was evidently sufficient to provide a false sense of confidence about future performance. Although subjects also overestimated their abilities on the memory task, this overestimation was smaller than that for problem solving. Subjects were closer to a realistic expectation about their own performance in the memory task than in the problem-solving task.

Table 2
Experiments 1 and 2: Predicted Probabilities and Actual Probabilities Correct

Task	Actual performance	Predicted performance
Experiment 1		
Memory	.28	.48
Problem solving	.28	.63
Experiment 2		
Memory	.23	.34
Problem solving	.22	.47

The present experiments provided no support for the idea that problem solving, like memory tasks, allows for veridical predictions about future performance. Although subjects had a reasonably good ability to predict, both at a general level and at the specific level, what and how well they would later be able to remember, these same subjects demonstrated no ability at all to predict how well, or which problems, they would be able to solve. The materials that were used in the problem-solving task were specifically chosen to be *insight* problems (i.e., those kinds of problems that provoke a subjective *aha* response upon solution). It seems likely that noninsight problems might involve the gradual accrual of information for their solution, and they might yield different results on the feeling-of-knowing tasks. Probably not all problem-solving activity is devoid of accurate premonitions of performance, although this remains to be seen. A reasonable conclusion from the present data is that subjects cannot predict future performance on insight problems that require a sudden illumination for their solution.

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(Appendix follows on next page)

Appendix

Problems Used in Experiments 1 and 2

1. Describe how to cut a hole in a 3 × 5 in. card that is big enough for you to put your head through. (Experiments 1 and 2)
2. The triangle shown below (Figure A-1) 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. (Experiments 1 and 2)

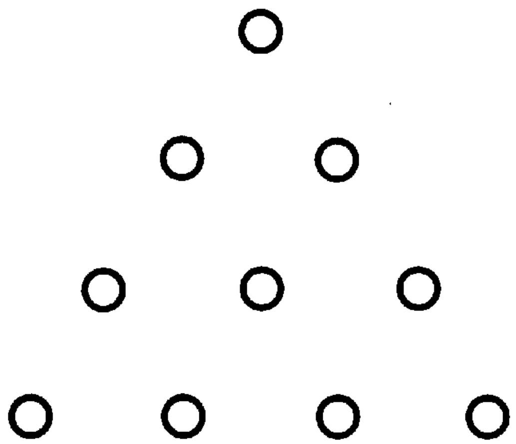

Figure A-1

3. 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 in the horse trading business? (Experiment 1)
4. 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 ring of chain. To open a link costs 2 cents and to close a link costs 3 cents. She has only 15 cents. How does she do it? (Experiments 1 and 2).
5. A landscape gardener is given instructions to plant four special trees so that each one is exactly the same distance from each of the others. How would you arrange the trees? (Experiments 1 and 2)
6. A small bowl of oil and a small bowl of vinegar are placed side by side. You take a spoonful of the oil and stir it casually into the vinegar. You then take a spoonful of this mixture and put it back in the bowl of oil. Which of the two bowls is more contaminated? (Experiments 1 and 2)
7. How can you draw this figure (Figure A-2) without raising your pencil from the paper, without folding the paper, and without retracing any lines? (Experiment 2)

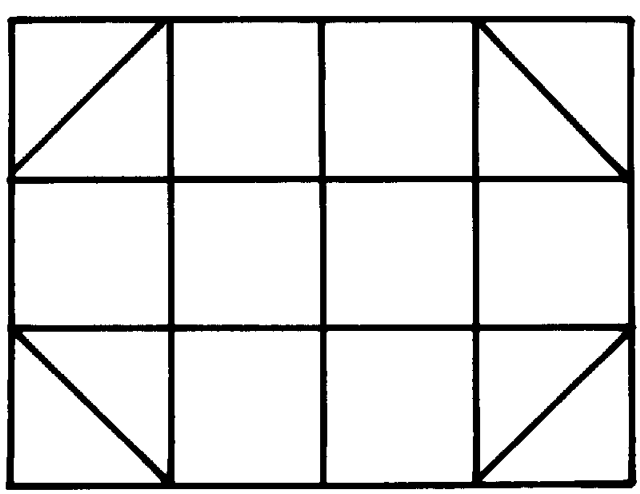

Figure A-2

8. Describe how to put 27 animals in four pens in such a way that there is an odd number of animals in each pen. (Experiment 2)
9. Show how you can divide this figure (Figure A-3) into four equal parts that are the same size and shape. (Experiment 2)

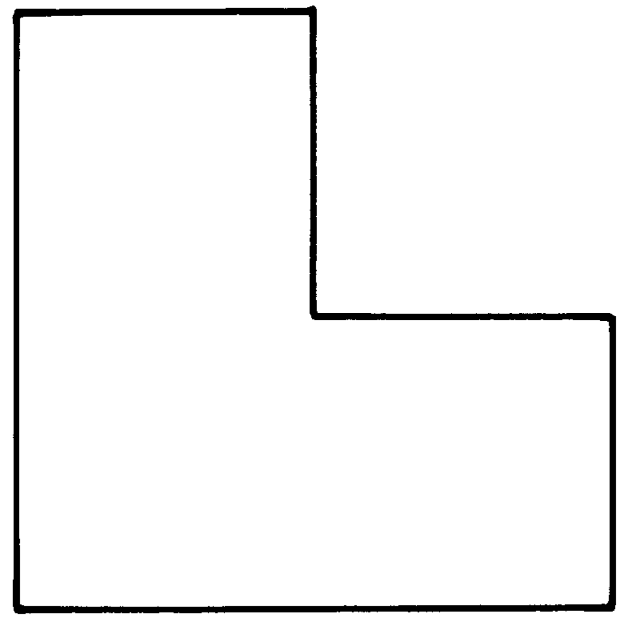

Figure A-3

10. Without lifting your pencil from the paper, show how you could join all sixteen dots with 6 straight lines (Figure A-4). (Experiment 2)

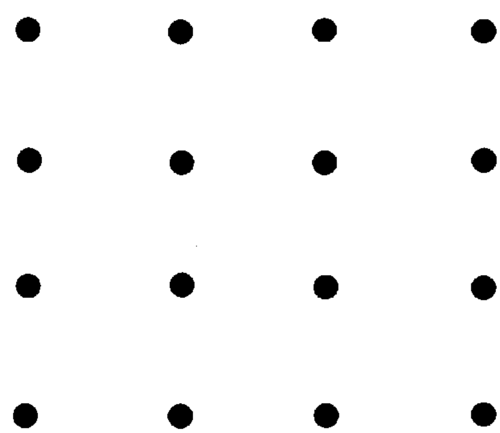

Figure A-4

11. Show how you can arrange ten pennies so that you have five rows (lines) of four pennies in each row. (Experiment 2)

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