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Context-dependent effects on analogical transfer

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The role of context in facilitating analogical transfer was investigated in two experiments. In both experiments, subjects first read two stories that were analogous to Duncker's (1945) radiation problem. Later, subjects attempted to solve the radiation problem. In Experiment 1, the radiation problem was presented in a different context than that of the stories, and followed them by 6 min. Transfer was observed in subjects who were prompted to use the earlier stories in solving the problem. However, the solution frequency of subjects not given such prompts did not differ from control levels. In Experiment 2, the radiation problem was presented in the same context as the earlier stories to some subjects, and in a different context to others. The timing of the radiation problem also was varied. When a 6-min interval separated the stories from the radiation problem, transfer was a function of context, with weak transfer being observed in the same-context condition, and no transfer being observed in the different-context condition. At a 45-sec delay, transfer was again observed in the same-context condition, and a nonsignificant trend toward transfer was observed in the different-context condition. The results were interpreted as indicating that context facilitates the retrieval of relevant problem-solving schemas, and as suggesting that the possession of relevant schemas is not sufficient to produce analogical transfer.

The cognitive processes involved in creative productions are of interest to workers in a variety of fields. Many researchers have emphasized the importance of processes involving analogy (e.g., Dreistadt, 1968; Gentner & Gentner, 1983; Gordon, 1961; Hoffman, 1980; Koestler, 1964; Oppenheimer, 1956). For example, Koestler (1964), in analyzing the first-hand reports about numerous scientific discoveries and inventions, argued that most resulted because scientists noticed novel connections between distant content domains (i.e., "the discovery of hidden similarities," p. 27). Although these first-hand accounts are suggestive, they are often incomplete and susceptible to the inaccuracies associated with all retrospective reports (Ericsson & Simon, 1980; Nisbett & Wilson, 1977). Thus, a definitive statement concerning the role of novel, remote analogies in scientific discovery is unlikely to be based solely on discoverers' accounts.

Experimental studies that come closest to addressing this issue have employed transfer designs. In these studies, subjects typically are given some experience (usually another problem) that is analogous to, and potentially helpful in solving, an outwardly dissimilar target problem. Using essentially this procedure, Gick and Holyoak (1980, 1983) and Luger and Bauer (1978) found unprompted transfer during problem solving. Gick and Holyoak (1983, Experiment 4) observed that transfer was significantly enhanced in subjects who were exposed to two analogs prior to solving a target problem. They argued that the advantage of multiple analogs over a single analog was due to their subjects' induction of a schema from their experience with the two analogous stories. Gick and Holyoak view these schemas as abstract categories, in which the domain-specific differences between story analogs are deleted, but the commonalities, based on their analogical relationship, are preserved. Consequently, schemas induced by multiple stories are more similar to the target problem than is any specific analog and are, therefore, more likely to be activated by the problem.

Gick and Holyoak's (1983) schema-based model suggests that analogy may serve a nondirected retrieval function during problem solving. That is, individuals, in attempting to solve a current problem, may be reminded of analogous knowledge on the basis of relatively abstract similarities. We refer to this as the *direct analogical-transfer view*.

In Gick and Holyoak's (1983) procedure, the story analysis and problem-solving phases were administered by the same individual within a single, relatively distinctive, context: a psychological experiment. The Luger and Bauer (1978) study was similarly administered. Contextual similarity has been found to facilitate recall in a variety of memory studies (e.g., Godden & Baddeley, 1975; Smith, 1979; Smith, Glenberg, & Bjork, 1978). Perhaps contextual similarity, rather than analogy, served as the basis for retrieval of the past problem in the Gick and Holyoak (1980, 1983) and Luger and Bauer (1978) studies. If so, then these studies may provide less support for a direct analogical-transfer view than previously thought. The present studies examine the role of context on analogical transfer.

EXPERIMENT 1

In Experiment 1, a systematic replication of Gick and Holyoak's Experiment 4 (1983) was carried out, with the addition that the analogs and the target problem were

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presented in different contexts. This was accomplished by presenting the analogs as part of a pilot experiment, and the target problem as a class demonstration. We felt that this manipulation would reduce the possibility of context-dependent retrieval, and thus would provide a more stringent test of the direct analogical-transfer view.

Method

Subjects and Design

At the beginning of their class, students attending a large section of introductory psychology at Temple University were asked to participate in an experiment. Two hundred forty students (over 95% of those attending) participated.

The experiment consisted of two phases. In the first phase (story analysis), all subjects read and answered questions about two brief stories. In the second phase (problem solving), subjects attempted to solve Duncker's radiation problem (1929, 1945). Two variables were manipulated between subjects: the number of stories that were analogous to the radiation problem (zero, one, or two), and whether or not subjects were informed, upon receiving the radiation problem, that the stories might help them solve the problem (hint-aided or nonhint). Thus, there were six conditions. Roughly equal numbers of subjects were randomly assigned to each of the treatment conditions, the smallest and largest groups having 33 and 46 members, respectively.

Materials

Story analysis. Booklets were constructed for use in the story-analysis phase. The first page contained instructions for reading the first story. Subjects were informed that after reading the story, they would be asked some questions regarding its comprehensibility, and then would be asked to briefly summarize the story. The first story appeared on the second page. On the third page, subjects were instructed to answer four yes-no questions regarding the story's clarity and readability. The fourth page instructed subjects to briefly summarize the story. These instructions discouraged verbatim recall, but encouraged the inclusion of all details necessary to understand the main point of the story. The next four pages used the same format to present the second story. Following the second story materials, subjects were instructed to rate the similarity of the two stories on a 7-point scale. Finally, on the last page of the booklet, subjects were instructed to describe in writing any way or ways in which the stories were similar.

The booklets differed among treatment conditions only in the stories that they contained. Stories were selected from a pool of four stories developed by Gick and Holyoak (1980, 1983). Subjects in the two-analog conditions read "The General" and "Red Adair." The analogical relationships between these stories and the radiation problem are summarized in Table 1. Subjects in the zero-analog conditions read two nonanalogous stories, and subjects in the one-analog conditions read either "The General" or "Red Adair" and one of the nonanalogous stories. The order of story presentation was counterbalanced in both the two-analog and zero-analog conditions. In the one-analog conditions, the four possible story pairings were equally represented across subjects; however, the analogous story was always presented last. This practice was adopted so that subjects in the one- and two-analog conditions would differ in the number of analogous stories to which they were exposed, but not in the recency of that exposure.

Radiation problem. In the second phase of the experiment, subjects received either the hint-aided or the nonhint version of the radiation problem. These two versions differed only in that the hint-aided version contained a sentence at the end of the instructions to the radiation problem, stating that one or both of the stories the subjects had read earlier might help them to solve the problem. In order to eliminate the possibility that some physical similarity between the radiation problem and the earlier booklet materials might lead a subject to suspect that Phase 2 was related to Phase 1, the radiation problem was typed using a typeface and ink different from that of the story-analysis materials.

Procedure

During the story-analysis phase, subjects were told that the experiment was being conducted in order to gather pilot data on several stories. The story-analysis phase was divided into three timed segments: 10 min in which subjects read, answered questions about, and summarized the first story; another 10 min in which subjects performed these same tasks with the second story; and finally, 7 min in which subjects first rated the similarity of the stories, and then described in writing the ways in which the stories were similar.

Approximately 6 min elapsed between experimental phases. During this interval, the experimenter collected the story-analysis booklets, thanked the subjects for their participation, and left the classroom. The class instructor then made several announcements

Table 1
Description of Analogous Relations between the Stories and the Radiation Problem

	Abstract Level	The General	Red Adair	Radiation Problem
Goal	A large force must be delivered to a central location	The general's army must reach the fortress.	A large quantity of fire-retardant foam must reach the base of the oil well.	High-intensity rays must reach the tumor.
Constraint	A direct approach, using a single path, cannot be used.	Any large body of men traveling on one of the roads will detonate the mines.	There is no hose large enough to carry the quantity of foam needed to extinguish the fire.	High intensity rays will kill the healthy tissue that they pass through.
Convergence Solution	Simultaneously deliver smaller forces to the central location such that the combined effect will equal the large force.	Split the army up into small groups. Have each group converge on the fortress, simultaneously.	Using many small hoses at the same time, pump a large quantity of foam on the base of the well.	Aim several ray-emitting devices at the tumor. Reduce the intensity of each device so that the healthy tissue will not be harmed, but deliver enough intensity, from these multiple sources, to destroy the tumor.

regarding the course before administering the radiation problem. The instructor introduced the radiation problem as a class demonstration, saying that it would be discussed in a subsequent lecture on problem solving. He instructed students to write down any and all solutions they thought of. Copies of the problem were then distributed, and students were allowed 10 min to solve it.

Results

The effectiveness of analogy in promoting transfer was assessed by probing the degree to which convergence solution frequency was dependent upon the number of analogous stories that the subjects had read. The two-analog subjects' similarity descriptions were then classified according to how well they captured the critical analogical relationships between stories. Finally, using these classifications, the relationship between subjects' similarity descriptions and transfer was explored.

Convergence Solutions

Each solution was evaluated by two scorers who were blind as to the subject's treatment condition. In order to be counted as a convergence solution, a subject's solution to the radiation problem must have explicitly mentioned the use of more than one low-intensity ray. It was also necessary that it be apparent that the subject intended for these rays to simultaneously converge on the tumor. A few solutions were initially evaluated differently by the scorers. In these cases, the solutions were reevaluated jointly by both scorers. This practice led to complete agreement regarding the classification of all solutions.

Hint-aided conditions. The present hint-aided results were very similar to those obtained by Gick and Holyoak (1983). As can be seen in the first row of Table 2, a relationship was found between the number of analogous prestories and the production of convergence solutions. The overall effect of the number of analogous prestories on the frequency of convergence solutions was significant [$\chi^2(2) = 19.02, p < .01$]. The comparisons between individual treatment conditions were also significant. More two-analog than one-analog subjects produced convergence solutions ($p < .035$), and more one-analog than zero-analog subjects produced convergence solutions ($p < .008$).[1]

Nonhint conditions. As can be seen in the second row of Table 2, few convergence solutions were produced by nonhint subjects, and convergence solution frequency was independent of the number of analogous stories that these subjects had read [$\chi^2(2) = 2.14, p > .10$]. Thus, presenting the story analogs and the radiation problem in different contexts appears to have eliminated the unprompted analogical transfer observed by Gick and Holyoak (1983, Experiment 4).

Table 2
Percentage of Non-Hint and Hint-Aided Convergence Solutions in Experiment 1, as a Function of the Number of Analogous Stories Read

	Number of Analogous Stories			
Condition	0	1	2	Total
Hint-Aided	10 (4/40)	34 (15/44)	57 (21/37)	33 (40/121)
Non-Hint	4 (2/46)	12 (4/33)	5 (2/40)	7 (8/119)
Total	7 (6/86)	25 (19/77)	30 (23/77)	20 (48/240)

Note—Frequencies are given in parentheses.

Quality of Similarity Descriptions

Gick and Holyoak (1983, p. 22) stated that their similarity-description procedure may have been a crucial determinant of analogical transfer in their study. Except for the similarity rating task, nowhere were their subjects (or those in the present study) explicitly asked to compare the prestories. Thus, the similarity description task is the main vehicle through which some subjects may have developed "convergence problem" schemas.

In the present experiment, similarity descriptions were classified into three categories, using a method devised by Gick and Holyoak (1983). This method differentiates subjects' similarity descriptions based upon how well they captured the analogical relations between stories, as outlined in Table 1. In order for a description to qualify as a "good" schema, the basic idea of having forces converge from different directions had to be present, either explicitly or as an inference. In addition, at least one other major aspect of the analogy had to be expressed: either the use of multiple small forces or a description of other parallels in the initial problem situations (e.g., centrally located targets). An actual example of a "good" similarity description is: "They each accomplished this by dividing their resources in order to place the resources at the objective simultaneously." An "intermediate" schema contained only one of these major features (e.g., "In both cases something prevented them from using the large force. Therefore, they had to break it down into smaller groups"). "Poor" similarity descriptions contained none of the critical analogical relationships.

As might be expected, the similarity descriptions of subjects who did not receive two analogous stories were uniformly rated as "poor." Thus, all analyses to be reported are restricted to the two-analog conditions.

A strong relationship was observed between the quality of hint-aided subjects' similarity descriptions and their production of convergence solutions. As can be seen in the first line of Table 3, hint-aided subjects who wrote poor similarity descriptions were less likely to produce a convergence solution than were hint-aided subjects who produced either an intermediate or a good similarity description ($p < .001$).[2] This finding replicates Gick and Holyoak's (1983) finding. Although there were too few convergence solutions to warrant a similar analysis of the nonhint condition, as can be seen in the second line of Table 3, no trend toward a relationship between quality of similarity descriptions and the production of convergence solutions was observed in these subjects. This finding, however, must be interpreted in light of the fact that no good similarity descriptions were produced in this condition.

Table 3
Percentage of Convergence Solutions in Experiment 1, and in Gick and Holyoak's Experiment 4, as a Function of the Quality of Subjects' Similarity Descriptions

	Quality of Similarity Description			
Condition	Poor	Intermediate	Good	Total
Experiment 1				
Hint-Aided	38 (8/21)	75 (9/12)	100 (4/4)	57 (21/37)
Non-Hint	4 (1/27)	8 (1/13)	(0/0)	5 (2/40)
Gick and Holyoak				
Hint-Aided	70 (21/30)	90 (9/10)	100 (11/11)	80 (41/51)
Non-Hint	30 (9/30)	40 (4/10)	91 (10/11)	45 (23/51)

Note—In parentheses, the frequencies of solvers is presented as a fraction of the total number of subjects, within a treatment condition, who produced a similarity description of a given quality.

Non-hint versus hint-aided was manipulated within subjects in Gick and Holyoak's (1983) Experiment 4.

Discussion

In the present experiment, transfer of analogous prior experience to the radiation problem was limited to subjects who were explicitly directed to use this prior experience (i.e., hint-aided subjects). In addition, factors that were found to facilitate hint-aided transfer (i.e., preexposure to more than one analog, and the quality of subjects' similarity descriptions) had no effect on nonhint transfer. The present hint-aided findings replicate those of Gick and Holyoak (1983). However, Gick and Holyoak found this same pattern of results in nonhint subjects, whereas we did not. Although the present study primarily differs from Gick and Holyoak's (1983) study in that the experimental phases were presented in different contexts, several other differences may have contributed to our contrasting findings.

First, in Gick and Holyoak's (1983) study, the problem-solving phase directly followed the story-analysis phase, whereas in our study 6 min elapsed between experimental phases. In light of the level of transfer observed in our hint-aided subjects, we are confident that the earlier stories were potentially available to our nonhint subjects as they solved the radiation problem. Nevertheless, it is possible that a brief interevent interval is necessary for spontaneous retrieval based on analogy to occur.

Another factor that may have influenced our contrastive findings concerns the absence of good similarity descriptions in the two-analog, nonhint condition. Although only 20% of Gick and Holyoak's (1983) subjects wrote good similarity descriptions, 90% of those subjects went on to produce the convergence solution. Thus, it is possible that unprompted transfer in the present study would have been observed if more of our subjects had written good similarity descriptions. It should be noted, however, that although none of our nonhint subjects wrote a good similarity description, the quality of their descriptions did not differ significantly from that of the hint-aided subjects, many of whom produced the convergence solution. Thus, the present study indicates, as have others (Perfetto, Bransford, & Franks, 1983; Reed, Ernst, & Banerji, 1974; Schoenfeld, 1979b; Weisberg, DiCamillo, & Phillips, 1978), that there is often a wide gap between the availability and the access of relevant knowledge during problem solving.

In summary, the main finding of the present study was the absence of unprompted transfer when the stories and radiation problem were presented in different contexts. The present study, however, did not directly address the question of whether similar encoding contexts would have brought about transfer. Both this issue and the sensitivity of transfer to the temporal separation of analogous events were investigated in Experiment 2.

EXPERIMENT 2

In this experiment, we directly examined whether contextual similarity would facilitate transfer, and whether relatively minor changes in the temporal interval between story analysis and problem solving would influence transfer. For these purposes, two levels of context (same and different) and two levels of the timing of the radiation problem (immediate and delay) were manipulated in a factorial design.

Method

Subjects

Ninety-two students in introductory psychology at Temple University served as subjects during class time. Although participation was voluntary, students received course credit for participating, and all students chose to participate. Instead of conducting the experiment in a single large lecture setting, as was done in Experiment 1, students were tested in seven smaller recitation sections. The number of students in each section varied from 6 to 23. Recitation sections were randomly assigned to one of the four treatment conditions, with the restriction that approximately equal numbers of subjects would ultimately be tested in each condition. The numbers of subjects within the four conditions ranged from 22 to 25.

Materials

Except for the similarity description instructions, the story-analysis booklets and radiation problem were identical to those used in the nonhint, two-analog condition of Experiment 1. The instructions for the similarity description task were modified, in an attempt to produce more "good" similarity descriptions. All subjects were asked to describe any way in which the situations faced by the stories' main characters were similar, and also to describe any way in which these characters' responses were similar. We hoped that these instructions would make it more likely that subjects would base their similarity descriptions on those aspects of the stories that were analogous, and that this, in turn, would provide a stronger basis from which transfer could occur during problem solving.

Procedure

All subjects were told that the purpose of the experiment was to collect pilot data on materials to be used in a future study. The story-analysis procedure was identical in all respects to Experiment 1. All subjects saw two analogous prestories, and no subject received a hint.

In the same-context conditions, a single experimenter administered both the story-analysis and problem-solving phases. In the different-context conditions, the experimenter left the classroom after story analysis, on the pretext of retrieving additional materials, and the recitation leader administered the radiation problem as a class demonstration, during the experimenter's absence.

In the immediate conditions, a 45-sec interval between story analysis and problem solving was used to collect the story-analysis booklets and to introduce the radiation problem. In the delay conditions, story-analysis booklets were first collected, and then the recitation leader resumed a normal class routine, by answering questions, taking roll, or lecturing for 5 min, 15 sec. This resulted in a 6-min delay. Then, either the recitation leader administered the radiation problem as a class demonstration (different-context-delay condition), or the experimenter returned and administered the radiation problem as the second part of a pilot study (same-context-delay condition). The instructions for the radiation problem and the time allowed to solve it (i.e., 10 min) were the same as in Experiment 1.

Results

Convergence Solutions

Table 4 presents the percentage of convergence solutions in each treatment condition, as a function of the quality of subjects' similarity descriptions. As can be seen in the fifth row of Table 4, none of the 25 different-context-delay subjects produced a convergence solution. This replicates the lack of transfer observed from the nearly identical nonhint, two-analog condition of Experiment 1. The proportion of different-context-delay convergence solutions is not significantly different from that observed of subjects in Experiment 1 who read two irrelevant prestories ($p > .221$).[3] The solution frequency in the different-context-delay condition may, therefore, be used as a baseline in judging whether subjects in the other treatment conditions benefited from their exposure to the two story analogs.

Although generally accepted nonparametric techniques for detecting an interaction in nominal data have not been developed, an inspection of the total convergence solution frequencies in the last column of Table 4 strongly suggests that an interaction exists between the timing of the radiation problem and the contextual similarity of the two experimental phases. Thus, the finding that context (collapsed across timing) was found to have a significant effect on the production of convergence solutions ($p < .029$) whereas timing (collapsed across context) did not ($p > .432$) is not an accurate description of the present results.

Table 4
Percentage of Convergence Solutions in Experiment 2 as a Function of Treatment Condition and Quality of Similarity Description

	Quality of Similarity Description			
Condition	Poor	Intermediate	Good	Total
Same-Context-				
Immediate	12 (2/17)	40 (2/5)	(0/0)	18 (4/22)
Delay	0 (0/10)	25 (2/8)	80 (4/5)	26 (6/23)
Collapsed	7 (2/27)	31 (4/13)	80 (4/5)	22 (10/45)
Different-Context-				
Immediate	14 (2/14)	17 (1/6)	0 (0/2)	14 (3/22)
Delay	0 (0/17)	0 (0/6)	0 (0/2)	0 (0/25)
Collapsed	6 (2/31)	8 (1/12)	0 (0/4)	6 (3/47)

Note—In parentheses, the frequency of solvers is expressed as a fraction of the total number of subjects who produced a similarity description of a given quality.

Significantly more convergence solutions were produced in the same-context-immediate and same-context-delay conditions than in the different-context-delay condition ($ps < .042$ and $.009$, respectively). In addition, there was a nonsignificant trend toward more convergence solutions in the different-context-immediate condition than in the different-context-delay condition ($p < .095$). All other comparisons between treatment conditions were also not significant (all $ps > .252$). Thus, after a delay, context was a crucial variable in determining transfer, with similar contexts facilitating transfer, and no transfer being observed in the different-context condition. At the more immediate test, transfer was again observed in the same-context condition. However, in the immediate conditions, transfer was not context-dependent.

Quality of Similarity Descriptions

The overall quality of subjects' similarity descriptions was comparable to that found in Experiment 1. The percentages of subjects producing good, intermediate, and poor descriptions were 10%, 27%, and 63%, respectively. Thus, despite our expectations, the revision of the similarity description instructions did not improve the quality of these descriptions.

As can be seen in Table 4, a strong relationship between convergence solution frequency and the quality of similarity descriptions was found in the same-context conditions. The more a same-context subject's similarity description captured the analogical relationships between stories, the more likely it was that the subject would produce a convergence solution. This result parallels that for the hint-aided two-analog subjects in Experiment 1. The difference in the frequency of convergence solutions between subjects who produced poor versus intermediate or good similarity descriptions was significant ($p < .006$). This finding replicates that of Gick and Holyoak (1984, Experiment 4). Considerably different findings, however, were observed in the different-context conditions. As can be seen from Table 4, the production of good and intermediate similarity descriptions by these subjects did not facilitate the production of convergence solutions.

If the quality of subjects' similarity descriptions is related to the likelihood of producing a convergence solution, it is conceivable that the observed differences in the frequency of convergence solutions among treatment conditions might be the result of differences in the quality of the similarity descriptions among these treatment conditions. The similarity descriptions of the two same-context conditions differed reliably [$\chi^2(2) = 7.466$, $p < .025$]. This difference seems to be due to the lower quality of the similarity descriptions produced in the same-context-immediate condition. No other comparison approached significance (all $ps > .10$). Thus, the lack of

transfer observed in the different-context-delay condition is not the product of abnormally deficient similarity descriptions.

Discussion

The results of the present experiment may be summarized as follows. No evidence of transfer was observed in the different-context-delay condition, replicating the findings of Experiment 1. Using these subjects' performance as a no-transfer control, a nonsignificant trend toward transfer was observed in the different-context-immediate condition, and reliable, although infrequent, transfer was observed in both same-context conditions. Finally, the quality of subjects' similarity descriptions was highly predictive of the production of convergence solutions in the same-context but not in the different-context conditions.

Given the small numbers of subjects who produced convergence solutions in our experiments, one may question whether this measure was too insensitive to accurately measure the effects of context and timing on analogical transfer. The radiation problem was indeed a difficult problem for subjects, independent of their treatment condition. However, the performance of the hint-aided, two-analog subjects of Experiment 1 (57% of whom produced convergence solutions) suggests that more than half of the subjects in Experiment 2 would have produced convergence solutions if they had attempted to apply their knowledge of the earlier stories in solving the radiation problem. In view of this latent potential for producing convergence solutions, the fact that so few of our subjects did so is one of the most interesting aspects of the present study.

This relative infrequency of convergence solutions was especially surprising in the same-context-immediate condition. Although we replicated Gick and Holyoak's (1983) results, with respect to the presence of transfer in this condition, we observed considerably less transfer (18% convergence solutions) than Gick and Holyoak did (45% convergence solutions). There are several factors that we feel are responsible for this difference in convergence solution frequency. First, as noted earlier, the similarity descriptions of our same-context-immediate subjects were deficient, at least when compared to those of the same-context-delay subjects. In Gick and Holyoak's study, nearly half of all convergence solutions came from subjects who produced good similarity descriptions. In our same-context-immediate condition, no good similarity descriptions were produced. Insofar as similarity description quality is highly related to the production of convergence solutions in same-context conditions, one would not expect many convergence solutions from a condition in which similarity descriptions were deficient.

A second possible reason why considerably fewer convergence solutions were produced by our same-context-immediate subjects than by Gick and Holyoak's subjects concerns the physical similarity of the story-analysis booklets and the radiation problem. As in Experiment 1, the story-analysis and problem-solving materials used in the present study differed with respect to the typeface and color of ink used. Since Gick and Holyoak (1983) do not report taking any special measures to reduce the physical similarity of these materials, we assume that they did not. Although it is unlikely that this physical similarity would, by itself, have an effect on transfer, it may be a determining factor, for some individuals, when paired with other contextual similarities, as it was in Gick and Holyoak's study (1983).

Despite the overall infrequency with which the convergence solution was produced, context and timing were found to have an interactive effect on transfer. A definitive answer as to why the context effect was limited to the delay conditions is beyond the reach of our data, and the inequality of similarity description quality across treatments makes any interpretation unduly speculative. However, whatever interpretation one takes with respect to the present study, it will have to accommodate the finding that intercontext transfer of past experience to a superficially dissimilar, but analogous, current event did not occur over interevent intervals as short as 6 min.

GENERAL DISCUSSION

In the present studies, a similar encoding context was a necessary factor involved in unprompted analogical transfer. It is important to note, however, that similar encoding contexts did not produce transfer in subjects who wrote poor similarity descriptions. Similar results were recently reported by Catrambone and Holyoak (1985), who varied context by informing one group of subjects that they would be in a series of separate experiments, and not giving a second group any information to induce them to separate story analysis from the radiation problem. From our perspective, it is somewhat difficult to interpret their results, because no zero-analog control subjects were included, and because the same experimenter conducted all phases of the study. These issues notwithstanding, Catrambone and Holyoak found that changing context essentially eliminated any effect of schema quality on transfer. As we found, all the subjects in the different-context conditions in the Catrambone and Holyoak study performed at the level of subjects producing poor quality schemas.

Assuming our context effect is real, two related questions arise. First, how does context influence transfer, and second, is possession of a relevant schema sufficient to produce transfer?

Concerning the role of context, it is possible that similar encoding contexts aided the retrieval of subjects' convergence schemas. This possibility is supported by the finding that only subjects who wrote intermediate or good similarity descriptions benefited from similar encoding contexts. Gick and Holyoak's model of analogical transfer assumes that relational commonalities are represented in schemas induced from multiple analogs. It is unclear as to whether their model would assume a common con-

text to be represented within such schemas as well. If so, then it is possible that encoding context, in addition to the radiation problem itself, may serve to retrieve schemas. However, if the radiation problem were a sufficient cue for the retrieval of convergence schemas, one may ask why no transfer was observed in our different-context conditions. This leads us to the question of whether possession of a relevant schema is sufficient to produce transfer.

Although Gick and Holyoak's schema-based model may easily accommodate a facilitative effect of similar encoding contexts on transfer, it does not view analogical transfer as being dependent upon such concrete similarities. Rather, it assumes that a schema at an appropriate level of abstraction may automatically be retrieved by a current analog. Thus, the complete absence of transfer in our different-context conditions would present difficulties for Gick and Holyoak's model, if "convergence schemas" were available to our subjects as they solved the radiation problem. However, since so few of our subjects produced good similarity descriptions, it must be assumed that few convergence schemas were induced during the story-analysis phase. Thus, although the present results raise the question of whether analogical transfer is, in actuality, dependent upon, rather than simply facilitated by, concrete similarities, an answer to this question must await studies in which subjects' knowledge is more certain. One such study is presently available. In a study investigating the induction and efficacy of mathematical problem-solving heuristics, Schoenfeld (1979b) found that students rarely derived heuristics from multiple-problem exemplars, without explicit instruction. This finding is consistent with the infrequency with which good similarity descriptions were written in the present study. More importantly, however, Schoenfeld found that the induction of a heuristic provided no guarantee that subjects would use it in solving a later related problem. It should be noted that Schoenfeld's heuristics and Gick and Holyoak's schemas are quite similar, operationally. Of course, a strong statement concerning the possible context-dependent nature of analogical transfer cannot be made until other studies, involving different materials, procedures, and subject populations, investigate this issue.

In this connection, it would be interesting to see whether findings similar to the present results are obtained with experts as subjects. Previous research has found that experts are able to get at "the heart" of problems within their fields of expertise (Larkin, McDermott, D. P. Simon, & H. A. Simon, 1980; Schoenfeld, 1979a; Schoenfeld & Herrmann, 1982). Based on experts' extensive experience in solving certain types of problems, one might expect that they would possess problem-solving schemas that would facilitate analogical transfer to distant content domains. Thus, future research, conducted on experts, might provide a more sensitive test of the direct analogical-transfer view than did the present studies.

As mentioned earlier, many investigators of creativity have asserted that creative discovery is often promoted by noticing an analogy in a remote domain (e.g., Gordon, 1961; Koestler, 1964). However, even if one assumes that this view is correct (see Weisberg, 1986), the question of how these creative discoverers initially noticed their analogies remains open.

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NOTES

1. The probabilities for all 2×2 analyses were computed using Fisher's (1950) exact method.

2. Since two cells in a 2×3 chi-square analysis had expected values of less than five, the intermediate and good similarity descriptions were combined and a Fisher exact probability was calculated. However, the result is significant by either method.

3. The data from the 0-analog, hint-aided condition was combined with that of the 0-analog, non-hint condition in this analysis.

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