Is a Hint Always Useful in Problem Solving? The Influence of Pragmatic Distance on Context Effects

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Abstract

This study explores the utilization of information accidently accessible in the environment when solving a problem. It contrasts the spontaneous use with the prompted use of such information, i.e. it investigates the relationship between the degree of *a priori* confidence in the relevance of the information and its efficient use. Three degrees are considered – close pragmatic distance (explicit hint to use it), intermediate (no instructions), and far pragmatic distance (discouraging its utilization claiming that it is irrelevant). The results are surprising: in this particular case the hint has a negative effect inhibiting the correct solution of the problem, while the far condition has a positive effect. These results are explained within the dynamic theory of context in terms of the performance of two different mechanisms used in the DUAL cognitive architecture – strategic vs. automatic retrieval.

Introduction

Psychologists and cognitive scientists have always been interested in the question why people often fail to solve problems although they possess all the necessary information. This necessary information could either be part of their past experience (be retrieved from memory) or be provided by the environment during the problem solving process (be perceived at the current moment), i.e. its utilization might depend either on memory or on perceptual processes. In both cases subjects can differ significantly in the degree to which they are informed about the relevance of particular piece of information to the target problem solving, i.e. the pragmatic distance between this piece of information and the target problem.

Informed vs. Uninformed Subjects in Retrieving Information from Memory

Most of the research has concentrated on the retrieval of information from memory – and the common finding is that *subjects seldom transfer relevant information to new problems without an explicit hint*. Thus Weisberg, DiCamillo and Phillips (1978) found out that the prior study of the candle-box paired associate increased the number of correct solutions to the "candle problem" (Duncker, 1945) only when the subjects were informed that one of the studied pairs was relevant to the target problem. Gick and Holyoak (1980) demonstrated that analogical transfer from a previously studied general story to the "radiation problem" (Duncker, 1945) was rarely performed unless subjects were explicitly prompted to use it. Perfetto, Bransford, and Franks (1983) provided surprising evidence that even when the necessary information was processed several minutes before the problem solving task and was obviously relevant (almost identical to the solution of the problem), subjects who were uninformed of its relevance to the target problem solving task failed to access it. Subjects solved successfully the riddles (Gardner, 1978) only when an explicit hint to use the previously studied material was provided. Ross, Ryan, Tenpenny (1989) replicated that result showing in addition that uninformed subjects did not benefit from their learning experience until they "caught on" and became informed subjects.

There are several experiments demonstrating that in some cases transfer is possible even without providing an explicit hint. Thus Spencer and Weisberg (1986) showed that when the time period between the learning experience and its possible use in problem solving is short enough (45 sec.) than there is a trend (although nonsignificant one) toward transfer even in uninformed subjects. Kokinov (1990) demonstrated priming effects on problem solving which lasted for more than 10 minutes, i.e. within this period uninformed subjects successfully accessed knowledge which otherwise turned out to be inaccessible. Still stronger results were obtained by Schunn and Dunbar (1996) who demonstrated the same type of effect after a period of one day. Using thinking aloud protocols they came to the conclusion that in this case the old knowledge was made available by an implicit process (i.e. unconsciously). Adams, Kasserman, Yearwood, Perfetto, Bransford, and Franks (1988) and Needham and Begg (1991) provided evidence that when the type of processing in both learning and target problem solving were similar than transfer was effective even without a hint.

In summary, the results suggest that subjects informed of the relevance of their past experience are far more effective in using it, while uninformed subjects often fail to use it unless it has been primed recently.

Informed vs. Uninformed Subjects in Using Information Provided by the Environment

This second source of information – the environment – has not been studied so extensively. Again, here subjects could be either informed or uninformed about the relevance of a particular element of the environment to the problem

solving task. However, in this paradigm most of the research explored the case of uninformed subjects. Thus Maier (1931) showed that accidently swinging one of the ropes facilitated the successful solution of the two ropes problem. Cooke and Breedin (1994) studied subjects' predictions about the trajectory of a ball coming out of a tube. They provided evidence that the form of the tube influenced subjects' conclusion, although the form of the tube is irrelevant to the trajectory of the ball.

Kokinov and Yoveva (1996) demonstrated that illustrations accompanying problems accidently placed on the same page as the target problem could also influence the type of target problem solution generated by the subjects (Figure 1). Although there was no hint to use these illustrations, it could be the case that subjects have "caught on". Thus it could be questioned whether subjects were really uninformed. The current experiment addresses this question by comparing this context condition with an explicit hint condition.

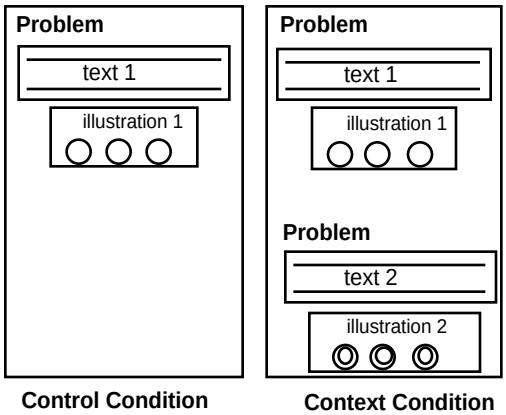

Figure 1. Experimental design of a previous experiment (Kokinov & Yoveva, 1996) demonstrating an effects of illustration 2 on the solution of the target problem 1.

In summary the current experiment is designed to contrast the influence of a context stimulus (an accidental element of the problem solving environment) on the target problem solving performance of informed subjects with that of uninformed subjects. The results could provide for a more precise interpretation of the previous experimental data. They could also shed some light on the role of hints for accessing information provided by the environment as compared with their role in accessing memorized information.

Theoretical Considerations

Two theoretical accounts help in formulating the hypothesis in the current experiment: the dynamic theory of context (Kokinov, 1995) and the general cognitive architecture DUAL (Kokinov, 1994b, 1994c).

According to the dynamic theory *context* consists of *all* entities which influence human cognitive behavior on a particular occasion, i.e. all active memory elements. These memory elements, however, change their activation (or relevance) over time and vary the degree to which they influence human behavior. As a consequence, *context is considered as the dynamic fuzzy set of all associatively relevant memory elements (mental representations or operations) at a particular instant of time.*

Three mechanisms are contributing to the construction of the current context: reasoning, perception, and memory.

Thus, when in the course of a problem solving process an explicit hint for the use a specific visually presented stimulus is provided, the reasoning mechanism establishes a subgoal to find a relation between this stimulus and the target problem and perception and reasoning interact in order to build up a representation of the stimulus and to find elements of that description which can be applied to the target problem.

On the other hand, when no explicit hint to use the stimulus is provided the reasoning mechanism does not actively look for such relations and the perceptual mechanisms do not actively search such stimulus. However, when the stimulus is presented in the visual field, the perceptual mechanisms are likely to automatically start processing it and building up a representation, while interacting with the automatic memory mechanisms. This representation will be influenced by the currently active concepts. Being linked to many other memory elements it will start activating them and incorporating them into the current context. In this way it could happen that concepts potentially useful in solving the problem become active and therefor the reasoning mechanism may use them in solving the problem.

As it is clear from the above explanations in a non-hint condition there is no guarantee that such relevant concepts will be incorporeted into the context and will be used in the problem solving process, however, if it happens it will be due to an automatic process (i.e. subjects will not be aware of it). This is in contrast with the hint condition where the use of the stimulus in the problem solving process is due to a strategic retrieval and mapping of the representations of the stimulus and the target.

These theoretical constructs have been further specified and implemented in a general cognitive architecture DUAL where the automatic memory processes are modeled by a spreading activation mechanism, while the strategic retrieval is modeled by a process of marker passing (Kokinov, 1994b, 1994c). In a specific analogical problem solving simulation (Kokinov, 1994a) it has been demonstrated that the presence of a specific visual stimulus (in a non-hint condition) can activate new concepts and change the way the problem is being solved. This prediction has been experimentally confirmed in (Kokinov & Yoveva, 1996).

As a consequence of this theoretical accounts a hypothesis can be formed that in principle it could happen that one and the same stimulus can affect the problem solving processes in different ways. This will depend on the specific way of its presentation simply because different mechanisms are used in the hint condition and in the non-hint (remote context) condition. Moreover, with certain stimuli and in particular contexts it could happen that they have greater influence in a remote context condition than in a hint condition, something that would contradict our naive (common sense) expectations. Unfortunately, no direct comparision between hint and non-hint conditions has been simulated on the bases of DUAL so far as it requires psychological data about the specific characteristics of the stimulus needed for such effect reversal.

Experiment

The purpose of the current experiment is to compare the influence of a context stimulus (an accidental element of the problem solving environment) on subjects' target problem solving performance in various experimental conditions. The pragmatic distance between the context stimulus (object) and the target task is varied from very small distance (in the hint condition) to very large distance (in the remote context condition).

Method

Design. In addition to the control condition where subjects had to solve only the target problem, there were three experimental conditions in which the pragmatic distance between the context stimulus (a second illustration) and the target problem was varied. In other words the degree to which subjects were informed of the relevance of the second picture to the target problem (Figure 2.) was varied. The three experimental conditions were as follows.

- hint condition – subjects are explicitly informed of the relevance of the illustration;
- intermediate condition – subjects are not informed of the relevance of the illustration, but there is no obvious explanation of the fact that the picture has been presented on the same sheet of paper;
- remote condition – subjects are not informed of the relevance of the illustration, and it is presented as an illustration of a second problem, i.e. there is a reasonable misleading explanation of its presence and its relevance is *a priori* rejected.

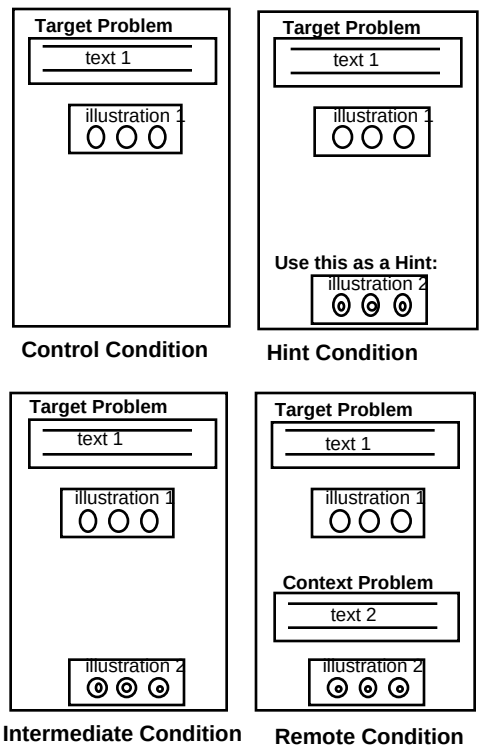

Figure 2. Experimental design. Layout of the sheets of papers with the target problems in each of the four experimental conditions.

The measured variable is the type of solution proposed by the subject (or his/her failure to propose any solution).

Subjects. Three hundred and seventeen university students participated in the experiment as part of their course requirements. They were tested in groups of 10 to 40 people and in each group subjects were randomly assigned to experimental conditions. They were asked to report if they knew the problem. The three subjects reported to be familiar with the problem were droped out from the data analysis. Finally, there were 78 subjects in the control condition, 63 in the hint condition, 68 in the intermediate condition, and 105 in the remote condition.

Materials. The target problem was the following one:: *Move 3 matches in order to reverse the direction in which the fish is facing*. (Figure 3.)

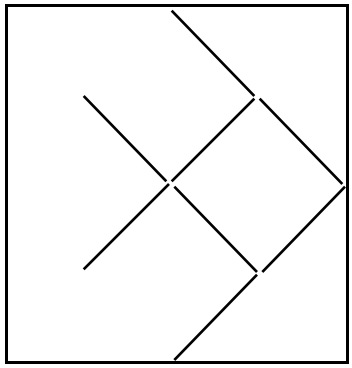

Figure 3. Illustration presenting the target problem.

This problem turns out to be a difficult one and few subjects were able to solve it correctly because the correct solution involves not only reversing the direction, but also shifting/displacing the axis of the fish so that one can use the bottom contour of the fish for a top contour of its reversed version. The correct solution is presented at Figure 4.

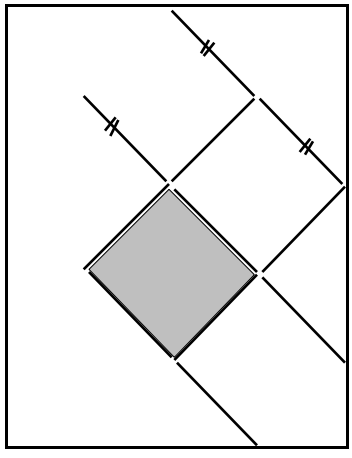

Figure 4. The correct solution of the target problem.

A drawing by Escher was used as a context stimulus (Figure 5). This drawing was supposed to activate the needed concepts of shifting the axis and having two reversed images sharing part of the contour. Thus in all three experimental conditions this drawing was present, however, the reason for this presence (from the perspective of the subjects) was different.

In the hint condition, the following text was immediately above the drawing:

Hint: Think whether the following picture could help you to solve the above problem.

In the intermediate condition, there was no text and no explanation of the reason of this presence.

In the remote condition, the following text was immediately above the drawing:

Problem: Count how many whole ducks are there on the following picture.

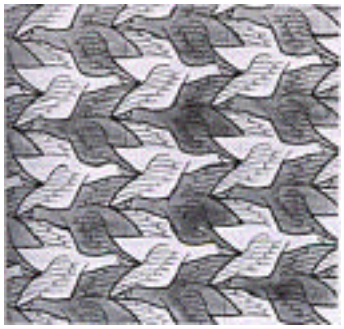

Figure 5. Context stimulus: Escher's drawing.

In this way the *a priori* estimation of the relevance of the drawing to the target problem solving task (i.e. its pragmatic distance) has been varied from very relevant (in the hint condition) to not relevant (in the remote condition). To put it in a different way, in the hint condition the subjects were informed of the relevance of the drawing; in the intermediate condition subjects were uninformed, but they could guess the relevance of the drawing; and finally in the remote condition they were completely uninformed.

Procedure. Subjects had to solve about ten problems each described and illustrated on separate sheet of paper. The target problem was one of these problems. In the remote condition subjects were instructed that the same forms had been used in many other experiments and that is why there are two problems on each sheet of paper, however, in the current experiment subjects were instructed to solve only the first problem on each sheet of paper and ignore the second one. The reason for instructing subjects to skip the second problem on each sheet (the context one) is that we would like to isolate the context effects from the priming effects. If the subjects were solving the context problem first or in parallel with the target one then all the concepts used in it would be activated prior to the target problem solving process and would have caused a priming effect. In this way we would test the influence of the memory-induced context instead of the perception-induced context.

In the intermediate condition there was no explanation of the presence of the second illustrations on each sheet of paper.

Subject had 2 minutes to solve the target problem and to write down its solution.

Subjects were asked to report if they were familiar with a particular problem and if so, their results were discarded.

Results and Discussion

In addition to the correct solution (Figure 4) a large number of subjects produced another, incorrect solution (Figure 6) hereafter called up/down solution. This solution changes the direction of the fish from left/right to upside/down (or to bottom/up) instead of reversing the direction to right/left. It is incorrect as it changes the direction of swimming instead of reversing it. In addition, the solution is incorrect because of moving only 2 matches instead of three.

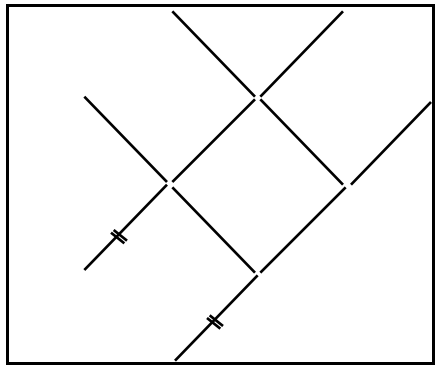

Figure 6. Incorrect (upside down) solution.

This solution is easier because the body of the fish does not change and therefore a large part of the contour does not change as well and that is why 49% of the subjects produced this incorrect solution in the control group (Table 1). However, the percentage of subjects producing this solution dropped significantly (to about 30 %) in all other experimental conditions. The results in both the hint and remote experimental conditions are significantly different from the result of the control condition according to the chi-square test – ($\chi^2(3) = 7.74$, $p<0.05$) for the hint condition and ($\chi^2(3) = 7.04$, $p<0.05$) for the remote condition. This can be interpreted as follows: the context stimulus (Escher's drawing) activates the horizontal reverse operation which blocks the horizontal to vertical axis change, i.e. the context stimulus always has an effect on the pattern of produced solutions. The intermediate experimental condition does not differ significantly from the control condition ($\chi^2(3) = 2.7$, $p>0.05$).

experimental group		solution type		
No	condition	correct	up/down	none
1	control	6	49	45
2	hint	3	29	68
3	intermediate	9	35	56
4	remote	10	29	61

Table 1. Percentage of generated solutions of each type (correct, incorrect, and failure) in the experimental conditions.

The more interesting result, however, is the change in the percentage of the correct solutions (Table 1 and Figure 7). In the hint condition the percentage of correct solutions has dropped twice compared to the control group, while in the remote condition (and even in the intermediate condition) the percentage of correct solutions has increased almost twice. The hint to use the drawing seems to have suppressed the correct solution, while the same drawing presented as a remote context stimulus has facilitated it. The results from the intermediate condition are closer to the remote context condition than to the hint condition

which means that the subjects have perceived the second illustration as irrelevant rather than as relevant.

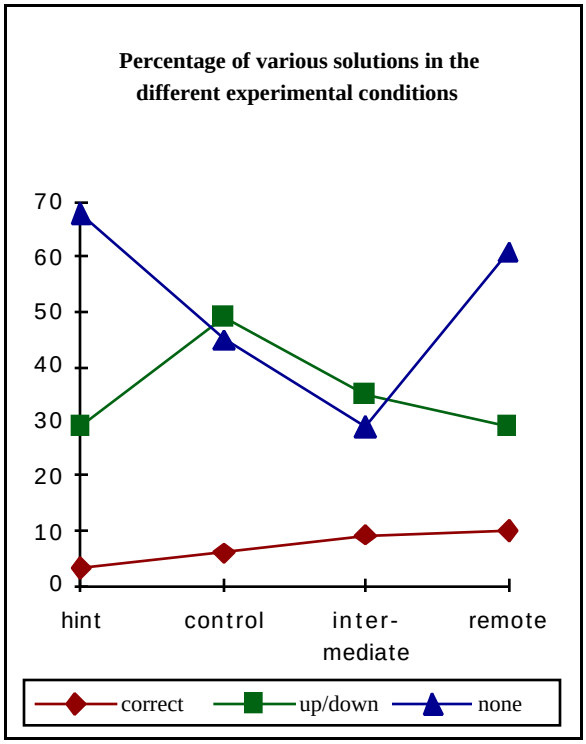

Figure 7. Percentage of correct, incorrect solutions and failures in each of the experimental conditions. The percentage of correct solutions increases from the hint to the control condition and even more to the remote condition. The percentage of incorrect (up/down) solutions decreases in all experimental conditions compared to the control condition.

General Discussion

The experimental data has provided an interesting example where although both the hint condition and the remote control condition have influenced the problem solving process, the remote context condition has facilitated the correct solution of the problem, while the hint condition using the same stimulus has inhibited it. This is a fact which contradicts common-sense expectations.

The interpretation of this fact could be done within the theoretical framework outlined earlier in the paper, namely that in the remote context condition the automatic mechanisms of spreading activation bring concepts like horizontal reversal, vertical displacement, common contours of identical figures, etc. into consideration during the problem solving process and this facilitates the successful solution. In the hint condition subjects are explicitly trying to find a mapping between the context stimulus and the problem at hand using reasoning mechanisms like marker passing and structure correspondence building. They fail in this case because of the fact that the shared relations are not obvious. At the same time the strategic retrieval process shifts the spread of activation along the analyzed links and in this way the concepts of vertical displacement and common contours of identical figures cannot be activated.

The general conclusion is that in certain cases explicit hints are not facilitating the problem solving process while implicit ones might turn out to be more efficient making it possible to use automatic spreading activation processes.

Acknowledgments

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