

# REASONING IN HUMANS<sup>1,2</sup>

## II. THE SOLUTION OF A PROBLEM AND ITS APPEARANCE IN CONSCIOUSNESS

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### INTRODUCTION

In an earlier study (5) it was found that experience and its proper selection were not enough to account for the appearance of an original solution. Rather an organizing principle which was called "direction" was necessary. The present study is concerned with the appearance of the solution and hopes to answer the following questions: (a) Does the solution develop from a nucleus or does it appear as a completed whole? (b) What is the conscious experience of an individual just before the solution is found? (c) Is the reasoner conscious of the different factors which aid in bringing about the solution?

### METHOD AND PROCEDURE

Individual subjects were presented with a problem to which there were several solutions. All but one of the solutions were

<sup>1</sup> From the Psychological Laboratory of the University of Chicago.

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quite obvious. The difficult solution was the one that was studied because it required originality and was less likely to be linked up with past experience. The simple solutions, however, were not excluded from the experiment. When one was found the subject was asked to find another. The easier solutions thus functioned as (a) a means for encouraging the subject; (b) a period of orientation and adjustment to the situation and the experimenter; and (c) a means of stating the problem without limiting the freedom of the subject.

The experiment was carried on in a large room which contained many objects such as poles, ringstands, clamps, pliers, extension cords, tables and chairs. Two cords were hung from the ceiling, and were of such length that they reached the floor. One hung near a wall, the other from the center of the room. The subject was told, "Your problem is to tie the ends of those two strings together." He soon learned that if he held either cord in his hand he could not reach the other. He was then told that he could use or do anything he wished. The experimenter then started his stop watch without the subject observing it.

When one solution was found the subject was told, "Now do it a different way." If he then attempted a modification of his first solution he was told that it really was no different. Thus he soon learned that a solution involving a different principle was desired. When the difficult or test solution was found the experiment ended. If it was not found and the subject insisted that he could find no other way of solving the problem, suggestions or "helps" were given.

After completing the experiment the subject was asked to report where he got the idea of his last solution and what was in his mind previous to the solution. After a free report, specific questions were asked. During the experiment, when the subject was inactive, he was asked of what he was thinking. When active such questions were unnecessary.

The different types of solutions to the problem were as follows:

*Solution 1.* One cord was anchored with a large object (such as a chair) placed part way between the cords, while the other cord was brought over to it.

*Solution 2.* One of the cords [was lengthened (with the extension cord, for example) and the other reached with the hand.

*Solution 3.* While holding one cord the other was pulled in with a pole.

*Solution 4.* A weight was tied to the cord hanging from the center of the room and then put in motion, thus making it a pendulum. The other cord was then brought near the center and the swinging cord caught as it approached the middle point between the two cords. Solution 4 is the one with which we are concerned in this experiment.

In case the last solution was not found and the subject was ready to give up after having conscientiously worked for at least ten minutes, suggestions or "helps" were given. (Subjects who were too prone to give up were encouraged to continue their efforts.) These hints were as follows:

*Hint 1.* The experimenter walked about the room, and, in passing the cord which hung from the center of the room, he put it in slight motion a few times. This was done without the subject knowing that a suggestion was being given. The experimenter merely walked to the window and had to pass the cord. It was noted whether or not the moving cord was in the subject's line of vision. If the subject was facing in a different direction, the action was repeated.

*Hint 2.* In case that hint 1 failed to bring about the solution within a few minutes, the subject was handed a pair of pliers and told "With the aid of this and no other object there is another way of solving the problem."

In case that hint 2 was not followed by the solution, hint 1 was repeated. If it again failed to produce the solution the subject was shown the solution.

The subjects used were graduate and under-graduate men and women students attending the University of Chicago. For the main part of this experiment, 61 subjects were used. Others used for testing certain points will be referred to when discussed.

#### RESULTS

On the basis of their success in solving the problem the subjects may be divided into the following three groups:

1. Those who solved the problem without the aid of "helps." There were 24 (39.3 per cent) subjects in this group.

2. Those who solved the problem after "helps" were given. This group contained 23 (37.7 per cent) subjects.

3. Those who failed to find solution 4 after the "helps" had been given. The remaining 14 (23 per cent) subjects were in this group.

The data obtained from the subjects in group 2 are the most enlightening. Where the subjects in group 1 got the idea of solution 4 can only be known through their introspections. Group 3 did not solve the problem and are therefore of no direct use in our analysis. In group 2, however, the function of the "helps" can be studied.

Table 1 gives the results of subjects in group 2. In the first column the numbers and sex of the subjects are indicated. In the second column, the solutions which were found by the subject before suggestions were given, are indicated in order (see page 185). The third column gives in minutes and seconds the time in which the last of these solutions was found (6:15, for example, means six minutes and fifteen seconds). The fourth, fifth, and sixth columns give the time at which the different "helps" were given. It should be noted that hint 1 was never given until ten minutes had been spent on the problem (except for subject 47) and the subject had had an unproductive period of considerable length after his last solution. In column 7 the time for the first appearance of the idea of solution 4 is given. (Any remark or behavior which indicated that the subject had the idea is regarded as the first appearance of the idea.) When the idea of swinging the cord occurred without the idea of attaching a weight, the time given is for the appearance of the idea of swinging the cord providing the subject did fasten a weight to the cord later without suggestions from the experimenter.

Column 8 gives the number of seconds which elapsed between the time that the effective "help" was given and the appearance of solution 4. It should be noted that this interval of time is usually very short (average 42 seconds).

In some cases the idea of the solution appeared complete, i.e.,

TABLE 1

*Subjects who solved problem after "helps" were given*

Column 1 gives number and sex of each subject; column 2 designates types of solutions appearing before hint 1 is given (see page 183); column 3 gives in minutes and seconds the time of the appearance of the last of these solutions; columns 4, 5, and 6 give the time at which the different "helps" were given; column 7 gives the time of the appearance of solution 4; column 8 gives the number of seconds elapsing between the time that the effective "help" was given and the appearance of solution 4; column 9 indicates whether the solution appeared as a whole (W) or in parts (P); and column 10 states whether or not the subject reported hint 1 as being a factor which aided him in finding solution 4.

1	2	3	4	5	6	7	8	9	10
SUBJECT	PRELIMI-NARY SOLUTIONS	TIME IN MINUTES AND SECONDS					NUMBER OF SECONDS FROM LAST HINT TO SOLUTION 4	HOW SOLUTION APPEARED	HINT 1 REPORTED
		Last solution	Hint 1	Hint 2	Hint 3	Solu-tion 4			
5 M.	1, 3, 2	6:00	13:00			13:35	35	W	No
8 M.	1, 2	2:45	13:30			14:10	40	W	No
10 M.	1, 3	4:30	10:00			10:45	45	W	No
14 F.	1, 3	3:30	10:00			11:00	60	P	Yes
18 M.	2, 1, 3	8:30	12:40			13:10	30	W	No
19 F.	3, 1	7:40	11:30			12:00	30	W	No
25 F.	1, 2, 3	9:25	16:00			18:00	120	P	Yes
30 F.	1, 2	5:00	10:30	13:30	19:00	19:40	40	W	No
31 M.	1, 3, 2	6:30	11:30			12:00	30	W	No
32 F.	1, 2, 3	13:40	15:00	17:20		18:00	40	W	No
35 M.	1, 3	5:30	10:10	12:50	14:00	14:30	30	P	Yes
38 M.	1, 2	4:00	10:00			10:20	20	W	Yes
40 F.	3, 1	5:05	10:30			10:50	20	P	No
42 F.	2, 1	4:50	10:15			10:30	15	W	No
43 F.	1, 2	5:40	10:30			13:00	150	P	Yes
44 F.	1, 2, 3	8:00	15:00			15:15	15	P	Yes
45 M.	1, 3, 2	5:30	12:50			13:50	60	W	No
47 F.	1	3:45	9:15			9:40	25	W	No
48 M.	1, 3, 2	5:00	10:00	16:15	18:10	18:30	20	W	No
51 M.	1, 3	5:00	11:00			11:25	25	W	No
54 F.	1, 2	6:10	11:10			12:00	50	P	Yes
59 F.	1, 2, 3	8:20	14:45			15:10	25	W	No
60 F.	1, 3	6:30	12:00			12:40	40	W	No
Average.....		6:07	11:47				42		
A.D.....		1:42	1:37				20.3		

the idea of the pendulum occurred to the subject. In other cases the idea of swinging the cord and the idea of attaching a weight appeared separately. Such subjects would throw things at the cord; say they wished the wind would blow harder; or speak of some magnetic force which might draw in the cord. A little later the utilization of a weight would occur to them. In column 9, W means that the idea of solution 4 appeared as a whole and P means that it appeared in parts. (This classification was made on the basis of the subjects' behavior and verified by their introspections.)

In column 10, "yes" means that the subject referred to hint 1 as aiding him in finding the solution. "No," means that hint 1 was not referred to in the free report of the subject and further questioning did not reveal that it played a part in bringing about the solution.

Inspection of the table shows that in the case of 16 subjects the solution appeared as a whole, whereas in 7 cases it appeared in parts. If we now examine the 16 subjects we find that only one of them (no. 38) reported that hint 1 aided in bringing about the solution. He stated that he noticed the cord sway and thought that perhaps it suggested the solution. He was sure that the pendulum idea was not a conscious development of the swaying, but rather that his attention had been attracted to it.

The other 15 subjects did not mention the swaying of the cord. When specifically asked whether or not they had seen it, 11 of them said that the experimenter was in the vicinity of the cord and that he perhaps did move it, but they paid no attention to him. They insisted that if the suggestion aided them, they were certainly unconscious of it. It seemed to them that hint 1 ought to be a good suggestion, but that they were unaware of it at the time. The other four insisted that their solution did not depend on the swaying of the cord. They said they did not even see the swaying.

Of the seven subjects to which the solution appeared in parts, 6 (subjects 14, 25, 35, 43, 44 and 54) reported that the swaying of the cord made them think of making it swing harder or made them wish it would swing to them. The other subject (no. 40) said she had the idea of swinging the cord from the beginning. If such is the case hint 1 could not have suggested the idea to her.

Thus we find two distinct types of experiences among the subjects in group 2. (a) Those who experienced the solution as a whole and (b) those who experienced it in two steps. When the experience was of the first type the swaying of the cord was not reported as having been an aid, except in 1 case; when it was of the second type the swaying was reported in all but 1 case. There is thus only one exception to each of these generalizations and when the exceptions are studied they are not at all in opposition to the generalization.

It is of interest to note that subjects who experienced the solution as a whole failed to report that hint 1 aided them in finding the solution. Three explanations as to why they did not report it are possible. They are as follows:

1. Hint 1 in reality did not help these subjects to find the solution. The additional time is all that was needed.

2. The subjects for some reason or other did not wish to admit that hint 1 assisted them.

3. Hint 1 was not experienced because the sudden experience of the solution dominated consciousness.

In order to test the first possible explanation these subjects are compared with 55 other subjects who were given as much time to solve the problem as they desired. At least thirty minutes of effort was requested before they were permitted to give up. It was found that 80 per cent of those solving the problem (solution 4) solved it within the first ten minutes. Only 20 per cent required more than ten minutes. As hint 1 was given after at least ten minutes had been spent on the problem and as 49 per cent of those solving the problem solved after hint 1 was given, the effectiveness of hint 1 can hardly be doubted. In fact, we should expect *less* than 20 per cent late solutions if hint 1 is ineffective, because subjects in groups 1 and 2 were often given more than ten minutes before the presentation of hint 1 when they had not shown signs of being unproductive.

A further reason for believing that hint 1 was effective is that the solution was found in an average of forty-two seconds after hint 1 was given. (In 78 per cent of the cases less than 42 seconds elapsed.)

The second possibility is unlikely for the following reasons:

1. Two "helps" were tested in order to determine which was the more likely to aid in producing solution 4. The one was that of putting the cord in motion, and was given casually as before. The other consisted of twirling a weight tied to the end of a cord, and the subject's attention was specifically called to it as a possible help. From limited data the first of these "helps" was found to be far more efficient than the second even though it was not known to be a suggestion and the second was called a suggestion. When, however, both "helps" were given to a small group of subjects (none of which knew suggestions were being given), three of them solved after the helps were given, all three said the "twirling" helped them. None however mentioned the swaying of the cord. The twirling of the weight preceded the swaying of the cord by several minutes, but the solution appeared only after the cord was swayed. Thus the subjects gave the wrong "help" credit for the aid they received.

2. In the 4 cases in which hint 2 was given (table 1) *it* was referred to in 3 cases.

3. Subjects who got the solution in two parts did not fail to refer to hint 1 as an aid.

The third possibility, i.e., that hint 1 played an important part in bringing about the solution, yet was not consciously experienced when the solution appeared as a whole, seems to be the most plausible explanation. Positive evidence in its favor will be found when the remaining results are presented.

On examining the reports of subjects in group 1 little is found which is of aid in explaining the development of the pendulum solution. Nearly all subjects were surprised when asked to tell about their experience of getting the idea of a pendulum and said that they did not think they could explain it. Then they made such statements as: "It just dawned on me"; "It was the only thing left"; "I just realized the cord would swing if I fastened a weight to it"; "Perhaps a course in physics suggested it to me"; "I tried to think of a way to get the cord over here and the only way was to make it swing over." A professor of Psychology reported as follows: "Having exhausted everything else the next



thing was to swing it. I thought of the situation of swinging across a river. I had imagery of monkeys swinging from trees. This imagery appeared simultaneously with the solution. The idea appeared complete."

The reports of subjects in group 1 are in every respect similar to those in group 2 who did not refer to hint 1. On the whole the reports show that the solution appeared suddenly and no development could be noted. The solution was often compared with other situations, but it was never known whether the similarity was seen after the solution to the problem had occurred or whether the recalled situation aided them in solving the problem.

The reports tend to favor a "trial and error" explanation of reasoning in that the subjects tell about thinking of one thing and trying it out, then thinking of something else and realizing that it would not work, etc. The pendulum solution was just another thing recalled.

Subjects in group 3 and those of group 2 who received hint 2 (pliers given to subject) reported that when they were told the problem could be solved with a pair of pliers, they immediately thought of using them as tongs and wished for nice long ones. Only one subject thought of using them as a weight. Three subjects, however, thought of using them as a weight when hint 1 was repeated.

Reports during and after the experiment showed that there was a great tendency to think of variations of previous solutions. For example, subjects could not rid themselves of the idea of anchoring one or the other of the cords and would apply it in different ways just to be doing something. This tendency was most marked in subjects who had great difficulty with the problem.

When the solution was shown to the subjects who failed, they immediately saw what hint 1 and hint 2 should have done for them, but could not understand why they had not seen it before. They insisted that they were not as stupid as their demonstration would seem to indicate.

## SUMMARY OF RESULTS

Sixty-one subjects were tested in a simple problem which required considerable originality. By controlling suggestions it was not necessary to rely entirely on the subjects' reports.

The results may be briefly summarized as follows:

1. Usually the solution appeared suddenly and as a complete idea.

2. There was a marked tendency to repeat variations of previous solutions.

3. When suggestions of "helps" were necessary, the very "help" which brought about the solution was not consciously experienced except in cases in which the solution appeared in steps.

4. The subjects' reports seemed to satisfy a "trial and error" theory, but the following discussion will point out that the objective results cannot be interpreted in this manner.

## DISCUSSION OF RESULTS

Previously it was found (5) that the manner in which one tried to solve a problem (the reasoner's "direction") was dependent on what one saw the difficulty to be. In the problem used in the present experiment the difficulty may be seen to be any one of the following four:

1. How to make one cord stay in the center while the other cord is reached. Solution 1 overcomes this difficulty.

2. What to do to make the cords long enough to bridge the gap. Solution 2 answers the purpose in this case.

3. What can be done to extend the reach. In this case solution 3 applies.

4. As the one cord cannot be reached while holding the other, one cord must in some way be made to move toward the other. In this case solution 4 is the possibility.

In the first three solutions activity on the part of the subject is necessary—he must use some sort of tool, but in the fourth, something must be put in operation,—a principle of a machine must be used. Making the cord do something is unusual, yet it is this type of principle that is involved in most creative work.

Another difficulty in the pendulum solution is that the cord must be transformed into something else. It must be seen as a pendulum rather than as a cord hanging from the ceiling. This change in meaning is a decided source of difficulty. (See Wertheimer's study (7).)

Making the cord sway (hint 1) is a helpful suggestion because a swaying cord is more nearly a pendulum than a stationary one. Hence the transformation from cord to pendulum is partly made by hint 1. Presenting the subject with pliers is of no benefit so long as the pliers are seen as pliers. They become useful, however, when they are seen as a weight. (The fact that the subjects did tend to see the pliers as pliers was shown from the subjects' behavior and introspections.) The swaying cord plus an object which might be seen as a weight can, however, more easily become a pendulum than a swaying cord without such a selected object. The "helps" are thus added elements which make the pendulum organization more readily experienced, just as additional points represent the organization of a circle more readily than three points.

That reasoning is characterized by such changes in organization and meaning as we have found is typical of the Gestalt view (3). Changes in meaning and in organization are experienced suddenly. This characteristic was well brought out by the problem used in the present study.<sup>3</sup>

When we picture the solution of a problem as the sudden combination and organization of elements, it is not at all surprising to find that the very thing which sets off this combination is unexperienced. Before the solution is found there is inharmony. The reasoner cannot quite see the relation of certain things in the room to the solution of the problem. The next experience is that of having an idea. The "transformation" or "organization" stage is not experienced in reasoning any more than in reversible perspective. The new organization is suddenly there. It is the dominant experience and covers any factor which just preceded it.

<sup>3</sup> The problem used in this study was well adapted to our purposes because (a) the solution involved but one transformation of meanings rather than a series of them, and (b) physical activity on the part of the subject was necessary and so it was possible to observe directly what the subject was trying to do.

If, however, the solution comes in two steps, as was true for part of the subjects, the case is somewhat different. The results showed that in such cases the suggestion (hint 1) was exaggerated, i.e., subjects conceived the idea of making the cord sway harder. The change from a slight sway of the cord to a violent sway involves no great change in meaning and the idea is in no way complete. True, it has become more nearly a pendulum, but only when the cord swings by itself, and not because of a breeze for example, is it the solution. Because this "swinging" stage of the solution is tried out for a short period before the application of a weight is seen it is experienced. Enough of this stage is present before the solution is found so as to receive attention and is thus not imbedded in it or covered by it, as in the cases when the solution is experienced as a whole. The transition stage has thus bridged the gap between the experience of the cord hanging from ceiling and the "pendulum" idea.

From the above it then seems that arm-chair speculation or experimentation which relies entirely on introspective data can never give a complete picture of the reasoning process. (The conclusions of the Wurtzburg School and the studies of Selz (6) and Lindworsky (4) can be questioned because the introspective data played the fundamental rôle in the formulation of their conclusions.) When a solution appears suddenly and completely the very factor which sets it off may be lost to consciousness. Just what factors set off a new organization cannot be known except by means of an objective measure. In the problem used in this study the cord was often swayed by the subjects themselves. Just how often such accidental movements of the cord gave rise to the solution cannot be stated. It is very likely that they often did. This being the case, we can see the very important rôle which chance plays in problem solving. Yet viewed in this way it is "trial and error" of quite a different nature. The chance swaying must organize other elements to form the pendulum. This ability to form new organizations depends on the individual. Köhler's ape (2) which put two sticks together by accident and then used them as a long stick with which to reach the food (p. 132) is a good example of chance solutions of this sort.

Because introspective reports are in harmony with a mental

“trial and error” theory the source of these theories is explained, but reasoning remains unexplained. The reports of the subjects in this experiment throw no light on the nature of reasoning. The objective data, though not in harmony with the reports on certain essential points do, however, throw light on the nature of reasoning. That the data from controlled experimentation should be accepted in preference to subjective reports can hardly be questioned.

Further, mental “trial and error” can hardly be regarded as an explanation. What must be explained is how and why certain ideas appear in consciousness. After the idea is conscious the fundamental process is over. Association (in the usual sense) can explain why some ideas are recalled, but it cannot explain the appearance of other ideas, e.g., original ideas. A problem which is similar to one that was solved in the past may call up a solution by similarity. If it works the explanation is satisfactory. If it does not work, however, such a memory becomes an obstruction. The writer (5), has shown how such past experiences give rise to interfering habits.

A problem which is different from one solved in the past, but which has the same principle involved in the solution, cannot have its solution explained by similarity because there is no similarity until both solutions are known. When the solutions of such problems are explained by the principle of similarity the explanation seems to be nothing other than rationalization. Dunker (1) found no transfer from problem to problem when the solutions were similar and the problems dissimilar.

#### CONCLUSION

The perception of the solution of a problem is like the perceiving of a hidden figure in a puzzle-picture. In both cases (*a*) the perception is sudden; (*b*) there is no conscious intermediate stage; and (*c*) the relationships of the elements in the final perceptions are different from those which preceded, i.e., changes in meaning are involved.

In case hint 1 (swaying of the cord) and hint 2 (suggestion to use pliers to solve the problem) have been given, the conscious stages

before and after finding the solution to the present problem may be diagrammed as in figure 1.

Before the solution is found the pliers are made up of qualities 1, 2, and 3; the cord of qualities 4, 5, 6, 7, and 8; and hint 1 of qualities 9 and 10. When the solution is found qualities 3, 7, 8, and 10 have been combined and integrated, and have formed a pendulum. The "Pendulum" organization appears complete and the cue which sets it off is not consciously experienced.

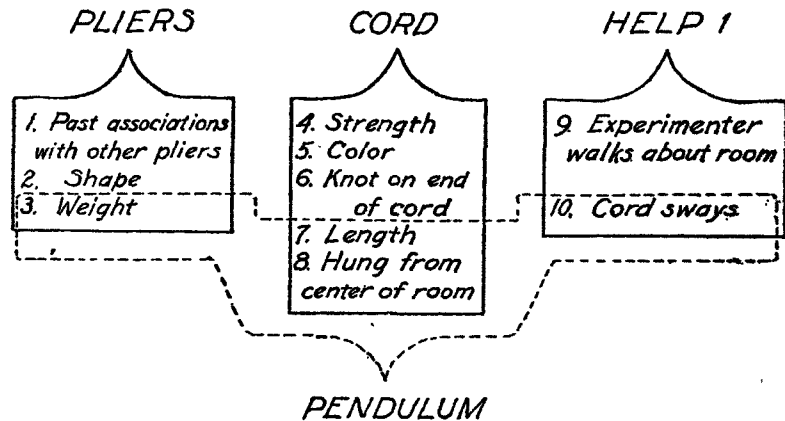


FIG. 1

"Trial and error" or association by similarity cannot explain this type of organization. In the previous study already referred to "direction" was found to be a determining factor in the organization of the elements (parts of past experiences) which constitute the solution.

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