REASONING IN HUMANS[1]

I. ON DIRECTION

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I. INTRODUCTION

Experience has played a very fundamental rôle in all theories of reasoning with perhaps the exception of the Gestalt theory. If one has had the necessary experiences and can recall them, then reasoning seems to follow naturally.

Theories which make mental "trial and error" the basis of reasoning recognize a selective factor in the trials and errors. Only such things as have some connection with the problem are tried out mentally. Thus a problem calls up past experiences which are tried out in the mind until some combination is found to work. The main point in such theories is to explain why only the more pertinent things are tried out. That the right experiences, if called up at all, will make for the solution, is taken for granted.

Abstraction theories also regard experience as most fundamental. Certain experiences are called up by similarity and after a time the common element "rolls out." Why it should roll out is in these theories a pertinent question. It may roll out because it is a common element and the sagacious individual sees it (James). This would be recognition of likenesses and would depend on frequency. Others regard the recognition of differences as just as important (Shepard).

The Gestalt theory says nothing of experience. Of course it recognizes that experience gives us the data to work with, but the experience is not the fundamental characteristic of reasoning.

[1] This is the first of a series of studies on Human Reasoning.

It is the data that one can take for granted. The fundamental characteristic is the process of the formation of new 'gestalten.' 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, i.e., the solution, is the process of reasoning. How and why it comes is not explained. It is like in perception: certain elements which one minute are one unity suddenly become an altogether different unity (Wertheimer). This can easily be demonstrated in the interchangeability of figure and ground. (See Koffka's review (4).)

Thus the part experience plays in reasoning is not agreed upon. Either specific experiences must be recalled or a general background of experience is taken for granted. Whether or not experience is conditioned, and if so, under what conditions it plays its part in the reasoning process, seems to have been neglected. The problem in this study is to find whether or not experience, if recalled, is the sufficient fundamental factor in problem solving, and if not, to discover, if possible, what the conditions are under which experience can best function.

II. PROCEDURE

If the experience as a whole is previously given to the reasoner then, naturally, reasoning is not necessary. The application of an old experience must be new for the individual. If this were not the case, then learning and habitual responses would be no different from reasoning. (In fact most of our so-called reasoning problems are nothing more than the selection of one out of several memories.) To test the influence of experience in the solution of a new problem, without unnecessarily hiding it in complex patterns, the solution of a problem was presented to the subjects in three separate parts. All the subject had to do, in order to solve the problem, was to recombine the parts in the right manner and thus obtain a unity which was the solution. Thus if the solution of the problem was ABC, the experience given was A, B, and C. In this manner all the experience necessary for the solution was given to the subject and did not have to be recalled by him.

Problem ABC was a construction problem. As part of the experiments were carried on at the Psychological Institute of the University of Berlin and part at the Psychological Laboratory of the University of Michigan, it was impossible to duplicate exactly all of the conditions. The differences in the conditions were, however, not such as to be a determining factor in the correct solution. Only the false solutions were affected.

At the University of Berlin the room in which the construction was to take place (fig. 1a) was 6.5 m. by 5.6 m. and was 2 meters

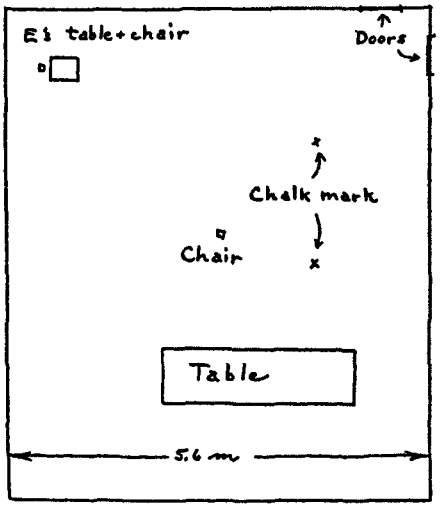

FIG. 1 A

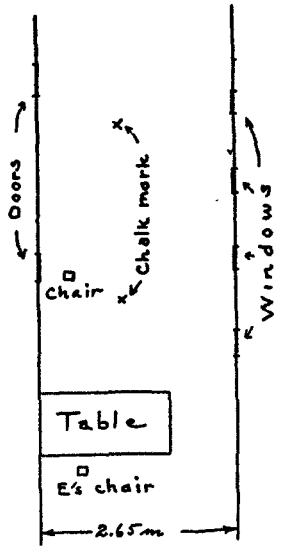

FIG. 1 B

high. It contained a large table which was not to be moved by the subject, 2 poles 1.9 meters long and 2 cm. square in cross-section, 2 other poles each about 1 meter long, 1 table clamp, 2 burette clamps, 2 pieces of electric bell wire about 2.3 meters long, 8 pieces of lead tubing 1 cm. in diameter and from 5 to 15 cm. long, and several pieces of chalk. The material was scattered about the table. There was a chair for the subject. The experimenter sat at a table in the far corner of the room.

At the University of Michigan a hallway on the fourth floor of the building was the only part of the building which had a low

ceiling and for this reason proved to be the most satisfactory place to continue the experiments. It was 2.52 meters high and 2.65 meters wide (fig. 1b). A table was placed across the width of one end of the hall, the poles were 2.4, 1.4, 1.2, and 1.0 meters in length, and in place of the lead tubing, several iron bolts were used. Otherwise everything was as above.

The subject when taken into the room was informed that he or she would be asked to do some building, that there were several ways of making the construction, but that we were interested in how different people went about it. There would be the difficulty of not always having all the material that might be desired, but that made it all the more interesting. A good, firm construction would, of course, be the best. This was not a "catch" problem, there was to be no time limit. We were only interested in the qualitative side.

The problem was then stated (and elaborated so far as was necessary, until it was perfectly clear to the subject), as follows: "Your problem is to construct two pendulums, one of which will swing over this point (cross indicated on the floor, see figure 2) and one which will swing over this other point (other cross indicated). These pendulums should be so constructed that they will have a piece of chalk fastened to them which will make a mark (which can be seen) on the points on the floor just indicated. Naturally you must have something to hang the pendulums to. That is for you to worry about. Don't try to move the table about. Otherwise do anything you want to. This material is at your disposal. That chair however, is not to be part of your construction; you may use it for a work bench or a place for meditation, or anything you wish so long as it is free when you are through. Ask any questions you wish. I'll be glad to assist you in building, only you must tell me what to do." These specifications were repeated and explained until everything was perfectly clear to the subject.

The three parts which were given as separate experiences were given under different conditions for the different groups used. These conditions will be described later. The separate parts may be called A, B, and C.

Part A. "In making a plumb line (a plumb line was explained if unfamiliar to the subject) one can, if he has not the desired material, combine this clamp (demonstrated with a burette clamp) with a pointed object such as a pencil and so have something which is both heavy and pointed at the same time and so will have the qualities of a plumb bob. Then we can fasten a cord or this wire to the thing and have a plumb line. This is to show you how it is possible to combine certain objects and so get the qualities we desire."

Part B. "If you were confined in a cage and wanted to reach a banana which was farther away than the longest of these poles what would you do? Most likely you would do what Koehler's apes did, combine two poles and make a longer one. This you can do very easily with the use of this table clamp. (This was demonstrated.) Thus you see how nicely we can make one long pole out of two short ones."

Part C. Now I will show you a way to do without hammer and nails. If, for instance, you wanted to make a lantern screen, you naturally would like to have nails with which to fasten the screen to the wall. If there are none to be had you could take these two poles, place one flat against the wall of the doorway, like this, and so keep your white cloth taut up and down, then place this stick at right angles to it and wedge it in the door way. (This was demonstrated by placing one of the sticks against the side of the doorway and wedging the other against the center of the first and the opposite wall of the doorway. Thus a "T" in a horizontal position was formed.) In the same way you could fasten the other side of the screen and so keep the cloth taut side ways. Thus we could do it without hammer and nails, do you see?"

In some cases the subject was also given the following experience which will be called "direction."

Direction: "I should like to have you appreciate how simple this problem would be if we could just hang the pendulums from a nail in the ceiling. Of course, that it is not a possible solution but I just want you to appreciate how simple the problem would be if that were possible. Now that it is not possible the

problem is, as you may find, really quite difficult." This was demonstrated by holding one of the wires against the ceiling. At the University of Michigan laboratory it was necessary to stand on a chair to do this.

The subjects used were advanced students at the University of Berlin, most of them working for a doctorate in Psychology, Physics, or Chemistry (several already had their degree) and students in an advanced course in experimental Psychology at the University of Michigan. The subjects were made to feel at ease and most of them enjoyed the problem. The German students were all volunteers. The observer joked with them, wrote as little as possible, and tried not to appear as if testing the subject's intelligence. The subjects entered into the spirit of the problem very quickly and many insisted, afterward, that they had entirely forgotten the presence of the observer, having been so engrossed in the problem. This attitude is more successfully obtained in problems in which the subject has things to manipulate than in problems that are solved with pencil and paper.

The subjects were divided into the following five groups each group being given the problem the solution of which was ABC:

Group 1. The problem only was given. (Control group.)

Group 2. Parts A, B, and C were given, but the subject was told that these preliminary problems were given in order to get him acquainted with the situation and the material. They were given as separate experiences and he was asked to judge whether or not he found them clever or neat ways of doing things. He was also told that he would be given a problem to solve and when he had finished would be asked to judge his own solution in the same manner. (After A, B, and C had been demonstrated the problem was given.)

Group 3. Each member of this group was told, "I'm going to give you a problem to solve. You will have to construct something. (Problem was then given.) Before you start on the solution I should like to show you three separate things each of which will involve a principle. If you combine the ideas, which I thus give you, in the right manner, you will have the best solu-

tion to the problem. Try to use them; they are the solution in three separate parts. You do not have to use them, but only by using them will you get the most satisfactory solution. So try to use them."

Group 4. Following a statement of the problem the "direction" (described above) was given.

Group 5. Same as group 3 except that the "direction" was also included.

In every case the subject was given to understand that the problem or any of the instructions would be repeated if he was in doubt or had forgotten something. At the University of Berlin group 4 was omitted, at the University of Michigan groups 1 and 2 were omitted.

Into which group a subject was to be placed was determined before the subject made his or her appearance. In case the subject was known and was considered intelligent he or she was not placed in group 5. Group 5 was, therefore, not a group superior in intelligence.

Each experiment was individual. Some subjects worked as long as three hours, those who got the solution worked five or ten minutes. If the subjects did not solve the problem after one and a half hours or if completely out of ideas before then, other variations were introduced and new suggestions given. This will be indicated if such results are discussed.

III. RESULTS

The solution was very seldom obtained unless many additional suggestions were given. These varied from individual to individual and therefore are difficult to tabulate. Only when the solution was found without additional suggestions will the subject be credited with success. The type of solutions that were attempted will also be given in table form.

The attempts at solutions were of the following types:

1. An attempt was made to use the ceiling in the solution. Two pieces of wood would be clamped together and wedged between the floor and ceiling. This required two pairs of sticks

in order to have the two pendulums in their proper positions. For this there was a shortage of material.

2. Poles would be clamped or tied together with one of the pieces of wire, and thus wedged between the walls of the room. In the Berlin laboratory the room was wide and required three poles. This combination could be made to pass over the two points indicated for the pendulums, but would never stay in place. At the University of Michigan laboratory the poles could only be clamped across the hallway and therefore two separate pairs of poles were necessary. Only one pair would, however, reach across the hall.

3. The table was often used as part of the structure. One of the poles was just long enough to span the distance between the points over which the pendulums were to hang. If this pole was clamped to the table it was not long enough to reach, because the table could not be moved. This necessitated clamping a piece to the longer pole, a procedure which made the poles too heavy to be firm, as well as used up an extra clamp.

4. The German subjects also attempted to wedge poles between the table and the opposite wall. The poles would never stay in place.

5. Building up from the floor was also a common attempt at the solution. A leg, a tripod, or sticks crossed to form an "X" were used to support the longer pole, in a horizontal position, from which pole the pendulums were expected to be hung. These attempts were unsuccessful because they either necessitated more material than was available or else were so poorly constructed as to fall over. Making them just balance was often attempted, but such a structure would not support pendulums.

6. The solution consisted in placing the longer pole (which spanned the distance between the two points) flat against the ceiling and then holding it in place by clamping two of the other poles together in such a manner that they were just long enough to reach the floor when one end was placed against the middle of the pole which was flat against the ceiling. Thus the pole was wedged against the ceiling and the poles formed a large "T." The pendulums could then be hung from either end of the pole

placed against the ceiling. A piece of chalk was then fastened in each burette clamp which formed the pendulum weight. The pendulum was made just long enough to allow the chalk to touch the floor. The structure was very simple and stable and

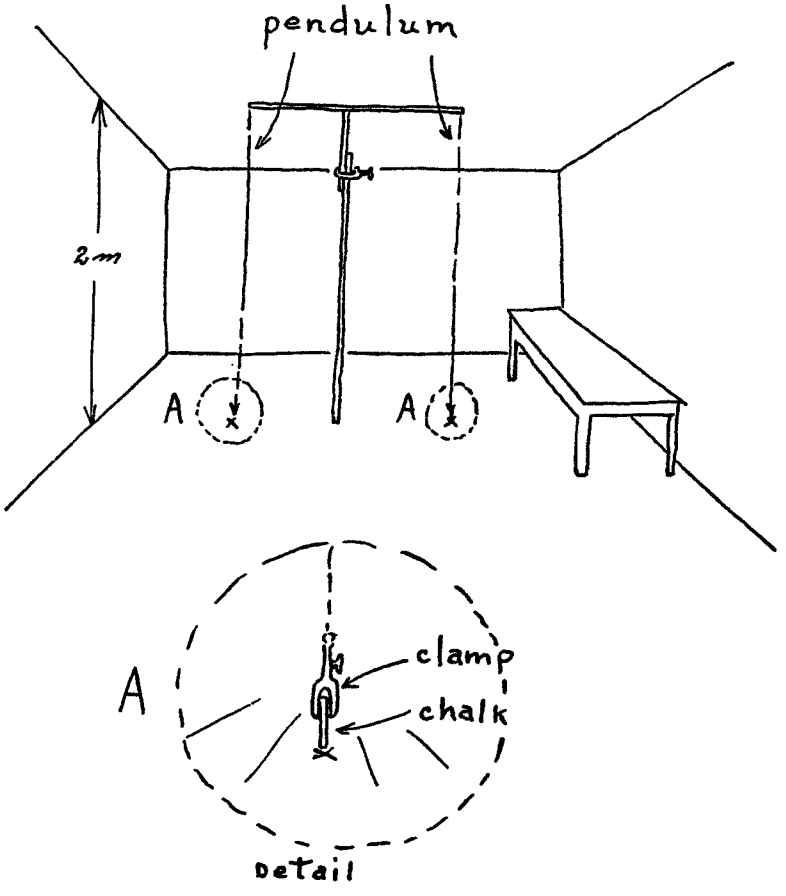

FIG. 2

required even one pole less than was given. All the subjects were surprised and pleased with the solution, whether it was shown to them or whether they found it themselves. Many were astounded at their "dumbness," and said they could not explain

why then hadn't done it themselves. (See figure 2 for diagram of solution.)

These types of solutions are indicated in table 1. Often many different things were tried out that obviously would not work, but finally one variation of the above solutions would dominate the attention and would be rebuilt and revised for hours. The subject was always permitted to try until apparently altogether out of ideas or ready to give up.

TABLE 1

	NUMBER OF SUBJECTS	NUMBER USING SOLUTION 1	NUMBER USING SOLUTION 2	NUMBER USING SOLUTION 3	NUMBER USING SOLUTION 4	NUMBER USING SOLUTION 5	CORRECT SOLUTION
University of Berlin:							
Group 1 (no parts)	15 (5)*	1	0	8	3	3	0
Group 2 (parts A, B, C)	9 (2)	0	0	6	0	3	0
Group 3 (use A, B, C)	18 (7)	0	3	3	6	5	1
Group 5 (A, B, C and direction)	10 (3)	3	0	0	0	3	4
University of Michigan:							
Group 3	10 (3)	1	4	3	0	2	0
Group 4 (direction only)	10 (2)	0	1	7	0	2	0
Group 5	12 (6)	1	4	2	0	1	4

* Number in parentheses indicates the number of women in the group. In group 5 there were about 40 per cent women and in all of the other groups together only 30 per cent were women. Thus group 5 was not favored as far as the manipulation of and experience with tools is concerned.

No difference between men and women as to resourcefulness was found. Many of the cleverest solutions came from women and many men were as unhandy as it was possible to be. The types of excuses, however, differed. The men said that they could do it if they had the proper material, the women said that they were inexperienced with carpenter work.

Table 1 shows the results for the different groups both for those at the Psychological Institute of the University of Berlin and for those at the Psychological Laboratory of the University of Michigan. Only the general type of solution which was concentrated upon is indicated.

Thus it is clear that only when parts and "direction" are given is the solution at all likely to appear. Only one out of 62 subjects in the first four groups found the solution, but 8 of the 22 subjects in group 5 were successful. It should also be noted that 4 of 14 remaining subjects in group 5 tried to use the ceiling and so were near the solution, and that only 2 of the 61 remaining subjects in the other four groups tried to do this.

Using the burette clamps to hold the chalk and at the same time make it heavy enough to write also seemed to cause certain difficulties. Many discovered that weight must be added to the chalk if it was to mark on the smooth floor. The small pieces

TABLE 2

	NUMBER OF SUBJECTS	USED A CLAMP FOR CHALK	USED LEAD FOR CHALK	NO WEIGHT USED; CHALK TIED DIRECT
Group 1	15	6 (3 used lead first)	5	4
Group 2	9	3 (1 used lead first)	4	2
Group 3	18	10 (3 used lead first)	4	2*
Group 5	10	8 (3 used lead first)	0	2

* These subjects knew that the burette clamps had to be used some way with the chalk, and were determined to use them. One of them used lead to weight the chalk, then fastened the wire to the very unsuccessful structure which had been built, with the clamp. The other used the lead for weight and fastened it to the chalk with the clamp. This obviously would not work.

of lead tubing suggested a weight and these were often used after trying to get the chalk to mark without the weight. Data on this point were only taken in Germany See table 2.

Thus part A was used quite extensively even when "direction" was not given. Part A was less nearly a perfect element in the solution than were parts B and C. A plumb line may be regarded as very different in function from pendulums. Part A is, therefore, not exactly the same A as the element A in the solution. On the basis of the "identical elements" theory it should be less successfully transferred than either B or C. Yet it was used most successfully. It might also be added that parts B and C fit together to make a single structure to which A is then added.

A does not lose its identity in the total structure in the same way that B and C do. The solution could perhaps be described as BC + A. However, if the solution is broken into its elements, B and C of the solution, are very much the same as parts B and C respectively.

Part A was not as successfully used by groups 1 and 2 as by group 3. This may have been due to the fact that the clamps had already been used for some other purpose by the time the need for the pendulum became apparent. In group 3 the parts were to be used and if the application of A was recognized the clamps were set aside for it.

The "direction" was given to 8 of the 10 University of Michigan students in group 3 after they had failed in solving the problem. (Group 3 had been given parts A, B, and C with the instructions to use them.) Almost immediately 2 of the subjects (7 and 11)[2] had the solution; 2 others (10 and 12)[3] returned to one of their old ideas, but got the solution when the "direction" was repeated a little later. The remaining 4 subjects seemed to receive no benefit from the "direction."

In order that the reader may better understand the way in which the subjects attempted to solve the problem, and how, in the case of failure, suggestions were continually given until the solution was obtained, the proceedings in two typical cases are given in detail.

Subject 14 in group 3 at University of Michigan

Begins to work after having been given A, B, and C.

Measures across room.

Measures from table to chalk marks on floor. Says, "I don't see where what you did in the doorway comes in" (referring to part B). Clamps the longest and shortest poles together and wedges them between the walls. Tries to figure out how the same can be done at a different point, but every thing tried needs more wood than is to be had. Takes poles apart again.

[2] Subject 7 had previously concentrated on solution 3 and subject 11 on solution 2 and to some extent on solution 5.

[3] Both subjects 10 and 12 had previously concentrated on solution 2.

Tries to use the table; rests one end of long pole on edge of table and holds other end. Stands thus and thinks. Makes feeble attempt at using walls again. Says she can't see how it can be done with what she has. (She is told that it can be done.)

Tries to find some way of using hall door (which is about half way between the chalk marks). Measures between walls again, trying to find a narrower place or some projection from the walls.

Measured distance to ceiling and suggested clamping two poles together and wedging them between floor and ceiling. "If this could be done in two places a wire could be stretched across the two and the pendulums hung from it." Sees that she has not material for this. Tries walls and table again. Loses interest.

At the end of one hour direction was given.

This made no difference in her procedure. She listened and admitted that she appreciated how simple that would make the problem.

She was then told that she already had done two things, which if put together, would lead to the solution. She wondered which things were referred to and asked if this or that was correct.

She was then told to use part C, that a pole must rest against the ceiling, that her idea of wedging poles between floor and ceiling was correct, and that it was necessary to know how to hold a stick in place without nails.

This gave her no idea. After a while she tried to hold a pole to the ceiling by running braces from the wall, which, of course would not stay in place any more than the pole at the ceiling.

She was then asked to recall how we got along without nails before. This only confused her (apparently).

The pole was then held to the ceiling by the operator who held it with his finger against the center of the pole.

She showed no signs of having thought of the solution.

The operator then said, "See, it stays there now."

She stood looking an instant, then quickly placed a pole so as to take the place of the operator's finger. She then lengthened the pole so as to reach the floor.

Correct solution.

Subject 26 in group 4 at University of Michigan

He begins measuring across walls trying different combinations of poles.

Sets tripod, made from poles, in middle of floor and holds them.

Tries walls again. Clamps two shorter pieces together and tries to fill in the few inches, they are too short, by wedging in a short bolt. This is soon given up. The combined poles are turned about end for end. He has to avoid hitting the ceiling because this same combination of poles more than reaches between the ceiling and the floor. This, however, gives him no idea. Tries using bolt with poles between walls again and after some time gets the poles to just stay in place.

He then said that he ought to have a clamp so that he could do the same over the other chalk mark. When asked about the burette clamps, he said that he was saving them for the pendulum.

Tries to figure out how to tie the poles together and still have wire for the pendulum. Tries different schemes. Finally says he doesn't believe he can do it.

After a while he sets all poles side by side, on the floor, in order to compare their different lengths. Then different combinations across the room are again tried out.

Next he tries making a pair of poles stand in the middle of the floor by leaning them against each other. He then varies this by supporting their bases against the walls.

After this possibility was exhausted direction was given.

He returned to what he had done just before, but instead of leaning two poles against each other, with their bases against the walls, he places an extra one at one end.

After a little while he again tried clamping between walls as in the beginning.

He was then told, "You'd like to drive a nail in the ceiling, well you've been shown how it is possible to get on without nails."

Thinks a while and tries to see how this can be applied to walls.

Then he was told, "You've had the wrong idea so far, get rid of that one idea and its variations; it will not give a satisfactory solution."

He then set a short pole on the floor and placed the long pole horizontally over the top. Next he tried placing the same long pole on a tripod, which he held together, in the center.

The operator then told him that his idea of using the walls would have been a good one if the ceiling and the floor had been the walls. Also that the three parts given in the beginning would have to be used more exactly.

He then tried placing a short piece cornerwise against the wall and ceiling and then placing a long pole under this cross piece to hold it in place. He tried many variations of this.

Then he tried to make the long pole stand by placing a bolt on one end to make it reach the ceiling, but the two together were too short. He returned to trying the cross piece again.

He was then told to get along without using the walls.

Clamps long and short pole together and wedges between floor and ceiling. Can't figure out how he can have a support for second pendulum.

Told to use the three parts more exactly.

Leans long pole against wall, holds onto it and thinks.

Told that the long pole must be horizontal and the pendulums hung from it.

No response, stands and thinks.

Operator asks for a description of part C. Subject describes and operator asks S to use it. S says he needs walls. O says that he told him to use floor and ceiling for walls. Subject says, "That gives me an idea." Then he proceeds with the solution.

Both of these subjects were good students, the first having a low B average, the second was an A student in most of his subjects.

Thus it seems that "direction," if given after the subject has already had ideas about the solution, is less likely to be beneficial than if it is given in the beginning. That experience without "direction" is not sufficient, can hardly be doubted. Nor can it be said that direction alone is sufficient. Experience is important, but only under certain conditions.

In a second problem the importance of "direction" was brought out in a slightly different manner. This problem was tested at the University of Berlin and 13 subjects were used individually.

The problem was to make a stick, 1.8 meters long, stand vertically in the center of the room. It was necessary that it stand quite firmly and not fall over with the least jar.

The material consisted of 3 poles 2 cm. square in cross-section and 1.8, 1.2, and .6 meters long respectively, 1 table-clamp, and 2 blocks, each 15 cm. on a side. The ceiling of the room was 2 meters high.

The solution was very simple if two of the poles were clamped together and wedged between the floor and the ceiling.

Most of the subjects, however, tried to either make a tripod, using the long pole as one of the members, or else tried to fasten

legs, of some sort, to the longer pole. Both of these types of attempts were unsuccessful because there was only the one clamp. A few subjects tried to put the blocks under the longest pole and so make it reach the ceiling, and thus be held firmly in place. The dimensions of the pole and the blocks were, however, not such as to make this possible. These subjects were thinking along the right line, i.e., they had the correct "direction." Those trying to fasten legs to the pole or build a tripod were thinking along an altogether different line and may be said to have had the wrong "direction." None of the subjects arrived at the solution, so when on the verge of giving up, the following help or suggestion or experience was given.

The subject was asked to sit on a chair and without leaving the chair, to reach a box of matches about 2.5 meters distant. After a few moments of thinking all of the subjects clamped two poles together and so made a pole long enough to reach to the matches. Some of them referred to the fact that Koehler's apes had succeeded in that too.

They were then asked to return to the problem. All of the subjects knew that a "help" had been given. They had served as subjects in some of the other problems of the same sort.

The two subjects that had tried using blocks (those going in the correct "direction") both solved the problem immediately after the "help" had been given. They exclaimed that they had it and one of them did not even finish reaching for the matches.

Two other subjects had alternated between two types of solutions, one type being in the right "direction" the other in the wrong "direction." Both of these subjects also solved the problem after the "help" had been given.

The nine other subjects tried continuously to solve the problem in one or the other of the wrong "directions." None of these benefited by the "help." They would say, "I don't see the connection;" or "That's nothing new;" or "I wonder what that is supposed to suggest;" or some other such expression, and then return to the problem, trying with renewed effort, to perfect what they had previously been trying to do.

Other problems brought out the same thing, but few subjects

were used, and the problems are somewhat difficult to describe. Taking all problems of this sort together, it was found that ten subjects had the right "direction" and all of them solved after the "help" had been given. Two alternated between the right and the wrong "direction" and both solved after the "help" had been given. Fifteen tried to solve in the wrong "direction" and none of these solved after the "help" had been given. Six tried solutions which were not exactly in the right or the wrong "direction" and are called "questionable." Three of these solved after the "help" had been given and three failed.

"Direction" in thinking is also brought out in the persistence shown by some persons in keeping at a certain way of trying to solve the problem. Altogether nine problems were used in the study in Germany and many sorts of "helps" were given. In order to discuss the results it would be necessary to study each individual case and this would require more space than is warranted. Here it is only necessary to say that, after a help was given, the subject usually returned to the problem and tried, in some way, to improve on an old idea. If a "help" was used it was usually so turned as to fit the dominating idea. A few examples will illustrate.

In the problem of making a stick stand, S 4, after having received other "helps," was asked to stand on a chair. The low ceiling of the room made it necessary to stoop over when standing on the chair so as not to bump ones head. This "help" was meant to suggest the ceiling. Some subjects did find this "help" useful, but this S saw something else in it. The chair was such that one had to place one foot on each edge of the chair so as not to break through the bottom. S 4, therefore, returned to the problem and placed the sticks with bases apart as had been done with the feet when standing on the chair. (This interprepation was verified from the subject's introspection.) Previous to the "help" S tried to fasten legs of some kind on the long pole.

S 7, in the same problem, was given the "help" of sitting on a chair and reaching for the matches. She said, "But I thought

you said that the chair was not to be used." This subject had tried to find something to lean the pole against. She had previously wanted to use the chair for that purpose.

In problem 9 the task was to put out some lighted candles while standing a given distance away. This could be done by fastening lead and rubber tubes together (so as to form a long tube) to a length of about four feet, then mounting this series of tubes on a long pole and blowing through it at the candles. A "help" was given in which water was siphoned from one container to another by means of such a series of tubes. The "help" was intended to suggest this series of tubes. Instead of getting such an idea from it, several subjects got the idea of throwing water at the candles, and one got the idea of inverting one of the containers over the candle so as to smother the flame.

Another subject had tried to put out the flame by blowing through a series of tubes of lead and rubber and held at arm's length. A "help" was then given in which this S was asked to hook a piece of cord on a nail in the ceiling by the use of a pole, and while seated on a chair. This "help," instead of suggesting the use of the pole, suggested the use of the cord. The cord was used to tie the junctions of the lead and rubber tubes so as to avoid any escape of air. This subject had remarked that she could not blow hard enough. She had almost exhausted herself blowing through her short series of tubes, and now she wanted to use the cord to avoid any unnecessary loss of air. Her problem was not to get a longer tube, but to get more air through the tube. A little later she was offered a cigarette. This she used also as a suggestion and started blowing smoke through the tubes. When next given the siphon "help" she wanted to blow water through the tubes.

In the footnote for table 2, two cases are described in which burette clamps were used, not as weights and holders for the chalk, but as clamps are usually used—to hold things together. When weights were necessary the lead pieces were used, but as the clamps were supposed to be used, they were taken in their older meaning and made to fit artificially into the solution.

IV. DISCUSSION OF RESULTS

From the results it is obvious that the mere conscious presence of the necessary experiences or data is not sufficient to solve certain problems. Some other factor is necessary before the elements can be integrated into a unified whole, the solution of the problem. This factor we have called "direction." "Direction" is the way the problem is attacked and depends on the way the problem is seen or what the difficulty of the problem is seen to be. Experiences are only useful if they aid in overcoming the difficulty. By giving "direction" it was intended that the subject should see the problem in a certain way.

It might, however, be argued that it is not "direction" that was given, but that a fourth element was given and that the advantage is due to the fact that more elements or more experiences were given. Yet it seems that if four elements make for the solution of the problem, then three elements ought to be of some use, especially when the three elements contain the whole solution. Then again, what has been called "direction" cannot be found in the problem's solution by analysis in the same way that A, B, and C can be found.

"Direction" might also be regarded as merely another way of saying "idea in mind," but as the latter has been used, at least, it has been given very little stress in theories of reasoning. "Idea in mind" also frequently carries a structural rather than a dynamic connotation.

The "trial and error" theories of reasoning have "similarity" to account for the selection of some experiences rather than others. They thus recognize that the solution of a problem is not a matter of chance combination. Selection and similarity, however, play no part in the calling up of experiences in this study because the experiences necessary for the solution were selected for the subject and given with the problem.

Ach (1) and other exponents of the Würtzburg School have a "determining tendency" at their disposal. The "determining tendency" is something that is given by the stimulus-situation.

It might be regarded as being the same as "direction;" but as it has been used it is something else.

In the first place it is used entirely as a selective factor. When the "Aufgabe" is to associate the whole with the part, the stimulus-word "sentence" might call up the reaction-word "paragraph." The "Aufgabe" has limited the possible reactions. If "determining tendency" is applied to problem solving it might explain how one old experience is selected rather than some other. It quite satisfactorily explains such problems as Dewey presents in his, "How we Think." Thus if it is our problem to get from one part of New York to some other part, within a limited space of time, we might consider trolleys, subways, elevated lines, buses, and taxis. The time allotted, the starting point, and the destination would determine which means of transportation would be used. None of these possibilities, as means of transportation, would, however, be new to us. We must merely choose the means that best satisfies the end: all the means being possibilities and familiar as such. In such a solution nothing new is brought about: no new configuration is formed.

In the second place the experiments on the "determining tendency" confine themselves to association-reactions[4] and the application of the term is limited to situations which are qualitatively of the same sort. Until association-reaction and reasoning are shown to be the same in principle, "determining tendency" can hardly be regarded as meaning the same as "direction."

In the third place, if it is insisted that the "determining tendency" does apply to the type of reasoning problem presented in this study, then it must be granted that the "determining tendency" is the setting or statement of the problem. The statement of the problem is obviously not what has been called "direction."

Selz (7) in his "Komplex theorie" elaborates the "determining tendency" and makes it a tendency to complete or fill in a complex. He points out (p. 118) how this completion process

[4] The word response one gives to a stimulus word. The response word is the word best associated with the stimulus under the conditions and time of the experiment.

gradually develops. Thus if we are given the instructions to respond with a word which begins with Mel... the following six stages are gone through:

(1) Conscious setting of the goal.
(2) Determination to reproduce.
(3) A determination to reproduce a complex.
(4) A determination to reproduce a word complex.
(5) A determination to reproduce a word containing Mel...
(6) A determination to reproduce a word beginning with Mel...

There is, it appears, a tendency, which is very general at first, and which gradually becomes more and more specific. This tendency seems to be entirely selective in its nature. In a later study (8) he speaks of a function which selects out fitting associations and keeps out those which do not fit (p. 50).

The way in which this selective function arises is very satisfactorily presented in his summarized study (9). He describes (p. 14) how the stimulus word and the instructions form a complex which is only completed when the reaction-word is found. This incompleted complex tends to complete itself and only a word which has the proper relation, which is determined by the instructions, will be caused to appear. On page 17 he points out that this gap in the complex is filled in by a middle term. The incompleted complex is thus made up of the goal and the starting point of the problem as well as the relation of each of these to an unknown middle term. There is thus an anticipation for the middle term set up. The complex, when completed, is new in so far as it has a middle term for the first time. The middle term, however, is taken from old situations and stands in relation to one of the old elements of the complex in the same way that it does in the new complex. Past experience is an important factor in finding such middle terms and it would seem that success in finding middle terms for new complexes is a matter of "identical elements."

Having arrived at these conclusions from his experiments on association reaction, in which the subjects were given a stimulus word and such instructions as, associate the whole with the part,

Selz next sets out to explain productive thinking. He explains how Darwin got his middle term by reading Malthus and so completed his complex and had the theory of "natural selection." It should, however, he pointed out that the middle term has not the same relations in the theory of natural selection as it has in the theory of population. Darwin's real act of reasoning did not depend on the reading of Malthus' book and selecting from it a certain relation, but rather on seeing a new relation. Malthus predicted ruin because of over population, but Darwin saw that not all would be ruined; only the unfit will perish. What Darwin got from Malthus was more than an associative bond. In other words Darwin did not select from his experience; he made over his experience.

In association reactions, experience is not made over and for that reason Selz cannot use his data to explain productive rather than reproductive thinking, unless he first reduces such problems as Darwin dealt with, to the problems which his subjects dealt with. That Selz regards reasoning as reproductive rather than productive, is indicated by the fact that he compares reasoning to the act of selection in the acquisition of skill (p. 18). Of course it is true that many of the subjects in this study did reproductive rather than productive thinking. Fastening legs to a pole to make a hatrack is really reproductive thinking. However, on the basis of selection only, the correct solution should have been the easiest because the correct elements had already been selected for it in many cases.

Another point which indicates that Selz is not using a concept which we have called "direction" is brought out in his discussion of error (8). He shows that errors (p. 50 and following) which his subjects made depended on a misunderstanding or a lack of full appreciation of the instructions or stimulus; or to an ignorance of the class that the stimulus-word belonged to; or to a stronger association coming to the foreground before the correct one. Errors also appeared very often when the subject tried to make a very quick reaction. None of these sources of error are, however, similar to the errors which we regard as due to the wrong "direction." If errors are due to a lack of a full appreciation of the

problem, or to a lack of sufficient knowledge, they can hardly be regarded as errors. In the present study every effort was made to eliminate errors due to a misunderstanding. If, in spite of precautions, they still appeared, such results were not used because the subject making them was not solving the same problem as one who understood the problem correctly. A failure to solve a problem in these experiments was mainly due to the fact that the subject attacked the problem from an unsuccessful angle. There are several angles or "directions" that one may take from the same starting point. The one that most successfully leads to the solution is the most correct one. Unsuccessful "directions" can be regarded as errors.

When we try to solve a problem we seek the solution from some point of view. That is, we see the difficulty to lie at some particular point. If two doctors wished to solve the "yellow-fever" problem they might see the difficulty altogether differently. One might believe that the cure depended upon making the human immune to the germ, the other might think that the germ must be kept from the human. The first might experiment with serums,[5] the other might seek to learn what carried the germ and hence seek a way to remove the carrier. The first doctor might find the solution to be difficult or impossible, the second might find it to be simple and quite obvious.

In the first problem given in this paper, the solution depended upon building a structure from which two pendulums could be hung. The presence of the table might suggest making it a part of the structure. As the table could not be moved, the next step would be to find some way of extending the structure from the table. If this idea did not work a substitute for the table might suggest itself. For a person who has been given the "direction," described in the experiment, a long pendulum has been suggested—one that reaches to the ceiling. The problem then is, "how to hang a pendulum from the ceiling without having

[5] The idea of the serum, I believe, would correspond to the Middle term of Selz. This associated idea (serums used for other diseases) would then give the thinking a certain "direction." A "direction" which is due to such an associative bond (similarity) is what we later call the "habitual direction."

nails in the ceiling?" How can the absence of nails in the ceiling be got around? Parts B and C fit together in substituting for nails in the ceiling. They do not, however, substitute for a table, and if that is what the subject needs, they are useless. The use of the walls at the heigth of the table seems to be an attempt at substituting for the table.

Only when experience fits the "direction" or the way the person has attacked the problem will it aid in the solution of the problem. Otherwise experiences given or called up by association have nothing to do with the problem and at best can only be made over so as to fit the "direction" which has been taken.

Part A, on the other hand, fits all "directions." It is, therefore, expected that group 3 would use it quite successfully.

Some "trial and error" is also present, but the general idea seems to be due to "direction" and usually the correct grouping comes suddenly and is not come upon by "trial and error." "Trial and error" seems to consist mostly of attempts to apply the habitual or usual experience (from similar problems) to the new situation. (Selz's middle term is taken from such past experiences.) The failure for such past experiences to function properly leads to "trial and error." "Trial and error" takes place when the solution is sought within the limits of a certain "direction" and no grouping has resulted. It might solve problems in which the right "direction" is the habitual one, but even then such an accidental combination must be recognized as the solution. (Koehler's ape fastened two sticks together by accident, but recognizing that combination of sticks as the solution to the problem was the important thing.) If, however, the successful "direction" is not one of the more habitual ones then the trials are within the limits of the wrong "direction" and are mostly errors.

Wertheimer (11) speaks of new configurations being formed when one does productive thinking. Parts group themselves in a new way and suddenly are the solution. He points out that the configurations which are formed follow definite laws and that these laws depend on the intrinsic nature of the task. "Und die Zentrierung führt zum Eindringen in den Sachverhalt, zur Erfas-

sung eines *bestimmten inneren Strukturzusammenhangs des Ganzen;* zum Erfassen *innerer* Notwendigkeiten" (p. 181). It seems that direction might be an important factor in determining what grouping might be formed.

Just how "direction" can determine which grouping will be formed is not easy to say and for the present perhaps it is best not to be too specific, but it might be suggested that "direction" is some kind of field of stress in which only certain groupings are possible. This field of stress need in no way have mystical consequences. Just as reflexes may be facilitated or inhibited, so neural patterns may be facilitated or inhibited. A conscious state might be described as due to the dominance of a certain neural pattern. A neural pattern is no more mystical than a chain reflex. The facilitation and inhibition of such a pattern may or may not be the same as in the case of reflexes. An explanation of the mechanism of facilitation and inhibition of patterns seems not to be necessary so long as this mechanism is not satisfactorily explained in the case of reflexes. Shepard and Fogelsonger (10) have shown that the concept of "association patterns" better explains the facts of association and inhibition than does the older notion of mere linkage. They successfully disprove the "drainage" theory and offer a "pattern" theory without resorting to mysticism.

Kokonda (6) studied the different degrees of difficulty that students had in filling words into blanks in sentences. The blanks most easily filled in were of this type: "I cannot buy books for myself because I have no ——." The most difficult were of this type: "The stove became very warm —— I had little coal."

She groups her blanks into two main types:

1. "Blanks which form a small part of a small complex and from it can be filled in."
2. "Blanks, the filling in of which depend on a first and a second complex, and the filled in word must be such as to form a harmonious complex."

In terms of "direction," the first type has but one "direction," the second has two "directions" which are not harmonious, and which must be made to harmonize. To say, "The stove became very warm," leads us in one "direction," and to say, "I had little coal," leads us in another "direction." A warm stove and little coal are contradictory if taken by themselves, i.e., taken in the usual or habitual sense. There must be a change in meanings (groupings) if the two "directions" are to harmonize and form a single and different "direction." As soon as the blank is filled in with "although" the harmony and change in meanings become obvious. I cannot see how mere associative bonds would ever cause "although" to be called up. Rather associative connections would seem to increase the difficulty. Something must account for the sudden change in meaning. A suggestion such as "Was it a good stove?" might serve to change the meanings and give rise to the new "direction" or give rise to a new "direction" and change the meanings.

Gottschaldt (2) has shown that the recognition of an element in a structure containing this element as a part, does not depend on experience, i.e., the number of times that the element has previously been exposed. At least 500 exposures of the element do not aid in the recognition of the element when it is part of a larger whole.

In a second study (3) he shows that the recognition depends on what might be called "expectancy." Thus, if the elements "a" and "b" are exposed alternately for about three times each, and if then "a" is again exposed and followed, instead of by "b," by a larger complex containing "b" as an element, then "b" will be recognized, even though it was not recognized in the first study.

Thus in these experiments on perception it is found that the recognition of an element in a larger whole does not fundamentally depend on experience. Rather it primarily depends on a "direction" which has been set up.

In experience we set up certain habits or ways of looking at things. We often miss obvious solutions because we try to solve problems in an habitual way (which is often the wrong "direction") and are thus blind to the obvious solution. We mis-

interpret the ideas of others to fit our own "direction" in the same way that suggestions in this study were made to fit the "direction" that the subject already had.

This habitual way of responding to a situation is what Koffka (5) calls "latent attitude" (latente Einstellung). If a person responds to certain problems in a characteristic way he will respond to a different problem in the same characteristic way even though this response may not be the usual one. There is a definite "carrying over" of the attitude or set from one problem to another which follows it. Thus if a person is asked, "What is the lightest city?" (in German the double meaning is not identical with the English, but the double meaning is common) and the answer is "Agram," then the question, "What is the largest city?" is made more difficult because a similar "catch" is looked for in the second question. In free association a tendency for the response to be a synonym may be set up and this tendency will result in further reactions which are unusual.

Zener in some preliminary experiments at the Psychological Institute of the University of Berlin (1927) habituated his subjects to solving certain types of problems in the same way. A test problem was then given. He found that an obvious and simple solution of the test problem was usually over-looked because the characteristic method of approach, set up in the preceding problems, was used on the test problem. Control subjects tended to solve the problem in the obvious and simple manner.

Koffka's "latent attitude" corresponds to what has been called "direction" in this paper, except that "direction" has not been confined to something which first has to be set up. "Direction" is always present, but preceding experiences, if in line with the problem at hand, are great factors in determining what the "direction" will be. "Latent attitude" is thus an example of "direction."

A few problems will illustrate how changing the "direction," rather than giving elements as suggestions, aids in the solution of a problem.

Given nine dots through which four lines must be drawn in such

a manner that all dots will be passed through. The pencil must not be taken from the paper and no line should be retraced.

The solution looks like figure 3. This problem is difficult because all attempts are made within the area of the square of dots. To leave this area seldom suggests itself as a possibility.

If it is suggested that one need not confine himself to the area within the square, a whole new field of possibilities presents itself. The way of looking at the problem may thus be changed and the solution made possible.

Again we might ask a person to make four equilateral triangles out of six matches, each triangle having a whole match as a side. This problem is impossible until it is recognized that three rather than two dimensions are required.

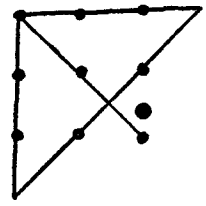

FIG. 3

A suggestion, it seems, may be one of two kinds. (1) It may be an element which fills in a gap in a pattern which is determined by the right "direction," which the subject already has, or (2) it may be such as to change the "direction," if the existing "direction" is wrong. The same "helps" might function differently as to their efficiency in changing "direction," depending on what elements in the "help" received stress. However, this is going beyond the experimental evidence presented in this paper.

This study does not attempt to explain the complete reasoning process. Only one factor in the process has been discussed. Before an adequate theory can be given, studies on the nature of the appearance of a solution, types of "helps" and their functions, transfer of training, meaning, and studies in animal reasoning (the first of which, "Reasoning in White Rats" appears in Comp. Psych. Mono. for 1929) must be completed.

V. SUMMARY

When the solution of a problem is broken into three parts and given to a subject as three separate experiences, then such experiences are not sufficient to bring about the solution of the problem. Thus a selected presentation of the experience is not enough. The parts or experiences must be combined in a certain manner and a "direction" or way the problem is attacked, seems to be a factor which determines the nature of the combination. "Trial and error" may be present in the attempts at the solution, but is inadequate to explain the sudden appearance of the correct or successful solution, when such solution requires productive rather than reproductive thinking.

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