PSYCHOLOGY REVIVALS

The Grasp of Consciousness

Action and concept in the young child

Jean Piaget

Psychology Press

Psychology Revivals

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Originally published in English in 1976, the book draws on and extends our knowledge of the process of learning. The subject of the study is the general stage in a child's development that comes between his successful performance of an activity without knowing how he did it – that is, what he had to do in order to succeed – and the times when he becomes aware of what went into that action. The book reports the results of experiments conducted at the Centre of Genetic Epistemology. Children, ranging in age between four and adolescence, were asked to perform such tasks as walking on all fours, playing tiddlywinks, building a ramp for a toy car. They were then asked to explain how they had performed the task, and in some cases, to instruct the interviewer. Their answers show a number of surprising inaccuracies in the child's ability to grasp the nature of what he has done.

Taking a broad view of his results, Piaget shows that they reveal several stages in the gradual development of the child's conceptualization of his actions. In analysing each stage, Piaget argues that the child's concept of his own action cannot be considered a simple matter of 'enlightenment', but must actively be reconstructed from his experience. This view has always been at the core of Piaget's work, and a new area of the child's mental world is here given definitive treatment.

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The Grasp of Consciousness

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Preface

When is a subject fully conscious of a situation? How is this consciousness acquired? In other words, what constitutes the dawn of consciousness or, as it is also called in this book, "cognizance"? Now that it is agreed, contrary to the classical behaviorist view, that there is no dichotomy or basic opposition between behavior and consciousness—since cognizance itself constitutes a type of behavior that interacts with all other types—the problem of cognizance is of increasing interest to scientific psychology. For the philosophical psychologist, introspection is fundamental and even has a sort of unlimited power, coextensive with all mental life. The behavioral psychologist has noticed that a considerable portion of behaviors (or their mechanisms) remain unconscious and that cognizance consequently demands the intervention of special activities, depending on other behavior and, in turn, becoming capable of modifying them. It would even seem that cognizance involves more than the incorporation of a new bit of information into an already established field (with all its characteristics) of consciousness. There is a genuine construction, which consists in elaborating not "the" consciousness considered as a whole, but its different levels—that is, its more or less integrated systems. Conceived in such terms, the problem has even come within the scope of psychological research into alertness or "vigilance." Finally, as is well known, it is also encountered by the psychoanalyst in connection with "catharsis."

This book is exclusively concerned with behavior—from material action to operations. The experiments described were conducted in the course of research devised to complete the study of causality at the Center of Genetic Epistemology in Geneva. (However, as cognizance has more psychological than epistemological significance, we are grateful to our friend,

Paul Fraisse, for including this study in his collection, *Psychologie d'aujourd'hui.*) While the concept of cause originates in the actual action, causal structures are profoundly transformed according to the degrees of conscious conceptualization that modify this action. Why then did research into causality lead to the problem of cognizance?

At the sensorimotor level, the few-months-old baby first discovers causal connections solely through his own physical action; only subsequently does he perceive them in the ways objects act on other objects. At the "representation" levels, on the other hand, the child's grasp of causality is initially limited to attributing to the objects activities that are analogous to his own actions; only later will he attribute to objects activities analogous to operations. It might be thought that this is merely a sort of rejuvenation of Maine de Biran's thesis. Indeed, this is how Michotte has interpreted our conception. However, there is a fundamental difference between Maine de Biran's theory and our conception of causality. For the French philosopher, the subject slowly achieves a more or less complete introspection (with an ego consciousness, a feeling of effort as an applied force, and the like) of the causal mechanism of his own action. Subsequently, this is generalized to external objects, through a sort of "induction" of what the subject has thus discovered in himself. We maintain, on the other hand, that the initial psychomorphism of the physical causality and subsequent attribution of operatory mechanisms to the objects themselves constitute basically unconscious inferential processes—processes that lack both this characteristic of immediate intuition postulated by the Biranian theory and, even more important, any relationship with an (initially nonexistent) consciousness of the ego. This was our first reason for seeking to analyze more accurately cognizance of the action itself and how this action is modified through such interiorization.

However, a second, and in fact our main, reason for these new studies is that it was of more general importance to examine the nature and content of the subjects' conceptualizations (including, but not restricted to, the causal explanations) when these do not concern the typical physical situations that we have already studied (transmissions of

movements, vectorial compositions, and so on), but the effects of the child's actions alone and of his "practical intelligence": making use of a sling or of an inclined plane, building a sloping path—in other words, easy problems that are solved early in life. In such cases, we first establish what the child is conscious of in his own actions and particularly what he notices of the regulations involved, both in the case of automatic sensorimotor regulations and in that of more active regulations with choice of method from among several possibilities. Then, when the problem under study involves causal relationships, we determine whether this causality of his own action on objects is clearer to the child, or more quickly understood by him, than the causal relationships between one object and another. This whole vast but little-known area is of great importance for psychology and epistemology. From the psychological point of view, cognizance is not merely a sort of interior illumination, it constitutes a far more complex process involving conceptualization. It is these conceptualization processes that have to be analyzed. In other words, although psychologists have tried primarily to determine in which situation a child is cognizant, they have too often neglected the other complementary question of how this happens, a question that demands equal attention. From the epistemological point of view, on the other hand, the interiorization of the actions is at the source of both logicomathematical and causal operatory structures and thus necessitates careful examination.

In this book the situations studied are those in which success in action is achieved early because the necessary coordinations result from simple differentiations arising from more or less automatic regulations of an initially general nature. A subsequent book (*Réussir et comprendre,* Presses Universitaires de France, Paris, 1974) analyzes what happens when success occurs later, as the result of successive stages based on coordinations between distinct schemes and more active regulations involving the introduction of new strategies, while the child is actually in the process of trying to solve a problem.

Contents

1 Walking on All Fours

In the other studies described in this book, the subject carries out actions on certain objects, with his cognizance of these actions depending on his observation of their effects on the objects, as well as of the results and of his own movements. It is therefore useful to begin by analyzing a situation in which the role of the objects is reduced to a minimum, but where the action nevertheless is sufficiently complex for the subject to have trouble grasping it completely, although not so complex that his cognizance is delayed too long. Asking subjects to walk on all fours provides an excellent situation, since most of us could do this before we could walk and because the only material required is a fixed floor, serving simply as a support and not as an instrument or goal. Furthermore, this allows a particularly useful opportunity to check one of our general hypotheses, namely that cognizance depends on active adjustments involving choices of a more or less deliberate nature rather than on automatic sensorimotor regulations. Walking on all fours, of course, because of its familiarity (unless deliberately obstructed), involves only reg-

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With the collaboration of Androula Henriques-Christophides.

ulations of this second sensorimotor type and at least one part of the hypothesis would be invalidated if it were accomplished at every age with full cognizance.

The subject is asked to walk (on all fours) about 10 meters, then to explain verbally how he did it. After this, he is asked to use a teddy bear (with jointed limbs) to execute the movements he describes. If necessary, the interviewer gets on the floor and asks the child to tell him which limb to move first, and so forth. Subsequently, the child is asked once more to walk on all fours, this time paying attention to what he is doing, and to give a running commentary. If the explanation is incorrect, he is asked to perform in the way he has just described to see whether it is right. Finally, if he feels another task is necessary, the interviewer suggests that the child walk on all fours quickly across the room and stop immediately when so instructed—at which point he is asked to describe how he started his last movement.

Level IA

At this level, four-year-olds (and sometimes slow developers up to the age of seven) describe their actions as follows (Z or its reverse Ƨ pattern): one hand, then the other one, then one foot, then the other one (or the feet first). This differs both from the N or its reverse И pattern (right or left hand, then the foot of the same side, then the other hand and the second foot) and from the X pattern (left or right hand, then opposite foot, then other hand and remaining foot).

Examples

SYL (4,4) walks a few meters (pattern X). How are you doing it? *I'm moving my hands, arms, feet, and legs, and my head.* But what first? *I'm moving everything at the same time.* (then with the bear) *First that one* (left foot), *that one* (right foot), *that one* (left hand), *and that one* (right hand). Now walk on all fours again yourself and really look at what you're doing. (Gives same description.) Someone else told me that it was like that (description of

X). Is that right? *No, first that one and that one . . .* (Z). Show me how I've got to do it (on the floor). *This hand, then that one, then this foot, then that one* (Z).

PAU (4,7) walks according to pattern X. How do you do it? *You put both legs and then both hands.* Show me on the bear. (Right foot, then left, right hand, then left.) Is that how you go on all fours? *Both feet and then your left hand and right hand.* How? *Both feet at the same time, then one hand, then the other one.* Show me what I've got to do (on the floor). (One foot after the other, then one hand after the other.) Get on the floor and do it the way you've just told me. (He puts both hands forward at the same time and gets stuck.) Is that how you told me? *Yes.* Do it again and tell me what you've done. (Again Z.)

NAD (4,9) has the same reactions as the other two: both hands, then both feet, each time one after the other, and so on. When she is asked to walk on all fours in this way, she tries, then hesitates and reverts to the X pattern. What did you move first? (She still gives the same description.)

MIC (4,6): After the same reactions as the others (*first my hands, first one and then the other. After that my legs, one and then the other*), except, surprisingly enough, for making the bear walk in the X pattern, MIC gets down on the floor again and walks, trying to give a running commentary: *I take this hand, then that one, then one foot and one foot* (his actions constantly bely his words). When the interviewer suggests the X pattern, he says, *No, it's animals that do it like that* (and he shows it again with the bear). Do it again yourself. (He does it according to X and again describes it as Z.)

The Z solution clearly indicates these subjects' complete lack of awareness of how they actually walk on all fours,

since none of them actually do it this way. (Although most subjects walk according to pattern X, pattern N is sometimes encountered.) Why then does pattern Z immediately come to their minds? This is surely because, if the subjects are asked to give an order of succession about which they themselves have no clue (*I'm moving everything at the same time,* says SYL), they are likely to describe the simplest order, that is, first hands, then feet (or the other way around), but always *both* hands before *both* feet (or vice versa) starting each movement with the same-side foot or hand (otherwise the pattern would be] or [and not Z). Of the 34 four- to eight-year-olds with this type of reaction, 30 Z opposed to only 4] were encountered, which is a fairly clear indication that these children are describing the simplest construction and are not attempting to determine the actual order of their movements.

MIC's manipulation of the teddy bear is, however, worthy of comment, since unlike the other subjects, he makes the bear move according to pattern X. We might have considered this pure chance, since immediately afterward he tells the interviewer to walk on all fours according to pattern Z, which is also the pattern that emerges from his (incorrect) running commentary on his own renewed slow motion walk; but there is his immediate response, at the end of the questioning, to the suggestion of the X pattern. Unlike SYL, he does not say it is wrong, but *it's animals that do it like that.* In other words, he seems to conserve as a memory image the way dogs, cats, or horses move, but this does not help him at all to become actively aware of his own movements; it seems easier to observe others than himself. To sum up, at this level the Z pattern seems to be chosen only because it is the simplest. As will be seen later, subjects at more advanced levels often start off describing the Z pattern, but progress to N or even X.

Level IB

The five- and six-year-old subjects give an N-type description: hand, then foot (or the other way round) of the same

side, then the two successively of the other side. This solution, not encountered with four-year-olds, is found with about one-third of the seven- to ten-year-olds and even with adults (who, however, walked according to pattern X).[1]

Examples

COL (5,6) starts off by describing the Z pattern, which he also uses when telling the interviewer how to walk on all fours. On the other hand, when he himself is asked to crawl again, this time slowly, and take note of what he is doing, he says, *Right hand, then right foot, left hand, and left foot*—pattern N, even though he walked according to pattern X. Walk on all fours again, slowly. *First that one* (right foot), *then right hand, then left foot and left hand* (inverted N pattern). Now do it and tell me what you're doing as you go along. (He walks according to X, while describing the inverted N pattern, then adapts his walking to match the latter.) Once more. (This time he walks the whole time according to X.) *My right foot, my right hand, my left foot, and my left hand.*

ART (6,2) walks according to pattern X. *I lift my legs and my hands.* How? (She starts off again according to X.) *That one* (right foot) *and that one* (left foot). And afterward? *Right hand and left hand* (thus pattern Z). Same thing for the bear and for the instructions to the interviewer. However, when she is asked to walk slowly, noting carefully what she is doing, she says, despite her X pattern, *Right foot, right hand, left foot, left hand* (thus inverted N). When she does it quickly, she reverts to describing the Z pattern. And now walk on all fours again

1. Before giving her paper at the 1970 Symposium on Genetic Epistemology, Professor Henriques tried out the experiment with several of the participants (she made them walk on all fours on the floor, as well as answer questions!). Logicians and mathematicians favored the N solution, while physicists and psychologists opted for the X pattern.

slowly and tell me at the same time what you are doing. *Right hand, left hand, left foot, right hand, left hand, left foot, right hand, right foot . . .* and so forth. In fact, having started off according to X, she then adapts her movements to match what she is saying and walks according to N.

LAI (6,11) walks according to pattern X, then, without saying a word, points to his right foot, right hand, left foot, and left hand (inverted N). He starts off by making the teddy bear move according to pattern Z, then changes this to N. However, he tells the interviewer to walk according to X, then, back on all fours himself, he walks slowly, with his commentary initially correctly describing pattern X, then reverting to N without noticing that his words no longer match his movements. Finally, the bear is again made to move according to N.

This N pattern, not encountered with four-year-olds but clearly predominant with fives and sixes, is also favored by a third of the seven- to ten-year-old subjects and, as mentioned above, by some adults. Unlike the Z pattern, it is a perfectly feasible way of walking on all fours, although the X pattern is far more common. What is important here is that most subjects describe their movements as if they formed an N pattern, whereas in reality they move in an X pattern (COL, ART, and LAI), and so are not fully conscious of their own movements. Sometimes it does happen (but this is in no way equivalent) that such a subject may try to match his movements to his commentary and move according to N (for example, ART, who at the end of the session stops walking according to X and begins moving according to N).

In this example there is, therefore, no cognizance conceptualized from a previous action, but there is influence of the conceptualization on the subsequent action. This difference is most significant. It indicates that when a child describes his movements only after he has stopped walking on all fours, his actions are directed by simple automatic sensorimotor regulations, which are not sufficient to make him actively con-

scious of his every movement. Still, when asked for a running commentary, he may even start to hesitate before putting a foot or hand forward, forced to choose between several possibilities: such a choice is a basic characteristic of an active regulation, which as a rule leads to full consciousness of the actions in question. In this particular case, it is true, there is no actively regulated action followed by a conceptualized and adequate cognizance, but instead, first a conceptualization that does not match the action, then an active adjustment resulting in the action matching the conceptualization and thereby becoming conscious. However, even if the active adjustment here stems from an incorrect conceptualization of the subject's action, these examples do demonstrate the need for a distinction—the value of which will become increasingly clear—between the two types of regulations, that is, between those that are automatic and those that are active.

Stage II

Half the subjects at level IIA (seven to eight years) systematically give what may now be simply termed the X solution, which previously was given only by LAI and even then not at all systematically. Two-thirds of the level IIB subjects (nine- and ten-year-olds) give this X solution.

Examples (Level IIA)

MAR (7,6) starts off walking on all fours according to X, but her description is of the Z pattern: *To walk like a little cat, I put my right hand, then my left hand, then my right foot and afterward the other one . . . always like that.* Try again. Did you notice what you were doing? *My right hand* (pause) *after it's the left hand, right foot, left foot* (still Z pattern). Very good. Try once more and see what you are doing. (She walks again, this time slowly.) *Right hand and after* (hesitation) *I put my left foot and then left hand and afterward my right foot*

(thus now X pattern). Show me with this teddy bear. (X solution.) And now have another try yourself. (She again describes the X pattern.)

JEN (8,11) first of all describes her movements according to pattern Z, then those of the teddy bear according to N, then again her own movements according to Z, and then according to N. However, when she is suddenly told to stop: Now, go on. *Right hand and left knee, then left hand and right knee* (pattern X). Now do it very quickly. *My right hand and left knee, then left hand and right knee.* Do you remember what you said before? (She repeats the Z description.) Was it right? *No, it was wrong.* Show me on the bear. (X solution.) Do you do the same? *Yes, I think so.*

Examples (Level IIB)

RAU (9,8): Can you walk on all fours? (pattern X). How do you do it? *I put my knees and hands on the floor. I go forward with my right hand and with my left knee as well, then I put my left hand forward, I put my right knee* (so, immediately, an X solution). Show me on the teddy bear. (X solution.) Now, I'm going to walk on all fours; you tell me what to do. *Put your right hand forward, left leg forward, left hand forward, right knee forward.*

JAC (10,6) crawls according to pattern X: Tell me what you did. *I knelt down, put both hands on the floor. I put my right hand forward, then left knee; my left hand, then right knee.* (Straightaway, an X solution.) And on the teddy bear? (Again, the X solution.)

JUL (10,3), by contrast, starts off by describing the Z pattern, then makes the bear move according to N. Is that how you said just now? *Not quite, I said that hands and feet had to be together.* Try doing it again. (N description followed by N pattern ac-

tions.) Now, do it very quickly. (Moves according to X.) How did you do it? *Left leg with right hand and left hand with right foot* (in other words, X pattern).

There is thus at this second level a clear grasp, or cognizance, of the individual movements involved in walking on all fours. How does this come about if, as has been hypothesized, the automatic regulations that direct sensorimotor actions cannot alone make this possible, when walking on all fours at ten years of age (or indeed at any age, see note 1) is clearly no less automatic than at four or five? To what extent are active adjustments directly or indirectly responsible for the accurate descriptions furnished by the level IIA and, above all, the level IIB subjects?

Two types of reaction seem worthy of comment in this respect. Firstly, the questioning may interrupt, or at the very least diminish, the automaticity of the subject's movements, thereby causing him to "stop and think"; this introduces an element of choice and forces the subject to make a conscious decision regarding his next action. Three methods of arousing this reaction were evolved:

(*a*) The subject could be asked to walk on all fours slowly and to try and observe exactly what he is doing (this request proved unnecessary for children like MAR who did so spontaneously); here, of course, the slowing down from the natural speed diminished the automaticity. A variation of this method consisted in asking the child to walk on all fours quickly, as in the case of JUL.

(*b*) Subjects could be requested to move according to the pattern they themselves had previously described, which slows them down and so lessens the automaticity.

(*c*) The most effective (see JEN) proved to be when subjects were asked to stop crawling and then to recommence; this again resulted in a break in the automaticity.

All these methods in fact proved largely ineffectual at levels IA and IB (two-sevenths of the subjects progressed only from Z to N) and effective at stage II (at level IIA five-sixths of the

subjects progressed at least from Z to N, and for levels IIA and IIB together eight-ninths of the children progressed in this way, with some of them finally giving the X solution).

The second type of reaction is exemplified by level IIB subjects like RAU and JAC, who spontaneously give the X solution and therefore do not fall into the preceding categories (progress to the X solution after at least a partial break in the automaticity of their movements). Here, in all probability, the subject thinks about how he moves right from the beginning and in so doing substitutes a certain number of choices for his automatic movements (as we all do when, for instance, in the middle of running downstairs we suddenly, for some reason, try to take active control of our steps and so probably slow ourselves down unnecessarily).

However justified these remarks may seem, there remains the problem of understanding why the various factors that cause a diminution in the automaticity and make the subject begin to think about his actions do not result in progress until level IIA, which sees the beginning of operatory reversibility. In fact, there is a close natural link between this reversibility and what is involved (a sort of retroaction) when a subject becomes conscious of an action that normally takes place autonomously and quasi-automatically, and he must have achieved a certain level of conceptualization before this can counterbalance the automaticity. Indeed, when a stage I subject is asked to walk on all fours according to the pattern he himself has given, he generally moves as before (except for COL and ART in IB), with perhaps a little hesitancy, while from age seven on, all subjects modify their movements. This appears to herald the beginning of the retroaction that is inherent in the subject's attempt to determine what he is actually doing. Does this lead to a grasp of the principle of reversibility, or is it the other way around? Clearly, it is in the modifications of the action that the explanation of the formation of reversible operations must be sought, and we have often stressed the role of anticipation and retroaction in this development. In this respect the essentially automatic character of the actions studied here constitute a rather special case. However, it is precisely because it is special that it can be ac-

counted for only in the general context of the actions at these levels. From such a viewpoint, the only valid reason for the declining resistance of the automatic responses around the ages of seven to eight lies in the general tendencies that during this period direct the child toward retroaction and anticipation and that are manifested more clearly in his overall behavior than in the particular situation analyzed in this chapter. Here, as in all analogous cases, for an effective conceptualization of the earlier distortions, which at levels IA and IB prevented the subject from making an accurate observation of his own action, the subject must have recourse to the inferential coordinations that enable him to make sense of observations that contradict his expectations. Naturally, the more distorted his observations are, the greater the delay in his acquisition of these coordinations.

2 The Path of an Object Launched by a Sling

The sling used in this experiment is of the simplest type: a wooden ball 5 cm in diameter, tied to the end of a string that the subject releases after swinging it around a few times, aiming it at a target. Even very young children manage to do this and, according to Diodore de Sicile, the inhabitants of the Balearic Islands were particularly good at it because the mothers used to hang their tots' bread on the end of a pole and make them go hungry until they had hit it using their sling (Encyclopedia, Diderot and D'Alembert, 1751, p. 337). However, sensorimotor success does not always lead to accurate conceptualization (in this case, of how one aims and the object's flight path) and it is interesting to find out why.

Throughout this chapter, for the sake of clarity, the reader is asked to picture a clockface as representing the circle described by the sling's rotation (see Figure 1). Positions of targets and subjects, and points on the circle where the sling is released (referred to as "release points"), are all designated with reference to the imaginary clockface.

With the collaboration of Michelangelo Flückiger.

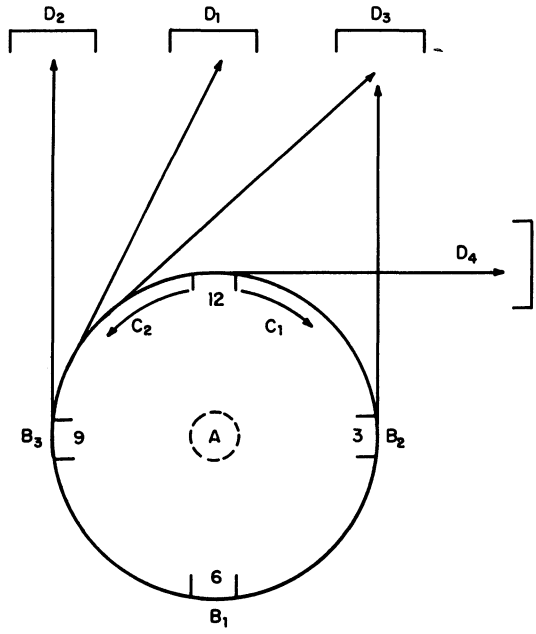

Figure 1

A: location of the hand when rotating the sling.

B: possible positions of the subject.

C: direction of rotation of the ball (C_1 = to the right, C_2 = to the left).

D: target (rectangular box).

1 to 12: positions on the circumference where the ball is released when the subject lets go of the string.

NOTE: It is only in the situations described in the supplementary experiment that the box can have its opening at the top.

The session starts, in most instances, with the interviewer holding one end of the string and demonstrating the circular movements described by the ball at the other end (in a horizontal plane on the floor and without pointing to any targets) and asking the subject in which direction the ball would go if it were released. The actual release points are not specified, but the interviewer sometimes swings the ball in a clockwise direction (subsequently referred to as "to the right of 12 o'clock") and sometimes counter-clockwise ("to the left") to see if the child predicts opposite directions. After this, the subject has a try himself and only after this is a rectangular cardboard box used as a target into which the child has to try to send the ball, simply by releasing it. In other cases, the

interviewer starts the session by asking the child to swing the sling around and around, then release it so as to send the ball into the box. The subjects' responses in both situations are most informative.

For the part of the experiment with a target, the box is initially placed outside the circle of rotation, at the 12 o'clock position, with the subject crouching down outside the circle at the 6 o'clock position: the position of the box is such that the string must be released at about 9 o'clock for a right rotation and 3 o'clock for a left rotation. Since almost all the subjects age four or older succeed in this motor task, there are no major steps leading to success in the physical action that can furnish criteria for the levels described in this chapter—although, of course, some children get the ball in the box more quickly than others, and all differences in responses were naturally most carefully analyzed. Because, as has been said, our main interest lies in how and when the child becomes conscious of his actions, the basic question asked of each subject concerns where he released the ball; he can answer verbally or simply mark the spot on the floor (with, for instance, a small cross), or make a drawing, or repeat his action in slow motion, or instruct the interviewer on how to get the ball in the box. In addition, the interviewer can alter either the position of the target (to the left or right of 12 o'clock) or that of the subject, or he can ask the latter where the ball would go if it were released at specific points. As shown by the examples, until stage III of the eleven- and twelve-year-olds, there remain marked differences between what the children do and what they say they do!

Finally, as we shall describe later in this chapter, the interviewer takes a whole group of subjects outside the classroom onto the school grounds, where he asks them to stand up and swing the sling in space. Initially, he does not specify the plane of rotation: vertical, oblique, or horizontal (over the head of or in front of the child)—although, where necessary, he does make suggestions. Here, a drawing is indispensable for judging the child's representation of his actions.

Level IA

Examples

LAU (4,7) is shown what to do by ALA (4,10). ALA is successful and LAU explains: *He turned and it went*

in the box. How did he do it? *Because he didn't . . . he made it turn a lot.* A second attempt by ALA is unsuccessful because, according to LAU, *he turned a lot.* What should he do? *Turn less.* LAU then tries three times, starting off by swinging the sling around and then stopping her rotation movement at about 6 o'clock and simply throwing the ball. Are you doing the same as he did? *Yes.* After three more analogous attempts, ALA explains to her, *You've only got to turn it.* LAU does this, releases the ball at the side, and gets it into the box. After this, she sometimes releases the ball at about 4 o'clock (left rotation) and sometimes throws it. These throws are from the 6 o'clock and not the 12 o'clock position, as if the ball should come from where the subject is and go diametrically across the clockface to the box opposite.

TOM (4,5), initially without a target, copies the rotations correctly. What would happen if you let it go? *It would go zoom (round and round), then zoom (the ball would go off).* Where? *Over there* (roughly opposite). *If you make it turn very hard, it turns right up to there* (back of the room). He does not realize that the ball's trajectory is determined by both the release point and the direction of rotation. With the interviewer acting as the target and standing opposite him, TOM releases the ball first at 12 o'clock (right rotation), then at 6 o'clock (clearly thinking the ball will travel straight across from 6 to 12 and so reach the target, but instead it goes off to the left), and then finally at 9 o'clock, which is correct. How did it go? *From the other side* (left as opposed to right rotation) *it goes too far; like that* (right rotation) *it goes there* (to the target). When it comes to telling the interviewer what to do, he says: *You've got to let it go quickly, then it goes over there* (direction not specified), without any reference to the release point. And to go there (to one

side)? *You've got to stand there* (opposite). And there? *Stand there* (again opposite). After some correct releases, the interviewer says, Now show me how it went. *Like that.* (Like LAU, he simulates a few rotations, then a release point opposite the target, near the subject with the ball crossing the circle of rotation from 6 o'clock to 12 o'clock.) How would you make it go over there (to one side)? *It's too far.*

HER (4,10) has a target (box) from the outset: he rotates to the right and misses, then to the left and releases involuntarily at 3 o'clock, almost getting the ball into the box. Does it matter which way you turn the sling, does the ball always go off in the same direction, regardless? *Yes.* Where does it go? *To the same place.* After several misses he gets the ball in the box (from 7 to 8 o'clock), but by pushing the ball with his hand toward the target. Where did you let it go? *Here* (12 o'clock). And if you turn the other way round? *You've got to let it go the other way round.* Where? *Here* (ball's trajectory from 6 to 12 o'clock).

ALA (4,10) starting without a target: If you let it go? *It goes straight* (that is, not in a circle). Where? *It goes everywhere.* Try. (Right rotation.) And the other way round? *The same thing.* With a target: success at the third attempt with release at 8 to 9 o'clock. And the other way round? *It's the same thing for letting it go.* (Despite this, he gets the ball in the box.) When do you have to let it go? *You have to let it go when it is . . . when you see the box.*

VOG (5,3) without target: *It would go everywhere, here in the corner.* (She points to the left in front of her, when turning to the left, which could be correct.) And if you went the other way round? (She releases the ball before answering.) *There* (to the right). Could it go anywhere else? *Yes, here* (to the

left). Target beyond 12 o'clock: she misses. Why didn't it go in the box? *Because it turned.* Where did you let it go? *Here* (center of the circle, where her hand was). Where did it go to? *Here* (6 o'clock, thus near the child herself with the ball's trajectory again following the diameter of the circle). After some very near misses, she continues to designate 6 o'clock as the release point.

It does seem remarkable that these young children manage to get the ball into the box by finding, through trial and error, the right place to release it. It is difficult to analyze in this respect the part played by proprioceptive information and that played by sensorimotor regulations stemming from the results of the child's actions during the session. The subject's cognizance and explanation of his actions place more emphasis on his own position and the force he uses than on the observable features of the object, except for the unanimous opinion that once the ball has been released it does not continue to turn in the same circle but, no longer held by the string, goes off *straight* (ALA) toward the outside, that is to say, following a trajectory, unspecified but outside the circle.

Having said this, the first consideration concerns the trajectories that the subject predicts for both right and left rotations when there is no set target. Of course, the ball's destination depends upon the release point and the direction of rotation. Only subjects who have reached stage III can understand these objective trajectories. However, with no set target, right from level IB on, the child imagines that the ball will always go off to the left for a left rotation and to the right for a right rotation, landing in what might be termed "privileged zones"—that is, for a small number of turns the ball will go to the right or left of the subject (according to the direction of the rotation) and for a greater number of turns it may land behind him. These trajectories to the left or right of 12 o'clock will be construed as the result of a sort of throwing. At level IA, where the idea of throwing is more firmly embedded, these privileged zones in the "no target" situations are only rarely accepted according to the direction of rotation.

Generally, the subject is not concerned with the release point and forecasts, like TOM, either just one trajectory or (where there is a set target) a favorable trajectory for one direction of rotation and an unfavorable one (*too far*) for the other. VOG does not even take account of those results she herself has seen.

When the subject at this first level IA aims at a target and ends up by hitting it, his ideas about how he succeeded show some remarkable characteristics (a younger child would have no ideas at all). The first is the tendency to believe that for the ball to go into the box, the subject must be opposite it (like TOM, for example). This leads to a second reaction: when asked where the ball was released (or more simply, for a description of what has happened), the subject designates as the release point the spot nearest his own position (6 o'clock if the target is beyond 12 o'clock) as if the ball traveled straight across this diameter (6–12) to reach the target. LAU even maintains that there are two distinct actions: making the ball turn several times, slowing down near 6 o'clock, then throwing it from this point to the target beyond 12 o'clock. By contrast, TOM and VOG picture the ball's release after rotation, but their conceptualization still corresponds to LAU's two distinct actions. HER first thinks (like the slightly more advanced level IB subjects) that the release point (in fact at 7 to 8 o'clock) is at 12 o'clock, but, after rotating the sling in the other direction, he again points to the 6 o'clock position, which shows that for him the ball first has to cross the circle from 6 to 12. ALA, by contrast, thinks that the line that links the subject to the target does not start from where he is, but from the spot where he *sees the box*. This explains why some of the children at this level correctly consider the ball's release point to be at 9 o'clock, for instance, and not at 12 o'clock, as is subsequently the case when the child coordinates conceptually (and no longer only in his physical actions) the need to aim at the target, on the one hand, with the circular trajectory of the rotation, on the other, in order to judge the correct release point. When a subject sees someone else (either the interviewer or another child) in action, he is sometimes better able to determine the release point, since he is no longer solely concerned with his own action. The ini-

tially correct answers given by some of these young children (they subsequently become more involved and correspondingly less accurate) stem from a simplistic view of the task. Older children see far more problems.

Level IB

Although there is no real homogeneity in the reactions at this level, they clearly indicate a transitional stage between levels IA and IIA. The subject may no longer consider it essential to be opposite the target; or (without a set target) he may now predict that the ball will go off in the same direction as he has been turning it; or he may designate 12 o'clock, or some other point, as the release point. But a child at this level, unlike one at level IIA, does not grasp all three of these points.

Examples

BOR (4,7), with no set target, forecasts that with a right rotation the ball will go off to the right and with a left rotation *it isn't the same; it would go on the other road* (to the left). Still, when a target is placed and then moved, he always puts himself opposite it and in fact does get the ball into the box. He considers the release point to be 12 o'clock.

CAR (5,8) succeeds by releasing the ball at about 11 o'clock, but thinks that the ball left him opposite the target, at 12 o'clock. Without a target, he predicts that with a right rotation the ball will go off opposite or to the right, and that with a left rotation it will go off opposite or to the left; but when he tries again with a target, he releases at 9 o'clock and thinks that he has rotated to the left and not to the right, while admitting that he released before 12 o'clock.

CEL (6,0) first of all thinks that the ball will drop to the floor at the point where she releases it, then

notes that *it goes far,* but without forecasting in which direction. Nevertheless, with the target opposite 12 o'clock she releases the ball at 9 o'clock, but thinks 12 o'clock is the release point. Rotating the sling the other way, she releases at half past two: Where did the ball go? (CEL goes through the motions of two rotations and then a release at 6 o'clock, indicating that the ball travels first to 12 o'clock and then on toward the box.) Could you aim at the box if you were turning the sling the other way? *Yes.* Where would you let it go? *Here* (12 o'clock).

REN (6,4) doesn't forecast the ball's trajectory in the case of a right rotation, but thinks that if you turn to the left, the ball will go straight forward from the 12 o'clock position or at right angles to the left. With a set target, she is immediately successful by releasing at 9 o'clock and agrees to change her position without insisting on staying opposite the target. However, after another success, she still thinks that the ball travels across the circle: 6 o'clock → 12 o'clock → target. Subsequently, she says that she releases *when I see that it's on the line* (from 12 o'clock to the target), but as the ball misses the box, *it was nearly there, but it turned before it got to the box.* Later, she announces that *if you turn this way* (right) *the ball will go to the right, and like that* (left) *it goes to the left,* then nine times she indicates 12 o'clock as the release point.

Progress achieved at level IB is thus only partial and varies from subject to subject without any clear pattern.

Level IIA

Examples

FRA (7,7) (who has not quite reached level IIA) is placed at 6 o'clock with the box opposite 12

o'clock: Where will you let the ball go? *There* (12 o'clock). Can you try? (The ball is released at 9 o'clock and almost reaches the left side of box.) *I ought to let it go a bit nearer here* (1 o'clock), so, had she corrected from the 9 o'clock position instead of the 12 o'clock one, her answer would have been right. In fact, she then releases the ball at 7 o'clock. Where did you let it go? *Here* (10 o'clock); *I made a mistake.* (She changes her own position to near 9 o'clock and successfully releases the ball at 9 o'clock as well.) Why did it go in? *I was a bit more there, to the side: like that, you can let it go a bit more like that* (ball going in a straight line from 9 to 2 o'clock) *and it goes there* (as if the ball had turned through a sharp angle at 2 o'clock to get into the box opposite 12 o'clock). The interviewer then moves the box and puts it opposite 6 o'clock, with the child staying opposite 9 o'clock. FRA successfully releases the ball at 3 o'clock: Where did you let it go? *There* (12 o'clock, as if the ball had to travel in a straight line from 12 to 6 before dropping into the box). The interviewer then suggests that he himself try it, following her instructions, that is to say, she must call out *go* when it is time to release the ball. The child then goes to the 6 o'clock position, with the target opposite 12. FRA says *go* at 12 o'clock (incorrect): Should I have let it go before or after? *Before* (points to 10 o'clock). Then FRA has another attempt herself and successfully releases at 9 o'clock, although again pointing to 12 o'clock as the release point. Didn't it go off from there (9 o'clock)? *No, there* (between 10:30 and 11 o'clock, thus an intermediate position between 9 and 12).

COR (7,6), starting without a target, correctly indicates that if you turn to the right the ball will go *over there* (to the right), and only to the right. Could it go anywhere else? *Yes, there* (points to the wall, moves so that she is opposite it, and indicates a trajectory perpendicular to it). Then she again points to trajectories on the right. How about trying

to make it come toward me (interviewer stands near 12 o'clock)? (Successfully releases at 9 o'clock but points to 12 o'clock). *I let it go here* (12 o'clock—she then actually does this and misses the target). Where now? *There* (10 o'clock, which is a good correction). And if I go here (opposite 12 o'clock)? *There* (2 o'clock, followed by another accurate correction). And if I go here (7 o'clock)? *There* (7 o'clock—her first attempts are unsuccessful, but then she tries again and successfully releases before 8 o'clock for a left rotation and near 6 o'clock for a right rotation, thus clearly having good motor regulation). Where did you let it go? *There* (7 o'clock for her actual release point of before 8, and 7:30 for that of 6). She draws a curved trajectory starting off opposite the target and perpendicular to the tangent.

MAR (7,6), starting off with a set target opposite 12 o'clock (child positioned opposite 6 o'clock): *I've got to aim* (he releases at 8 o'clock: misses). What did you do? *I let go too quickly* (second attempt: releases at 9 o'clock, successful). However, he indicates a release point of 10 o'clock, then after another miss from 8 and renewed success from 9, he indicates 11 o'clock as the release point. The box is then moved to opposite 1 o'clock: Now where are you going to let it go? *There* (1 o'clock). In accordance with the interviewer's instruction, he marks the spot with a cross, but then goes on to release the ball after the cross. Now, I'm going to try it; you tell me where to let go. *Where the cross is* (the interviewer does this: misses). *It wasn't quite on the cross . . . You let it go right, but it won't work, because when it's going around, the ball keeps on going around.* The box is then placed opposite 10 o'clock, and the child makes several attempts so that he can really do it properly. On the sixteenth try, he releases at 8 o'clock for a right rotation and at 4 o'clock for a left rotation. How do

you do it? *When you see that the ball is there* (10 o'clock), *you see that it's there, then you let it go.* After fresh attempts, he is asked to choose between 8, 9, and 10 o'clock: he points to 9 as a compromise between what he sees actually happen and what he feels should happen (conceptualization).

TON (8,6), with the box opposite 12 o'clock, lets go of the ball at 8 o'clock. (Miss.) *It went off to the left* (of the box) *because I let it go when it was there* (11 o'clock instead of 8 o'clock!). Where should you have let it go? *There* (12 o'clock, which she means to try to do, but in fact releases it at 8 o'clock). *It's gone again* (to the left of the target). Are you going to change where you let it go, or go on as you were? *Do the same, aiming better.* Can you aim at the target? *No.* What about me? *Yes.* You told me that you wanted to let it go here (12 o'clock)? *No, more there* (1 o'clock: she thus moves the release point in the right direction with respect to the supposed, not the actual, point of 8 o'clock). (She tries again, releasing at 8:30, but pushing the ball with her hand.) *It always wants to go somewhere else.* How come? *Because my aim's bad.* Try again. (Releases at 8:30.) Put this (small object) where you let go of the ball. (Puts it at 11:30, then successfully releases at 9 o'clock.) Good. Where did you let it go? *Here* (11:30). I'm going to try: you say *go* when I ought to let it go. (She says *go* at 12 o'clock and the ball goes toward the child.) *It's come to me!* Where did I let it go? *Here* (2:30! opposite the subject). This does not stop TON from continuing to say *go* at 12 o'clock, attributing her misses to the fact that the ball goes too slowly. She tries again herself, releasing at 8:30, then successfully at 10, but indicates the release points at 12 and 11 o'clock. She even changes the direction of rotation without realizing it and successfully releases five times at 2:30, then misses three times (at 1, 3, and 3:30). When do you get it in and when do you miss? *When I let go*

of it there (at 2:30—so she does realize her mistake!) *I miss, and when I let go of it there* (12 o'clock) *I get it in.* Have a good look. (2:30—success.) Where did you let it go? *There* (1 o'clock). The drawings are at first almost correct (ball's departure virtually along a tangent, with the trajectory curved toward the box), but subsequent drawings match her conceptualization (trajectory virtually perpendicular to the box). Look: I'm going to let go there (successful release at 9:30). (TON is amazed.) *It went in the box.* Where did I let it go? *There* (12 o'clock). Have another look. (successful release at 9 o'clock.) Did I let it go at the right time? *No*! Are you sure? *Yes.*

VER (8,0) rotates to the left and successfully releases at 2:30. Where did you let it go? *There* (1 o'clock). *It went straight off and went in the corner of the box.* How did it turn? *Like that* (toward the right—incorrect) *around my hand.* When the interviewer successfully releases at 10 o'clock, she recognizes that it is the right place because it went in the box; but soon afterward, when she is asked to make a drawing, she draws a straight line from 12 o'clock to the box. But to be sure of getting it in? *There* (12 o'clock).

JOS (8,0), by contrast, having successfully released at 9 o'clock and almost reached the box from 8 o'clock, indicates that he released at 12, then at 11:30, then at 10, thus gradually bringing his conception nearer to true cognizance of the event and showing that he is close to level IIB; however, a moment later, when asked to mark the release point, he says, *If you put it more to the left the ball will go farther to the left, while if you put it more here* (opposite the target) *it goes into the target.* When the interviewer releases the ball at 3 (left movement), *You've done it right, but the ball went straight . . . sometimes it goes straight for a bit*

and sometimes it goes around for a bit. (Fresh attempt.) *It kept on going* (on the tangent), *it didn't want to turn.*

ISA (9,2), starting without a set target, predicts the release points *there or there* on the correct side or opposite her. The box is then placed in position and she releases at 6 o'clock (thus opposite 12), at 8 o'clock, and twice successfully at 9. Where did you let it go? *Here* (at 12), and so on with slight variations between 11:30 and 12:30, while continuing to release successfully between 9 and 10.

COL (8,10 then 9,0) at the first session starts off with reactions similar to those of the preceding subjects; she attributes her misses to the fact that she was *not yet quite near the target, not opposite.* When the interviewer takes the sling, ISA suggests that he release at 12, then when the ball misses the box, recognizes that *you've got to let it go a bit before,* having clearly located the release point, which leads her to say: *The ball flies off to the side,* and so on. But after two attempts at releasing at 9 o'clock, she sums up from memory: *If I made it go from there* (12 o'clock), *it could go there* (a little to the right of the target) *or there* (in the box). During a second session she progresses to level IIB.

Thus, all the subjects initially questioned without a set target think it possible to predict whether the ball will go to the left or to the right according to the direction of the rotation, although they cannot specify the actual direction or, of course, the relevant tangential departure of the ball. Instead, they designate a sort of special area, with possible variations, but take no account of the release point. Furthermore, these subjects succeed in reaching the target regardless of their location or that of the box, without asking to be placed opposite the target. On two counts this provides us with evidence of decentration regarding the actual action, since in their prediction of the trajectories these children pay more attention than