

III. THE APPLICATION OF PIAGET'S THEORY TO THE TRAINING OF THE SUBNORMAL

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I. INTRODUCTION

The main educational application of Piaget's work is that it offers a means of teaching subjects when children have the necessary concepts for understanding them. According to Piaget (1950) the child's intellectual development proceeds in a definite sequence, in which different kinds of thinking succeed one another. With certain forms of thinking the child attains some concepts that underlie school subjects; other concepts depend on the subsequent development of a more advanced type of thinking. For example when they show the type of thinking which Piaget has called concrete operational, children have a concept of number which enables them to understand the principles of elementary calculations and to perform the measurement of length with understanding. More advanced concepts, for example those that make possible the understanding of the measurement of area and volume, depend on the form of thinking which Piaget has termed abstract operational. Inhelder and Piaget (1958) have shown that with this development children can discover for themselves some of the principles taught in secondary school science, if they are given the appropriate material to experiment with. Lovell (1961) repeated some of these studies, and reports that children who had been instructed in the experiments before they had the concepts for understanding the general principles tended to forget what they had learned or to retain it only as rote knowledge; teaching when children had the necessary operational concepts appeared to be of greater value. Similarly Biggs (1959), surveying studies of the teaching of number by different methods, concluded that teaching by "understanding" at a later age followed by drill was more effective than drill without understanding at an earlier age.

Studies of subnormal children and adults reveal that concrete operational thinking is rarely found in junior training centres, though some adults in the senior centres may have developed it. This indicates, for instance, that the teaching of number is inappropriate in relation to the concepts of children in the junior centres.

The principle of teaching in accordance with children's concepts does not imply that the teacher sits back and passively waits for the concepts to mature. Maturation undoubtedly plays a part in their development, but Piaget stresses also the role of experience, particularly in the form of the child's activities with objects during infancy (Piaget, 1953) and later in relation to the development of concepts of space (Piaget and Inhelder, 1956). Moreover Churchill (1958) has demonstrated that appropriate experiences encourage the development of number concepts in normal children.

Hence the educational task with children who have not the concepts of number and space to be able to learn elementary calculations, etc., is that of providing them with appropriate manipulative and other experiences that will foster the development of these concepts. For this Piaget's investigations of the process by which concepts develop are of great value.

Studies of subnormal adults and children (Woodward 1959, 1961, 1962) have indicated that they develop through Piaget's sequence in the same order as normal children do. The difference is in the rate of development through it, and in the

end point which is reached. To apply the results of Piaget's work to the education of the subnormal therefore we need to know at what ages they achieve the different types of thinking. Then those activities of training centres which have the object of encouraging the maximum development of intelligence can be graded progressively in accordance with the development of children. Thus Piaget's theory provides a rational basis for this aspect* of training centre activities.

II. CONCEPTS OF NUMBER AND SPACE

The study of concepts of number and space is probably most relevant to training centre activities; these involve Piaget's intuitive and concrete operational thinking, beginning normally at about four and seven years respectively. Two stages occur before this. The first, the sensori-motor, ends at about the age of 18 months in normal infants and at any time after about the age of three years in severely subnormal children, the age depending on the degree of subnormality. During most of this stage (Piaget, 1953 and 1955) the child is gaining experience of objects through manipulating them. But his world is bound by what he directly perceives; "out of sight" is literally "out of mind." Developments during this stage culminate in the child's ability to respond to objects in their absence, as for example when he searches persistently for a toy he has lost. Objects begin to be represented internally in symbolic form, in memory images; symbolism is also evident in imaginative play and in language. Further developments in these occur during Piaget's next stage, the pre-conceptual (Piaget, 1951). After the intuitive and concrete operational stages, the final stage of abstract operations develops, from about the age of 11 years in normal children; it is not likely to be found in the subnormal.

One of the main features of the intuitive stage is that the child's thinking is dominated by what he sees in front of him rather than by successive events which he has just seen. The following illustrations are drawn from Piaget's (1952) investigations of number concepts and replications of some of these with subnormal adults and children by the writer (Woodward, 1961). If the subjects are presented with identical glasses containing the same amount of liquid, they agree that there is the same amount in both glasses; but if the contents of one glass are poured into a glass of a different shape, e.g., taller and thinner, they maintain that there is more liquid in the latter, "because it is higher." They hold to this view, even when they have seen the water exchanged between the glasses several times.

An individual who does not realise that a quantity remains invariant, regardless of the spatial form it may take, has not the necessary concepts for understanding elementary calculations with numbers. Operations of addition, multiplication, etc., cannot be performed on numbers that are believed to vary with the spatial arrangement of the concrete elements. Piaget has demonstrated these points by further experiments. For example the young child of five or six years does not agree that, if he has four sweets in the morning and three in the afternoon, he will have the same total number of sweets if he has five in the morning and two in the afternoon. Nor is it evident to young children without checking that if five and four add up to nine, four and five will necessarily give the same total. Similarly the reciprocity between addition and subtraction is not realised. Faced with the problem of making equal in number two unequal groups of counters, say six and 16, the young child goes on adding to the smaller group from the larger as if the latter were inexhaustible. Some manage by intuitive thinking to solve this problem, though in a laborious trial and error manner, e.g., some of the severely subnormal

* This is usually referred to as "sense training" but this term is considered by the writer to be outmoded and inappropriate. The activities it refers to help to develop perceptual and motor co-ordinations and concepts.

adults who were observed counted both groups of counters, moved one over from the larger to the smaller group, counted both groups again, moved another over and counted, and so on until they arrived at the solution.

During this stage, however, accurate object counting can be achieved. The operation of assigning one number to one object is a matter of pairing, or of making a one-to-one correspondence between numbers and objects. Children at the intuitive stage can place a row of counters in a one-to-one correspondence with another row. But if the counters of one row are spread out or closed up, the individual in the intuitive stage thinks there are more in the longer row. With discrete elements then, as with continuous quantities (the glass problem), the individual at this stage has not a concept of the invariance of numbers, independent of the spatial arrangement of the elements. Thus ability to count objects does not by itself imply ability to understand the principles of elementary calculations, though specific additions, etc., can be learned off by heart. Similarly, ability to recite numbers does not mean that a child can learn to count objects accurately. Some children who reel off numbers cannot make a one-to-one correspondence of two rows of counters. They think they have complied with the instruction if they make another row of the same length.

Furthermore, the ability to recite numbers in the correct order does not mean that numbers are understood as a series, in which each number has one place, where it is more than those before it and less than those that follow. This can be demonstrated with an experiment using sticks graded in length; these sticks have to be placed in order of size. Severely subnormal children and adults who lacked a concept of a series could compare two sticks at a time and select the longer one: they could by this means place the sticks in order in a trial and error manner, by comparing only two sticks at a time. But their limitations were revealed when they were given a second set of sticks to be inserted alternately in order of size in the first set, since the solution requires either selection each time of the next longest stick or the comparison of three sticks at a time; this could not be done with a trial and error method.

Similarly Piaget and Inhelder (1956) have demonstrated the limitations of the thinking of five- and six-year old children when they deal with problems involving concepts of space, and this has also been found with subnormal adults and children. The main feature is a failure to use external reference points in their concepts of space, since they cannot, in their thinking, step outside their own viewpoint. During this stage they are, however, able to reproduce a spatial sequence under certain conditions; for example, given a model of coloured beads on a rod, they are able to place beads on another rod with the colours in the same order. But they have difficulty in reversing the order; this involves concrete operational thinking.

At the stage of concrete operational thinking (beginning normally at about seven years) the child understands numbers as a series; he considers that numbers are invariant whatever the spatial arrangement of the concrete elements, and he gives a logical reason for his belief. He takes account of successive events, of two factors at once, and of other viewpoints besides his own. He thus has the necessary basis for understanding elementary numerical operations.

The next question to be considered concerns the ages at which these stages occur. In a study by the writer, intuitive thinking for number concepts was not found in severely subnormal children below the age of 10.9 years; only two children under 11 years showed this type of thinking for spatial concepts. (Intuitive thinking was, however, found in two younger E.S.N. children in the group.) One older E.S.N. child showed concrete operational thinking for all problems, and another was approaching this level. Only four of the older severely subnormal children

showed concrete operational thinking for one spatial concept problem. Thus children in the junior training centres range from the beginning of Piaget's pre-conceptual stage to the end of his intuitive stage. The latter begins to appear some time after the age of 11 years.

At the senior training centres some adults may have reached the concrete operational stage. Some of the 50 adults who were investigated had number concepts at the concrete operational level, and they thus had the basis for understanding elementary calculations. If classes on elementary number are held in the senior training centres, this method of selection is useful. The number concepts of the adults can be directly investigated, instead of being inferred from an intelligence test result. In the group of 50 adults there was little relation between I.Q. and number concepts in the I.Q. range of 50 to 70. For example one adult with a Wechsler I.Q. of 47 and two others with Wechsler I.Q.s of 55 had operational number concepts on all problems.

What are the implications of these results for the teaching of number and letters in the junior training centres? Children under about the age of 11 years (and many older ones) are unable to make a one-to-one correspondence between two sets of objects; it is therefore unlikely that they will be able to learn to make one number correspond with one object, in counting. They are also unable to reproduce the order of a row of objects; a sequence of letters and words will have little meaning for them. Older children, however, will be able to count accurately, though the studies quoted suggest that virtually all severely subnormal children lack the concepts necessary for the understanding of elementary calculations. Indeed if a child does develop these concepts (concrete operational), then it is doubtful whether he should be considered to be severely subnormal: he would be more suitably placed in an E.S.N. school than in a training centre.

Thus the most suitable material for the older children, when they can count accurately, is that which is most likely to facilitate the development of concepts of number and space.

Apparatus of a jigsaw type, in which children fit a piece with three apples to another piece on which is written the figure three, in fact teach children very little about number; the children can match the pieces correctly by fitting, without needing to observe and match the number of objects with the figure. Ability to fit two or three pieces of a picture puzzle together by shape develops well before elementary number concepts (see section III). Material is more useful if it requires the child to match or pair sets of objects in a one-to-one correspondence, to place in order elements that are graded in length, to break up a number of elements in different ways and reassemble them into a whole; to divide up a whole into two equal parts, or to make two unequal groups equal.

Since motivation is an important factor in learning, children will learn more from this sort of material if it is interesting to them. This interest might be achieved by making it a game; research is needed to try out such games, in order to find out which are most interesting and practicable.

In order to encourage the development of concepts of spatial order, activities which require children to copy a sequence of items in the same order would be useful. Children who can copy a spatial order can also copy letters in the correct order; it was found, however, that severely subnormal children tended to be relatively most backward in drawing. Nearly half the children who could copy a spatial order correctly were unable to draw a square or triangle from a model; they produced either a circle, or a circle with corners beginning to appear. Thus such children may be able to copy the order of letters, but not to reproduce their shape correctly. This

accounts for the rows of circles which some severely subnormal children produce when copying letters. Such an activity seems useless until the children can copy shapes more accurately. Moreover mere ability to copy or to recite the alphabet is far removed from the skills necessary to learn to read.

III. MANIPULATIVE MATERIAL FOR JUNIOR TRAINING CENTRES

Piaget's studies of intuitive and concrete operational thinking in concepts of number and space suggest manipulative material only for older severely subnormal children. His investigations of the pre-conceptual period, dealing with symbolism in dreams and imaginative play, cannot be applied in this way. Thus a study of this period in severely subnormal children was made by the writer, using Piaget's method of approach. This means that attention was directed to the method the children used to tackle the problem, instead of to the fact of success or failure alone, or the time taken to succeed. The aim was to study, through observations of children's manipulation of various kinds of material, the functions that develop in this period, and then to derive a progressive sequence of manipulative material appropriate to classes in junior training centres.

The 105 children studied were all those attending the training centres of the Fountain Hospital Group, with the exception of those with a severe motor or visual handicap, or severe emotional disturbance. This investigation was carried out at the same time as that on concepts of number and space, though only 44 of the 105 children were sufficiently advanced to tackle the latter type of problem.

Appreciation of differences in size and form is necessary for the development of concepts of number and space. Hence manipulative materials varying in size and form were used, together with some picture problems, as follows:

1. a wooden box of 16 bricks (one-inch cubes).
2. a nest of 12 cylindrical cups.
3. a nest of four cubes.
4. the Seguin formboard (10 geometrical figures).
5. the three picture puzzles from the Merrill-Palmer intelligence test (Stutsman, 1931) consisting of two, three and four pieces respectively.
6. the Manikin item from the Merrill-Palmer test (trunk, head, arms and legs to be assembled).
7. a two-figure board (a cross of four pieces and a rhombus of five pieces).
8. the Picture Arrangement test from the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949).
9. the Block design test from the WISC.

For the first four items spontaneous manipulation was observed; then a specific task was suggested for items 2, 3 and 4, namely nesting and completing the formboard, if this had not already been done spontaneously. Observations were made of the method the child used, both in success and in failure. The Merrill-Palmer and WISC instructions were followed for tests taken from these scales.

For the nesting problems and the formboard task, three levels of performance were distinguished: (1) efficient method based on selecting the cups and cubes by size and the blocks for the formboard by form. (2) trial and error methods (several methods were used, but they are not considered separately here; the more technical implications of these for learning will be discussed elsewhere). (3) inappropriate

use: the material was used in other ways without any attempt at a solution of the task.

Tasks were placed in an order of difficulty, indicated by the number of children who used the trial and error and the most efficient methods. On the basis of this and of the results of the study of concepts of number and space, the following categories were derived.

Piaget (1955) observed that infants of 12 to 15 months (before the end of the sensori-motor period) repeatedly put small objects in and out of larger, hollow ones, and he concluded that they were learning about spatial relations. This type of play with the bricks and box was found among the youngest of the present group, who had reached the end of the sensori-motor period in other respects. Their use of the other material was of the inappropriate type. These children form category A in Table 1.

Succeeding this type of brick play was another, fitting the bricks neatly into the box. This, as was the in and out play, was a very dominant interest with some children who resented interference with it, or suggestions that they might, for example, build with the bricks. Some of these children used the rest of the material inappropriately (category B in Table 1), but some began to tackle the nesting problems in a trial and error manner (category C in Table 1).

The next group (D) in addition began using trial and error methods with the formboard. Those in category E were guided by size in either or both of the nesting problems, and Group F in addition were guided by form in the formboard task. Children placed in categories A to F all failed to achieve intuitive thinking for the number and spatial concept problems, or failed to understand the task. Category G consists of children who achieved partial success with the easiest spatial order problem, but did not succeed in copying it correctly.

The three groups of children showing intuitive thinking are as follows: H, Intuitive thinking for the spatial order problem but not for number, i.e., they could copy a row of coloured beads in the correct order. J, Intuitive thinking for both spatial and number concepts, i.e., in addition to copying the spatial order, they were able to make a one-to-one correspondence between two rows of counters. The four children in category K showed concrete operational thinking for one spatial concept problem (copying a spatial order), though they still performed all number tasks in an intuitive manner. Most of the children in categories H to K were guided by form in the formboard task, and they used size in the nesting problems.

The numbers of children in each of these categories and their ages are shown in Table 1. (E.S.N. children have not been included in this analysis.) Of the 105 severely subnormal children, 101 were classifiable in the categories in Table 1. Four had slightly different patterns of results, and did not fit into these categories. (All four were pre-conceptual.)

The numbers of children in the above categories who succeeded with the other five types of problem are shown in Table 2.

It will be seen that success with simple picture puzzles (two or three pieces) begins to occur among children in category D, who were solving problems involving size and form in a trial and error manner, and is more frequent among children in categories E and F, who were beginning to be guided by size and form. The method of all these children with the picture material was to try the pieces in various ways until they fitted together. They did not appear to be using colour or the pictures as an aid; none of them succeeded with the problems which required use to be made of the picture or colour (the Manikin, picture arrangement and block design prob-

TABLE 1
Manipulative Categories and Age

Category	Manipulative material:				N	Age in years:	
	Bricks	Cups	Cubes	Form-board		Median	Range
A	In/out	0	0	0	10	3.7	3.0 to 4.8
B	Fitted in box	0	0	0	7	7.6	6.2 to 11.6
C1	"	0	t & e	0	8	8.6	6.8 to 14.5
2	"	t & e	0	0			
D1	"	0	t & e	t & e	10	9.75	6.2 to 14.9
2	"	t & e	0	t & e			
E1	"	size	t & e	t & e	22	9.9	7.2 to 15.5
2	"	t & e	size	t & e			
F		size	size	form	6	11.3	6.9 to 14.1
Concepts:							
	Space				Number		
G	Pre-conceptual (partial success)	Pre-conceptual			9	12.2	11.3 to 14.6
H	Intuitive	Pre-conceptual			6	11.7	9.75 to 15.9
J	Intuitive	Intuitive			19	13.9	10.9 to 15.9
K	Concrete operational	Intuitive			4	13.4	11.6 to 14.7

0=inappropriate use, t & e=trial and error method.
size=guided by size, form=guided by form.

Categories A to F were pre-conceptual for the number and spatial concept problems.

TABLE 2
Manipulative Categories and Success with other Problems

Category	No. in each category	Picture Puzzle No			Manikin		2-figure board		WISC P.A.* score 1+	WISC Block Design Score 1+
		1	2	3	Partial Success	Correct	One correct	Both correct		
A.B.C.	25	0	0	0	0	0	0	0	0	0
D.	10	8	5	3	0	0	0	0	0	0
E.F.	28	23	20	10	4	0	4	0	0	0
G.H.	15		15		2	3	6	2	2	0
J.K.	23		23		12	7	13	9	21	16

* Picture Arrangement.

lems in which fitting by shape was not possible). The intermediate groups (G and H) did little better with the picture and design tasks. In fact, there was a total failure with the block design type of problem until children could pair rows of objects and copy more complex spatial orders (categories J and K).

These results suggest that ability to use size and form when co-ordinating perception of these with motor activities develops before use can be made of colour and pictures in a similar manner. (Actual discrimination of size, form and colour probably develops earlier, since this appears in normal children before they can deal with these types of problem.)

From the results in Tables 1 and 2 a scheme of manipulative activities for junior training centres has been derived. The assumption is made that the child's manipulative interests and the methods he uses are pointers to the functions he is developing: if young children, or at any rate, emotionally stable ones, keep on at the same activity, it is likely that they are learning something from it. (Other factors enter into the manipulative activities of emotionally disturbed children.) Interpretations of the method used by the children were made as follows: if the child uses a particular material in an inappropriate way, then that material is too advanced for functions which he is developing; if he tackles it in a trial and error manner, then it is useful in encouraging the appearance of developing functions; if he tackles it by the most efficient method (e.g., being guided by size and form in the nesting and formboard problems) then the function has already developed, and the material has little developmental value for him.

The suggested sequence of successive functions and the appropriate material to foster their development is as follows. The youngest children, although they had reached the end of the sensori-motor period in that they responded to objects they did not directly perceive, were still manipulating objects in the manner of children in the last stage but one. They thus need hollow containers and small objects such as bricks, and also spinning objects, water and vessels for pouring. These younger children put a few bricks in the box and took them out again, repeating this without ever putting all the bricks in the box. The next group, on the other hand, appeared interested in fitting the bricks neatly and closely into the box, so these need a container which exactly holds the bricks (e.g., a trolley and bricks). This fitting behaviour has also been observed in the classroom. If the available material does not readily lend itself to this activity they try to make it do so. With a "posting-box" type of equipment, in which differently shaped blocks have to be "posted" in the appropriately shaped slits, they dismantle the box and use the lid as a container into which to fit the blocks. They become annoyed when the blocks do not fit neatly into the lid, as bricks do in a box designed to hold them. Such a strong interest suggests that the activity has a developmental function, and its use indicates a need in the first class of a training centre for material that provides opportunities for its exercise. Differently shaped blocks would be too difficult, but ordinary boxes of bricks in the shape of cubes, or trollies holding cubes, would be suitable. Picture puzzles are beyond the capacity of these children, so that colour and pictures are more usefully introduced in the form of picture books.

The trial and error methods of the next groups with the nesting problems and subsequently with formboards suggest that this material is useful in developing perceptual-motor co-ordination in relation to size and form. Simple picture puzzles may also be useful, though the children depend on fitting shapes for a solution.

When the ability to use size and form has developed, more complex formboard material (several pieces for a form) appears appropriate. It may also be useful to introduce material that requires the child to copy the order of elements (colours on a string). For the more advanced classes (mainly for children over the age of 11 years) the number material suggested earlier in this paper is suitable, together with more complex types of picture material which cannot be fitted, so that children have to make use of the picture.

The scheme outlined is only a preliminary one based on the study of a few problems. It is, however, suggested that further investigations of this type could provide the basis for a scheme of progressively more complex activities for successive classes in junior training centres, based on functions which are successively developing.

The scheme, of course, deals only with manipulative activities, and is concerned only with the development of perceptual and conceptual development. Other

important aspects of training, such as gross motor activities, opportunities for imaginative play, language development, drawing, music, dancing and games, are not of course dealt with.

One further point should be mentioned. It is not being suggested that children who are unable to use size, colour and form in a problem, or to use trial and error methods to tackle it, should be deprived of material that is varied in colour, size and form. Material that varies in many respects is obviously important for their perceptual development. The point being made is that they should not be pressed either by the nature of the material or by the teacher to attempt to use in a "correct way" material that is too far advanced for their stage of development. If the material has various possibilities, the children can handle it in a manner dictated by their developmental needs. Whether they need to be shown other ways of handling it, or whether they can in time discover this for themselves, is a matter for research. At any rate there is no harm in the teacher's showing the child an alternative way of dealing with it, without insisting on it. Frustration for both teacher and child arises only when pressure is applied to adopt the alternative method when it is well beyond the child's capacities. The order in which children's abilities develop therefore needs to be known. The value of Piaget's approach is that the sequence of progressively more complex developmental steps can be distinguished. The educational task is to provide the experiences that are appropriate to the point the child has reached in this sequence, so that the development of the next step may thereby be encouraged.

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