THE NEED FOR A SCHEMATIC LEARNING THEORY

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SUMMARY. Current learning theories have little direct application to problems of teaching and learning school subjects. The development of a schematic learning theory will, it is hoped, help to remedy this deficiency. Such a theory will also have wider applications.

I.—INTRODUCTION.

AMONG the branches of psychology applicable in the field of educational research, one would expect learning theory to be the most prominent of all. Learning is a child's chief task throughout his school days, and beyond: and the teacher's main concern is the extent and quality of this activity. How much help in these tasks have psychologists been able to offer, and teachers to use?

A search of the three main journals in the field of educational psychology and research, over the 21 years from 1940 to the year of writing (1961), has only revealed a total of five papers on applications of learning theory; the distribution being as follows:

British Journal of Educational Psychology—None.

Journal of Educational Psychology—Three.

Journal of Educational Research—Two.

This most important topic seems to be much neglected: and the reason is not far to seek. In one of the five papers listed above, Buswell* (1956) says: "Without the slightest criticism of experiments in general psychology, we cannot continue to be satisfied with implications for education from results of experiments with simple mental processes, with animals, and at the sub-language level . . . I am proposing that educational psychologists take their cues for research from the problems of learning in schools, where the processes are complex and where the learnings carried on are at the language level." In other words, theories relating to conditioning, reinforcement learning, sign learning, perceptual learning, etc., are not adequate for the classroom. A theory is required which takes account (among other things) of the systematic development of an organised body of knowledge, which not only integrates what has been learnt, but is a major factor in new learning: as when a knowledge of arithmetic makes possible the learning of algebra, and when this knowledge of algebra is subsequently used for the understanding of analytical geometry.

The only theory yet available which does this has been put forward by Piaget (1950). He calls such a body of knowledge a 'schema.' The incorporation of new knowledge into an existing schema is called 'assimilation'; and the enlargement of a schema, which may be necessary if it is not adequate for the above purpose in its existing form, is called 'accommodation.' These three related concepts would seem to offer a basis for the kind of learning theory which is needed.

* In his presidential address to the Educational Psychology division of the American Psychological Association, September, 1955.

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Yet in a standard text on Theories of Learning, Hilgard (1958) makes no reference to it. The name of Piaget does not even appear at all in the list of authors referred to. This could mean either that Hilgard is not familiar with the work of Piaget, or that he does not regard it as applicable to learning theory. The latter hypothesis seems tenable, since the book by Piaget here referred to is called *The Psychology of Intelligence* ; and Hilgard says (op. cit. p. 25) " . . . the problems of the nature of and measurement of intelligence lie outside the scope of this volume." This will perhaps seem strange to most teachers, who believe that intelligence and learning are rather closely related : and indeed, that the more intelligent a child, the better he can learn. But Hilgard does not thereafter refer to the subject of intelligence, and the learning theories he presents are indicated by the chapter headings : Thorndike's Connectionism, Guthrie's Contiguous Conditioning, Skinner's Operant Conditioning, Hull's Systematic Behaviour Theory, Tolman's Sign Learning, Classical Gestalt Theory, Lewin's Field Theory, Freud's Psychodynamics. This text is the only one on learning theory which is recommended to doctoral students by one-half or more of the American and Canadian psychology departments granting doctors' degrees, and appeared in this category in both 1953-4 and 1958-9 (Sundberg, 1960). If this text may on the foregoing evidence be taken as both representing and largely determining the state of learning theory in America, the lack of application of learning theory to education is easy to understand.*

In this country, however, the work of Piaget is rapidly becoming more widely known and appreciated, particularly during the last decade. Two authors who have played an important part in this are Peel (1956 and 1960) and Lovell (1960) : who, long before the dates of these books, were (like the present writer) presenting Piaget's work to their students. Here, if anywhere, would one expect to find presented a schematic theory of learning.

In his earlier book, Peel discusses the following learning theories : association, S-R theory, conditioned responses, Hull's reinforcement theory and Tolman's theory of sign-learning ; Gestalt psychology, and learning as insight ; transfer. The index gives six references to Piaget, but in none of these is there any reference to a schema.

In the foreword of the second of the two works cited, Peel declares that " Piaget's work forms the core of the treatment." The word ' schema ' does not however appear in the glossary, nor in the index. I have found it twice in the text (Chapter VI), but not in relation to learning.

Lovell makes only two references to schemata. One is, however, important enough to be given in full, for several reasons. It points out that the concept of the schema was described earlier by Head and Bartlett, and was taken over by Piaget who developed it and added the concepts of assimilation and accommodation. Also it contains a clue why the idea has not yet been applied to learning theory.

> (page 97). " Much earlier, Head, the distinguished neurologist, had proposed that the cortex . . . was a storehouse of past impressions which normally remain outside consciousness. These impressions form organisations called *schemata* which modify all future impressions produced by incoming sensory data, so that all perception is affected by what has gone

*A colleague has since called my attention to a passage in the last chapter in which Hilgard himself points out the need for learning theories which are more relevant to real life situations, and refers to "the sterility of contemporary learning theories". I would therefore like to remedy a possible implication in my reference to his work, that he was less aware of their shortcomings than he here shows.

> before. Somewhat similar views on the building up and functioning of schemata have been proposed by Bartlett* and Hebb†. For Piaget *assimilation* and *accommodation* are fundamental processes. The former term implies the absorption and integration of new experiences into previously organised schemata, and the latter term the modification of schemata by new experiences or the build-up of new schemata."

This extract is in the chapter called " Imagery and Thinking," and it will be seen that the concept of the schema is considered only in relation to perception, and with a background of neurophysiology. In the chapter devoted to learning, it plays no part at all.

Without, therefore, doing injustice to the value of these books in providing an introduction to many aspects of Piaget's work, I think that it is fair to say that although there may be oblique reference to it, the concept of schematic learning as such does not appear in them. This is perhaps not surprising, for Piaget presents it in a book about intelligence, and the connection with learning is not made explicit : still less its implications for practical learning and teaching tasks. Again, no criticism is implied of this important but difficult work. It was not written as a text on educational psychology.

The purpose of the present paper is to put forward the view that only by developing further a theory along the lines which Piaget has begun can learning theory be made fully relevant for educational psychology (particularly since it offers a hope of relating certain kinds of learning to intelligence) ; and to describe an experiment which both supports this view and indicates the kind of way in which a beginning can be made with the practical application of the theory in the classroom.

II.—EXPERIMENT.

The chief object of this experiment was to demonstrate the crucial importance of a schema even for a relatively straightforward learning task, less difficult than most of those required of pupils in the usual school subjects.

To isolate the schema as the experimental variable, two different artificial schemata were devised, each based on sixteen basic symbols with associated meanings. These symbols were combined into pairs and threes, and then into successively larger groups ; symbolising new meanings which were not arbitrary, but based on the meanings of the sub-groups, which, in turn, were based on those of the individual symbols. This can best be understood by reference to Figure 1, which shows part of schema 1.

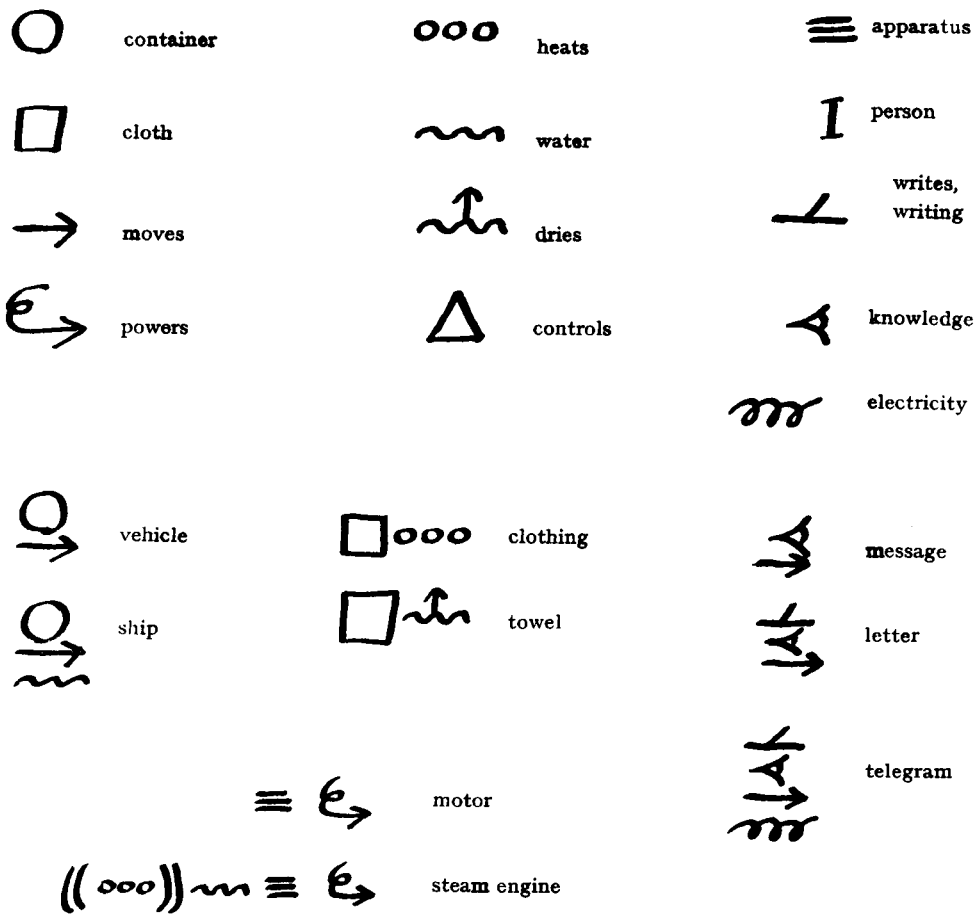
For experimental control of the other variables a second schema was prepared, similar in principle to the first. Twelve of the same sixteen basic symbols were used but with new meanings, together with four new ones. An extract from this second schema is shown in Figure 2. From considerations of space, it has only been possible to show a few of the more complex groups in these two figures. Apart from their content, however, it is hoped that they will help to clarify the concept by showing two examples of how schemata can be progressively built up.

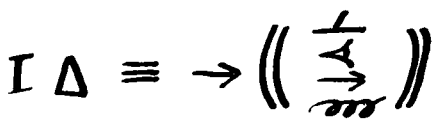
* Remembering.

† The Organisation of Behaviour.

PART OF SCHEMA 1

FIGURE 1



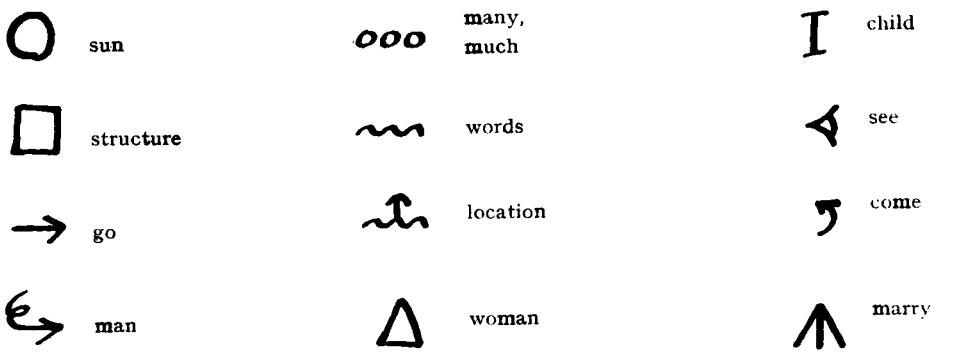


telegraphist

NOTE.— (( )) in this schema acts as a frequentative.

PART OF SCHEMA 2

FIGURE 2



The subjects were two parallel first forms at a boys' grammar school, numbering 23, 24, respectively, after excluding boys who were absent for any part of the experiment. In the preliminary part, each form learnt one of these schemata : that is, they were asked to memorise first the basic word and symbol pairs, and then the successively larger groups which symbolised new words. Pencil and paper were given to them, and they were advised that the best way to learn was by attempted recall with self-testing and correction of errors. This extended over three school periods on consecutive days, and the subjects were then ready for the final part of the experiment : which involved learning with, and without, the aid of the respective schemata which they had learnt.

For each schema a set of ten multi-symbol groups was prepared, these groups ranging from 8 to 14 symbols in size, and each set totalling exactly 100 symbols together. (One example from each final set has been included in Figures 1 and 2, being in each case the last one shown). Both forms were asked to learn both of these final sets : the task being, as before, to learn the group of symbols associated with each word. For one set, they had learnt a schema into which the new symbols and their meanings could be assimilated ; for the other, their own particular schema was no use. The aid given by the schemata could thus be quantified, by combining the scores which represented schematic learning for each group, and comparing these results with the combined scores on non-schematic learning (hereafter called rote learning). Both groups of subjects were learning the same total material, the two halves of which were approximately equal objective difficulty. There was, of course, a considerable subjective difference ; but this, the effect of the previously learnt schemata, is just what the experiment was concerned with.

TABLE 1

SUMMARY OF EXPERIMENTAL DESIGN.

Subjects.	*Preliminary stage.*	*Final tasks and their nature for the subjects.*				
Group I	Learn schema I	Learn material assimilable to schema I	Schematic learning	Learn material assimilable to schema II	Rote learning	
Group II	Learn schema II		Rote learning			Schematic learning

Composition of scores.

Schematic learning :	Group I, recall of material fitting schema I, combined with Group II, recall of material fitting schema II.
Rote learning :	Group I, recall of material fitting schema II, combined with Group II, recall of material fitting schema I.

The experimental design is summarised in Table 1. It took care of any slight difference between the abilities of the two forms, and also of whatever differences there may have been between the two final tasks. The number of presentations of the individual symbols previously to the final tasks were equal for the two schemata. It should further be emphasised that, in the final test, all the subjects were learning to associate new groups of symbols with new meanings. There was no question of learning different meanings for any of the basic symbols, or earlier groups of symbols, which they had already learnt.

III.—RESULTS.

In Table 2 are shown the percentages of symbols correctly recalled by all subjects immediately after learning, the following day, and twenty-eight days later (i.e., twenty-nine days after the original learning). By ' total scores ' is meant percentage recall of all the symbols in the final learning task. The ' controlled scores ' are calculated for those symbols only which occurred in both schemata, and which for each group constituted twelve of the sixteen originally learnt by them.

TABLE 2

PERCENTAGE RECALL BY ALL SUBJECTS (N=47).

	Immediate	1 day	28/29 days
Total Scores :			
Schematic learning	70	68	51
Rote learning	35	26	7
Controlled Scores :			
Schematic learning	69	69	58
Rote learning	32	23	8

In both cases, the difference between schematic and rote learning is striking. Schematic learning resulted in twice the number of symbols being recalled immediately after learning, and seven times as many after four weeks. It gave both faster learning and better retention.

TABLE 3

AMOUNT FORGOTTEN (AS PERCENTAGE OF AMOUNT ORIGINALLY LEARNT).

	First Day	Following 28 Days
Controlled Scores :		
Schematic learning	0	16
Rote learning	28	47

The rates of forgetting, expressed in percentages of what was originally learnt (as shown by immediate recall), are shown in Table 3. It can be seen that the subjects forgot more of the rote-learnt material in a day than of the schematically learnt material in four weeks.

IV.—IMPLICATIONS FOR TEACHING.

(*a*) *Schematic presentation of material.* The obvious consequence of these results is that, so far as possible, the subject matter of lessons should be arranged in such a form that pupils can use schematic learning rather than rote learning. What this means in its detailed application to the many subjects taught in schools and colleges has yet to be worked out. The main part of this task must of course, be the concern of the teachers who are specialists in various subjects :

but further psychological research is needed to establish more clearly what are the basic principles of schematic presentation. Probably the best teachers have always tended intuitively toward this method: but only by detailed investigation of the underlying processes can it be used most effectively.

(*b*) *Triple advantage of schematic learning.* The most obvious point established by the present experiment is the superiority of schematic learning over rote learning for both immediate recall and long-term retention. But two further advantages appear when the method is considered in the wider setting of school and college learning, and also in many of the learning situations of childhood and everyday life. In schematic learning, not only the material is learnt, but *the schema itself*: which is thus available to provide the same advantages for future learning (provided that this can be assimilated to the schema). Moreover, this subsequent learning, to the extent that it makes use of the schema, is also practising it: thereby providing, without extra work, revision of the earlier material. To give a simple example from algebra: a pupil who learns to factorise is also helping to prepare a schema for learning to solve many kinds of equation. When afterwards he is solving equations by this means, he is also revising factorisation. These advantages are absent from rote learning, in which successive tasks remain unrelated.

The same is true for some of the most basic schemata, such as speaking, reading and writing one's own language. Not only is later learning made possible (and also structured) by them, but they are constantly being practised and developed during the learning and exercise of more advanced topics. These basic schemata are, therefore, never forgotten, though not practised as such after the initial learning.

Schematic learning thus has a triple effect: more efficient current learning, preparation for future learning, and automatic revision of past learning.

(*c*) *The basic schemata.* Another point arises in connection with these. When a child first enters an entirely new field of learning, elementary schemata have first to be built up *ab initio*. What other forms of learning may enter into this process is a matter for further investigation, but two points of importance for teaching seem clear. First: learning will be much slower at the stage when a new schema is being formed than later when it has become available for use as a tool of further learning. The teacher must, therefore, know at which of these stages his pupils are, and adjust his pace accordingly. Second: the experiment has shown how little is retained of material which cannot be assimilated to a schema; and the discussion of the previous section has indicated how self-perpetuating a schema tend to be. It therefore follows that whatever schemata are formed in the early stages of a child's education are of crucial importance for his future learning; and that any major changes of teaching method, beyond the powers of accommodation of existing schemata, could being progress almost to a standstill. One might well adapt William James' famous utterance about habit, and say that "we must guard against the development of schemata that are likely to be inappropriate for future learning as we should guard against the plague." Since the basic schemata are formed by children at an age before they are able to direct their own learning activities, it is parents and teachers who must guard them in this respect.

V.—Some other considerations.

To consider all the implications for psychology in general of the concepts which have here been introduced, and the leads for further research which need to be followed to develop a useful body of knowledge about the processes of

schematic learning, would be beyond the scope of this paper. Here I would like to mention two.

(*a*) *Learning theory and intelligence.* One of the criticisms here made of existing theories of learning, so far as they applied to educational psychology, has been their exclusion of the factor of intelligence. There may well be, even in adult humans, many learning processes into which intelligence does not enter. But where it is a factor at all, it is one which, to put it mildly, ought not to be to be ignored !

Piaget's concept of intelligence is a difficult one. " To define intelligence in terms of the progressive reversibility of the mobile structures which it forms is therefore to repeat, in different words, that intelligence constitutes the state of equilibrium towards which tend all the successive adaptations of a sensori-motor and cognitive nature, as well as all assimilatory and accommodatory interactions between the organism and the environment." (Op cit., page 11). It is hard to see immediately how this relates to the concepts of intelligence in the tradition of Binet, Spearman, Terman, Moray House, Wechsler, etc., which are familiar to British and American psychologists. Nor have we yet a Piagetian intelligence test, based on the above definitions.

Nevertheless, it is possible to see in the concept of a learning schema at least the possibility of a reciprocal assimilation (to use another concept from the same author) between theories of learning and of intelligence. This follows from the intrinsic properties of concepts in classifying knowledge and inter-relating it in other ways also, thereby providing a ready means of schematisation. The formation and application of concepts has always been an important feature of traditional intelligence tests. Thus, the development of certain kinds of schemata can be regarded also as functioning of intelligence. Further development of our understanding along these lines would enable us not only to estimate the extent to which an individual is possessed of intelligence, but also to indicate how this intelligence might most effectively be used for various learning tasks. We could then, perhaps, teach children to use their intelligence intelligently.

(*b*) *Meaningful vs. non-meaningful learning.* Much work has already been done relating to this, by the Gestalt school and others. A major contribution has been that of Katona (1940), who showed with an abundance of experiment that meaningful learning was better retained than rote learning, and also gave better transfer. The reader might, therefore, reasonably ask what is new about the present study.

The crucial difference lies in the introduction of the schema, itself the result of learning, as that which gives meaning. Hitherto the emphasis has been on meaning as a property present or absent in the material itself. " We defined meaningful learning as learning which proceeds by organisation appropriate to *the inherent structure of the material.*" (Katona, op. cit., my italics). Where the meaning is not at once apparent, it is considered as resulting from a sudden perceptual re-structuring described as ' insight.' This gives an all-or-nothing character to the Gestalt approach. Insight either happens, or it does not, and the part played by learning in the process of organisation is not considered. An unfortunate result is that conversely, the part played by organisation in the process of learning has also been too little considered : in spite of its highly relevant subject matter, Katona's work is not mentioned by any of three books of Educational Psychology already cited.

The view here put forward is that meaning results from the existence *in the mind of the subject* of a suitable schema which, though it may be based on innate organisations, is chiefly the result of learning. Meaning is thus synonymous

with the process of assimilation to an existing schema : and by the development of an appropriate schema, meaning can be given to a set of hitherto unrelated data. Scientific theories are advanced schemata of this kind : and it is a far cry from this lengthy, systematic, and deliberate building up of meaning to the spontaneous perceptual restructuring of the Gestalt approach. Nevertheless, when the experiments of the latter are reconsidered in the light of the present approach, I think that they will be found to offer a useful contribution to a schematic theory of learning.

VI.—Conclusion.

In this paper an attempt has been made to clarify and develop the concept of a schema in the context of educational psychology ; and to point out its central importance for school and college learning. Before concluding, however, it must be remembered that there are many other kinds of schemata besides the examples here given : for as here used, the concept includes all mental organisations which integrate existing knowledge and behaviour, determine its use in new situations, and form the basis for further learning. They certainly need not be conscious—the ability to reflect on one's schemata is a highly sophisticated one. They can be predominantly sensori-motor, such as driving a car ; predominantly cognitive, such as mathematics ; or have important elements of both, as in a surgical operation. Even the simplest trial and error learning Piaget believes to be not random, but directed by an existing and more basic schema : while, as already argued, complex cognitive skills such as mathematics and systems of science are also examples of schemata. Their varieties, development, internal organisation, transfer effects, and also their interaction with other factors of learning such as reinforcement and intelligence, are subjects for future research : having in every case applications within and beyond the field of educational psychology.

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