CHILDREN'S RECONSTRUCTION OF SERIAL PICTURES

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INTRODUCTION

Many researchers have insisted on the development and use of models for measuring cognitive development in addition to the conventional methods of observations and experiments. Some of these workers have developed such models (i. e., Norman, D. A. & Bobrow, D. G., 1975). Recently, the problem of constructing and implementing such models has received much attention in the literature of developmental psychology (Siegler, R. S., 1978).

Herein we report our study of some of the cognitive processes involved in the performance of a reconstruction task by a group of children and describe the model used to examine the developmental changes and processes. We were able to differentiate two kinds of models, a descriptive model which describes how the child acts under certain conditions, and a normative model which suggests how he should act in certain conditions (Takada, Y., 1974). The latter model was primarily used in current psychological researches.

In developing models, it is often difficult to determine what is the most rational act (optimal response) as a certain act may be judged as irrational (classified as an "error" or "mis-understanding") using one norm but judged as completely rational by another. The few models used in developmental psychology have clearly demonstrated this problem (i. e., Gelman, R., 1979).

Although it is not necessary that the models be mathematical in nature, it is important that they be based on mathematical or logical thinking processes (Indow, T., 1973). The ambiguities inherent in the data or descriptions obtained in some areas of developmental psychology add to the problem of constructing reliable mathematical models, because the accuracy of the descripsion is inevitably limited by the normative point of view (Takada, Y., 1974).

According to J. piaget's genetic model of cognitive development, which is based on the normative point of view, intellectual development can be understood, as changes of the structure of logical operations based on the sensori-motor scheme and is not influenced by a specific environment. In the past five years, several attempts have been made to describe these changes by using more accurate norms (Case, R., 1978, 1980 ; Gelman, R., et al., 1978). These workers have attempted to describe the stages involved in the developmental periods suggested by Piaget and, furthermore, to explain the transition processes of these stages, for which Piaget's theory has failed to account.

We would like to mention here the importance of recognizing not only the children who have reached the developmental stages of maturity suggested by piaget but also the children who have not reached these stages. As Flavell (1977) says, they also have the right to be described in positive terms, and they may be used to shed light on the reason

for thir difficulty in performing a certain task. In our study, we have tried to avoid using an experimental method which relies upon predetermined or judgemental norms. Case, R. (1978) and Gelman, R. (1979) have recognized the problem of using norms and have criticized piaget's tasks of conservation and counting. Our serial reconstruction task was devised with the hope that the cognitive processes could be observed more overtly.

This paper will present two models. One is the temporal-spatial transformation hypothesis in the previous paper (Chen, S., & Kojima, Y., 1980). Another is the "n+1" cummulation hypothesis in that paper. The former explanatory hypothesis will be shown briefly as a model in this paper, and the latter will be revised and shown in a more explanatory form of model.

EXPERIMENTAL PARADIGM

In most of studies of children's recognition memory or unerstanding of a story where picture are stimuli employed, the subject is usually required to arrange a set of pictures and the resulting order of the pictures is considered as the subject's response.

This procedure limits the subject's response behavior to manipulating pictures and arranging them in an order which presumably had its origin in the subject's mind. However, since it is this very process of the mind which formulates the kind of pictures to be recalled and in decides the order of presentation, that interest us, we decided to allow the subject a greater degree of freedom in performing the task so that any hidden response could be externalized. Our Reconstrucion of Serial Pictures Task was designed with the view that by asking the subject to use component cut-outs to reconstruct the pictures "from the beginning" and to arrange the pictures thus reconstructed, it would be possible to reconstruct the cognitive processes involved while solving the task problem through observing the subject's actions.

Furthermore, our previous observations suggested that one of the essential conditions for successful performance was the acquisition of the concept in viewing pictures. Judging from their verbal responses, young children tend to identify individual components in a picture as the picture and do not seem to distinguish the entire from these parts. Thus when asked whether a picture of a pony and a boy are the same as a picture of the pony alone, preschoolers tend to answer positively. Since the stimulus used in our reconstruction task involved pictures containing more than one component, we reasoned that the status of the subject in regard to the acquisition, of the frame concept was one of the critical cues in connecting the children's cognitive status to the kind of pictures they subsequently reconstructed. Therefore, a test of the acquisition of the frame concept was administered together with the reconstruction task. What follows is a description of the Reconstruction of Serial Pictures Task and the test for showing aquisition of frame concept.

RECONSTRUCTION OF SERIAL PICTURES TASK

Method. The sample consisted of 98 kindergarten children ; ranging in age from 4 years 2 months to 5 years 8 months with an average of 5 years 3 months.

Stimulus Materials. One set of slides illustrated four scenes from a story entitled "The Elephant Takes A Walk". The four slides were photographs of black and white line

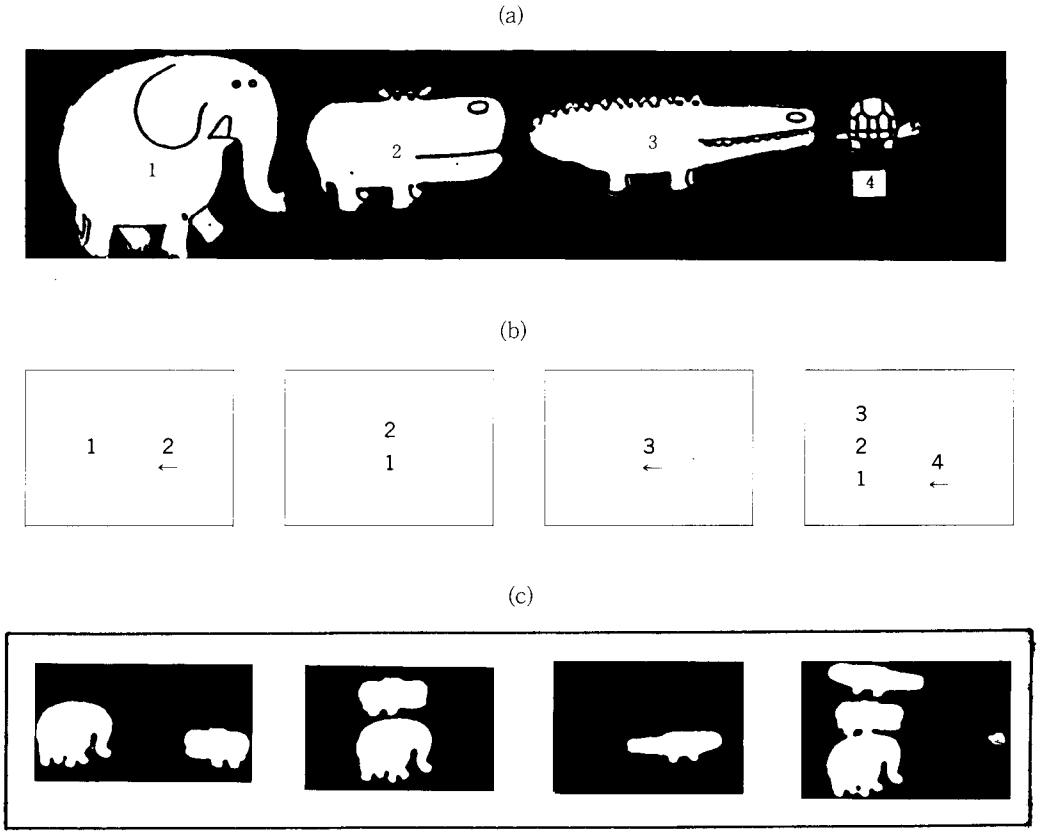


FIGURE 1

drawings of animals (an elephant, hippopotomus, crocodile, and tortoise) (fig. 1). The two minutes narration of the story was recorded by a female voice on a cassette tape.

Performance Materials. Cut-outs of the animals were made on magnesic sheets. Four identical cut-outs of each animal and four tin plates painted black for reconstruction were prepared for use in reconstructing the serial pictures.

Procedure. Subjects were tested individually for a total time of about fifteen minutes. First, the subject was invited to sit beside the experimenter at a distance of 40 cm from the piece of screen (actual screen size 25×20 cm) and then asked to look at the screen and watch the pictures while listening to the story narration. Next, the subject was instructed to reconstruct the four pictures which were presented on the screen "as exactly as he could". Both the audio and the visual stimuli were presented simultaneously. Each slide was presented for about 10 seconds and following the stimulus presentation, the subject was given four reconstruction plates and the cut-outs and told to recall and reconstruct the four pictures as best he could. Each completed picture was hung on a cardboard which was visible to the subject. The subject's performace was observed and notes taken and the completed picture series was recorded by still photos.

Results. Four main types of picture reconstructions were discerned (fig. 2).

Type O : Both the number of plates reconstructed and the content it the picture series were almost identical to the stimulus pictures. Only one of the 13 six year olds and

none of the 12 five year olds responded with this type of reconstruction (fig. 1c).

Type A : At least three different pictures were reconstructed, and although some of the reconstructed pictures differed slightly from the stimuli, the story line was not violated. Three of the 13 six year olds (23%) and three of the 12 five olds (25%) responded with this type of reconstruction (fig. 2a).

Type B : Four plates were completed but each consisted of only one kind of animal cut-out. Nine of the 6 year olds (69.2%) and five of the 5 year olds (41.6%) showed this type of reconstruction (fig. 2b).

Type C : Eiter only one picture with all of the animal cut-outs piled up was completed

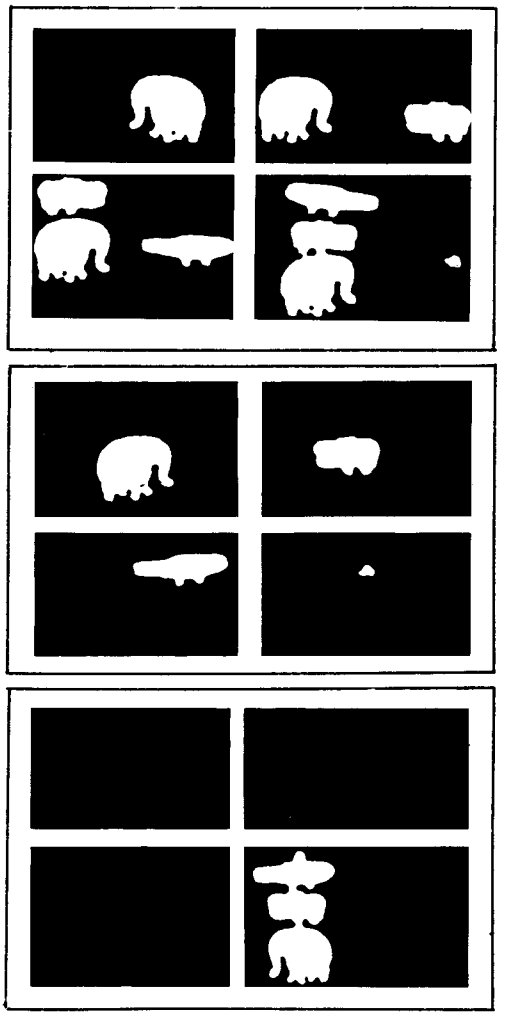


FIGURE 2

or the same pictures were repeated four times. Some of the subjects verbalized the story as they remembered it and reacted the story with actions. One of the six year olds and three of the five year olds performed this way.

TEST OF ACQUISITION OF FRAME CONCEPT.

Subject. Same as above.

Materials. Two kinds of pictures, one containing one element and the other two elements, were prepared (fig. 3).

Procedure. Task 1. The subject was shown both kinds of pictures and asked "Is this picture (pointing to A) the same as this picture (pointdng to B) ?" Task 2. Subject was shown simultaneously (i) two pictures with a single element (fig. 3c, d) and (ii) one picture with two elements (fig. 3 e) and asked "which of these is the picture of a donkey ? ", the subject's answer and other nonverbal response behavior were observed and notes were taken.

Result. The subject's status of the acquisition of frame concept was judged according to his answers to the above questions. The subject's status in the acquisition of the frame concept in viewing the pictures. The following table shows the criteria for classification. The subjects who before answering the Task 1 question queried the experimenter (e. g. by asking "Which one do you mean ?" or "Do you mean this picture [pointing to one of the pictures] ?") were conwidered to have acquired the frame concept.

None of the subjects whose picture reconstruction was classified as Type B answered the questions in such a way that the frame concept could be accorded to them. Furthermore, more than 50% of the subjects whose picture reconstruction was classified as Type A were classified as not having acquired the concept.

TABLE 1

Criteria for judging S's acquisition of frame concept

	Question	Answer	Status
Task 1	"Is A the same picture as B" ?	Yes	Not acquired
		No	Acquired
		(query)	Acquired
Task 2	"Which is the picture of a donkey" ?	D	Acquired
		E or E & D	Not acquired
	"Which is the picture of a donkey and a man" ?	E	Acquired
		(otherwise)	Not acquired

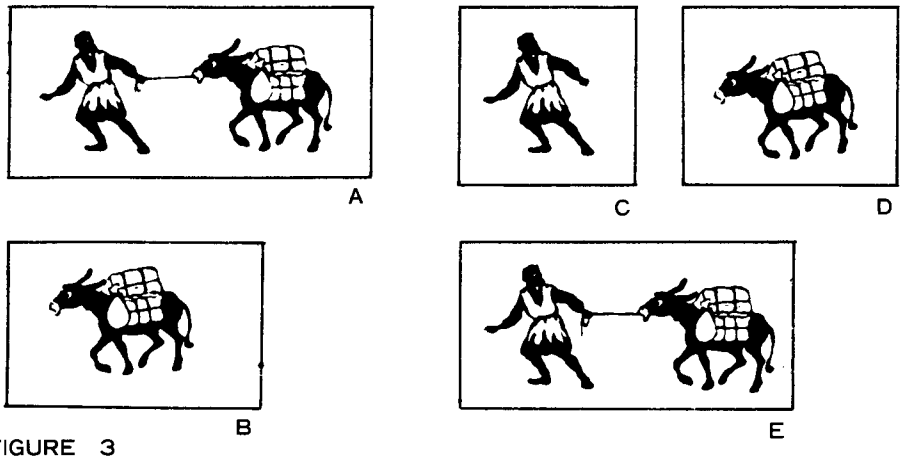


FIGURE 3

TWO MODELS AND DISCUSSION

Although the serial reconstruction task in Experiment I was originally used as a task of integration memory (Chen, S. & Kojima. Y, 1979), we found it to be acceptable for our purposes here because it contained some fundamental problems which have not, to our knowledge, appeared elsewhere. In an earier paper (Chen, S. & Kojima, Y., 1980), both the temporal-spatial transformation hypothesis and problem-solving ('n+1'cummulation) hypothesis were introduced. However, in this paper, the former hypothesis will be given brief attention while the latter will be explained more fully, here.

TEMPORAL-SPATIAL TRANSFORMATION MODEL

First, the 'serial picture reconstruction task' requires the ability to transform temporally organized experience (memory) into a spatially organized format. The main types of a subject's reconstruction are explained by the model. In other words, the convention of expressing temporally presented stimuli into consecutive frames is a learned operation. Two features will be specified here.

A) The rule that requires the transformation of events in a temporal sequence (e.g. T1→T2→T3) into an arrangement of spaces (space 1, space 2, space 3, — from left to right or from upper side to lower side, etc.) in specific direction.

B) The rule that enables spatial arrangement to represent a temporal sequence in specific order. A certain spatial representation expresses the end state of that which has been accumulated up until that time (Tn).

Thus, T1(x1)→T2(x1 x2)→T3(x1 x2 x3)→…However, it is possible to accept only one element the pattern to represent all the others providing that it is clearly representative of serial events. How does the representational from explain these types of reconstruction ? Since Type O agreed with, and Type A was close to the conventional representaional procedures of adults their meanings were unproblematical. In Type B, the fact that 4 frames were completed was more the result of the experimenter's demanding 4 reconstructions that the active decision of the subject to create 4 meaningful spaces in sequence. Consequently, this type of reconstruction could be considered as having the temporal-

spatial property of 'frame' as mentioned above. We considerd Type C to represent the storing of frames for which the subject had not acquired the representational convention yet, it already had the same representational aspects as Type A in the sense that it involved reconstruction processes. That is to say, it included the operation of transforming some of the temporal events presented as plural sequential 'frames' into a spatial dimension.

Whether the differences between Type A and C were of a single or plural nature depended upon whether the representative space contained single or plurales. It was natural to consider that Type C was closer than Type B to the original stimulus set to represent story scheme. Since Type C demonstrated the succesful reconstruction of the temporal component of the stimulus into a single space, we considered it to be a more developed type of reconstruction than Type B, which did not show the transformation.

'N+1' CUMMULATION (RULE) MODEL

In this model the subject's reconstruction was investigated as a problem-solving behaviour rather than only a memory recall activity. There were two aspects in this model, one concernd mainly with the stimuli and the other concerned with the subjects (or organism).

1. Stimulus matter : memory loads, characters, and number of rules necessary for solving the task. 2. Subject's matter : the subject's comprehension of the task depended mainly on his memory span (capacity) and a variety of cognitive strategies.

While it was necessary for subjects to recognize 4 elements, 'elephant', 'hippopotomus', 'crocodile', and 'tortoise', there was no difficulty because the subjects could recall them perfectly verbally. The question here was composition the 4 elements in the pictures.

The subjects were required to remember which elememts had appeared and their relation to each other in order to reconstruct the pictures ; in other words, the task involved problem solving processes and the goal state of operating or fixing 'frames'. The following strategies, which included memory loads, were needed.

1. 'segmentation' strategy : Using this strategy, the subject takes each stimulus picture as a part or a whole as an independent 'frame' and treats each as a memory unit. According to the results of Exp. II (kojima, Y.& Chen, S.,1980), this strategy is not acquired until the age of 7 although it may emerge earlier.

2. 'n+1' cummulation strategy : This strategy implies that subjects add new elements onto previous ones in succession, and all the elements are subsequently presented in cummulating forms. This strategy consists of two rules.

A) 'n+1' addition rule

This rule represents the way a certain element is added to a previous one from 'elephant', to 'tortoise', such as 'hippopotomus' is added to 'elephant' and the former animal riding on the latter one, and 'crocodile' is added to 'hippopotomus riding on elephant', and last 'tortoise' is added to 'crocodile riding on hippopotomus which has been ridden on elephant'.

B) 'cummulation' rule

This rule represents the way a certain element being added to previous one climb up the previous state into a final state such as 'hippopotomus on the elephant', 'crocodile on

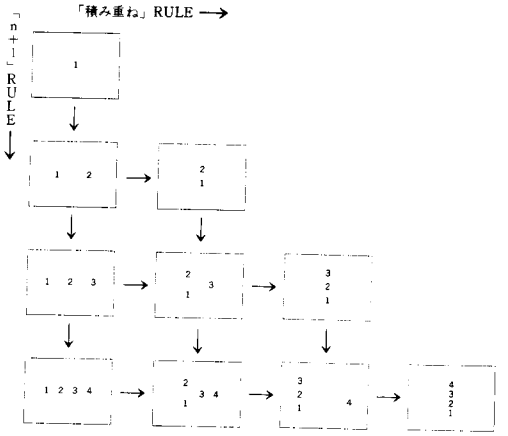
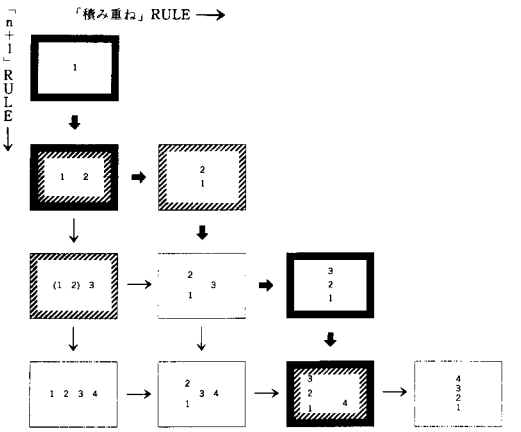
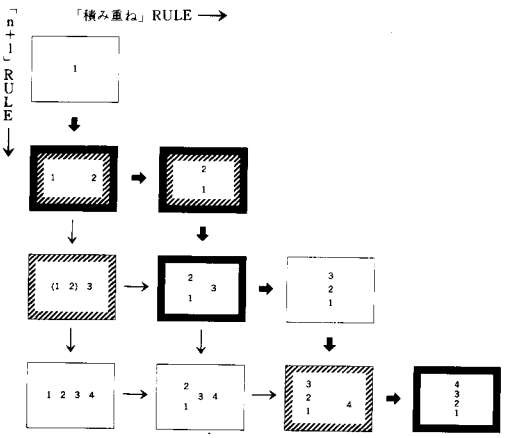


FIGURE 4 Each number in these frames corresponds to the number in fig. 1. 1 ; elephant, 2 ; hippopotomus, 3 ; crocodile, 4 ; tortoise.



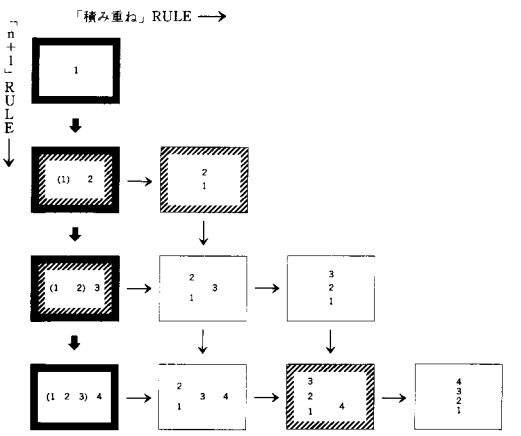
5 op.+4 fr.=9

FIGURE 5a-I



6 op.+4 fr.=10

FIGURE 5a-II



3 op.+4 fr.=7

FIGURE 5b

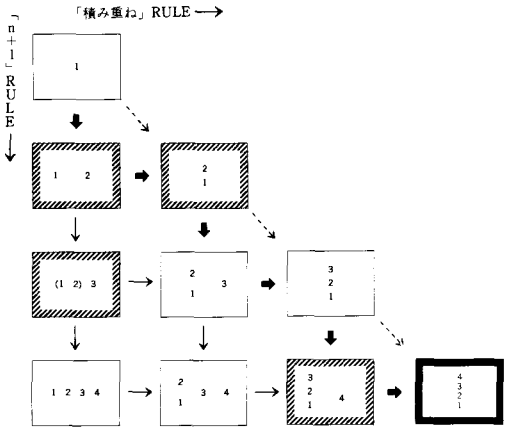


FIGURE 5c

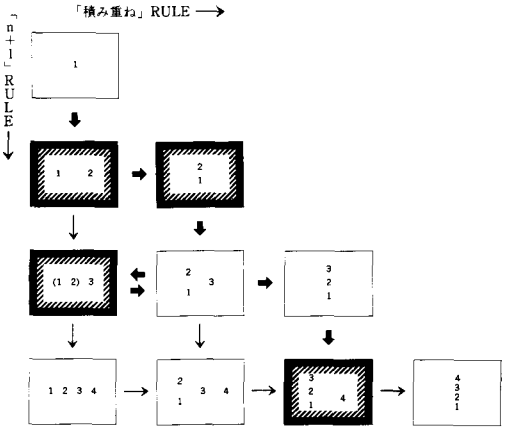


FIGURE 5d

the hippopotomus which has already been on the elephant', etc.

We attempted to explain the subjects' typical reaction types from the point of view that the number of 'operation' and 'frames' needed for making mental spaces (Pascal-Leone, 1970) was constant at certain developmental stages.

Two independent factors required for making mental spaces were assumed in this model. One is the 'frame' which is agreement with the segmentation strategy or with the memory storage of the frame's content. The other is the 'operation' which controls the elements of the picture or transforms the relation between one element and the other. We examined two of the rules involved in this strategy. One was the 'n+1' additional rule, which is more generally appeared in nursery stories, and the other is the 'cummulation' rule, which is relatively specitic to the task.

The final goal of this task was the type O reconstruction, however, it appeared that various processes other than the logical one suggested by the two rules mentioned above were employed (fig 4). Whether the steps of the process were realized overtly when actually practiced or whether they were implicit in the subject's mind is difficult to determine at this point.

In fig. 5 a~d. the pictures with slanted frames represent the stimulus materials and those framed by heavy lines show the subject's reconstructions. The heavy arrows show the constructive process. The processes are counted as a number of operations. As shown, Type B and C were typical. Type B showed the maximum number of frames and the minimum number of operations within the space limits, while Type C showed the maximum number of operations and the minimum number of frames. Thus Type B was represented by 3 op. + 4 fr. =7, and Type C by 6 op. + 1 fr. =7, both types

were equal to each other in the numbers of mental spaces (fig. 5b, c). There were no significant age differences between Types B and C.

Type A, which is generally used at higher age levels, employed maximum operations and frames; it was represented by 5 op. + 4 fr. = 9 or 6 op. + 4 fr. = 10 (fig. 5 a- I , II). We considered that the number of mental spaces between Types A, B, and C may differ. Although Type O may contain a different process mechanism from the other types which reach their goals only with some of the strategies mentioned above, we tried to account for them within the model. The subjects were asked to work harder to construct a third unnatural picture (only one element in it as a stimulus but) which would employ more operations. It appeared that Type O used more mental spaces than Type A. Type O was represented by 7 op. + 4 fr. = 11 (fig. 5d). Additional transitional types (i. e., Type X) were observed but the data is omitted here. Generally speaking, as children mature the number of operations they employ for reconstruction increase. Two types of reconstruction appear : Type B, which decides the frames first and increases the operations gradually, and Type C, which organizes the elements as many times as possible and segments them later. These are only speculations so it is difficult to confirm which type indicates the better development.

CONCLUSION

Our previous study was undertaken to investigate the integration of memory in young children (Chen, S. & Kojima, Y., 1979) ; however, the reactions we were in this study were very dissimilar to what we had expected before. If we had followed a usual experimental paradigm, these reactions would have been classified as an 'error', or a failure. In this study, we have attempted to examine those processes using the experimental method involving Piaget's clinical point of view. In other words, we have allowed for children's 'misunderstanding' or 'errors' and thought it possible to clarify the processes of performing the task.

In our observations of the performing processes, we noted that the task was not only a test of memory but also one of problem solving; therefore, we judged it as unsuitable for use in usual experimental methods of recall or recognition. Our subjects tended to view the given task as a problem solving situation and employed various strategies to solve the problem.

Naturally, the four reconstruction types and the rules used in Experiment I depended greatly upon an appropriate selection of materials. However, we feel that it was possible to find same structures common to many nursery stories. Although the procedures were more limited, some workers have reported same kind of hypothesis on story comprehension (Takagi, K., & Maruno, S., 1980 ; Maruno, S., & Takagi, K., 1979). And we have obtained similar results using different materials (Chen, S., 1980).

In conclusion, we feel that despite the results of this and other studies, it is still not possible to draw any strict generalizations concerning the universality of development. Piaget's tasks' low correlations and other workers' (Cole, M., & Scribner, S., 1974) findings that cultural differences play a role in children's problem solving reinforce our contention that children's development must be understood within a given context.

This report represents only one method of analysis. Future studies are needed to

develop more appropriate models of problem solving which can be related to larger developmental models (i. e. Case, R., 1980).

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