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ABSTRACT

Reported is a study related to the Project on an Information Memory Model and designed to encompass the claims of Piaget and Inhelder on differences of kinds of cognition and recall done on figural sorting task cognition at the Project on an Information Memory Model. The work of Piaget and Inhelder has defined learning information flow and related that to cognition. The contrast criterion of this study's design was to determine the information flow of pre-operational children in doing a repeated concrete task and then to establish the nature of difference in cognition which occurred for immediate reconstruction recall, followed by an immediate memory recall, and later by a delayed memory recall. Thirty six-year-old children were randomly selected from a suburban elementary school and tested individually. The practice classification sorting and immediate recognition recall tasks were given within a 30-minute period. The delayed memory recall was given the following day. Analyses of the data appeared to confirm the hypothesis of Piaget and others about the schema role for reconstruction and pure memory recall but not, however, their claims of the information theoretic definitions of memory and mental maturation. The findings do, nevertheless, report the first explanation of how the pre-operational human memory processes information in learning and cognition. (Author/PEB)

INFORMATION MEMORY PROCESSING AND RETRIEVAL: RELATIONSHIPS OF CONCRETE LEARNING AND CONCRETE AND ABSTRACT COGNITIONS

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Introduction

The pre-operational child is believed to do cognitive tasks differently from children of the operational levels defined by Piaget (1). A related question is whether or not learning modes of concrete objects evoke different levels of cognition for pre-operational children in reconstruction and memory types of recall. According to a recent claim by Piaget, Inhelder, and others (2), immediate and delayed cognition is enhanced by a reconstruction mode of recall task.

There have been several reports of how humans process information in multiple figural sorting learning tasks and then conduct an immediate or delayed recall of the figures and properties (3,4,5). The information theoretic memory model (6) quantifies the quality of the learning behaviors of the humans and has been found to relate them to cognition. These studies, however, have been of operational level children and adults (by chronological age). They did not explore the memory information processing of figural sorting tasks by pre-operational children. Empfield (7) recently found that pre-operational children differ from operational level children in the learning and cognition levels by memory information flow for enumerating picture items. His study, supported by findings of Ross and Youniss (8), revealed that a reconstruction mode of cognition delineates the performance of pre-operational and concrete and formal operational children in a geometric output of almost two to one for recall by formal operational children, as compared to that of five year old children.

Purpose of the Study

This study was designed to encompass the claims of Piaget and Inhelder (2) on differences of kinds of cognition and recall done on figural sorting task cognition at the Project on an Information Memory Model. Their work has defined learning information flow and related that to cognition. The contrast criterion of the design was to determine the information flow of pre-operational children in doing a repeated concrete task and to then establish the nature of difference in cognition which occurred for immediate reconstruction recall, followed by an immediate memory recall, and later by a delayed memory recall.

Procedure

Thirty six-year old subjects were selected at random from a suburban elementary school. Each subject was tested individually. The practice classification sorting and immediate recognition recall tasks were given within a 30 minute period. The delayed memory recall was given the following day.

The practice classification sorting task involved the manipulation of 14 geometric figures into sets according to attributes (color, number, shape, pattern, or other). Two boxes containing duplicate geometric figures were used in this task. One box of figures was used for spatial location reference and the other box was used for practice sorting task purposes. Orientation and observation for this task were given 3-5 minutes. Each subject was allocated 15 minutes to practice sort the block figures into sets according to his or her own chosen attributes.

The block figures chosen for each set were placed on a table. As each block figure was positioned, the number identifying the figure was sequentially recorded for later placement within a matrix.

Immediately following the practice sorting task, the reference box of figures was covered and the subject was instructed to replace in the open box all the blocks into their original spatial location. This immediate reconstruction recall was given a five minute period.

With completion of the immediate recognition recall task both boxes were covered and the subject was given an immediate memory recall. This task involved drawing the 14 block figures on a sheet of paper recording attributes and spatial location. Five minutes were allotted for completion. These tasks completed the first phase of the research.

The delayed memory recall task was presented on the following day. The procedures were the same as the immediate memory recall. The second phase of the research was repeated except for the delayed memory recall.

RESULTS

The behavior characteristics of six year old subjects in the learning and cognition of the figural sorting task were examined for differences in set formations, recall levels in kinds of tasks, and the amounts of information memory flow in the two learning tasks. The descriptors for the characteristics are listed in Tables 5 and 6. These tests for significance of differences were for corresponding characteristics of the two figural learning tasks.

There was evidence that the subjects did not regard the two learning experiments as different tasks. As shown on Table 1, the subjects had spurious information levels of processing channels which were not significantly different in the two learning tasks. This information measure, NOISE:X:M[1], has been found in previous studies (6) to define the human perception of the task strategy needed to process the environment task. It was found the six year old subjects perceived the figural sorting task as one of problem solving. This level of noise was somewhat high, as compared to that Moser (9) reported for seven year old subjects doing the same kind of task.

The subjects did significantly more set elements (messages) in the second learning task than was done in the first learning task (see Table 5). However, any linear regression analyses of dependence between the number of set elements done in learning tasks and the recall of the sorting items was not found to be significant. It seems that a second experience in sorting figures did not have any increased dependence between learning practices and cognition levels.

These two characteristics of strategy perception (NOISE:X:M^1) and set formations were found to interact in an interesting manner. Linear regression analyses revealed that NOISE:X:M^1 of the second learning task was significantly related to the set elements formed in learning task number two (r of .42), but the same relationship was not found for the first learning task. These relationships are discussed further in the later section of results on linear analysis findings.

The information flow for the processing of the two learning tasks, with the exception of % LTM:M^1, was not found to be significantly different. The difference was that the rate of chunking (%LTM:M^1) increased when the subjects repeated the figural sorting task practice in set formations.

The levels of cognition in the task of recall by different reference forms were studied for significant differences. The t-test statistics for differences are shown in Table 6. The kinds of recall performed by the subjects seemed to play a major role in the level of cognition. The pure memory recall tasks which followed the immediate recall of the first learning experience were significantly lower in total score than that obtained by a reconstruction performance in the immediate recall. These were the immediate "mental" and "delayed" recalls and they had scores about one-half as great as the cognition level of the immediate reconstruction task (see Table 2).

The six year old subjects obtained levels of cognition in recall tasks after the second learning task, which did not significantly differ from that made in the immediate reconstruction or concrete task which followed the first learning task (see Table 6). These findings indicated the subjects increased their retrieval of learning items in a second experience of the figural sorting task. Moreover, their pure memory recall increased to a level not significantly different from that done for a reconstruction recall in the first learning task phase of the experiment.

The level of cognition reached after a second learning task was significantly greater than pure memory recall scores made after the first learning task, with the exception of a delayed recall. It was found that the six year old subjects were able to recall a greater amount of learning task items and properties in a pure memory recall after a delay of approximately 24 hours from the learning experience. This level of cognition was not significantly greater than a similar kind of immediate recall after the learning task, but was also not significantly different from a cognition level obtained in an immediate pure recall performed after the second learning task. It seems that a delayed recall after a first learning experience is quite like the pure memory recall done immediately after a second learning task. Nevertheless, the level of cognition made in a pure memory recall (see Table 2) after a second learning experience was significantly less than that obtained for a reconstruction recall (see Table 6) after a second learning experience.

The behavior data of the two learning and five recall tasks were believed to indicate memory processing of the six year old subjects. Moser (9) has developed algorithms for forecasting levels of cognitions, hypothesizing the information memory model components represent elements and functions of the human memory involved in cognitions. Two of these algorithms were used in this study as a means for gaining some insight into how preoperational children memory process the figural sorting task.

The first algorithm used was the message processing algorithm (9). It proposes the message behavior is encoded (% CODE) and processed (% REAL:M^1) to the long and short term memory stores for retrieving useful information (LTM:M^1 and REAL:SS kinds of measures). The operation involves the C. Shannon (10) principle that information is "carried" per behavior message. The cognition levels for the reconstruction immediate recall tasks of learning task one and two were forecast by the treatment of each subject's learning behavior data. The results of the treatment are shown in Table 3. It was found that a forecast score for reconstruction recall one was 12.04 (actual was 14.57), for a 17.36 percent error of prediction. The forecast of the second reconstruction recall was 16.76 (actual was 17.43), for a prediction error of 3.84 percent. The prediction discrepancy for the first reconstruction recall was believed due to the treatment not taking into account association recall, as reported by Moser (9) for subjects aged nine and fifteen years who had done a symbolic figural sorting learning task. He hypothesized that association recall is a "loop" feedback for the encoder or processor element with the short or long term memory storages of useful information. It can be seen by consulting Tables 1 and 3 that the processing action on the short term (M^1) storage of useful information (% REAL:M^1 times M^1 storage) would obtain an association retrieval of 2.04 items. The "initial" recall of 12.04 items, and association retrieval would obtain a total average recall of 14.08 (actual 14.57), or an error of 3.33 percent.

TABLE 1

Characteristics of Learning Tasks

Characteristic	Learning Task One		Learning Task Two	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Messages	85.4667	15.4758	94.2333	23.5367
% CODE	.4847	.0714	.4610	.1041
% REAL:M[1]	.3454	.0626	.3337	.1104
LTM:M[1]	.1283	.0556	.1534	.0804
% LTM:M[1]	.0669	.0273	.0831	.0395
NOISE:X	.4809	.0709	.4970	.1113
REAL:SS	.1431	.1149	.1642	.1461
% REAL:SS	.0190	.0163	.0225	.0214

TABLE 2

Characteristics of Cognitive Tasks

Characteristic	Mean	Standard Deviation
Immediate (T-1): Concrete (A)	14.57	8.74
Immediate (T-1): Abstract (B)	6.03	4.46
Delayed (T-1): Abstract (C)	8.43	8.56
Immediate (T-2): Concrete (D)	17.43	10.41
Immediate (T-2): Abstract (E)	11.40	8.10
Sub-Task: Immed. (T-1) Concrete:		
Items T-1-A	4.53	4.83
New Score Items	1.60	1.22
Sub-Task: Delay (T-1) Abstract:		
Items of Previous Cognitions	6.30	6.56
New Score Items	1.93	1.82
Items of T-1, A (above)	2.13	3.05
Items of T-1, B (above)	.73	.98
Items of T-1, A and B	3.53	4.17

The second algorithm for predicting cognition levels is one which assumes the subjects perceived a Gestalt field of dimensions of the figural task. The displayed field of 14 figures and properties of color and identity number was hypothesized to have 42 dimensions (14 shapes, colors and identity numbers). These dimensions were encoded (% CODE) by the subjects. The 42 dimension algorithm model includes the premise that the human memory stores information in units of .1548 (M unit) bit. This storage has a structure which differs by increments of .0129 (M) bit, depending on maturation level and learning redundancy. The algorithm is expressed as (M unit ± M/% CODE) (42 dimensions = cognition.

The M algorithm was used to determine recall scores of individual subjects in the five recall tasks. The encoder (% CODE) of the first learning task, for each subject, was used to obtain the recall scores for the first immediate reconstruction and pure memory recall. The encoder (% CODE) of the second learning task was used to determine recall scores of tasks following that experience: a reconstruction and immediate pure memory recall. It should be noted that these algorithm treatments were not used to forecast levels of cognition, but rather to establish the M increment changes occurring for the kinds of cognitions performed by the subjects in the study. The average M values for a less than two percent prediction error in total recall are shown in Table 4. It was found that the experience of a repeated learning experience increased the .0129 M value in immediate reconstruction recall levels of cognition by two M values (from an M unit of 1.17 to 3.37). The same experiences resulted in a deficit decrease of 4.5 M values, (from -6.43 to a -1.93 M units) in immediate pure memory kinds of recall. The reader should keep in mind that the M value of .0129 bit is reported here of differences from the basic unit of .1548 bit of information. In other words, the pure memory recall operated as less than .1548 bit of structure information and the reconstruction kind of memory retrieval operated at one to 3.4 M values of .0129 bit of information above the level of a .1548 bit basic unit of structure.

The linear relationships between the levels of recall of the five tasks are shown in Table 7. As previously mentioned the items recalled on a delayed basis, and those of the second immediate abstract or pure basis, were analyzed as to their origins. This was done to isolate the sequence of retrieval; whether they had originated in a reconstruction recall (immediate concrete recall) of the first learning task.

The total scores for recall by the six year old subjects in each of the five recall tasks were found to be positively related to each other*. However, the amount of items which

*Hereafter, the term "related" means significantly related.

TABLE 3

Characteristics of Encoding Algorithm

Characteristic	Learning Task One		Learning Task Two	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Encoder	41.20	9.11	42.35	9.60
Processor	29.41	7.47	30.28	8.41
M^1 Storage	5.92	3.62	8.19	5.72
SS Storage	6.12	4.93	8.57	8.18

TABLE 4

Characteristics of Dimension Algorithms for Cognition Levels

Recall Characteristics		M Value		M Unit of Information		M Useful Information	
		$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Immediate Recall (Task One):	Concrete	1.1667	9.2776	.1699	.1199	.3429	.2081
Immediate Recall (Task One):	Abstract	-6.4333	4.5081	.0717	.0583	.1449	.1080
Delayed Recall (Task One):	Abstract	-4.0667	8.6141	.0971	.1124	.1911	.2053
Immediate Recall (Task Two):	Concrete	3.3667	11.3243	.1983	.1463	.4153	.2471
Immediate Recall (Task Two):	Abstract	-1.9333	8.4565	.1298	.1093	.2712	.1926

TABLE 5

Significant Differences Between Characteristics of the First and Second Learning Tasks

Characteristic	t-statistic	Characteristic	t-statistic
Task Messages (elements)	1.705	NOISE:M[1]	.668
Information Measures		REAL:SS	.622
% CODE	1.028	% REAL:SS	.712
% REAL:M[1]	.505	Message Algorithm Elements:	
LTM:M[1]	1.406	Encoder	.476
% LTM:M[1]	1.848*	Processor	.426

TABLE 6

Significant Differences Between Levels of Cognition in Recall Tasks (t-statistics)

	Concrete I	Mental I	Delayed Recall	Concrete II	Mental II
Concrete I		4.763**	2.747**	1.155	1.456
Mental I			0.772	5.514**	3.180**
Delayed Recall				3.659**	1.384
Concrete II					2.506**
Mental II					

*Significant at the .10 level.

**Significant at the .05 level.

were found to be new in the first learning task cognitions of a pure memory recall were not related to the total recall of the preceding reconstruction recall. This was found to be the case for either an immediate or a one day delayed recall. However, the new items, or those not previously retrieved, recalled in the immediate pure recall were positively related to those never before recalled, or new, in the delayed pure memory recall. In other words, the new items which a subject would retrieve for the first time, and in a 24 hour delayed cognition, were linearly related only to those new items which had been previously retrieved in a cognition of the same kind: a pure memory recall. The reader is cautioned to note that new items of a subsequent recall had never been recalled in previous recall tasks.

The way in which cognition occurs could be related to the nature of information memory processing which took place with the learning behavior of the first concrete (reconstruction) learning task. The linear relationships of information measures describing the first learning task behaviors are shown in Table 8. The relationships were found to be, with the exception of the chunking effect ($LTM:M^1$). related to partial cognitions. That is to mean the scores previously occurring in cognitions, or having occurred for the first time.

Three patterns of relationship existed for the memory information flow in the learning task and cognition. The first one was that all total recall scores were negatively related to the chunking effect ($LTM:M^1$ or % $LTM:M^1$). The same relationship existed for the immediate pure memory recall as was found for the total recall. However, the new, or not previously occurring items of cognitions were found to be positively related with the chunking effect of the learning task. The learning task chunking effect information was also negatively related to the delayed recall items previously retrieved in cognitions. Quite interestingly, the delayed recall items which had been retrieved in the preceding, and similar preceding pure memory recall, was not found to be related to the chunking effect of the learning task.

The second pattern of cognition and information relationships was for the encoder element (% CODE) of the information memory model. The encoder element was found related to the old, or previously retrieved, items of the delayed recall task, and those which occurred in the first reconstruction, immediate recall, as well as with those items recalled in the preceding cognitions. The third pattern was that the steady state useful information (REAL:SS and % REAL:SS) of the learning task was negatively related to new items retrieved for the immediate pure memory recall and positively related to the delayed recall items which had also been retrieved in the first and immediate reconstruction recall, following the learning task.

TABLE 7

Coefficients of Correlation Between Task Characteristics

Recall Tasks	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Immediate (T-1): Concrete (A)		.75	.31	.70	.69	.77		.82		.81		.73
2. Immediate (T-1): Abstract (B)			.72	.65	.76	.92		.82		.47		.85
3. Delayed (T-1): Concrete (C)				.75	.76	.31	-.37	.92		.73		.84
4. Immediate (T-2): Concrete (D)					.84	.63		.79		.56		.74
5. Immediate (T-2): Abstract (E)						.70		.87		.54		.80
Sub-Task: Immed. (T-1) Concrete												
6. Items T-1-A							.44	.86		.55		.90
7. New Score Items								-.35	.35	-.38	.69	-.46
Sub-Task: Delay (T-1) Abstract												
8. Items of Previous Cognitions										.77		.93
9. New Score Items											.51	
10. Items of T-1, A (above)											.32	.61
11. Items of T-1, B (above)												
12. Items of T-1, A and B												

Significant at .31 for the .10 level and .37 for the .05 level.

The information measures of the second learning task were tested for linear relationships with the levels of cognitions in the five recall tasks. This relationship was interpreted to mean that the information flow of the behaviors used to do set formations in the second learning task were related to the amount of items recalled prior to or after the second learning task.

The linear relationships of the information flow for the second learning task were found to exist with the old items recalled in the first immediate pure memory recall. The relationship was one not existing for information flow of the first learning task (see Table 8). This was of % CODE, % REAL:M^1 and % LTM:M^1) information measures.

It was also interesting to find that there was a decrease of significant correlations between recall scores and the LTM:M^1 measure, as compared to the relationships found for the chunking effect of the first learning task. A smaller reduction occurred for linear relationships of cognition with the rate of chunking useful information (% LTM:M^1).

The same information measures of both learning tasks, being related to the same recall tasks and parts of recall tasks suggested the information flow of the two learning tasks were also related. The significant coefficients of correlation between the information measures are listed in Table 10. There were three distinct groups of information measure relationships. The pattern was quite symmetric with encoders related to encoders, as well as matching relationships of chunking effect and spuriousness for input information (NOISE:X:M^1). These relationships were all positive. On the other hand, encoders of the first learning task were related negatively with the NOISE:X measures of the second learning task. The same kind of relationship existed with the % LTM:M^1 and NOISE:X:M^1 of the learning task one being related to the encoders of learning task two.

It was quite noticeable that the long term memory useful information (REAL:SS and % REAL:SS) of the two learning tasks were not related to each other, or to the other aforementioned information measures. An examination of the significant correlations on Tables 11 and 12 provided some evidence of the role of the long term useful information measure in the memory processing for the two learning tasks. Note that these are of relationships between measures in the same behavior model. The interinformation flow of the first learning task was between encoders and processors of the short term memory and the chunking effect useful information element of the short term memory. The encoding functions shifted for the second learning task, with the relationship now between the flow of spurious information (NOISE:X:M^1) and quite interestingly, with the long term memory useful information. It is of note that the encoding process was negatively related to the useful information measures.

TABLE 3

Coefficient of Correlation Between Learning Task One Characteristics and Recall Task Cognitions

	Learning Task One						
Recall Tasks	Messages	%CODE	%REAL:M[1]	LTM:M[1]	%LTM:M[1]	REAL:SS	%REAL:SS
Immediate (T-1): Concrete (A)				-.5156	-.5381		
Immediate (T-1): Abstract (B)				-.3863	-.3787		
Delayed (T-1): Concrete (C)				-.4464	-.4885		
Immediate (T-2): Concrete (D)					-.3349		
Immediate (T-2): Abstract (E)				-.4556	-.4821		
Sub-Task: Immed. (T-1) Concrete							
Items T-1-A				-.4154	-.4176		
New Score Items				.3790	.3487	-.3671	-.3904
Sub-Task: Delay (T-1) Abstract							
Items of Previous Cognitions		.3418		-.5002	-.5430		
New Score Items							
Items of T-1, A (above)		.4030	.3475	-.4684	-.5149	.3188	.3217
Items of T-1, B (above)							
Items of T-1, A and B		.3498		-.4691	-.5134		

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 9

Coefficient of Correlation Between Learning Task Two Characteristics and Recall Tast Cognitions

Recall Tasks	Messages	%CODE	Learning Task Two %REAL:M[1]	LTM:M[1]	%LTM:M[1]	REAL:SS	%REAL:SS
Immediate (T-1): Concrete (A)				-.3687	-.4190		
Immediate (T-1): Abstract (B)		.3096					
Delayed (T-1): Concrete (C)		.3010			-.3059		
Immediate (T-2): Concrete (D)							
Immediate (T-2): Abstract (E)					-.3148		
Sub-Task: Immed. (T-1) Concrete							
Items T-1-A		.3935	.3699		-.3137		
New Score Items				.3256	.3923		
Sub-Task: Delay (T-1) Abstract							
Items of Previous Cognitions		.4267	.3790		-.3548		
New Score Items							
Items of T-1, A (above)		.3025					
Items of T-1, B (above)						.3379	
Items of T-1, A and B		.4851			-.3482		

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 10

Coefficients of Correlation Between Learning Task Characteristics, Tasks One and Two

Learning Task One	Learning Task Two						
	%CODE	%REAL:M[1]	LTM:M[1]	%LTM:M[1]	NOISE:X	REAL:SS	%REAL:SS
%CODE	.6692	.6512			-.6855		
%REAL:M[1]	.6703	.6321			-.6716		
LTM:M[1]			.4508	.5155			
%LTM:M[1]	-.4570	-.3954	.3625	.4914	.3598		
NOISE:X	-.6430	-.6050			.6514		
REAL:SS							
%REAL:SS							

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 11

Coefficients of Correlation Between Learning Task Characteristics, Learning Task One

Characteristics	%CODE	%REAL:M[1]	LTM:M[1]	%LTM:M[1]	NOISE:X	REAL:SS	%REAL:SS
%CODE		.9894		-.4466	-.9788		
%REAL:M[1]				-.3202	-.9964		
LTM:M[1]				.9337			
%LTM:M[1]							.9906
NOISE:X							
REAL:SS							.9906
%REAL:SS							

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 12

Coefficients of Correlation Between Learning Task Characteristics, Learning Task Two

Characteristics	%CODE	%REAL:M[1]	LTM:M[1]	%LTM:M[1]	NOISE:X	REAL:SS	%REAL:SS
%CODE		.9767			-.9799	.3721	.4242
%REAL:M[1]			.3054		-.9890	.4097	.4691
LTM:M[1]				.9134	-.3544		
%LTM:M[1]							
NOISE:X						-.4061	-.4599
REAL:SS							.9956
%REAL:SS							

Significant at .31 for the .10 level and .37 for the .05 level.

The model for forecasting cognition levels, mentioned on page 4, was tested for relationships with actual recall scores of the five tasks. These relationships, as shown on Table 13, were found to be largely of the short term memory storage element of the message algorithm. These relationships were negative, and had a pattern of dependence previously described for the information flow of learning task one and the various cognitions. The information flow of learning task two showed a contrast (see Table 13) in that only the encoder algorithm element was related to cognition levels. One of these was for the first immediate recall occurring after the second learning task. That relationship was positive, whereas, the second one was negative and with the old items of the first concrete recall after the first learning task, and occurring again in the delayed pure memory recall, which followed that recall by a period of 24 hours.

It was noted on page 7, that a second forecasting model was tested for the levels of cognitions of the six year old subjects. The algorithm utilized only the % CODE measure of the learning tasks. That measure was used from the first learning task in forecasting the total scores of the three recall tasks which followed the first learning task, but preceded the second learning task. Of course, the % CODE measure of the second learning task was used to forecast cognition levels of tasks following the second learning task in real time. This algorithm was used as it had relevance to the premise that subjects processed information dimensionally rather than through overt learning behaviors. It was labelled the M algorithm, with the M representing "Memory," and theorized useful information of a base value of .1548 bit represented the unit structure of the human memory.

The linear relationship between cognition levels and the M structure unit were tested to verify the linearity of the forecast algorithm. The results of the test are shown in Table 14, and they verify that premise. The M unit structure was then tested for linearity dependence with the actual information flow in learning tasks one and two. The results are shown in Tables 15 and 16, respectively. An examination of Tables 8 and 9 show the same patterns of relationship generally occurred for the significant correlations. However, the chunking effect ($LTM:M^1$) of the first learning task was now found to be related to the M forecast of the first cognition occurring after the second learning task.

The message algorithm elements were tested for linear relationships with the M unit of the M algorithm. The results of these analyses are shown on Table 17. The STM storage element of the first learning task was found to have the same pattern of relationships with the M unit of cognition kinds as seen for actual cognitions in Table 13. The major finding was that the learning task two message algorithm elements shifted in the pattern of relationships. One of the changes

TABLE 13

Coefficients of Correlation Between Message Encoder and Processor Algorithm Elements and Cognition Tasks

Recall Tasks	Learning Task One: Encoder	Learning Task One: Processor	Learning Task One: STM Storage	Learning Task One: LTM Storage	Learning Task Two: Encoder	Learning Task Two: Processor	Learning Task Two: STM Storage	Learning Task Two: LTM Storage
Immed. (T-1): Concrete (A)			-.43					
Immed. (T-1): Abstract (B)			-.33					
Delay (T-1): Concrete (C)			-.34					
Immed. (T-2): Concrete (D)					.61			
Immed. (T-2): Abstract (E)			-.34					
Sub-Task: Immed. (T-1) Concrete								
Items T-1-A			-.36		-.34			
New Score Items			.38	-.52				
Sub-Task: Delay (T-1) Abstract								
Items of Previous Cognitions			-.38					
New Score Items								
Items of T-1, A (above)			-.37	.32				
Items of T-1, B (above)								
Items of T-1, A and B			-.37					

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 14

Coefficients of Correlation Between the 42 Dimension Algorithm M-Units and Cognitive Tasks

	M-Units											
Recall Tasks	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Immed. (T-1): Concrete (A)		.78	.84	.70	.71	.78		.83		.81		.73
2. Immed. (T-1): Abstract (B)			.72	.68	.77	.92		.82		.47		.85
3. Delayed(T-1): Concrete (C)				.75	.76	.81	-.37	.92		.73		.84
4. Immed. (T-2): Concrete (D)					.81	.63		.79		.56		.74
5. Immed. (T-2): Abstract (E)						.70		.87		.54		.80
Sub-Task: Immed. (T-1) Concrete												
6. Items T-1-A							-.45	.86		.55		.90
7. New Score Items								-.35	.35	-.38	.69	-.46
Sub-Task: Delay (T-1) Abstract												
8. Items of Previous Cognitions										.77		.93
9. New Score Items											.51	
10. Items of T-1, A (above)											.32	.61
11. Items of T-1, B (above)												
12. Items of T-1, A and B												

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 15

Coefficients of Correlation Between the 42 Dimension Algorithm
M-Units Information Processed in Learning Task One

M-Unit	Learning Task One						
	%CODE	%REAL:M[1]	LTM:M[1]	%LTM:M[1]	NOISE:X	REAL:SS	%REAL:SS
Recall Tasks							
Immediate (T-1): Concrete (A)	.44	.37	-.51	-.59	-.33		
Immediate (T-1): Abstract (B)	.37	.31	-.43	-.47			
Delayed (T-1): Concrete (C)	.38	.33	-.46	-.53			
Immediate (T-2): Concrete (D)	.44	.41	-.37	-.46	-.37		
Immediate (T-2): Abstract (E)	.44	.37	-.49	-.57	-.33		
Sub-Task: Immed. (T-1) Concrete							
Items T-1-A			-.42	-.42			
New Score Items			.38	.35		-.37	-.39
Sub-Task: Delay (T-1) Abstract							
Items of Previous Cognition	.34		-.50	-.54			
New Score Items							
Items of T-1, A (above) Items of T-1, B (above)	.40	.35	-.47	-.51	-.31	.32	.32
Items of T-1, A and B	.35		-.47	-.51			

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 16

Coefficients of Correlation Between the 42 Dimension Algorithm
M-Units Information Processed in Learning Task Two

	Learning Task Two						
M-Unit	%CODE	%REAL:M[1]	LTM:M[1]	%LTM:M[1]	NOISE:X	REAL:SS	%REAL:SS
Recall Tasks							
Immediate (T-1): Concrete (A)	.36		-.31	-.41			
Immediate (T-1): Abstract (B)	.47	.45			-.41		
Delayed (T-1): Concrete (C)	.40	.35		-.31	-.34		
Immediate (T-2): Concrete (D)	.60	.58			-.60		
Immediate (T-2): Abstract (E)	.56	.52		-.34	-.50		
Sub-Task: Immed. (T-1) Concrete							
Items T-1-A	.39	.37		-.31	-.33		
New Score Items			.33	.39			
Sub-Task: Delay (T-1) Abstract							
Items of Previous Cognition	.43	.38		-.35	-.36		
New Score Items							
Items of T-1, A (above)	.30						
Items of T-1, B (above)						.34	
Items of T-1, A and B	.49	.46		-.35	-.42		

Significant at .31 for the .10 level and .37 for the .05 level.

was it being related to the M unit of the memory recall following the second learning task, with the new items retrieved in the pure memory recall, and also those of the delayed pure memory recall. The other changes were to relationships of the new items retrieved in the pure memory immediate and delayed recall tasks which followed the first learning task.

The patterns of relationships between the memory information flow, its forecast of cognition levels, and the various total and partial levels of cognition in recall tasks prompted an analysis of the way in which information flow was related to the observed behaviors of the subjects as they did the two figural sorting learning tasks. Linear regression analysis of the number of set formation elements (messages) done in the tasks and the total or partial recall scores of the five tasks revealed none were significantly related. In other words, the amount of learning behavior for learning was not linearly related to the amount of figures and their properties which would be recalled from the memory in either immediate or delayed reconstruction or pure memory kinds of recall by the six year old subjects.

A study of the information flow occurring in the two learning tasks revealed they were related to the messages or learning behaviors performed in the learning tasks. The linear relationships of this treatment are shown in Table 18. Keeping in mind that the messages of a task were entered into a matrix for calculating the information measures for each subject, the relationship of measures with messages describes the nature of the structure of behaviors evoked in the respective learning task.

The useful information measures of the first learning task were found to be linearly related to the messages or behavior performed in that same task. The short term memory chunking effects ($LTM:M^1$ and % $LTM:M^1$) were positively related and the long term memory useful information (REAL:SS and % REAL:SS) measures were negatively related to the messages processed in the first learning task.

The messages done in the second learning task were related to the information flow of that task by negative correlations with the encoder (% CODE) and processor (% $REAL:M^1$) of the memory model. The rate of chunking (% $LTM:M^1$) and channel spuriousness ($NOISE:X:M^1$) of the short term memory were positively related to the messages processed in the same learning task (number two). In other words, the messages processed in the learning tasks were linearly related to the simultaneously occurring memory information flow; depending on whether it was the first figural sorting experience or a repetition of the experience for six year old subjects.

TABLE 17

Coefficients of Correlation Between Message Encoder and Processor Algorithm Elements and the 42 Dimension Algorithm M-Units of Cognition Tasks

M-Unit	Learning Task One: Encoder	Learning Task One: Processor	Learning Task One: STM Storage	Learning Task One: LTM Storage	Learning Task Two: Encoder	Learning Task Two: Processor	Learning Task Two: STM Storage	Learning Task Two: LTM Storage
Recall Tasks								
Immediate (T-1): Concrete (A)			-.39					
Immediate (T-1): Abstract (B)			-.33					
Delayed (T-1): Concrete (C)			-.33					
Immediate (T-2): Concrete (D)								
Immediate (T-2): Abstract (E)			-.35			.34		
Sub-Task: Immed. (T-1) Concrete								
Items T-1-A			-.36					
New Score Items			.37	-.32			.33	
Sub-Task: Delay (T-1) Abstract								
Items of Previous Cognitions			-.39					
New Score Items					-.34			
Items of T-1, A (above)			-.37	.32				
Items of T-1, B (above)								
Items of T-1, A and B			-.37					

Significant at .31 for the .10 level and .37 for the .05 level.

TABLE 18

Linear Relationaships Between Information Measures and M unit Algorithm Elements and Messages Processed in Two Learning Tasks

Characteristic	Messages:Task One H of One	Messages:Task One H of Two	Messages:Task Two H of One	Messages:Task Two H of Two
% CODE	-.210	-.276[a]	-.220	-.491**
% REAL:M[1]	-.140	-.270	-.189	-.422**
LTM:M[1]	.474**	-.009	.301	.224
% LTM:M[1]	.482**	.107	.317	.450**
NOISE:X:M[1]	.118	.263	.160	.421**
REAL:SS	-.444**	.238	-.068	-.280
% REAL:SS	-.430**	.197	-.066	-.292
M unit for Recall:				
Concrete I	-.272		-.245	
Abstract I	-.199		-.173	
Delayed	-.320		-.251	
Concrete II		-.168		-.295
Abstract II		-.187		-.087

[a]To be read that % CODE of learning task two had a -.276 coefficient of correlation with the messages of learning task one.

*Significant as .307 for the .10 level.

**Significant as .361 for the .05 level.

It can be seen on Table 18 that only one information memory model component was related to messages processed in both sorting tasks. The % LTM:M[1] measure, or rate of chunking, of the first learning task was positively related to the messages of set formations in the first learning task and to the messages of the second learning task. As the messages processed in the two learning tasks were linearly related (r of .42), there were then two direct links between the message behaviors of the subjects performing the two learning tasks.

The previously described M dimension algorithm for forecasting cognition levels was tested for linear relationship with learning task behaviors. This was regarded as a proper analysis as the M algorithm did not use messages in the prediction equations. The M unit of the algorithm analyses of regression with learning task messages are shown in Table 18. This M unit was of the forecast of the delayed recall score and the relationship was negative. This was interpreted to mean that as there was a decrease of messages completed in the first learning task, there would have been an increase in the level of the M unit of useful information processed in the dimension forecast of the delayed cognition.

Conclusion and Discussion

This study explored the effect of repeated learning of a figural sorting task on the cognitions of six year old children. More specifically, the information memory processing was described to determine how it was related to immediate reconstruction recall and immediate and delayed pure memory recall of six year old children. The experiment was done to explore the claims made in 1968, by Piaget, Inhelder and others that reconstruction is involved in memonic retention and is in some ways superior to pure memory recall (11).

The six year old subjects had levels of cognition which varied as to the mode in which they were set for doing a recall task. They were able to recall a significantly greater amount of the learning experience if given the items to be located than if they were asked what figures were to be located in a particular geographic site. In other words, pre-operational children are able to do reconstruction recall more efficiently than a pure memory recall task. However, this difference is probably a function of learning, as the experience of a repeated learning task revealed they were able to increase memory retrieval of a pure memory type to where the cognition level did not significantly differ from the recall score earned in a reconstruction recall.

The pure memory recall task done by sic year old subjects on a delayed basis, though not significant, was greater than one done in a similar task immediately after a learning experience. Both cognitions were done with the subjects remembering new figures and properties, other than those retrieved for a preceding reconstruction recall. In both pure memory recall tasks the ratio of new items to old items was about one to three. The retrieval of new items recalled in a delayed pure memory cognition was by a linear relationship with the new items previously retrieved in another pure memory recall, indicating this kind of cognition is enhanced by association retrieval mechanisms in the human memory.

The learning of a figural sorting experience is not directly related to cognitions of that task. The number of elements done in set formations of the geometric figures and their properties was not found to be directly related to the amounts remembered in reconstruction or pure memory immediate recall or in a delayed pure memory recall. The lack of relationship was a surprising finding, even though the subjects did significantly more set formations in the repeated learning task, the amount of recall after that experience was not significantly greater than done in previous cognitions.

The discovery that overt learning behaviors could not predict levels of cognition could raise a question of how six year old subjects do relate learning experiences because it was found there were direct linear relationships between all five kinds of immediate and delayed cognitions. Thus the conclusion could be that cognitions of retrieval are related through memory functions but these are not related to learning behaviors, but with the learning behaviors being related to each other. This seemed to be an isolation of cognition and learning. The solution to this problem was found in the information flow of learning behaviors in the two practice sorting tasks.

The amount of elements of set formations in learning tasks was related to the short term memory chunking effect components of the memory model. The chunking effect (LTM:M^1 and % LTM:M^1 measures) was in turn related to all five cognitions in reconstruction and pure memory recall tasks. Furthermore, the chunking effect of information flow in the first learning task was related to its counterpart descriptor of behaviors in the second learning task. The conclusion was that pathways of memory activity and learning environment behaviors were related to cognitions by the logarithmic structure of the memory of the memory of the six year old subject.

The nature of the memory processing for the two learning tasks differed even though it was not observable in the overt behaviors of the subjects during the two tasks in sorting figural objects. The encoding processes operated in the same manner in both learning tasks. Spuriousness of information in both tasks were related to the encoding process in the same way. However, the chunking effect was related to the channel spuriousness of the short term memory in learning task two but not in the first learning task. The short term memory chunking effect was related to encoding processes in the first learning task, whereas it was not related in the second learning task. Instead of that pathway existing, a new pathway of useful information flow developed for the second learning task. That pathway was a direct relationship of the message encoding processes with the storage of useful information in the long term memory. This conclusion was supported by the finding that an encoding component of a forecast message algorithm was directly related to the reconstruction recall occurring immediately after the second learning experience. Since this algorithm incorporated the subjects learning behaviors into the forecast equations, it was concluded the memory pathway for information processing learning repetition was encoding for storage of useful information in the long term memory.

The short term memory chunking effect figured prominently in the learning and cognition events of pre-operational subjects in the study. It was interesting to note that cognitions were negatively related to this information flow component, whereas the elements of set formation in the learning tasks were positively related to it. The explanation is probably feasible by considering the memory model elements and their relationship to each other.

The message behaviors of an initial learning task were processed as long term memory information and later retrievable under conditions of a delayed recall of items of a previous reconstruction recall. This kind of information storage also indirectly figured in the association recall of new items in an immediate pure memory recall, and not occurring in a preceding reconstruction recall. The delayed pure memory recall pathway for long term memory most likely occurred as an encoding operation, differing thusly from an immediate pure memory recall.

The recall of new items of a delayed pure recall had an interesting relationship to the encoding of information in the memory processing during a subsequent second learning task. These new items, of figures and their properties, were related to the input of messages for encoding in the second learning activity. The recalling of pure memory recall items in an earlier cognition was, however, directly related to the useful information utilized in a delayed cognition and thence to the second learning task useful information stored in the long term memory. In this way, one can conclude that new items of a delayed pure recall are related to new items of a similar and earlier cognition and the information processing is of the chunking effect of short term memory. However, these new items later give mnemonic retention for recalling additional new items in a delayed recall, with the effect of influencing the long term memory which becomes active during the learning of the same task at a later time.

These conclusions can raise the question of the role of memory encoding and of the structure of the human memory with regard to a figural sorting task done in a concrete mode by pre-operational children. This question was explored by using two forecast models of information memory processing. A comparison of M dimension forecasts (of actual cognitions to less than a two percent error) with the actual information flow of information in learning task behavior processes revealed the role of the structure of memory information in cognitions. The relationship of construction recall ordinary information to a delayed cognition of the pure memory type is one of direct retrieval of a unit structure of information. Herein, too, is the rationale of how the same structure is involved in the long term memory being active during the human behaviors of a second or repeated learning experience. It is very probable, from this finding and the evidence of the M unit of the 42 dimension algorithm being so extremely correlated with other elements of information processes for learning tasks, that the unit of structure of the memory of pre-operational children has been identified from this study.

The study then confirms the hypothesis put forth by Piaget and others about the schema role for reconstruction and pure memory recall. It does not, however, confirm their claims of the information theoretic definitions of memory and mental maturation. Nevertheless, the findings in this study report the first explanation of how the pre-operational human memory processes information in learning and cognition. This kind of research report should facilitate more meaningful research approaches to how children learn science.

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