DOCUMENT RESUME

ED 091 191 SE 017 741

AUTHOR	Dunlop, David L.
TITLE	Information Memory Processing and Retrieval: The Use of Information Theory to Study Primacy and Recency Characteristics of Ninth Grade Science Students Processing Learning Tasks.
PUB DATE	17 Apr 74
NOTE	26p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (47th, Chicago, Illinois, April 1974). For related documents, see SE 017 740 - 744 and SE 017 760
EDRS PRICE	MF-$0.75 HC-$1.85 PLUS POSTAGE
DESCRIPTORS	Biology; *Cognitive Measurement; *Educational Research; Grade 9; *Information Theory; *Memory; Science Education; Secondary School Science; *Thought Processes
IDENTIFIERS	Research Reports

ABSTRACT

Reported is another study related to the Project on an Information Memory Model. This study involved using information theory to investigate the concepts of primacy and recency as they were exhibited by ninth-grade science students while processing a biological sorting problem and an immediate, abstract recall task. Two hundred randomly selected students were given a biologically oriented classification sorting problem which required them to observe, for 15 minutes, a color slide composed of 14 different animals commonly recognized by ninth-grade students. Student scores were divided into low and high primacy (recall of items early in a list) and into low and high recency (recall of those items at the end of a list) groups. There were generally no significant differences between the low and high groups (primacy and recency) with respect to their set formation scores. When the groups were segregated on the basis of their ability to recall, there were significant differences between high and low groups. Total cognition scores were slightly greater for the recency students when compared to the corresponding ability group for primacy, suggesting that a slight but not significant advantage in recall belonged to the recency group. (Author/PEB)

INFORMATION MEMORY PROCESSING AND RETRIEVAL: THE USE OF INFORMATION THEORY TO STUDY PRIMACY AND RECENCY CHARACTERISTICS OF NINTH GRADE SCIENCE STUDENTS PROCESSING LEARNING TASKS

NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

ANNUAL CONFERENCE

CHICAGO ILLINOIS

17 APRIL 1974

DAVID L. DUNLOP

UNIVERSITY OF PITTSBURGH AT JOHNSTOWN

INFORMATION MEMORY PROCESSING AND RETRIEVAL: THE USE OF INFORMATION THEORY TO STUDY PRIMACY AND RECENCY CHARACTERISTICS OF NINTH GRADE SCIENCE STUDENTS PROCESSING LEARNING TASKS

NATIONAL ASSOCIATION FOR RESEARCH IN
SCIENCE TEACHING

ANNUAL CONFERENCE:

17 APRIL, 1974
CHICAGO, ILLINOIS

DAVID L. DUNLOP

UNIVERSITY OF PITTSBURGH AT JOHNSTOWN

(PROJECT ON AN INFORMATION MEMORY MODEL)

ADDRESS:

PIMM, 2610 CL, SCHOOL OF EDUCATION,

UNIVERSITY OF PITTSBURGH,

PITTSBURGH, PENNSYLVANIA 15260

INTRODUCTION

Information theory is an objective approach, based on mathematical concepts used to study an information signal as it moves through some medium (channel) from an information source to a destination. Moser[1,21] has shown how this theory may be modified and developed into a memory model potentially capable of describing information processing of cognitive tasks within the human brain. The principles of information theory are not new nor did they appear suddenly. Roberts[2] presents a comprehensive review of the events leading to the development of information theory which, in its contemporary form, began in 1948 when Claude E. Shannon[3] published "The Mathemetical Theory of Communication." The following year Warren Weaver published a closely related article consisting of an expository introduction to the general theory. Information theory as described by Shannon and Weaver[4] was originally applied to electronic channels; however, its use in areas other than electronics has been described by Dahling[5], and its use is rapidly increasing.

With the exception of electronics, the field of psychology has done more experimenting with information theory than any other field. Garner[6] prepared a bibliography of articles and books concerned with applications of information theory to psychology.

Using a physiological approach, Trehub has tied information theory directly to the functioning of a mammalian brain. By use of bioelectic signal - to - noise ratios in a rat brain, he has demonstrated that the brain functions as a coherent signal detector; an important class of detectors that are explicitly formulated within the statistical theory of communications. Further, he claims that the mammaliam brain has evolved into the most efficient stochastic signal detection scheme known. In addition, it has been reported by Deutsch[8] that tonal sounds are logarithmically arranged in the human memory. This lends strong support to the memory model developed by Moser[1] which, in addition to using information theoretic measures to quantify the model, makes strong reference to qualitative memory models described by other researchers in the field.

Although researchers do not agree on the specific processes occuring within the brain, many agree that the human brain does indeed have two types of memory processes and have labeled them as the short-term and the long-term memory. Kintsch[9] provides a memory model in which a distinction has been made between structural components of memory and control processes. In his model the structoral components are the three memory stores; sensory memory, primary memory, and secondary memory. The primary and secondary memories approximately correspond to the short and long-term memories described by Atkinson[10] while the sensory memory seems to be a large-capacity store where information is held for very brief periods of time and is related to phenomena such as visual after-images.

Jensen[11] points out that it is not yet understood whether short-term memory and long-term memory involve different psychological or neurophysiological processes or merely represent an arbitarary procedural distinction while the basic processes or mechanisms are the same for both. It is clear, however, that the two types of memory processes can be operationally distinguished for experimental purposes.

A recent study by Shiffrin[12] approaches the question of one or two separate memories by investigating the independence of the list-length effects from serial-position effects. He points out that many single memory theories consider the serial-position effects and list-length effects to be integrally related. On the other hand, the two memory paradigm considers these effects to be relatively independent. Since, by having subjects recall complex pictures, he can demonstrate the relative independence of list-length effects and serial-position effects, he concludes that the case for a two memory paradigm has been strengthened.

Further support for a duplex theory of memory comes from Atkinson and Shiffrin.[10] Their model states that input from the external world is accepted via the nervous system. Here information can be processed in three general ways. First, the information can become lost. Second, the information can be maintained in the short-term memory by rehearsal. Third, the information can be transferred into the long-term memory for permanent storage.

Once the information has been transferred into the long-term memory, it is of no value to an individual unless that information can be located at some later time. Sternberg[13] has used reaction time data to study the retrieval of information from short memorized lists. One is a high-speed exhaustive scanning process, used to determine the presence of an item in the list; the other is a slow self-terminating scanning process used to determine the location of an item in the list. He also points out that the retrieval process is impaired if the information being retrieved is not also being rehearsed in the short-term memory.

The model described by Atkinson[10] assumes the long-term memory to be relatively permanent and hence forgetting is believed to be the result of inadequate selection of probe information and consequent failure of the retrieval process. There is another model, although less well supported, which explains forgetting as the result of memory trace erosion.[14] Wulf[15] reported distortion in delayed recall as compared to the original figures. This can happen in two different ways. First, the trace can decay through time, or it may be distorted through time. Both ways attribute the changes in recall to changes in the brain tissue after the information enters the long-term memory. More recent studies by Bruner and others[16] indicate that the distortions in delayed recall occur at the time the figures are first seen.

Another alternative to explain forgetting may be examined. This alternative is that of interference theory. In brief, this model states that an association between two items, say a-b, is made. If a new association, say a-c, is established it will interfere with the old one. This model also states that an original association, say a-b, may be unlearned but subject to spontaneous recovery.[9] Atkinson[10] seems to agree to some extent with interference theory but adds that the interference is caused only by similar information entering the short-term store. Interference which arises from associations learned later in time is called retroactive inhibition due to its retroactive effect, while interference arising from associations learned earlier in time is called proactive inhibition. Underwood[17] believes that it is proactive inhibition which appears to be the major cause of forgetting.

Jensen[11] discusses forgetting in the short-term memory and questions whether it is due to spontaneous decay of the memory trace or to active interference with the consolidation of the memory trace by other stimuli. He states that the more control the experimenter has over the subject's attention during the interval between presentation and recall, the less the subject can recall. The intervening demand on attention is presumed to interfere with whatever process takes place under less attention-demanding conditions that result in greater recall. He goes on to point out that forgetting in the long-term memory is probably due to response competition and extinction. These are both specific cases of interference theory.

An interesting phenomenon in forgetting is the concept known as the serial position curve. This refers to the fact that when a list of homogeneous items are learned, best retention will occur for the two ends of the list and poorest retention will be in the middle.[18] Wickens[19] demonstrated that if, after a few items the nature of the list was changed, the subjects would recall the items in the middle of the list almost as well as those items at the beginning of the list. Atkinson[10] has demonstrated that the primacy effect can be made to disappear by forcing the subject to rehearse all items in the list an equal number of times. Hence, it seems that primacy (retention of those items early in the list) is related to the newness of the items[19] and the amount of attention (rehearsal) given to them.[10]

The explanation for recency (recall of those items at the end of the list) is probably due to the primary (short-term) memory phenomena. In other words, the information is immediately ready for recall because it is already in the short-term memory being rehearsed.[18] Atkinson's[10] data support the view that the recency effect reflects the retrieval from both short-term and long-term memory, whereas the primacy effect reflects retrieval from the long-term storage only.

PROBLEM

The purpose of this study was to use information theory to investigate the concepts of primacy and recency as they were exhibited by ninth grade science students while processing a biological sorting problem and an immediate, abstract recall task.

The following hypotheses were tested: 1) There is no significant difference in the values of information theoretic measures for students who demonstrated high primacy scores in a recall task and the corresponding measures for students who demonstrated low primacy scores. 2) There is no significant difference in the values of information theoretic measures for students who demonstrated high recency scores in a recall task and the corresponding measures for students who demonstrated low recency scores.

METHODS

Two hundred randomly selected ninth grade science students were given a biologically orientated classification sorting problem. The problem required the students to observe, for fifteen minutes, a color slide composed of fourteen different animals commonly recognized by ninth grade students. Each animal of the composite picture was in natural color and was located randomly on a red background. Each animal in the picture was within a rectangular, circular, or an irregular border and had a large black number at the lower right corner of the shape for identification purposes.

Prior to the actual projection, the students were briefed as to what to expect, and they were instructed to group the animals by name, shape or any other criterion into sets of three or more animals. At the end of each set, the reason for grouping that set was stated. The students were encouraged to study the picture for the full fifteen minutes and form as many different sets as possible.

At the end of the fifteen minutes, the papers were collected and unlined white paper was given to each student. The instructions stated that each student, without the help of any notes, should sketch the picture as he remembered it. He was to include the position of the animal, its name (spelled out instead of drawn), and the identification number associated with each animal. As they made the sketches they were to place a letter, beginning with "A", beside each animal as they recalled the object. This provided a means to examine the order in which the students sketched the recalled animals. At the end of three minutes all papers were collected, and the task was completed.

The recall score (cognition) was determined by giving the student one point for each name, shape, or number in the proper relative position in his sketch. The maximum score possible was forty-two. The set formation scores were derived from the student's groupings made while looking at the slide. The reason given by the student for each formation was placed into one of the following categories: shape, name, identification number, pattern, attributes, and other. The category of pattern refers to the spatial locations, and the category of attribute was used if the student cited two or more different reasons for the set formation.

By analyzing the order of recall in conjunction with the set formation list, a primacy and a recency score was determined for each student. On the basis of these scores the students were separated into the following groups: low primacy, high primacy, low recency, and high recency. These groups were examined with respect to their achievement on standard tests, cognition scores, set formation scores, and information values which were derived from the set formation elements. The algorithms described by Moser[1,20] were used in the calculations of the information measures value. Linear analysis, product moment correlations, and t-tests were used to analyze the data.

RESULTS

Six standard test scores were used to make initial comparisons between various groups. Table 1 compares low and high primacy groups of students as well as low and high recency groups of students. It may be seen that the low scoring students are equal to the high scoring students for both groups (primacy and recency) with respect to these six tests.

Set formation and cognition scores for both groups were compared; Tables 2 and 3 show the t-test results. It may be seen that the low and high primacy groups do not differ in their set formation (practice) scores; however, they do indicate significant differences in all of their cognition (recall) scores. When comparing the t-values shown in Table 3, one may see that the low and high recency groups do not differ in their set formation sub-scores; the single exception is for the set formation sub-score of name. In addition, these two groups are different with respect to their cognition scores; significant differences are seen in all four of the cognition score categories.

TABLE 1.—Summary of t-test values for six standard test scores of low and high primacy groups as well as low and high recency groups of students

Test	Low[a] $\bar{X}$	Low[a] s	High[b] $\bar{X}$	High[b] s	t-value	Level of Significance
			Primacy			
Shipley	15.98	2.44	16.62	2.60	- .41	n.s.
I. Q.	111.42	12.88	111.88	10.92	- .13	n.s.
Paragraph	56.39	26.71	61.55	26.65	- .64	n.s.
Spelling	49.22	26.30	60.60	28.05	- 1.39	n.s.
Language	53.39	24.23	59.70	18.78	- .95	n.s.
Science	56.28	30.86	55.15	25.67	.11	n.s
			Recency			
Shipley	15.97	2.44	16.80	2.61	- 1.01	n.s.
I. Q.	109.08	11.92	115.00	10.74	- 1.63	n.s.
Paragraph	54.25	26.84	64.50	25.71	- 1.20	n.s.
Spelling	54.75	25.56	55.72	30.13	- .01	n.s.
Language	51.75	20.40	62.22	21.91	- 1.52	n.s.
Science	48.84	30.25	62.56	24.72	- 1.54	n.s.

[a] n = 25 for the primacy group and 32 for the recency group

[b] n = 35 for the primacy group and 28 for the recency group

TABLE 2 —Summary of t-test values for set formation and cognition scores of low and high primacy groups of students in task two

Score	Low Primacy (n = 25) $\bar{X}$	s	High Primacy (n = 35) $\bar{X}$	s	t-value	Level of Significance
SETS:						
Shape	3.12	3.67	3.17	3.24	- 0.06	n.s.
Name	8.16	3.57	9.19	5.09	- 0.88	n.s.
Number	0.60	1.26	0.51	1.17	0.27	n.s.
Pattern	0.48	1.58	0.09	0.51	1.33	n.s.
Attributes	0.04	0.20	0.14	0.60	- 0.86	n.s.
Other	0.24	0.60	0.20	0.47	0.29	n.s.
Total	12.64	5.73	13.78	7.67	- 0.93	n.s.
COGNITION:						
Shape	4.52	2.49	6.43	2.62	- 2.89	.005
Name	6.48	2.65	7.97	2.50	- 2.24	.025
Number	1.24	1.79	2.69	3.69	- 1.89	.05
Total	12.24	4.63	17.09	5.22	- 4.35	.0005

TABLE 3 —Summary of t-test values for set formation and cognition scores of low and high recency groups of students in task two

Score	Low Recency (n = 32)		High Recency (n = 28)		t-value	Level of Significance
	$\bar{X}$	s	$\bar{X}$	s		
SETS:						
Shape	3.09	3.30	3.21	3.56	- 0.14	n.s.
Name	7.66	2.52	10.00	5.84	- 1.97	.05
Number	0.53	1.14	0.57	1.29	- 0.13	n.s.
Pattern	0.13	0.71	0.39	1.42	- 0.90	n.s.
Attributes	0.00	0.00	0.21	0.69	- 1.65	n.s.
Other	0.13	0.49	0.32	0.55	- 1.45	n.s.
Total	11.54	4.57	14.70	8.45	- 1.77	.05
COGNITION:						
Shape	4.75	2.50	6.64	2.63	- 2.85	.005
Name	6.44	2.46	8.39	2.50	- 3.04	.005
Number	1.41	2.21	2.86	3.79	- 1.78	.05
Total	12.60	5.09	17.89	4.59	- 4.52	.0005

The information values of the low scoring students were compared to the corresponding values of the high scoring students for the categories of primacy and recency. The t-test results are shown in Table 4.

From Table 4 it may be seen that low and high primacy groups did not differ significantly in any of the eleven information measures tested. On the other hand, the low and high recency groups differed in nine of the eleven measures tested. Only LTM and H(Y) did not show the recency groups to be different.

Multiple regression equations were used to examine the flow of information in the following four groups: low primacy, high primacy, low recency, and high recency. In these equations the information measures were used as the dependent variables and the set formation and cognition scores were entered as the independent variables (forecasters). Tables 5 and 6 show the partial RSQ's for the four groups. It may be seen that for both the primacy and the recency groups the low groups are better able to forecast the variance of the information measures than the high groups. When considering the low primacy group one may see that the set formations of number, shape, pattern, and color are all of significant value in the forecasting of the variance of the information measures. In the high primacy group it is the set formations of color and number which are used as significant forecasters. The low recency group shows shape, number, and color as the best forecasters, while the high recency group seems to have only set formation pattern as a significant forecaster of the variance of the information measures. Further, both low groups show some indication of using cognition scores as forecasters. From Table 7, one may see that the total RSQ's indicate the primacy groups as better able to predict the information measures than the recency groups. Further, the low groups have more significant forecasters than do the high groups. Generally, the independent loads did not indicate any significant serial correlation.

Product moment correlations were used to relate set formation scores and cognition scores to different levels of the memory. Seventeen information measures representing aspects of short-term memory along with nine measures representing long-term memory and five measures representing the strength of dependence were examined for significant correlation with cognition scores and set formation scores (see Appendices A to D). The percentages of significant correlations are summarized in Table 8.

When examining low and high primacy groups of children, Table 8, it may be seen that short-term memory measures correlate better with set formation and cognition scores than do long-term or strength of dependence measures. Further, the short-term measures of the high primacy groups correlated better with the set formation scores than did the measures of the low primacy group; however, it is the low primacy group indicating better correlation of the short-term measures with the cognition scores. The strength of dependence measures of the high primacy group correlate with four of the six set formation scores, but with none of the cognition scores. The long-term measures show trends toward correlations with cognition scores, but only for the low primacy group.

Table 8, showing the percentages of significant correlations between three memory levels and cognition and set formation scores of low and high recency groups, indicates almost no correlations with cognition scores. Set formation scores, however, show significant correlations with short-term measures in 67% of the categories. Further, with the exception

TABLE 4 —Summary of t-test values for eleven information measures of low and high primacy groups as well as low and high recency groups of students in task two

Measure	Low[a] $\bar{X}$	Low[a] s	High[b] $\bar{X}$	High[b] s	t-value	Level of Significance
			Primacy			
H(X)	3.7182	0.0876	3.7217	0.0705	- 0.17	n.s.
Hx(Y)	1.4922	0.3562	1.5487	0.3553	- 0.61	n.s.
CODE	2.2261	0.3556	2.1731	0.3247	0.60	n.s.
H(Y)	3.8343	0.1123	3.8161	0.1155	0.62	n.s.
Hy(X)	1.3762	0.3274	1.4544	0.3365	- 0.91	n.s.
REAL-M1	2.3421	0.3272	2.2674	0.3104	0.01	n.s.
LTM	0.1160	0.0683	0.0943	0.0064	1.25	n.s.
REAL-SS	0.1789	0.1752	0.1718	0.1410	0.17	n.s.
H(X,Y)	5.2105	0.3778	5.2704	0.3963	- 0.60	n.s.
M16	0.0032	0.0032	0.0033	0.0036	- 0.11	n.s.
NOISE:X	0.3700	0.0877	0.3901	0.0872	- 0.89	n.s.
			Recency			
H(X)	3.7049	0.0881	3.7378	0.0599	- 1.71	.05
Hx(Y)	1.4054	0.3367	1.6619	0.3270	- 2.99	.005
CODE	2.2995	0.3245	2.0758	0.3132	2.71	.005
H(Y)	3.8029	0.1141	3.8474	0.1101	- 1.54	n.s.
Hy(X)	1.3075	0.3120	1.5523	0.3103	- 3.04	.005
REAL-M1	2.3974	0.3012	2.1855	0.3009	2.72	.005
LTM	0.0979	0.0616	0.1096	0.0743	- 0.66	n.s.
REAL-SS	0.2054	0.1762	0.1397	0.1197	1.71	.05
H(X,Y)	5.1104	0.3702	5.3997	0.3506	- 3.11	.005
M16	0.0023	0.0026	0.0043	0.0040	- 2.26	.025
NOISE:X	0.3526	0.0827	0.4151	0.0813	- 2.95	.005

[a] n = 25 for the primacy group and 32 for the recency group

[b] n = 35 for the primacy group and 28 for the recency group

TABLE 5 —Summary of Partial RSQ's in task two for a high primacy and a low primacy group of children

Dependent	Set Formation						Cognition		
Measure	Shape	Color	Number	Pattern	Attribute	Other	Shape	Color	Number
				High Primacy Group (n = 35)					
H(X)	.00	.01	.04	.00	.05	.03	.00	.01	.02
Hx(Y)	.02	.22*	.19*	.04	.02	.01	.00	.02	.02
CODE	.03	.23*	.18*	.04	.04	.01	.01	.02	.01
H(Y)	.01	.17*	.08	.00	.07	.02	.00	.00	.00
Hy(X)	.03	.12*	.14*	.03	.03	.01	.00	.02	.02
REAL-M1	.03	.12*	.12*	.03	.05	.00	.00	.02	.02
LTM	.03	.32*	.08	.01	.05	.00	.01	.01	.03
REAL-SS	.00	.01	.04	.00	.05	.03	.00	.01	.02
H(X,Y)	.02	.19*	.18*	.03	.00	.02	.00	.02	.02
M16	.02	.37*	.15*	.00	.10	.01	.00	.00	.00
NOISE:X	.03	.12*	.13*	.03	.03	.01	.00	.02	.02
				Low Primacy Group (n = 25)					
H(X)	.22*	.00	.26*	.00	.00	.06	.46*	.25*	.00
Hx(Y)	.34*	.24*	.48*	.33*	.07	.06	.00	.01	.01
CODE	.46*	.27*	.42*	.37*	.08	.10	.06	.06	.01
H(Y)	.00	.12	.34*	.07	.02	.00	.39*	.14	.05
Hy(X)	.26*	.16	.42*	.27*	.09	.04	.01	.01	.04
REAL-M1	.38*	.18*	.36*	.30*	.11	.08	.09	.06	.04
LTM	.21*	.22*	.15	.13	.03	.02	.06	.00	.11
REAL-SS	.22*	.00	.26*	.00	.00	.06	.46*	.25*	.00
H(X,Y)	.22*	.20*	.49*	.28*	.05	.03	.04	.00	.01
M16	.00	.23*	.56*	.35*	.01	.03	.21*	.02	.07
NOISE:X	.33*	.17*	.39*	.28*	.10	.05	.02	.02	.04

*Significant at the .05 level

TABLE . 6 -Summary of Partial RSQ's in task two for a high recency and a low recency group of children

Dependent	Set Formation						Cognition		
Measure	Shape	Color	Number	Pattern	Attribute	Other	Shape	Color	Number
				High Recency Group (n = 28)					
H(X)	.00	.01	.06	.02	.08	.07	.01	.01	.02
Hx(Y)	.10	.07	.13	.20*	.01	.04	.04	.04	.00
CODE	.10	.07	.10	.19*	.03	.02	.06	.05	.00
H(Y)	.01	.20*	.08	.17*	.14*	.05	.00	.01	.02
Hy(X)	.10	.01	.09	.10	.02	.03	.04	.04	.00
REAL-M1	.10	.01	.07	.09	.05	.01	.05	.04	.01
LTM	.03	.31*	.04	.22*	.09	.00	.00	.01	.01
REAL-SS	.00	.01	.06	.02	.08	.07	.01	.01	.02
H(X,Y)	.09	.07	.15*	.20*	.00	.06	.03	.02	.00
M16	.02	.32*	.14*	.31*	.13	.01	.03	.05	.04
NOISE:X	.10	.01	.08	.10	.03	.02	.04	.04	.00
				Low Recency Group (n = 32)					
H(X)	.12*	.02	.11	.01	.00	.01	.09	.02	.02
Hx(Y)	.46*	.53*	.54*	.01	.02	.18*	.14*	.05	.13*
CODE	.57*	.52*	.48*	.01	.02	.21*	.06	.09	.10
H(Y)	.00	.10	.20*	.02	.01	.00	.12*	.01	.01
Hy(X)	.36*	.45*	.47*	.01	.01	.16*	.09	.04	.21*
REAL-M1	.46*	.42*	.38*	.02	.01	.18*	.03	.07	.17*
LTM	.23*	.19*	.18*	.02	.01	.01	.07	.01	.14*
REAL-SS	.12*	.02	.11	.01	.00	.01	.09	.02	.02
H(X,Y)	.27*	.45*	.51*	.00	.02	.11	.16*	.02	.12*
M16	.00	.29*	.53*	.04	.00	.04	.19*	.00	.01
NOISE:X	.43*	.45*	.44*	.02	.01	.16*	.06	.06	.20*

*Significant at the .05 level

TABLE 7 --Summary of RSQ and Durbin-Watson values in task two using set formation and cognition as forecasters of information measures for high and low primacy and recency groups of students

	High Group[a]		Low Group[b]	
Dependent Measure	RSQ	Durbin-Watson Value	RSQ	Durbin-Watson Value
		Primacy Group		
H(X)	.0000	1.45**	.5415*	2.29
Hx(Y)	.4392*	2.21	.5521*	2.56
CODE	.4483*	2.26	.6096*	2.27
H(Y)	.2439*	1.38**	.3986*	2.29
Hy(X)	.2969*	2.29	.4794*	2.49
REAL-M1	.2832*	2.30	.5468*	2.18
LTM	.3609*	1.65	.1614	2.32
REAL-SS	.0000	1.45**	.5415*	2.29
M16	.6003*	1.80	.5195*	2.31
H(X,Y)	.4028*	2.10	.4998*	2.73
NOISE:X	.2927*	2.29	.5066*	2.40
		Recency Group		
H(X)	.0623	2.43	.1519	1.34**
Hx(Y)	.3981*	2.21	.7341*	1.74
CODE	.3804*	2.04	.7383*	1.78
H(Y)	.3411*	1.91	.1049	1.35
Hy(X)	.1804	2.16	.6842*	1.80
REAL-M1	.1562	2.04	.6646*	1.77
LTM	.3457*	1.56	.2576	1.78
REAL-SS	.0623	2.43	.1519	1.34**
M16	.5864*	2.00	.5902*	1.72
H(X,Y)	.3926	2.36	.6651*	1.60
NOISE:X	.1737	2.11	.6896*	1.82

*Significant at the .05 level with 9 and 25 degrees of freedom for the high primacy group, 9 and 15 degrees of freedom for the low primacy group, 9 and 18 degrees of freedom for the high recency group, and 9 and 22 degrees of freedom for the low recency group.

**Serial correlation at the .05 level of significance.

[a] n = 35 for the primacy group and n = 28 for the recency group.

[b] n = 25 for the primacy group and n = 32 for the recency group.

TABLE 8 Percent of significant correlations between three memory levels and set formation and cognition scores of low (n = 25) and high (n = 35) primacy groups as well as low (n = 32) and high (n = 28) recency groups of students in task two

Score	Short-term		Long-term		Dependence	
	Low Group	High Group	Low Group	High Group	Low Group	High Group
			Primacy			
SETS:						
Shape	47.1	76.5	100.0	00.0	00.0	100.0
Name	52.9	88.2	00.0	00.0	00.0	100.0
Number	64.7	64.7	00.0	00.0	100.0	100.0
Pattern	00.0	00.0	00.0	00.0	60.0	40.0
Attributes	00.0	05.9	00.0	00.0	00.0	00.0
Other	00.0	00.0	00.0	00.0	00.0	00.0
COGNITION:						
Shape	17.7	00.0	100.0	00.0	00.0	00.0
Name	17.7	23.5	100.0	00.0	00.0	00.0
Number	41.2	00.0	00.0	00.0	00.0	00.0
			Recency			
SETS:						
Shape	70.6	76.5	00.0	00.0	00.0	100.0
Name	52.9	82.4	00.0	00.0	00.0	100.0
Number	82.4	00.0	100.0	00.0	100.0	80.0
Pattern	00.0	05.9	00.0	00.0	00.0	80.0
Attributes	00.0	11.8	00.0	100.0	00.0	00.0
Other	00.0	11.8	00.0	100.0	00.0	00.0
COGNITION:						
Shape	00.0	00.0	00.0	00.0	00.0	00.0
Name	00.0	00.0	00.0	00.0	00.0	00.0
Number	35.3	00.0	00.0	00.0	00.0	00.0

of number, the high primacy group shows stronger correlations with set formation scores than does the low primacy group. Strength of dependence measures also correlate significantly with set formation scores in the high recency group. Long-term measures show a slight trend to correlate with set formation scores; however, this trend is weak and generally not significant.

Tables 9 and 10 show correlations among selected information measures. It may be seen from table 9 that correlations between Real-ss and other measures are different for the low and high primacy groups. The low and high recency groups, however, indicate differences based upon correlations between LTM and other measures. The M-Unit (as described by other papers in this paper set) is significantly correlated with $H_y(X)$ in the high recency and low primacy groups.

Conclusions:

Does the ability to demonstrate high primacy or high recency scores on a recall task affect the values of information theoretic measures? (A definition of low and high primacy as well as low and high recency group appears earlier in this paper.)

When making a general comparison between high and low primacy as well as between high and low recency groups of students, it was concluded that there was no significant difference in their general intellectual ability. In addition, there were generally no significant differences between the low and high groups (primacy and recency) with respect to their set formation scores. Since these two groups were segregated on the basis of their ability to recall, it was assumed that differences in recall between the low and high groups would be significant. This was indeed the conclusion reached after studying the data. Further, it was demonstrated that total cognition scores were slightly greater for the recency students when compared to the corresponding ability group for primacy. This suggested that a slight, but not significant, advantage in recall belongs to the recency groups when compared to the primacy groups.

From a study of the information measures, it was concluded that the low and high primacy groups do not differ in the quantitative aspects of information processing. However, based upon relationships between memory levels and set formation and cognition scores, it appears that the actual processing for the two groups is somewhat different. The high primacy group tends to use the short-term memory to a greater extent than does the low primacy group with respect to the set formation part of the task. It is the low group, however, showing greater relationships between cognition sub-score and short-term memory measures. Similar statements may be made for the low and high recency groups. The conclusions seem to be that both the high primacy and the high recency groups make more efficient use of the short-term memory store than do the low primacy and low recency groups. A general lack of linear correlation between long-term memory and cognition and set formation scores may be due to the possibility of a non-linear relationship between the two. It is also possible that the long-term memory does not become significantly involved in this type of recall task since the recall follows within one or two minutes of the sorting task.

TABLE 9. -- Linear correlations of selected information measures for low and high primacy groups

Low Primacy n = 25

	Hy(X)	%Real	LTM	Real-SS	M-Unit
% Code	-.97*	.99*	-.50*	.02	.20
Hy(X)		-.99*	.33	-.13	-.23
% Real			-.39*	.04	.20
LTM				.02	-.05
Real-SS					.22

High Primacy n = 35

	Hy(X)	%Real	LTM	Real-SS	M-Unit
% Code	-.98*	.98*	-.35*	.46*	.17
Hy(X)		-.99*	.19	-.46*	-.19
% Real			-.22	.43*	.17
LTM				-.42*	.02
Real-SS					.17

*Significant at the .05 level

TABLE 10. -- Linear correlations of selected information measures for low and high recency groups

	Hy(X)	%Real	LTM	Real-SS	M-Unit
Low Recency n = 32					
% Code	-.97*	.99*	-.48*	.16	.05
Hy(X)		-.99*	.31	-.26	-.05
% Real			-.37*	.17	.05
LTM				-.13	-.12
Real-SS					.16
High Recency n = 28					
% Code	-.97*	.98*	-.31	.24	.28
Hy(X)		-.99*	.11	-.25	-.39*
% Real			-.14	.20	.30
LTM				-.33	.02
Rea-SS					.25

*Significant at the .05 level

Data from linear correlations among information measures suggest that high primacy students processed the information differently than did the other groups, and further, this difference is related to information processing in the long-term memory. This supports Atkinson's[10] conclusion that the primacy effect reflects retrieval from the long term storage. Both the low primacy and the low recency groups exhibited short term correlations only, suggesting the lack of any effective long term processing. One may have expected the high recency group to show significant long and short term processing correlations. This trend is present; however, it is not significant at the .05 level of significance. It is interesting to note that only this group (high recency) has a significant correlation between the M-unit and equivocation ($H_y(X)$). The M-unit as discussed in some detail in other papers in this set appears to be an inportant aspect of the memory model. Its specific role in the primacy and recency effect is still under investigation.

1. Moser, Gene W. "An Information Theoretic Model for the Human Processing of Cognitive Tasks." Paper presented to the National Association for Research in Science Education, April, 1972.

2. Roberts, Tommy L. "Theoretical Framework." Oklahoma State University Research Foundation at Stillwater, Oklahoma, 1969.

3. Shannon, C.E. "A Mathematical Theory of Communication." Bell System Technical Journal, 27 (1948), 623-656.

4. Shannon, Claude E., and Weaver, Warren. The Mathematical Theory of Communication. Urbana, Illinois: University of Illinois Press, 1949.

5. Dahling, R. L. Shannon's Information Theory: The Spread of an Idea in Studies of Innovation and of Communication to the Public. Ed. by E. Katz. Stanford University, 1962.

6. Garner, W.R. Uncertainty and Structure as Psychological Concepts. New York: John Wiley and Sons, Inc., 1962.

7. Trehub, Arnold. "The Brain as a Parellel Coherent Detector." Science (Nov. 12, 1971), 722-723.

8. Deutsch, D. "Mapping of Interactions in the Pitch Memory Store." Science, 175 (1972), 1020-1022.

9. Kintsch, Walter. Learning Memory and Conceptual Processes. New York: John Wiley and Sons, Inc., 1970.

10. Atkinson, Richard C. and Shiffrin, Richard M. "The Control of Short-term Memory." Scientific American, (September, 1971), 82-90.

11. Jensen, Arthur A. Individual Differences in Learning: Interference Factor. Berkeley, California: Institute of Human Learning, 1964.

12. Shiffrin, Richard M. "Visual Free Recall." Science, 180 (1973), 980-982.

13. Sternberg, Samuel. "Memory-Scanning: Mental Processes Revealed by Reaction-Time Experiments." American Scientist, 57 (1969), 421-457.

14. Hilgard, Ernest R. and Atkinson, Richard C. Introduction to Psychology. 4th ed. New York: Harcourt, Brace and World, Inc., 1967.

15. Wulf, F. Uber die Veranderung von Vorstellungen. Translated by Ernest R. Hilgard and Richard C. Atkinson. 4th ed. New York: Harcourt, Brace, and World, Inc., 1967.

16. Bruner, J.S., Busiek, R.D., and Minturn, A.L. "Assimilation in the Immediate Reproduction of Visually Perceived Figures." Journal of Experimental Psychology, 44 (1952), 151-155.

17. Underwood, B.J. "Interference and Forgetting." Psychological Review, 64 (1957), 49-60.

18. Waugh, Nancy C., and Norman, Donald A. "Primary Memory." Psychological Review, 72 (1965), 89-104.

19. Wickens, D.D.; Born, D.G.; Allen, C.K. "Proactive Inhibition and Item Similarity in Short-Term Memory." Journal of Verbal Learning and Verbal Behavior, 2 (1963), 440-445.

20. Moser, Gene W. "An Information Theoretic Memory Model for Describing the Information Processed in Cognitive Tasks." Proposal for Research submitted to the U.S. Commissioner of Education, December, 1971.

21. Moser, Gene W.; Korth, Willard; Fazio, Frank; Dunlop, David; and Felen, Barbara. "The Use of Information Theory to Study Human Learning." Symposium presented to the National Association for Research in Science Teaching, March, 1973.

APPENDICES

APPENDIX A—Correlations for high primacy, task two (n = 35)

	Set Formation						Cognition		
Measure	Shape	Color	Number	Pattern	Attribute	Other	Shape	Color	Number
H(X)	.15	.18	.34	.12	.33	-.11	.02	.09	.04
H(X)RE	.15	.18	.34	.12	.33	-.11	.02	.09	.04
Hx(Y)	.53	.63	.41	.29	.06	.01	.24	.37	-.04
Hx(Y)RE	.85	.67	-.02	.02	-.05	-.10	.13	.22	-.18
CODE	-.54	-.65	-.37	-.29	.01	-.04	-.26	-.38	-.18
% CODE	-.53	-.63	-.39	-.29	-.03	-.02	-.24	-.37	.05
H(Y)	.28	.44	.40	.21	.36	-.14	.10	.20	-.12
Hy(X)	.49	.55	.36	.26	.01	.04	.22	.34	.01
REAL	-.50	-.55	-.31	-.25	.07	-.07	-.24	-.35	.01
% REAL	-.45	-.55	-.36	-.25	-.01	-.04	-.22	-.34	-.02
LTM	.33	.59	.34	.23	.28	-.12	.15	.25	-.25
% LTM	.56	.74	.40	.31	.23	-.09	.21	.33	-.26
H(Y)-SS	-.15	-.18	-.34	-.12	-.33	.11	-.02	-.09	.31
Hy(X)-SS	.15	.18	.34	.12	.33	-.11	.02	.09	.04
REAL-SS	-.15	-.18	-.34	-.12	-.33	.11	-.02	-.09	-.04
% REAL-SS	-.15	-.18	-.33	-.12	-.32	-.12	-.02	-.09	-.04
H(X,Y)-SS	.15	.18	.34	.12	.33	-.11	.02	.09	.04
NOISE-SS	.15	.18	.34	.12	.33	-.11	.02	.09	.04
% NOISE-SS	.15	.18	.33	.12	.32	-.12	.02	.09	.04
NOISE:X-SS	.15	.18	.33	.12	.32	-.11	.02	.09	.04
NOISE:Y-SS	.15	.18	.34	.13	.34	-.11	.02	.09	.04
M1	.37	.52	.48	.27	.30	-.07	.16	.28	-.06
M2	.40	.55	.50	.29	.32	-.06	.17	.29	-.08
M4	.46	.60	.51	.33	.33	-.05	.19	.30	-.12
M16	.53	.67	.49	.37	.31	-.04	.20	.31	-.17
M256	.62	.75	.38	.37	.21	-.03	.20	.33	-.23
H(X,Y)	.50	.59	.42	.28	.11	-.01	.21	.34	-.03
NOISE	.51	.59	.39	.27	.03	.02	.23	.35	-.02
% NOISE	.45	.55	.36	.25	.01	.04	.22	.34	.02
NOISE:X	.49	.55	.34	.26	-.02	.05	.23	.34	.01
NOISE:Y	.50	.60	.37	.27	.01	.03	.24	.36	-.02

APPENDIX B —Correlations for low primacy, task two (n = 25)

	Set Formation						Cognition		
Measure	Shape	Color	Number	Pattern	Attribute	Other	Shape	Color	Number
H(X)	-.40	-.04	.36	.08	.15	-.30	.50	.45	.02
H(X)RE	-.40	-.04	.36	.09	.15	-.30	.50	.45	.02
Hx(Y)	.37	.27	.43	.44	.01	.03	-.12	.11	.38
Hx(Y)RE	.03	.02	.02	.10	-.06	.35	-.35	-.33	.03
CODE	-.47	-.28	-.34	-.42	.02	-.10	.24	-.00	.37
% CODE	-.43	-.28	-.39	-.43	.00	-.05	.17	-.07	-.37
H(Y)	-.04	.11	.39	.22	.01	-.27	.44	.39	-.00
Hy(X)	.32	.25	.43	.43	.05	.04	-.15	.11	.41
REAL	-.42	-.26	-.33	-.41	-.01	-.12	.28	.01	-.41
% REAL	-.36	-.29	-.40	-.40	-.04	-.05	.19	-.07	-.41
LTM	.43	.22	.19	.25	-.18	-.05	.08	.08	-.03
% LTM	.59	.22	.20	.34	-.17	-.01	.00	.03	.04
H(Y)-SS	.40	.04	-.36	-.09	-.15	.30	-.50	-.45	-.02
Hy(X)-SS	-.40	-.04	.36	.09	.15	-.30	.50	.45	.02
REAL-SS	.40	.04	-.36	-.09	-.15	.30	-.50	-.46	-.02
% REAL-SS	.40	.04	-.35	-.09	-.15	.29	-.50	-.45	-.02
H(X,Y)-SS	-.40	-.04	.36	.09	.15	-.30	.50	.45	.02
NOISE-SS	-.40	-.04	.36	.09	.15	-.30	.50	.45	.02
% NOISE-SS	-.40	-.04	.35	.09	.15	-.29	.50	.45	.02
NOISE:X-SS	-.40	-.04	.35	.09	.15	-.29	.50	.45	.02
NOISE:Y-SS	-.39	-.03	.36	.08	.16	-.31	.50	.44	.01
M1	-.01	.19	.53	.35	.05	-.18	.27	.35	.20
M2	-.02	.18	.55	.37	.04	-.16	.26	.34	.19
M4	-.03	.14	.57	.40	.01	-.13	.24	.32	.17
M16	-.04	.08	.57	.46	-.04	-.07	.22	.26	.14
M256	-.03	-.04	.48	.56	-.09	.02	.19	.15	.11
H(X,Y)	.26	.25	.49	.44	.05	-.05	.00	.21	.36
NOISE	.35	.26	.43	.44	.03	.03	-.13	.11	.40
% NOISE	.36	.29	.39	.40	.04	.05	-.19	.07	.41
NOISE:X	.38	.26	.39	.42	.04	.06	-.20	.06	.41
NOISE:Y	.40	.28	.39	.42	.02	.05	-.18	.07	.39

APPENDIX C—Correlations for high recency, task two (n = 28)

Measure	Set Formation: Shape	Set Formation: Color	Set Formation: Number	Set Formation: Pattern	Set Formation: Attribute	Set Formation: Other	Cognition: Shape	Cognition: Color	Cognition: Number
H(X)	.14	.12	.31	.05	.39	-.38	.10	.03	-.29
H(X)RE	.14	.11	.31	.05	.39	-.38	.10	.03	-.29
Hx(Y)	.56	.57	.33	.35	-.05	-.03	.11	.29	-.24
Hx(Y)RE	.93	.71	-.02	.02	-.07	-.10	.11	.24	-.17
CODE	-.56	-.57	-.29	-.36	.13	-.04	-.10	-.30	.19
% CODE	-.56	-.57	-.31	-.36	.08	.00	-.10	-.30	.22
H(Y)	.28	.43	.35	.27	.34	-.27	.12	.16	-.33
Hy(X)	.52	.47	.28	.29	-.10	-.01	.10	.26	-.19
REAL	-.51	-.46	-.23	-.28	.18	-.07	-.08	-.26	.14
% REAL	-.49	-.48	-.28	-.31	.10	-.01	-.08	-.27	.18
LTM	.31	.54	.27	.36	.18	-.09	.09	.22	-.26
% LTM	.54	.65	.30	.44	.12	-.05	.12	.27	-.27
H(Y)-SS	-.14	-.12	-.31	-.05	-.39	.38	-.10	-.03	.29
Hy(X)-SS	.14	.12	.31	.05	.40	-.38	.10	.03	-.29
REAL-SS	-.14	-.12	-.31	-.05	-.39	.38	-.10	-.03	.28
% REAL-SS	-.14	-.11	-.31	-.05	-.38	.39	-.10	-.03	.29
H(X,Y)-SS	.14	.12	.31	.05	.40	-.39	.10	.03	-.29
NOISE-SS	.14	.12	.31	.05	.39	-.38	.10	.03	-.29
% NOISE-SS	.14	.11	.31	.05	.38	-.39	.10	.03	-.29
NOISE:X-SS	.14	.11	.31	.06	.38	-.39	.10	.03	-.29
NOISE:Y-SS	.14	.12	.31	.05	.40	-.38	.10	.48	-.28
M1	.38	.49	.43	.35	.27	-.21	.13	.22	-.33
M2	.41	.50	.44	.36	.27	-.19	.15	.22	-.32
M4	.45	.53	.43	.39	.26	-.15	.16	.22	-.31
M16	.51	.56	.40	.42	.22	-.09	.19	.22	-.30
M256	.60	.61	.30	.43	.12	-.05	.19	.24	-.29
H(X,Y)	.55	.55	.36	.34	.02	-.09	.12	.28	-.27
NOISE	.54	.52	.31	.32	-.07	-.02	.11	.28	-.22
% NOISE	.49	.48	.28	.31	-.10	.01	.08	.27	-.18
NOISE:X	.51	.47	.26	.29	-.13	.02	.09	.26	-.17
NOISE:Y	.53	.53	.29	.32	-.10	.00	.10	.28	-.21

APPENDIX D—Correlations for low recency, task two (n = 32)

	Set Formation						Cognition		
Measure	Shape	Color	Number	Pattern	Attribute	Other	Shape	Color	Number
H(X)	-.30	-.05	.39	.09	.00	-.20	.22	.30	.25
H(X)RE	-.30	-.04	.39	.09	.00	-.20	.22	.30	.25
Hx(Y)	.41	.36	.54	.26	.00	-.09	-.13	.04	.32
Hx(Y)RE	.02	-.05	-.01	.03	.00	.25	-.17	-.22	-.07
CODE	-.51	-.38	-.45	-.25	.00	.04	.19	.05	-.27
% CODE	-.47	-.38	-.50	.26	.00	.07	.15	-.00	-.30
H(Y)	.00	.08	.46	.05	.00	-.21	.15	.21	.07
Hy(X)	.36	.35	.52	.29	.00	-.07	-.13	.04	.40
REAL	-.46	-.37	-.43	-.27	.00	.02	.20	.04	-.33
% REAL	-.39	-.39	-.49	-.26	.00	.07	.16	-.01	-.36
LTM	.44	.20	.29	-.03	.00	-.11	-.04	-.03	-.23
% LTM	.61	.23	.33	.02	.00	-.10	-.10	-.07	-.18
H(Y)-SS	.30	.05	-.39	-.09	.00	.20	-.22	-.30	-.25
Hy(X)-SS	-.30	-.05	.39	.09	.00	-.20	.22	.30	.25
REAL-SS	.30	.05	-.39	-.09	.00	.20	-.22	-.30	-.25
% REAL	.31	.05	-.39	-.09	.00	.19	-.22	-.30	-.26
H(X,Y)-SS	-.30	-.05	.39	.05	.00	-.20	.22	.30	.25
NOISE-SS	-.30	-.05	.39	.09	.00	-.20	.22	.30	.25
% NOISE-SS	-.31	-.05	.39	.09	.00	-.19	.22	.01	.26
NOISE:X-SS	-.31	-.05	.39	.09	.00	-.19	.22	.30	.26
NOISE:Y-SS	-.30	-.04	.40	.09	.00	-.21	.21	.29	.25
M1	.06	.20	.62	.17	.00	-.18	.06	.20	.26
M2	.05	.18	.65	.17	.00	-.18	.05	.20	-.23
M4	.03	.15	.70	.16	.00	-.17	.04	.20	.20
M16	.01	.09	.75	.12	.00	-.15	.01	-.30	.12
M256	-.01	.03	.76	.03	.00	-.13	-.04	.10	.02
H(X,Y)	.30	.32	.58	.26	.00	-.13	-.06	.10	.36
NOISE	.39	.36	.53	.28	.00	-.08	-.13	.04	.36
% NOISE	.39	.39	.49	.26	.00	-.07	-.16	.01	.36
NOISE:X	.41	.36	.49	.29	.00	-.06	-.16	.01	.37
NOISE:Y	.44	.38	.50	.27	.00	-.07	-.15	.01	.33