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DEPARTMENT OF PSYCHOLOGY

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Second Annual Report
HUMAN INFORMATION HANDLING PROCESSES

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Principal Investigator

ORA Project 08773

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SYNOPSIS

This is the second annual report of research carried out on human performance in information processing and memory at the Human Performance Center, Department of Psychology, University of Michigan, under Contract No. AF 49(638)-1736. The report lists 15 publications and 8 "in press" articles that are products during the last year. The past and present emphasis of the project is on selective encoding of input information and the effects of the selectivity, variability, and numerosity of encodings of nominally invariant stimuli on perception and memory.

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I. OBJECTIVES OF CONTRACT PROGRAM

This is the second annual report for the period 1 Jun 1968 through 31 May 1969 on Contract No. AF 49(638)-1736 which is currently funded for the period 1 Jun 1967 through 31 May 1970. This contract continues the research program on Human Performance in Information Handling and Storage which extended from 1 Jun 1963 through 31 May 1967 under Contract No. AF 49(638)-1235. One of the general objectives of the original contract and the present contract was to establish, in a University environment, a permanent research facility for the investigation of human performance capabilities and limitations that are of importance for the performance of men in a wide variety of man-machine systems. With the support for such an effort by these contracts, the Human Performance Center of the Department of Psychology, University of Michigan, was established in 1963 and has now become a stable federation of experimental and mathematical psychologists interested in advancing knowledge about man's information processing activities in perceiving, remembering, skillful manipulation of controls, and decision-making. Over time the effort within this contract program within the Human Performance Center has been directed more and more to the perceiving and remembering functions, with increasingly heavy emphasis on cognitive and intellectual factors and skills, in large part because support was obtained for the research of Professor Pew on perceptual-motor skills from NASA, and for Professor Edwards' research on decision processes from elements of the Air Force, from NASA, from USPHS, and elsewhere. However, the research environment in which the present contract work is conducted is intended to be inclusive of all principal functions that man performs in information handling, and achieved this inclusiveness in the summer of 1968 with the addition to the staff of the Center Associate Professor David H. Krantz, who is concerned

especially with the investigation and mathematical modeling of sensory and perceptual processes, and of Professor James G. Greeno, who is concerned not only with problems of perceiving and remembering but also, and particularly, with problems of concept utilization, thinking, and problem solving.

This consortium of scientists engaged in research on one or another aspect of the general problem of human information handling processes has resulted in a healthy intermixing of the theoretical notions and methodologies of different areas of specialization within human experimental psychology. This has, in turn, resulted in the production of new Ph.D.-level scientists at the University of Michigan who are broadly based in theory and method appropriate to the investigation of human information handling processes and committed to careers of research on such problems.

The specific objectives of research under Contract No. AF 49(638)-1736 are stated as follows in the Contract:

a. Taxonomy of information handling processes. This effort will seek to improve knowledge of the ways of classifying types of information and information inputs, storage and processing activities required, and types of measures of outputs relevant to information processing systems.

b. Selective information handling processes. This will include research on searching, filtering, transmitting, and condensing information and on human adaptive capacities in optimizing performance relative to the probability and significance of information components.

c. Information storage and retrieval (memory). This will include work on development of a quantitative model of human short-term memory, resolution of critical issues in the theory of human memory, refinement of short-term memory methods and measures, and determination of the contribution of short-term memory to performance in information processing and decision-making tasks.

d. Work on the organization and synthesis of knowledge regarding human information handling processes.

Publications, papers presented at scientific meetings, and future plans and emphases are reported in Section III, entitled, "Technical Program." Accounting for technical effort and expenditures and future operational plans are reported in Section II, entitled "Operations."

II. OPERATIONS

Technical Effort

All technical effort on the project is not chargeable to the project, either because of optional use of University-paid research time on the project by the senior scientists, independent support of senior scientists (post-doctoral fellowships; sabbatical leaves) for study and research in the Human Performance Center, or support of junior scientists (graduate research assistants) by graduate fellowships or traineeships supplied by other agencies (e.g., NSF, NIH). Therefore, the accounting of technical man-months is made separately in Table 1 for those charged to the contract and for those not so charged.

TABLE 1
MAN-MONTHS OF TECHNICAL EFFORT

Project Staff	Period 1 Jun 68 - 31 May 69			Cumulative: 1 Jun 67 - 31 May 69		
	Charged to Contract	Not Charged	Total	Charged to Contract	Not Charged	Total
Senior Staff	23.67	20.00	43.67	39.92	35.00	74.92
Grad. Res. Asst.	67.25	9.50	76.75	169.55	27.00	196.55
Total	90.92	29.50	120.42	209.47	62.00	271.47

The following senior staff worked on the project during the year covered by this report and for the number of man-months of paid and unpaid time indicated:

TABLE 2
MAN-MONTHS OF SENIOR STAFF EFFORT ON PROJECT WORK

Staff Member	Man-Months of Effort		
	Paid	Unpaid	Total
Arthur W. Melton (Principal Investigator) Professor of Psychology (Ph.D., Yale Univ., 1932)	2.00	2.75	4.75*
Edwin J. Martin (Ph.D., Univ. Iowa, 1963) Associate Professor of Psychology	3.00	1.00	4.00

Staff Member	Man-Months of Effort		
	Paid	Unpaid	Total
Richard W. Pew (Ph.D., Univ. Michigan, 1963) Associate Professor of Psychology	1.00	.75	1.75
James G. Greeno (Ph.D., Univ. Minnesota, 1961) Associate Professor of Psychology	.33	1.50	1.86
Robert A. Bjork (Ph.D., Stanford Univ., 1966) Assistant Professor of Psychology	5.17	----	5.17
Judith P. Goggin (Ph.D., Univ. California, Berkeley, 1964) Assistant Professor of Psychology	4.67	----	4.67
David J. Murray (Ph.D., Cambridge Univ., 1964) Visiting Research Psychologist and Lecturer (Asst. Prof., Queens University, Kingston, Ontario)	6.50	----	6.50
John A. McNulty (Ph.D., Univ. Toronto, 1962) Visiting Research Psychologist and Visiting Scholar (Assoc. Prof., Dalhousie University, Halifax, N. S.)	1.00	6.00	7.00
David S. Gorfein (Ph.D., Columbia Univ., 1962) NSF Science Faculty Fellow (Assoc. Prof., New College, Sarasota, Fla.)	----	5.00	5.00
John C. Jahnke (Ph.D., Northwestern Univ., 1955) NSF Special Fellowship (Assoc. Prof., Miami Univ., Oxford, Ohio)	----	3.00	3.00
Totals	23.67	20.00	43.67

* Prof. Melton was on sick leave from the University of Michigan from 20 July 1968 to 1 Jan 1969.

During this reporting period, the following 7 consultants visited the project, reported their ongoing research related to project work, and advised us regarding specific aspects of our work:

Dr. Robert G. Crowder, Asst. Professor of Psychology, Yale University

Dr. Murray Glanzer, Professor of Psychology, New York University

Dr. Chizuko Izawa, Asst. Professor of Psychology, State University
of New York at Buffalo

Dr. Raymond S. Nickerson, Bolt, Beranek and Newman, Cambridge

Dr. Peter G. Polson, Asst. Professor of Psychology, University of Texas at Austin

Dr. Richard M. Shiffrin, Asst. Professor of Psychology, Indiana University

Dr. Saul Sternberg, Bell Telephone Laboratories, Murray Hill, N. J.

In the year ending 31 May 69, 6 graduate students completed doctoral dissertations on studies under Contract No. AF 49(638)-1736. These are listed in Table 3.

TABLE 3

DOCTORAL DISSERTATIONS COMPLETED ON PROJECT TASKS
DURING THE PERIOD 1 JUN 1968-31 MAY 1969

<u>Student</u>	<u>Dissertation Topic or Title</u>	<u>Chairman of Committee</u>	<u>Publication</u>
Kamlet, A. S.	Processing of sequentially presented signals in information combining tasks.	I. Pollack	In press as HPC Tech. Rep. No. 15
Lively, B. L.	The Von Restorff effect in very-short-term memory.	A. W. Melton	Publ. as HPC Tech. Rep. No. 11, Nov 1968
Pollatsek, A. W.	Rehearsal, interference, and spacing of practice in short-term memory	R. A. Bjork	In press as HPC Tech. Rep. No. 16
Swensson, R. G.	The elusive tradeoff: Speed versus accuracy in choice reaction tasks with continuous cost for time.	W. Edwards	Publ. as HPC Tech. Rep. No. 13, Dec 1968
Triggs, T. G.	Capacity sharing and speeded reactions to successive signals.	I. Pollack	Publ. as HPC Tech. Rep. No. 9, Aug 1968
Tversky, B. G.	Pictorial and verbal encoding in short-term memory.	A. W. Melton	Publ. as HPC Tech. Rep. No. 10, Oct 1968

All of the graduates of the Ph.D. program in human experimental psychology listed in Table 3 have emphasized human information handling and

memory in their training. They have been placed in the academic or research positions shown in the following list:

- Dr. A. S. Kamlet, Bell Telephone Laboratories, Whippany, N. J.
 Dr. B. L. Lively, Asst. Prof., Psychology, Bowdoin College
 Dr. A. W. Pollatsek, Asst. Prof., Psychology, Univ. of Massachusetts
 Dr. R. G. Swenson, Bell Telephone Laboratories, Holmdel, N. J.
 Dr. T. G. Triggs, Hughes Aircraft Co., Culver City, California
 Dr. B. G. Tversky, Asst. Prof., Psychology, Hebrew University,
 Jerusalem, Israel

In Table 4 are listed the 8 graduate student members of the project staff who are actively engaged in dissertation research on topics relevant to and supported by the project.

TABLE 4
 DOCTORAL DISSERTATIONS IN PROGRESS ON PROJECT TASKS
 AS OF 31 MAY 1969

<u>Student</u>	<u>Dissertation Topic or Title</u>	<u>Chairman of Committee</u>	<u>Present Status</u>
Adams, R. A. S.	Short-term memory for motor responses.	A. W. Melton	Pilot Studies
Collins, A. M.	Repetition effects in visual short-term memory.	E. J. Martin	In Writing
Gardner, G. T.	Spacial serial vs. parallel processing of briefly-presented foveal arrays.	R. W. Pew	Pilot Studies
Garskof, M. H.	The effect of spacing and variation of repetition in short-term memory.	J. P. Goggin	Final Writing
Gelfand, H.	Interresponse times as a measure of idiosyncractic and normative organization in memory.	A. W. Melton	Final Writing
Roberts, K. H.	Paraphrasing and semantic encoding.	E. J. Martin	Final Writing

<u>Student</u>	<u>Dissertation Topic or Title</u>	<u>Chairman of Committee</u>	<u>Present Status</u>
Shulman, H. G.	Presentation rate, retention interval, and encoding in short-term recognition memory for homonyms, synonyms, and identical words.	A. W. Melton	Data Analysis
Wattenbarger, B. L.	Representation of nominal stimulus events in the comparison stage of rapid memory search.	R. W. Few	Pilot Studies

Fiscal Status

Planned and actual expenditures for the period 1 Jun 1967 through 31 May 1969 are shown in Table 5. No financial problems are anticipated during the third year of the contract.

TABLE 5

PLANNED AND ACTUAL EXPENDITURES BY QUARTERS

Quarter-Year	Quarterly Budget		Cumulative Balance	
	Planned	Actual	Planned	Actual
1 Jun 67-31 Aug 67	\$72,000	\$57,428	\$356,374	\$370,946
1 Sep 67-30 Nov 67	44,400	71,195	311,974	299,751
1 Dec 67-29 Feb 68	44,400	43,868	267,574	255,883
1 Mar 68-31 May 68	53,600	38,616	213,974	217,267
1 Jun 68-31 Aug 68	72,000	56,140	141,974	161,127
1 Sep 68-30 Nov 68	44,400	46,572	97,574	114,555
1 Dec 68-28 Feb 69	44,400	44,483	53,174	70,072
1 Mar 69-31 May 69	53,174	53,889	0	16,173
Addition to funding on 1 Jun 1969				233,562
Funds available on 1 Jun 1969.....				249,735
1 Jun 69-31 Aug 69	\$92,000		\$157,735	
1 Sep 69-30 Nov 69	56,000		101,735	
1 Dec 69-28 Feb 70	46,000		55,735	
1 Mar 70-31 May 70	55,735		0	

Future Operational Plans

Plans for the year 1 Jun 1969 to 31 May 1970 involve no major changes in objectives, organization, or management of the project. Some changes in the senior staff of the project, or in the level of effort they will expend on the project, will occur.

1. Associate Professor Edwin Martin will be full-time on the project for the period 27 Aug 1969 to 3 Jan 1970, and will be in residence and active in the direction of project work during his full-time sabbatical leave which extends from 3 Jan 1970 to 25 May 1970.

2. Professor James G. Greeno will be working on the project for 1.5 months during the summer of 1969, and will continue during the ensuing academic year in the supervision of 2 first-year graduate students in research on strategy selection by man in handling input information.

3. Professor Peter D. McCormack (Ph.D., University of Iowa, 1957), Professor of Psychology, Carleton University, Ottawa, Canada, will join the staff of the Center and the Project for the period 1 Jul 1969 to 31 May 1970. Dr. McCormack, who has conducted an extensive series of studies of eye-movements and eye-fixation as indices of what is being attended to during storage of information in memory, will be working on the Project from 1 July 1969 to 26 Aug 1969, and will continue with his involvement in project work during the period 27 Aug 1969 to 1 May 1970, while on sabbatical leave from Carleton University.

4. Assistant Professor Judith P. Goggin will complete her formal duties with the Project on 31 Jul 1969, at which time she will leave the University of Michigan for a position as Associate Professor of Psychology at the University of Texas at El Paso, El Paso, Texas.

5. Assistant Professor Robert A. Bjork will be on leave to the Rockefeller University for collaborative work with Professor William K. Estes for the period 27 Aug 1969 to 3 Jan 1970.

6. Dr. John A. McNulty will remain involved in Project work until 31 Aug 1969, at which time he will return to his professorship at Dalhousie University, Halifax, Nova Scotia, after a year of residence in the Human Performance Center. During this last three months on the Project it is expected that a definitive review of methods, research and theory on recognition memory will be brought near to completion.

III. TECHNICAL PROGRAM

PublicationsPublications in Print

During the period of this report 15 articles based on current work appeared in scientific journals or the Human Performance Technical Report or Memorandum Report series. These are listed in Table 6. All publications have been given report numbers (e.g., 08773-19-T) appropriate to the local account number for Contract No. AF 49(638)-1736. Two of the publications have appeared since the Quarterly Letter Report dated 1 Mar 1969 (08773-37-L) and copies have not yet been transmitted. Copies of these reports (Bjork, Rept. 08773-39-T, and Martin & Walter, Rept. 08773-38-J) are attached to this report.

TABLE 6

PUBLISHED REPORTS: 1 JUN 68-31 MAY 69

Bjork, R. A. Repetition and rehearsal mechanisms in models for short-term memory. <u>Human Performance Center Technical Report</u> , No. 14, May, 1969	08773-39-T
Garskof, M. H. Short-term retention of paired associates as a function of instructions and retention method. <u>J. verb. Learn. verb. Behav.</u> , 1968, 7, 409-412.	08773-31-J
Greeno, J. G. Theory of graphs on sets with application to problem solving and understanding. <u>Human Performance Center Memorandum Report</u> , No. 6, October, 1968.	08773-27-M
Greeno, J. G. How associations are memorized. <u>Human Performance Center Technical Report</u> , No. 12, December, 1968.	08773-32-T
Jahnke, J. C. The Ranschburg paradox. <u>Human Performance Center Memorandum Report</u> , No. 5, July, 1968.	08773-22-M
Jahnke, J. C., & Melton, A. W. Acoustic similarity and the Ranschburg phenomenon. <u>Proc. 75th Am. Conv., Amer. Psychol. Assoc.</u> , 1968, 65-66.	08773-24-J

- Lively, B. L. The von Restorff effect in very-short-term memory. Human Performance Center Technical Report, No. 11, November, 1968. 08773-29-T
- Martin, E. Stimulus meaningfulness and paired-associate transfer: An encoding variability hypothesis. Psychol. Rev., 1968, 5, 421-441. 08773-30-J
- Martin, E. Recognition and correct responding mediated by first letter of trigram stimuli. (Suppl. Rep.) J. verb. Learn. verb. Behav., 1968, 7, 703-704. 08773-34-J
- Martin, E., Roberts, K. H., & Collins, A. M. Short-term memory for sentences. J. verb. Learn. verb. Behav., 1968, 7, 560-566. 08773-25-J
- Martin, E., & Walter, D. A. Subject uncertainty and word-class effects in short-term memory for sentences. J. exp. Psychol., 1969, 80, 47-51. 08773-38-J
- Roberts, K. H. Grammatical and associative constraints in sentence retention. J. verb. Learn. verb. Behav., 1968, 7, 1072-1076. 08773-36-J
- Swensson, R. G. The elusive tradeoff: speed versus accuracy in choice reaction tasks with continuous cost for time. Human Performance Center Technical Report, No. 13, December, 1968 08773-33-T
- Triggs, T. J. Capacity sharing and speeded reactions to successive signals. Human Performance Center Technical Report, No. 9, August, 1968. 08773-23-T
- Tversky, B. G. Pictorial and verbal encoding in short-term memory. Human Performance Center Technical Report, No. 10, October, 1968. 08773-28-T

Publications in Press

In addition 8 articles have been accepted for publication and are "in press" on 1 Jun 1969. These are listed in Table 7.

TABLE 7

REPORTS ACCEPTED FOR PUBLICATION AND IN PRESS ON 1 JUN 1969

-
- Goggin, J. Retroactive interference with multiple interpolated lists. In press, J. exp. Psychol.
- Goggin, J., & Stokes, C. Whole and part learning as a function of approximation to English. In press, J. exp. Psychol.
- Kamlet, A. S. Processing of sequentially presented signals in information-combining tasks. In press, Human Performance Center Technical Report, No. 15.
- Lachar, B., & Goggin, J. The effects of changes in word length on proactive interference in short-term memory. In press, Psychonomic Science.
- Pew, R. W. The speed-accuracy operating characteristic. In press, Acta Psychologica.
- Pollatsek, A. W. Rehearsal, interference, and spacing of practice in short-term memory. In press, Human Performance Center Technical Report, No. 16.
- Reicher, G. Perceptual recognition as a function of meaningfulness of stimulus material. In press, J. exp. Psychol. (Published version of Human Performance Center Technical Report, No. 7, 08773-17-T, February, 1968.)
- Tversky, B. Pictorial and verbal encoding in a short-term memory task. In press, Perception & Psychophysics. (Published version of Human Performance Center Technical Report, No. 10, 08773-28-T, October, 1968.)
-

Presentations at Scientific Meetings

Finally, with respect to formal communication of the products of the research program, there were oral presentations of research of the Contract at scientific meetings. These are listed below.

PAPERS PRESENTED AT SCIENTIFIC MEETINGS: 1 JUN 1968-31 MAY 1969

-
- Bjork, R. A. Repetition and rehearsal mechanisms in models of short-term memory. Paper presented at Symposium on Models of Short-Term Memory at the Mathematical Psychology Meetings at Stanford University, August, 1968.

- Bjork, R. A. The short-term and long-term effects of recency in free recall. Paper presented at the annual meetings of the Psychonomic Society, St. Louis, October 31-November 2, 1968.
- Carey, S. T., & Martin, E. Stimulus meaningfulness and spontaneous recovery: Single tests in a STM situation. Paper presented at annual meetings of the Midwestern Psychological Association, Chicago, Ill., May 8-10, 1969.
- Garskof, M. H. The effect of conceptually similar and different specific stimuli on the short-term retention of generic categories. Paper presented at annual meetings of the Midwestern Psychological Association, Chicago, Ill., May 8-10, 1969.
- Goggin, J. P., & Robinson, J. The effect of stimulus variation on the recall of generic stimuli. Paper presented at annual meetings of the Midwestern Psychological Association, Chicago, Ill., May 8-10, 1969.
- Greeno, J. G. Psychological representation of structured knowledge. Paper presented at meetings of the American Educational Research Association, Los Angeles, February 6, 1969.
- Greeno, J. G. Time-sharing by subjects in paired-associate learning. Paper presented in symposium on "Distribution Effects in Learning and Memory," at annual meetings of the Midwestern Psychological Association, Chicago, Ill., May 8-10, 1969.
- Jahnke, J. C., & Melton, A. W. Acoustic similarity and the Ranschburg phenomenon. Paper presented at the annual meetings of the American Psychological Association, San Francisco, August, 1968.
- Jahnke, J. C., & Melton, A. W. An analysis of the Ranschburg effect. Paper presented at the annual meetings of the Psychonomic Society, St. Louis, October 31-November 2, 1968.
- Martin, E. Subject uncertainty and word-class effects in sentence memory. Paper presented at the annual meetings of the Psychonomic Society, St. Louis, October 31-November 2, 1968.
- Melton, A. W. The situation with respect to the effects of spacing of repetitions and memory. Paper presented as chairman and discussant in symposium on "Distribution Effects in Learning and Memory," at meetings of Midwestern Psychological Association, Chicago, Ill., May 8-10, 1969.
- Pew, R. W. The speed accuracy operating characteristic. Paper presented at Donders Centenary Conference on Reaction Time at Eindhoven, Netherlands, July, 1968.
- Walter, D. A., & Martin, E. Stimulus meaningfulness and spontaneous recovery of associations: Repeated tests in a stimulus recognition situation. Paper presented at meetings of the Midwestern Psychological Association, Chicago, Ill., May 8-10, 1969.

Overview and Future Emphases

During the past year, completed and in-progress research has sharpened our theoretic approach to information-handling processes and has focussed our planning for ongoing and future research. Although of continuing usefulness as preliminary descriptors of information-processing tasks men (and experimental Ss) are required to perform, we have become convinced that such taxonomic notions as information conservation, information reduction, stimulus-response mapping and simple readouts from memory are deceptive in their grossness. Instead, we have found that in order to understand how humans process information, it is necessary to investigate, and construct theories about, the selective and integrative nature of input processes as they operate on particular features of to-be-remembered and to-be-responded-to stimuli.

Such conclusions follow imperatively from most of the experimental and theoretic reports listed on pages 11-14 of this document. Systematic variation of the constraints on which of several available features of input material are entered into memory have been accomplished by Goggin, Martin and Melton and their students (see Garskof, 8773-31-J; Martin, 8773-34-J; Martin, Roberts & Collins, 8773-25-J; Martin & Walter, 8773-34-J; Roberts, 8773-36-J; Tversky, 8773-28-T). Other investigations either completed or in progress have yielded results that affirm our theoretic emphasis on the numerosity and variability of alternative encoding representations of input materials. A systematic analysis of the consequences of stimulus encoding variability has been made by Martin (8773-30-J). Melton and his students have studied extensively the effect of the time interval between two nominally identical input events on the probability of recall, and on the correlated variability and numerosity of encoding responses;

Goggin and her students (see MPA papers by Goggin and Robinson, Dissertation in progress by Garskof) have studied the effects of adjectival modifiers on encoding variability and numerosity, and the consequences for recall from memory. It is now clear that encoding variability and numerosity has a beneficial effect on recall of information from memory under a wide variety of conditions, and that encoding variability and numerosity can be manipulated experimentally. Thus, it becomes possible to develop, test, and refine an input encoding theory which will account for the relations between recognition and recall and some of the principal phenomena of memory storage and retrieval, such as the relations between repetition and remembering, the beneficial effects of spaced repetitions, and the dependence of retrieval from memory on adequate cuing. As steps in this direction during the past year, Bjork (8773-39-T) and his student, Pollatsek (Dissertation, in press), have examined critically the theoretical models of the repetition and rehearsal mechanisms in short-term memory, and Greeno (8773-32-T) has carried out extensive reanalyses of extant data to the end that the traditional notion of association formation is replaced by the notion that pairs of input units (as in paired-associate learning) are encoded as pairs, with these unitized pairs independently held in memory, and with their recall dependent on a successful memory search route that is sensitive to task demands as well as unit characteristics.

Several important studies that were initiated during the past year, but will be completed in the next reporting period, reflect this emphasis on input encoding processes. For example, Shulman (Dissertation in progress) has demonstrated the component nature of word encoding in the short-term information holding system: graphemic, phonemic, and semantic features, together with dependence on input processing time and their decay

rates, were isolated and identified. Similar component encoding analyses are in progress by Collins (see Dissertation in progress) for alphabetic units and by Adams (see Dissertation in progress) for motor units.

These and other developments have forced certain specific emphases in our planning for the coming year. Experimental designs will more effectively control and manipulate the selectivity and variability of the multiple features of input information. The organization of accompanying context and its effect on feature selection and integration will be emphasized. This implies, among other things, a special interest in the relation between initial input conditions and the conditions of cuing or stimulus reinstatement at the time of the retention test. It implies also considerable emphasis on recognition memory procedures, where nominal cue reinstatement approaches identity with the initial presentation conditions. Greeno will be studying these matters in the problem-solving situation, where the principal concern is with how attention is distributed over the various features and components of the problem and how this distribution of attention affects such stored knowledge as formulae and arithmetic operations. Martin will continue his research on how and what features of grammatical messages are selectively encoded. Special emphasis will be placed on the role of sequential and hierarchical organization in the control of selective attention, and increasing use will be made of the recognition procedure. Melton will continue to investigate the sources of variability (and hence numerosity) in the encoding of a variety of nominal stimuli and the consequences of such variability and numerosity for the effectiveness of repetitions, the effectiveness of spacing of repetitions, and the interactions of these variables with the mode of cuing at the time of the test for retention (uncued recall, cued recall, and recognition). This latter program will be accomplished with

substantial direct collaboration by Martin and Bjork.

In summary, the past year has been particularly fruitful in directing our attention, and the attention of psychologists in other laboratories, toward the important realization that human information processors selectively utilize only certain of the myriad features that define an input event, that feature selection (encoding) varies according to the current opportunities for combining the encoded input with other information in long-term memory, and that selective encoding depends heavily on the context or surrounding organization of the environment, which may be simultaneously present in real time or through the operation of short-term memory (which has levels of fallibility dependent on interference factors defined in earlier research). Our future focussing on the interface between perceptual-attentional processes and memory organization processes is convergent with progress in other major laboratories, as, for example, the ARPA-supported facilities at the University of Oregon.

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