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This document constitutes the narrative portion of the Annual Progress Report of the Center for Research in Human Learning for the period 15 June 1967 to 15 June 1968. It was submitted to the National Science Foundation, the National Institute of Child Health and Human Development, and the Graduate School of the University of Minnesota as an official report on the fourth year of support for the Center. Following a listing of the Center personnel are descriptions of the Center's research activities in (1) animal research, (2) perception and choice behavior, (3) verbal and nonverbal cognition in children, (4) learning in children, (5) language behavior, (6) memory and recall, (7) verbal and motor learning and transfer, (8) instruction, and (9) theoretical issues. Descriptions of the training program, organization and facilities, and publications from May 1967-May 1968 conclude the Report. (AMM)

UNIVERSITY OF MINNESOTA

Annual Report

of the

Center for Research in Human Learning

1967-68

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

Supported by the National Science Foundation, the National Institute of Child Health and Human Development and the Graduate School of the University of Minnesota

400 Ford Hall, University of Minnesota
Minneapolis, Minnesota 55455

15 June 1968

Center for Research in Human Learning

Annual Report

15 June 1967 - 15 June 1968

Contents

Preface

This constitutes the narrative portion of the Annual Progress Report of the Center for Research in Human Learning for the period 15 June 1967 to 15 June 1968. The progress report is submitted to the National Science Foundation, the National Institute of Child Health and Human Development and the Graduate School of the University of Minnesota as an official report on the fourth year of support for the Center. This report is an edited version of the two progress reports submitted earlier to the National Institute of Child Health and Human Development, one reporting the research program and the other reporting the training program.

The report of publications at the end of the text has been arranged to facilitate requests for reprints from readers. Insofar as it is possible, the Center will endeavor to supply reprints to other research workers and teachers who need particular articles when we receive specific requests.

Introduction

The Center for Research in Human Learning at the University of Minnesota was established by the Regents of the University in January, 1964. Its major mission is to develop a continuous and close-working relationship among psychologists in various departments of the University doing research on human learning and on processes related to human learning. The Center brings together persons of many viewpoints representing different research interests and different goals, both practical and theoretical. The aim of the Center is to encourage and support research in human learning and to provide a stimulating atmosphere for the discussion and investigation of a wide range of issues, from the theoretical questions about human learning posed by the research psychologist to the practical applied problems faced by the educator.

A grant to support the work of the Center was made by the Graduate School of the University of Minnesota in January, 1964, and annual grants from the Graduate School have continued since that time. Broader financial support for the Center's activities was granted from the National Science Foundation (GS 541) and the National Institute of Child Health and Human Development (HD 01136) for three years beginning in the fall of 1964. In the spring of 1967 these same two agencies granted continuation support for the Center's research program; a five-year continuation (1 September 1967 through 30 August 1972) was granted by the National Institute of Child Health and Human Development, and a two-year continuation (1 September 1967 through 30 August 1969) was granted by the National Science Foundation. A related training program grant was awarded by the National Institute of Child Health and Human Development (HD 00098) from 1 January 1965 through 30 June 1968. A continuation grant to support this training program has been awarded for the period 1 July 1968 through 30 June 1973.

The original proposal for program project support pointed to the obvious need of our society for a better understanding of the processes involved in altering human behavior. Special notice was given to the demands that are being imposed on our educational system as a result of social change and to the gulf that exists between research on human learning and practices which depend upon the application of this

knowledge. The major argument was that there is much to be gained by bringing the laboratory psychologists together with practitioners interested in research in learning and instruction to advance our knowledge of the human learning processes by working in concert. Both should profit from the interaction, should be stimulated to attack new problems, and should, in the long run, work toward bridging the gap that exists.

The faculty members who staff the Center for Research in Human Learning have been drawn from the group of established investigators in the four departments directly involved in the Center, viz., the Institute of Child Development, the Department of Educational Psychology, the Department of Psychology, and the Center for the Study of Programmed Learning. All students in the Center's training program are first accepted into the Ph.D. programs of one of the three participating academic departments and must satisfy all of the requirements of their home departments before being awarded a degree.

The research and training programs of the Center for Research in Human Learning are designed specifically (a) to bring together into fruitful interaction researchers from several departments of the University who have a common interest in the study of learning; (b) to stimulate, encourage, support and facilitate research on learning; and (c) to provide the best and most flexible conditions for training students in the participating departments for research careers in the learning-related area. By being brought into close intellectual contact with other individuals having different interests, employing different techniques and reflecting different theoretical orientations, the participants are influenced and stimulated in significant and productive ways.

The Center attempts to achieve its aims with varied forms of support. It provides funds to the academic departments to secure released time for investigators to conduct research during the academic year and the summer sessions. It provides research equipment, clerical assistance, data processing, computer programming and computer time for research purposes. It organizes symposia with visiting professors, sponsors special courses and programs of instruction, schedules colloquia and provides formal and informal meetings for the generation and criticism of research. It conducts a special training program and arranges for re-

search apprenticeships for predoctoral and postdoctoral personnel associated with the organization. Finally, it supports publications, reports, papers at scientific meetings, and other forms of dissemination of the research and theoretical efforts of its personnel.

In 1967-68 the Center's research and support personnel reached a size indicative of the growing number and complexity of its research and training programs. Twenty-one faculty members were participants during this period. Two special postdoctoral fellows, two postdoctoral trainees and one postdoctoral associate were involved in the Center's programs this year. There were 14 predoctoral trainees and eight predoctoral associates during the 1967-68 year. (Associates are personnel who have the desired characteristics of personnel associated with the Center but who already hold fellowships of their own.) The support personnel included one computer analyst, one systems engineer, five part-time computer programmers, eight undergraduate clerks and research assistants, two electronic mechanics and two secretaries.

Center Personnel

Involved in the several programs of the Center are various categories of membership. During the past year, twenty-one faculty members, two special postdoctoral fellows, two postdoctoral trainees, one postdoctoral associate, fourteen predoctoral trainees and eight predoctoral associates have been involved in the research and training programs of the Center.

Administration Staff

Principal Investigator: John G. Darley, Chairman, Department of Psychology, University of Minnesota.

Director of Research: James J. Jenkins, Center for Research in Human Learning, University of Minnesota.

Executive Officer: Russell W. Burris, Center for the Study of Programmed Learning, University of Minnesota.

Director of Training: Wells Hively II, Center for Research in Human Learning, University of Minnesota.

Research Staff

Russell W. Burris, Ph.D., 1958, Indiana University, Associate Professor, Center for the Study of Programmed Learning.
Programmed instruction, learning, achievement motivation.

William R. Charlesworth, Ph.D., 1962, Cornell University, Associate Professor, Institute of Child Development.
Cognitive development, learning, motivation, and attentional processes in children.

John H. Flavell, Ph.D., 1955, Clark University, Professor, Institute of Child Development.
Development of language and cognition.

Paul W. Fox, Ph.D., 1964, Tulane University, Associate Professor, Department of Psychology.
Human learning and retention, motor skills.

Wells Hively II, Ph. D., 1961, Harvard University, Associate Professor, Department of Educational Psychology.
Experimental analysis of instruction.

James J. Jenkins, Ph.D., 1950, University of Minnesota, Professor, Department of Psychology.
Psycholinguistics, mediational processes, verbal learning.

Paul E. Johnson, Ph.D., 1964, Johns Hopkins University, Assistant Professor, Department of Educational Psychology.
Learning, verbal behavior, psychology of science.

David L. LaBerge, Ph.D., 1955, Stanford University, Professor, Department of Psychology.
Learning, perception, quantitative theories.

Kenneth MacCorquodale, Ph.D., 1946, University of Minnesota, Professor, Department of Psychology.
Experimental analysis of behavior, verbal behavior.

Frank B. Murray, Ph.D., 1966, Johns Hopkins University, Assistant Professor, Department of Educational Psychology.
Cognition, psychology of curriculum.

Daniel C. Neale, Ph.D., 1961, University of Minnesota, Associate Professor, Department of Educational Psychology.
Learning in educational settings, teacher education.

J. Bruce Overmier, Ph.D., 1965, University of Pennsylvania, Assistant Professor, Department of Psychology.
Conditioning, learning.

Herbert L. Pick, Jr., Ph.D., 1960, Cornell University, Associate Professor, Institute of Child Development.
Learning, perceptual learning, perceptual development.

Wallace A. Russell, Ph.D., 1949, State University of Iowa, Professor, Department of Psychology.
Motivation, verbal behavior, experimental psychodynamics.

S. Jay Samuels, Ed.D., 1964, University of California, Los Angeles, Assistant Professor, Department of Educational Psychology.
Verbal learning, reading.

Robert E. Shaw, Ph.D., 1965, Vanderbilt University, Assistant Professor, Department of Psychology.
Cognitive psychology, psycholinguistics, perception.

Harold W. Stevenson, Ph.D., 1951, Stanford University, Director and Professor, Institute of Child Development.
Learning, reinforcement effects.

Milton A. Trapold, Ph.D., 1961, State University of Iowa, Associate Professor, Department of Psychology.
Learning, motivation, behavior theory.

James Turnure, Ph.D., 1965, Yale University, Assistant Professor, Department of Special Education.
Cognitive development, learning, attentional processes.

John C. Wright, Ph.D., 1960, Stanford University, Associate Professor, Institute of Child Development.
Cognition, learning, motivation.

John I. Yellott, Ph.D., 1965, Stanford University, Assistant Professor, Department of Psychology.
Verbal learning, perception.

Research Support Staff

Judith Baxter, M.A., 1967, University of Michigan, Computer Programmer.

Mervyn A. Bergman, M.A., 1963, University of Minnesota, Research Fellow, Institute of Child Development.

Linda Horowitz, B.A., 1967, University of Minnesota, Computer Programmer.

Robin McEntire, B.A., 1966, Wellesley College, Computer Programmer.

Robert L. Witkofsky, Electronics Mechanic.

Special Postdoctoral Fellows

Daniel V. Bryan, Ph.D., 1953, University of Minnesota, Professor and Director, Communications Program.

Cecil Wood, Ph.D., 1963, Yale University, Professor, Department of German.

Postdoctoral Trainees

Donald V. DeRosa, Ph.D., 1967, Kent State University.

Peter B. Pufall, Ph.D., 1966, Catholic University of America.

Postdoctoral Associate

William Brewer, Ph.D., 1967, University of Iowa

Predoctoral Trainees

John D. Bransford, B.A., 1966, Hamline University.

Judith E. Chapman, B.A., 1965, University of Wisconsin.

Paul F. Curnow, B.A., 1965, Macalester College.

Thomas E. Curran, B.S., 1959, Marquette University.

Nancy C. Flood, B.A., 1967, Beloit College.

Jeffery J. Franks, B.S., 1966, Michigan State University.

Douglas M. Gross, B.A., 1965, Utica College.

Robert A. Hoff, B.A., 1966, Wagner College.

Daniel P. Jaffe, A.B., 1967, Franklin and Marshall College.

Stuart C. Juuti, B.A., 1964, Indiana University.

Terrence J. Keeney, B.A., 1964, University of California.

Alan R. Moffitt, M.A., 1966, University of Western Ontario.

John B. Pittenger, B.A., 1966, University of Pennsylvania.

Ronald D. Thurner, B.A., 1962, University of Minnesota.

Predoctoral Associates

Samuel Cannizzo, B.A., 1965, University of Illinois, NIH Fellow.

Marvin Daehler, A.B., 1964, University of Illinois, NIH Fellow.

Terry Halwes, B.A., 1965, Arlington State College, NSF Fellow.

Lucie Johnson, Licenciée, 1964, Universitat Catholique de Louvain, NDEA Fellow.

Scott Miller, B.A., 1966, Stanford University, NIH Fellow.

Edwin Myers, B.S., 1964, Ursinus College, NDEA Fellow.

George Rabehl, B.S., 1960, University of Minnesota, NDEA Fellow.

Frances Wynns, M.A., 1967, University of Rochester, NIMH Fellow.

The Research Program

All staff members and graduate students are productively engaged in research. Support from the Center for Research in Human Learning is important in providing for the conduct of research, analysis of data, and the writing of articles and reports. Funds from the Center for the release of investigators' time have made possible concentrated research activity and have accelerated the research output of the participants. The research activities of the members can best be described within the nine general areas which follow.

Animal Research

The work of Trapold has continued to be directed mainly at the mechanisms responsible for transfer of training from the classical appetitive to the instrumental appetitive conditioning paradigm. Much of this work starts with the basic observations that (a) if a rat is subjected to classical pairings of some CS with a known instrumental reinforcer, it will subsequently show facilitated acquisition and/or performance to that CS of an instrumental response for that reinforcer, and (b) if a rat is subjected to classical pairings of some CS with active nonreinforcement, it will subsequently show inhibited acquisition and/or performance of instrumental responses to that CS. Much recent work has been concerned with delineating the mechanisms which mediate these transfer effects. One series of studies effectively rules out explanations of this transfer which make reference to mediation via overt instrumental responses that are inadvertently acquired during "classical" conditioning and which then interact in a facilitative or inhibitory fashion with the subsequent measured instrumental response. This has been done (a) by showing in one set of studies that the basic transfer phenomena still occur when the reinforcer is delivered in such a way as to preclude the inadvertent acquisition of potential mediating instrumental responses during "classical" conditioning, and (b) by showing in another set of studies that similar transfer occurs to an instrumental discrimination task that was explicitly designed so that even if instrumental responses were inadvertently acquired during "classical" conditioning, there is no known way that such behaviors could affect the instrumental discriminative performance.

A related set of studies has been concerned with how reinforcer-specific such transfer effects are. Will a stimulus paired with one reinforcer facilitate instrumental responses reinforced by a different reinforcer? Preliminary evidence suggests that whereas there is a fair amount of generalization across appetitive reinforcers, there also nevertheless is a measurable degree of specificity as well. In the most compelling demonstration of the latter, it has been shown that Ss will learn a single presentation discrimination of the $S_1 - R_1 - S^R_1$, $S_2 - R_2 - S^R_2$ variety much faster if the subject is given previous classical pairings of $S_1 - S^R_1$ and $S_2 - S^R_2$.

Another series of studies has been concerned with establishing the species generality of these transfer effects by attempting to replicate the basic phenomena in pigeons, quail, and dogs.

A related series of studies has been concerned with the broad empirical question of the range of known instrumental learning phenomena that can be produced or facilitated by the appropriate classical conditioning operations (e.g., partial reinforcement effects, improvement over successive discrimination reversals, generalization peak shift effects, errorless discrimination learning and other possibly related selective attentional effects, etc.).

Another series of studies has been concerned with the extent to which reinforcement paired stimuli possess motivational properties (as a possible basis for the observed instrumental response facilitating properties of such stimuli) as has been assumed by numerous theorists. Data to date indicate that the increases in activity normally seen in such stimuli are not artifacts of instrumental responses inadvertently acquired during the "classical" conditioning, and current work is focusing on the question of whether these activity increases are an automatic and necessary reaction to such stimuli. Douglas Gross and Roger Schnaitter have been active in several of these sets of studies throughout the past year.

MacCorquodale and Winokur have continued to explore the basis of a set of latent learning phenomena closely related to those being studied by Trapold, in which on the basis of classical pairings of stimuli and reinforcement and/or nonreinforcement, Ss acquire expectancies about reinforce-

ment which are evidenced by a variety of abrupt changes in their behavior with respect to these stimuli.

Overmier has continued to study classical instrumental transfer of training in the average case. One recent line of work has shown the algebraic summation of classically conditioned (shock UCS) excitatory and inhibitory processes via the facilitative and/or inhibitory effects these processes exert on ongoing avoidance behavior. Another line of work has established the functional independence of stimuli to which avoidance responses have been directly trained, and independently established fear-excitatory and -inhibitory stimuli; the latter exert control, via transfer, over the avoidance response that appears to depend only upon their own current status as fear stimuli, and not upon the status of the stimulus that was used to get the avoidance response into the repertory in the first place.

Another line of research in Overmier's lab is concerned with identifying the nature of the avoidance performance decrement produced by forebrain ablation. Results to date indicate that the ablation does not interfere with fear conditioning, nor does it interfere with instrumental response acquisition, thus strongly suggesting that the deficit is produced by interference with the mechanism whereby fear reduction is normally reinforcing.

Perception and Choice Behavior.

Work in perception has progressed in a number of directions mainly under the guidance of LaBerge, Pick, and Yellott. LaBerge and Yellott have continued their investigation of attention. LaBerge's work conducted while he was a visiting scholar at Stanford University has focused on (1) temporal factors in attention switching between modalities, (2) whether irrelevant items in a visual search task are blocked completely or merely attenuated, and (3) prediction of changes in latency distributions by biasing conditions in reaction time experiments.

In reaction time experiments, Yellott has applied a "correction for guessing" model to data collected under a variety of conditions including both visual and auditory choice stimuli and various biased and unbiased presentation schedules. It appears that reaction times "corrected" for fast guessing according to the model are indeed invariant across

all conditions. The implications of this invariance for such models as Stone's sequential likelihood ratio model and La-Berge's recruitment model are being investigated.

Yellott, DeRosa, and Van Gelder have been studying the effects of attention on subjective loudness. Introspection suggests that a sound which occurs when one is concentrating on some other stimulus modality seems less intense than it would if one were attending to it. It is, of course, known that distraction can decrease the detectability of an auditory signal. The present research is attempting to demonstrate the attenuation of subjective loudness using a magnitude estimation procedure. Such an attenuation has been found but it is a small effect and doesn't occur under some forms of distraction.

The classic problem of measuring recognition time not confounded by response time is under investigation by Yellott and Hildreth. Their unique procedure is to use two-dimensional stimuli (e.g., color--red or green; symbol--"1" or "2") in a two-choice reaction time task. The subject must know the values of a given stimulus on both dimensions before he can respond correctly. If one dimension is turned on before the other, and the delay is sufficiently long, the S in effect is required to process only the second dimension. In essence reaction time measured from the onset of the second dimension will be reduced the longer the delay, up to a delay sufficient to permit complete processing (i.e., recognition) of the first dimension.

The interest in language processes has been extended to the area of perception. Judy Chapman, A. D. Pick, and H. L. Pick have been studying the masking of visually presented words by random noise and by other more structured interfering noise. The hypothesis is that structured noise will have an interfering effect over and above the masking effect predicted by simple occlusion of the visual stimulus. Susan Rydell, completing her dissertation with Pick, has investigated the implicit visual scanning in the reading of briefly exposed letter sequences. If letters are exposed sequentially in a spatial array, an orderly spatial sequence (left to right or right to left) is perceived at faster presentation speeds than a disorderly array even though total presentation time is too short for eye movements to occur. John Pittenger, Mike Riegle, and Terry Halwes have been investigating the extension of categorical perception, found originally with phonemes by the Haskins Laboratory, to visual processes. Two hypotheses are being entertained: Categori-

cal perception will occur when the perception involves specific property detectors or categorical perception will occur when the perception task involves short-term memory such as in a successive recognition task.

Work on adaptation to visual distortion continues with Pick, Richard Martin, Tom Hertz and Nancy Flood investigating adaptation to rotation of the visual field. One aspect of this work concerns the question as to whether a person can be adapted to optical inversion by slowly rotating the visual field. Preliminary results suggest that, in fact, the opposite occurs. Gradual introduction of the distortion may interfere with adaptation. Work presently in progress is directed toward using similar techniques to investigate the structure of the perceptual coordination system. Pick, Dave Warren and Mike Riegle have been investigating the interrelations of the sense modalities, vision, proprioception, and audition in spatial localization tasks. Conflicts between these modalities have been generated using wedge prisms and pseudophones. Results of such conflict indicate that vision is dominant over proprioception and proprioception over audition. Vision is also dominant over audition but not to any greater degree than it is over proprioception.

The resolution of such sensory conflict has been studied in a developmental framework. In general, children seem less able to ignore sensory conflict than do adults. For example, if asked to locate an auditory stimulus with conflicting visual information about the source, children are more biased by the visual information than adults. In a similar vein, Marvin Daehler, completing his dissertation under Wright's direction, has been teaching children strategies for overcoming perceptual illusions. Another significant study of perceptual development is Alan Moffitt's dissertation problem being completed under Charlesworth's direction. Moffitt has found phoneme discrimination in infants using habituation and dishabituation of heart rate as an index of perception.

Verbal and Non-Verbal Cognition in Children

The acquisition of symbolic representational abilities in children has been a popular subject of research study in the field of developmental psychology. However, relatively little attention has so far been paid to the factors that determine whether or not the child will, in any given problem situation, actively call into service and use those symbolic abilities which he has already acquired, i.e., which are already in his

cognitive repertoire. Current research by Flavell and his students indicates that age or developmental status is one such fact. There appears to exist a systematic time lag between the initial developmental attainment of various symbolic representational capacities and their spontaneous utilization by the child as mnemonic aids in recall tasks.

The initial study in this area gave clear evidence that kindergarten children do not spontaneously rehearse the names of objects as a strategy for recalling these objects, despite the fact that they have no difficulty in correctly labeling them when later requested to do so. Thus, while capable of representing objects verbally, they have not yet developed a disposition to exercise this capability as a means to particular cognitive ends. A subsequent study, conducted with Terrence Keeney and Samuel Cannizzo, demonstrated that first-graders who fail to rehearse the object names in this task recall fewer objects than first-graders who do spontaneously rehearse. However, non-rehearsers of this age can readily be induced to rehearse through brief instruction, and they dramatically improve their recall as a consequence. But when no longer instructed to rehearse, they quickly abandon this symbolic activity and their recall regresses towards its initial level.

Three additional studies have recently been completed. In one (with Drs. Anne Pick and David Corsini), developmental differences were found in the child's ability to spontaneously utilize available non-verbal representations in the service of recall; in this case they use paper replicas of wooded forms to facilitate recall of the forms. In a second (with Dr. Barbara Moely, Frances Olson, and Terry Halwes), similar developmental lags were revealed with respect to the manual clustering of object pictures according to their class membership (e.g., moving all animal pictures together), preparatory to subsequent verbal recall of the objects. The third (with Marvin Daehler, Alan Horowitz, and Frances Wynns) pointed up the deliberate, selective character of verbal rehearsal: Children verbally rehearsed color names when required to remember the color information presented in a visual display (increasingly so as a function of age) but carefully refrained from doing so when other features of the same display had to be recalled. Current research includes further study of the Pick-Corsini task (with Sara Ryan and Ada Hegion), a developmental investigation of planning skills (with Barbara Koslowski, Jeffrey Kassel, and Barbara Lindman), and a critical test of certain of Luria's assertions about verbal mediation of sensory-motor performance (with Jev Shelton and Scott Miller).

Charlesworth has continued refining techniques for analyzing film records of infants engaged in a number of Piagetian-like tasks aimed at establishing the presence or absence of the object concept. This effort is part of a larger research program of assessing cognitive abilities in infants and young children by means of evaluating both changes in expressive behaviors, in the form of facial expression and posture, as well as changes in instrumental behaviors. The general aim of the program is to establish a complete map of the child's behavior at various levels of cognitive competence before undertaking training studies directed toward accelerating the development of such competences.

Charlesworth has also been studying the young child's sensitivity to a contradictory event involving the use of the Jastrow illusion. In a cross-sectional developmental study, children ranging from three to seven years were presented with a series of simple tasks involving judgments. One such task involving the illusion produced an apparent contradiction between two sequential judgments. The subject's behavior was filmed without his awareness and the subject was subsequently questioned and tested with new materials in a variety of ways to determine to what extent he was aware of the apparent contradiction. Data to date indicate significant differences between younger and older children in a number of different response categories.

In an attempt to assess perceptual abilities in the young infant, Charlesworth has worked with Alan Moffitt who conducted a study on the infant's capacity to discriminate differences in various kinds of auditory stimuli. Different synthetic speech sounds developed by Terry Halwes at the Haskins Laboratory and variations in intensity of pure tones were presented to infants during a waking state. Changes in heart rate were used as the main indicator response from which inferences were made concerning the subject's ability to discriminate between pairs of sounds.

Following the work reported last year on the training of reflection-impulsivity, Wright and his students have been extending the experimental analysis of this cognitive style dimension in fourth-grade boys. Last year it was found that both speed and accuracy could be affected by training procedures designed to change speed of response only in match-to-sample tasks. Subjects were reinforced on a titration-type

schedule for responding either faster or slower than on their preceding trial. This work, part of which was a dissertation by Chari Briggs, was continued this year in a dissertation by Terry F. Nelson (School Psychology) in which the attentional strategy itself, rather than response speed, was shaped to match a theoretically optimum reflective strategy. Once again the results showed that both speed and accuracy were affected, both during training and in a before-and-after test battery.

The training in this study was designed to change the 24 parameters of observing behavior that had been found last year to characterize the performances of reflective (slow and accurate) and impulsive (fast and inaccurate) responders. The children who were trained to locate and compare critical features of the stimulus array, and then to use the standard only to eliminate one of each discrepant pair of alternatives, performed somewhat more slowly and much more accurately after training than before, and this difference significantly exceeded that of a baseline control group. The other observing response measures also showed changes with training in the direction characteristic of reflective responders in previous studies of different children. The integrating theme of this research has not been to demonstrate the trainability of problem solving styles and strategies, but to determine the degree to which the discrimination of critical features, relevant dimensions, and informative aspects of stimuli by selective observing responses is an important precursor to effective discrimination learning and concept formation. The results of this work so far favor the interpretation that the discovery of what is relevant is more important than, should come before, and is frequently obscured by the search for what is correct or reinforceable.

In a dissertation by Richard Weinberg (also School Psychology) an attempt was made to compare the effectiveness of different types of motivation and reinforcers for reflective and impulsive boys in a training task designed to slow down their rate of response. The reinforcement schedule for all experimental groups required successively longer and longer response times over trials in order for reinforcement to continue. The types of reinforcement used were simple feedback (lights indicating right or wrong), feedback plus social reinforcement by the experimenter, feedback plus token rewards which could be exchanged at the end for a very elaborate toy previously chosen by the child, and

feedback plus cumulated points that could be compared with a dummy set of norms allegedly describing poor, fair, good, and excellent scores for third, fourth, and fifth graders.

As in the Briggs' study last year, the training was more effective for boys initially scoring already at the reflective end of the distribution than for those at the impulsive end. This was true for all reinforcement conditions except the achievement (points and norms) group. The achievement motivated training was most effective with impulsive children and least effective with reflective children, contrary to all predictions. This datum has not yet been satisfactorily explained, and a replication study is being planned.

One aspect of selective attention and observing behavior on the perceptual side has relevance to the work of Piaget: the spontaneous juxtaposing or superimposing of stimuli prior to making perceptual judgments such as size or brightness. Such pre-judgmental motor responses are especially helpful to veridical perception under conditions of ambiguous or illusory background, illumination, and other conditions of viewing. Marvin Daehler, in a Ph.D. dissertation, has studied both developmentally and experimentally the role of such responses (1) in relation to age, (2) in relation to accuracy of discrimination, (3) in relation to the child's capacity for conservation, and (4) in relation to the child's ability to discriminate real from phenomenal or apparent visual information. Using four different perceptual tasks he also trained superimposition or juxtaposition for some children in one task and observed the generalization of that training in the other three. In general, the results again supported the notion that active involvement in the stimulus materials and manipulation and selective comparison of them by the children is often sufficient and may be necessary for the development of veridical perception in ambiguous situations. By the age of six, children appear to make these responses spontaneously. If trained to do so they can make them earlier. In all cases they aid perception, but they do not in general appear to become a stable part of the child's spontaneous behavior unless the child has already developed some notion of the real-phenomenal distinction.

Another project Wright has undertaken is a replication of some of Piaget's recent work on memory. Using Piaget's tilted bottle of liquid and length-ordered line series stimuli, he has tested for immediate recall, 24-hour recall and 5-6-months' recall, using the methods of reproduction, prompted

reproduction, and recognition. Partial results so far fail to confirm Piaget's report that in many cases children between four and eight years of age show an improvement in retention at six months as compared with a few days.

Finally, in collaboration with David Lachar, Wright has been studying the development in pre-school children of the ability to conserve degrees of freedom to the end of a sequential matching task wherein the child matches tiles by color to a model. Some of the child's supply can only be used as one color, while others have one color on one side and a different color on the other. Knowing this, the child can only complete the task if he saves his two-color tiles to the end. The development of this particular kind of foresight and planning is being studied using the learning set paradigm in preschool children. This research has in common with the work described above a concern with the concrete, observable things children can learn to do which make perceptually explicit for themselves the core logic or strategy previously determined to be critical for the solution of a class of problems. In each case, once these core operations have been established, the research strategy will be to bring them under experimental control so that they can be taught to children at ages younger than those at which they spontaneously appear.

Learning in Children

While on leave at the Center for Advanced Studies in the Behavioral Sciences at Palo Alto, California, Stevenson completed writing up the results of a large-scale project investigating the interrelationships and correlates of children's performance on a variety of learning and problem-solving tasks. The main focus of much of his work has been upon correlates of individual differences in learning. Stevenson, in addition, has reviewed studies in the area of children's learning and analyzed literature dealing with learning processes. These efforts are currently being directed toward a forthcoming book on children's learning.

Language Behavior

Research directed toward language behavior has taken three major routes this year: studies of speech perception,

studies of ellipses and studies of miniature linguistic systems and other abstract rule systems.

Research on speech perception has been accomplished with the generous assistance of the personnel of Haskins Laboratories. Perception of synthetic speech sounds (stop consonants) in neonates is being studied via adaptation experiments. Dichotic stimulation is being used with adults to study the major locus of the perception of consonants and vowels. Equipment for presentation of stimuli and the conduct of these experiments have been greatly improved over the last year.

A grammar for elliptical sentences and other context-dependents has been further tested. Over 98% of all ellipses secured in the laboratory situation are predictable via the grammar. The remaining productions appear to be obvious errors of memory and other situational effects. Reaction times in the production of ellipses have been the object of current studies. Reaction time appears to be a complex function depending on the nature of the prompting question employed, the familiarity of the material and the grammatical nature of the responses required.

Acquisition of miniature linguistic systems by college students has concerned itself with transfer effects from one set of items to another, from one set of responses to a logically related set and from one type of language to another of the same type as opposed to a language of a different type. As expected, impressive positive transfer can be shown between logically related sets, and good transfer is found between languages of the same type. Changing the type of language employed, however, produces impressive difficulty in learning a new miniature language.

Memory and Recall

Stimulation of verbal recall received major emphasis this year, both in the research of several members of the Center staff and in the memory colloquia presented by E. A. Bilodeau, E. Tulving and H. P. Bahrick. Fox, in collaboration with Dick Bohner, Daniel Jaffe, Thomas Curran, Robert Dick and Richard Hiss performed several experiments on recall facilitation as a function of indirect associative networks between the to-be-remembered word

and the verbal stimuli presented at recall. Other experiments in the series examined (1) the effect of introducing cues subsequent to S's attempt at free recall; and (2) the efficacy of stimulated recall when the direct associative relation between cue word and to-be-remembered is nearly zero. Substantial amounts of recall facilitation were obtained in several of these studies, and current research has thus shifted to a closer examination of the associative behaviors set up when verbal cues are introduced at recall.

Verbal and Motor Learning and Transfer

Fox, Robert Dick and Daniel Jaffe also initiated research on motor memory this year. Subjects were trained to make a positioning response and thereafter tested for retention of the learned response over intervals ranging from three minutes to 28 days.

Instruction

Burris and Wood have continued to study the problems of evaluation of second language learning in German. An assessment is being made of several tests developed during the year. These tests are based on several hypotheses developed in the German language project. Using implications for language learning from Shaw's work on ellipses, Wood has incorporated partial utterances and their grammar into the instructional and evaluation programs. Currently the first twenty drills are being programmed into the 1500 computer-based system to develop techniques for control and observation of second language learning.

Burris has worked toward developing more powerful ways of describing what students learn in applied instructional situations. For this work algorithms are being developed for empirical testing in short sequences of engineering graphics and a remedies course in law. It is expected that these algorithms can be used in developing grammars which describe what has been learned.

Work in the area of universe-defined achievement testing continues to occupy a substantial amount of time, both theoretically and in the practical context of Minnemast and the Job Corps. Hively and Johnson hope to complete several

methodological and theoretical papers on this topic during the coming summer along with a description of their practical application in Minnemast.

The establishment of a laboratory for basic-applied research in the Emerson Elementary School has provided a much needed facility for studies in optimization of instruction. Exploratory work has focused on interactions between teaching procedures and motivational variables (schedules of reinforcement and punishment) utilizing a simple, motor-skills task (line drawing), several non-verbal association tasks, serial behavior (counting by fives), disjunctive concept formation, and complex discrimination (reading a clock). Plans are to expand this work considerably during the coming period and eventually to fuse it with the work in universe-defined achievement testing.

Neale continued his work on the role of attitudes in school learning. Using Osgood's model for connotative meaning, attitudes toward school subjects were measured with a version of the semantic differential. Using a multiple regression procedure, achievement of elementary school children at the close of a school year was predicted from I.Q., achievement, and attitudes measured at the beginning of the year. Attitudes made a significant contribution to the predictions. A second study showed that such attitudes can be manipulated by an educational intervention program for culturally disadvantaged elementary school children. Neale also began a related inquiry using individual study rates of high school students as a dependent variable. Such study rates proved to be a highly stable measure of school performance, and such rates varied enormously among students. The application of a class of contingencies to increase study rates yielded mixed results, substantiating the view that such rates are best manipulated with contingencies that are designed separately for each individual. The development of procedures for the design of such contingencies is planned for the coming year.

Samuels and his associates have continued their investigations of verbal learning and reading. A laboratory study comparing the look-say method of reading training with one emphasizing decoding indicated the latter method provided a better basis for transfer to reading new words. Several studies have shown that associative connection between words in printed texts affects learning to read new words, reading

speed, recall, and guessing on multiple-choice tests. Continued investigations on what the effect is on word recognition speed when words are tachistoscopically presented which do or do not correspond to anticipated word association has indicated that both children and adults recognize words at below "threshold" speeds when the flashed word conforms to anticipated word association. Whenever anticipated word associations were not presented, adults were superior to children, indicating that adult strategies and word recognition were different from those used by children. This work has led to formulations on how word recognition occurs.

Exploratory research is being conducted on the modifiability of visual recognition memory and the relationship of visual memory to paired-associate learning. Another focus of inquiry has been to determine the nature of the learning curve when stimuli, in a paired-associate task, are presented in fixed or random order. Work on the von Restorff effect (faster learning of an S-R pair which has been isolated from the rest of the list by printing it in a different color) continues in order to determine under what conditions a von Restorff effect may be produced in a low stimulus similarity list.

Johnson and his students continue their research in the psychology of science. The focus of this work is upon the conceptual structures used to communicate knowledge in science. Present work emphasizes psychological scaling, transfer studies and the collection of word association norms for concept words in physics.

The effect of extraneous background stimuli on the learning of a discrimination task has been studied by Turnure. In one study with retarded children he found that these subjects were not as distractable as previous reports have suggested. When compared to data available from normal subjects, in many cases the retarded glanced away from the task less than the normal. When subjects of any I.Q. were given a task too difficult for them, they tended to look away from the task. Two following studies suggested that looking away from the task was used as an attempt to seek additional information on how to proceed. These studies indicate that non-task orientations, which typically are punished in the classroom, should be viewed as a cue from the student that additional information is required.

Murray and his students have been doing research in the general area of the psychology of curriculum. Some specific topics they have researched are: familiarization effects on reading comprehension; children's concept of time; some relevant and irrelevant transformations of objects that influence judgments of the weight of the object; the effects of the level of concreteness on conservation of weight; and the effects of various conservation assessment questions on conservation of length. At present they are looking for a possible relationship between connotative meaning and non-conservation.

Theoretical Issues

In the past year, Pufall and Shaw have been developing experimental projects on three major topics:

(1) The sequential pattern task: a set of experiments aimed at validating a finite model of a two-pushdown stack memory device as a minimal model of short-term and long-term memory processes involved in the standard probability learning situation as well as in the learning of patterns of stimuli generated by formal grammars;

(2) The child's conceptualization of space: a set of experiments aimed at modeling the way in which children from four years to twelve years utilized systems of cues in locating and orienting an object on a geometric three-dimensional display;

(3) The child's concept of number task: an experiment aimed at determining what mathematical operations children at various ages use in deciding that one row of items has more in it than another.

In the planning stages are: (a) the Martin Bug Task and (b) a tachistoscope task aimed at discovering the perceptual scanning strategies Ss use in processing sentences when the whole sentence is presented simultaneously.

The Training Program

As indicated in the grant proposal and previous progress reports, the Center for Research in Human Learning is not a teaching department of the University; the three academic departments, viz., Psychology, Child Psychology, and Educational Psychology, from which the trainees and staff are drawn provide the formal courses in the degree programs. The Center, however, has had an influence in the development of course offerings in the areas of learning by the three departments, and the Center supplements and aids the formal course instruction in its training program for learning researchers.

Special Summer Coursework

The success of the Special Institute on Higher Mental Processes sponsored by the Center during the summer of 1966 led to the decision to continue sponsorship of special summer programs with a focus on issues not covered in depth in formal curriculum for the trainees during the academic year. In the summer of 1967 we had an intensive, broadly-based course on Behavior Modification and Control (Psychology 215). This course, which met two hours per day, five days a week, was taught each week by a different visiting professor, each of whom has been active in applying laboratory-derived learning principles to practical problems of behavioral manipulation and control. This course was supported in part by the summer session of the University of Minnesota. The five visiting professors and their topics for the week were:

Dr. Frank Logan University of New Mexico Albuquerque	Theory for Educational Psychology
Dr. O. Ivar Lovaas University of California Los Angeles	Behavior Therapy with Schizophrenic Children
Dr. Peter Lang University of Wisconsin Madison	The Laboratory Study of Fear Reduction and Autonomic Control

Dr. Lloyd Homme Westinghouse Research Laboratories Albuquerque, New Mexico	Technological Advances and Retreats in the Field of Behavioral Engineering
Dr. Ogden Lindsley Children's Rehabilitation Unit University of Kansas Medical Center Kansas City, Missouri	The Wonderful World of Behavior Modification

This course was taken by ten predoctoral and two postdoctoral trainees as well as 56 qualified students and staff at the University.

In an evaluation of this course by students, all respondents indicated that their objectives in taking the course were fulfilled and all stated that if they had it to do over, they would take the course again. Comments were numerous on the exceptional enthusiasm, involvement and zeal of the lecturers. That the speakers broke away from the traditional lecture format to share their experiences, giving insights into the thought and philosophy behind behavioral engineering, was also a high point for some students. All of the speakers were named at least once as being particularly outstanding. Many students expressed their pleasure at being able to obtain different viewpoints on the same topic. For several students the practical orientation of the course, its emphasis on techniques, suggestions and methods and its presentations of the problems and possibilities of non-laboratory behavior modification was most rewarding. Several students commented on the research and consultation possibilities which the course opened up for them.

For the summer of 1968 a special grant was made to the Center under the Advanced Science Seminar Projects of the National Science Foundation. With special funding available, four courses were organized as a Program in the Psychology of Higher Mental Processes for the five-week session. The four courses to be offered are as follows:

215 SEMINAR: SPECIAL AREAS OF PSYCHOLOGY -- PSYCHOLINGUISTICS

A consideration of the problems involved in the development of an adequate psychology of language. Linguistic structure is viewed from the point of view of the

generative grammarian. This is presumed to constitute the competence of a language user. How competence is acquired and how it is manifested in behavior are the basic questions in a psychology of language. The interplay of theory and experimentation in the search for adequate models is stressed. Philip Gough, University of Texas.

216 SEMINAR: SPECIAL AREAS OF PSYCHOLOGY -- THE PERCEPTION OF SPEECH

The problem of understanding the perception of speech is approached experimentally and analytically. The development of speech synthesizers is reviewed as offering powerful tools to the task. Research by both western scientists and Russians is critically reviewed and discussed in the context of theories of speech perception. Alvin Liberman, University of Connecticut and Haskins Laboratories.

217 SEMINAR: SPECIAL AREAS OF PSYCHOLOGY -- THE SENSES AS PERCEPTUAL SYSTEMS

The theory is advanced that perception is not the building up of percepts from stimulus elements furnished by the senses but rather is the direct registering of information about the world. Perceptual learning is seen as the education of attention to information in the available stimulation. The theory is illustrated mainly through examples from vision but applies as well to the other senses. The evolution of perceptual systems and the development of subtle perceptual skills in man are explored in the light of the theory. James J. Gibson, Cornell University.

223 SEMINAR: CURRENT ISSUES IN CHILD PSYCHOLOGY -- PERCEPTUAL DEVELOPMENT

A differentiation theory of perceptual development and learning will be systematically explored. A wide variety of perceptual problems such as strategies of visual search, discrimination learning, inter-modal transfer, and reading will be analyzed in relation to the theory. Attention will be focused on exploratory and selective processes in perceptual development. Eleanor Gibson, Cornell University.

Other Formal Training

During the academic year a major program sponsored by the Center is a lecture series on general issues of learning. This year fourteen lectures were held and were attended by faculty, trainees, associates and other interested faculty and students from the University and other colleges in the region. A list of the lecturers and their titles for 1967-68 were:

Dr. Endel Tulving University of Toronto Canada	Coding and Retrieval Processes in Human Memory
Dr. Harry P. Bahrick Ohio Wesleyan University Delaware, Ohio	Methodology of Long-Term Memory
Dr. Edward Bilodeau Tulane University New Orleans, Louisiana	Associative Structures in Word Association Norms
Dr. John Yellott University of Minnesota Minneapolis, Minnesota	Models of Short-Term Memory
Dr. Edward B. Colemen University of Texas El Paso, Texas	Collecting a Data Base for an Educational Technology
Dr. Ernest Z. Rothkopf Bell Telephone Laboratories Murray Hill, New Jersey	Attention-Like Processes in Learning from Written Discourse
Dr. Laurence J. Victor University of Minnesota Minneapolis, Minnesota	Role of Method and Metaphor in Scientific Understanding
Dr. Frank B. Murray University of Minnesota Minneapolis, Minnesota	Cognition and Curriculum
Dr. J. Bruce Overmier University of Minnesota Minneapolis, Minnesota	Acquired Apathy in Animals
Dr. Frank D. McKinney University of Minnesota Minneapolis, Minnesota	The Evolution of Social Systems in Birds

Dr. Warren Roberts University of Minnesota Minneapolis, Minnesota	Hypothalamic Mechanism of Motivation and Species Typical Behavior
Dr. William Mason Delta Regional Primate Center Covington, Louisiana	Social Deprivation in Monkeys and Apes
Dr. John Morton University of Cambridge Cambridge, Massachusetts	Sources of Information in Immediate Memory
Dr. David Premack University of California Santa Barbara, California	Language in the Chimpanzee?

Informal Training

During the fall and winter quarters, informal luncheon meetings were held in the Center for all trainees twice each week. Each faculty member of the Center presented and led a discussion of his current research projects during the two meetings of a week. In addition to providing a view of the range of research projects, the trainees were encouraged to affiliate with one of the projects. It was also stressed in these sessions that a trainee is expected to have been affiliated with several of these projects during his first two years as part of his training.

These luncheon meetings during the spring quarter were continued and the postdoctoral and second and third level trainees reported on their research. These sessions were attended by both faculty and trainees and provided a valuable experience for the individuals reporting as well as for other trainees who were expected to ask questions and make suggestions in the discussion period at each session.

Another important part of the Center's training program continues to be in the various research meetings. Center faculty members hold periodic research meetings with assistants, trainees, staff and colleagues in which a particular topic or technique is the major focus. These meetings are listed in the weekly calendar and trainees are encouraged to attend as many as possible. More than seven such groups met during the year. Some of the titles under

which the groups were organized were: Reinforcement, Modeling Attention, Thinking, Psycholinguistic Research, Memory, Motor Skills Learning and Research Uses of Computers.

Organization and Facilities

Organization

The Center attempts to make the process of administering the Center as simple as possible. Most immediate decision-making is concentrated in an Executive Committee with broad policy decisions residing in an Advisory Council. The current structure is as follows:

Advisory Council

This body determines the broad administrative policy of the Center. It consists of representatives from the President's Office, the Dean of the Graduate School, the Dean of the College of Liberal Arts, the Dean of the College of Education and the Chairmen of the Departments of Child Development, Psychology, and Educational Psychology. The Center staff is represented by the Director of Research and the Executive Officer.

Representatives on the Council this year have been:

Associate Dean John Turnbull, Chairman
Dean Francis M. Boddy
Dr. Russell Burris
Dr. John G. Darley
Dr. James J. Jenkins
Assistant Vice President Stanley B. Kegler
Vice President Donald K. Smith
Dr. Jack Merwin

Executive Committee

This committee is charged with the task of administering the Center and making working policy decisions. It consists of a staff member from each of the participating departments and the Director of the Center for the Study of Programmed Learning as well as the Director of Research.

Members this year have been:

Dr. Russell W. Burris
Dr. Wells Hively II

Dr. James J. Jenkins
Dr. Herbert Pick
Dr. Milton Trapold

Facilities and Equipment

During the academic year 1967-68, the Center helped to establish a Laboratory for Experimental Analysis of Instruction in the Emerson Elementary School in Minneapolis in cooperation with the Department of Educational Psychology, the University Center for Curriculum Studies and the Minneapolis Public Schools. A unique feature of this laboratory has been its integration into the normal school schedule. Each child in a first-grade class spends approximately one-half hour per week in the laboratory throughout the year. This makes possible long-term, well-controlled research on problems of complex learning of a type heretofore impossible as well as a direct contact with practical educational problems--a salutory experience for Center trainees and staff.

An IBM 1500 Computer-Based Instructional System was added as a special supporting facility in the Center. This equipment was made available by grants from the University and the National Science Foundation. The research of several Center faculty members will concentrate on four major problem areas: (1) analysis of subject matter domains; (2) techniques for describing the learner's state of knowledge; (3) mathematical sequencing models; and (4) mathematical theories of algebraic structures for experimentation.

Equipment was added during the year to continue building a solid base of research components. The major pieces purchased this year were tape recorders, noise generators, voice relays, amplifiers, eight pairs of stereo earphones, an oscilloscope and several components of solid-state switching equipment. Also interfacing equipment was constructed for the CDC 160 and the IBM 1130 component of the 1500 system in order to attain more general experimental uses of these computers.

Publications

The following publications by the Center staff, trainees and associates have appeared in the period 1 May 1967 and 1 May 1968. An asterisk indicates a report of research with major support from the resources of the Center for Research in Human Learning.

The publications have been numbered. For those papers whose numbers appear on the request blank at the end, the Center will try to supply reprints to interested and qualified research workers and scholars.

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