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ON CERTAIN AREAS OF HUMAN FACTORS
A Literature Search

HUMAN FACTORS LABORATORY

SPACO, INC.

HUNTSVILLE, ALA.

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A Literature Search

by

Charles Edward White
Human Factors Laboratory
SPACO, INC.
Huntsville, Alabama

For the

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

August 1964

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ABSTRACT

The purpose of this literature survey report is to assure that the later phases of this contract will not unnecessarily duplicate previous efforts in the human factors field. This report covers only the Phase A (Literature Search) of contract NAS8-11675.

This literature survey report fulfills Phase A of contract NAS8-11675 under the direction of Richard W. Foster, Deputy Chief of the Advanced Systems Engineering Section, Flight Systems Analysis Branch, Vehicle Checkout Division, Quality and Reliability Assurance Laboratory, Marshall Space Flight Center.

FOREWORD

This human factors literature search was conducted by the personnel of the Human Factors Laboratory of SPACO, INC. under Phase A of NASA MSFC contract NAS8-11675. Phase A is defined in the contracted scope of work as follows:

"The contractor shall study the capabilities and limitations of the input-processing-output characteristics of the human operator. Further, the contractor shall perform a thorough literature search using the facilities of the Defense Documentation Center System and shall further perform a search and abstraction of pertinent periodical literature to the extent required to assure that no unnecessary duplication of previous efforts will occur. A literature search report, listing all pertinent references and abstracting all significant references shall be delivered to the contracting officer or his duly authorized representative."

The documents listed in the Bibliography were primarily selected because of their probable application to later phases of this contract. Particular attention was paid to DDC documents because we believe that most of the work of interest has been government sponsored. Commercial books supplied the broad background for the areas of interest.

TECHNICAL DISCUSSION

During the course of the literature search, the wide latitude of information collected required a subject type cataloging system. The general groupings of information used in this report are those that seemed to divide the collected data most effectively. These groupings are:

1. Man's Basic Characteristics
2. Man's Characteristics at an Interface
3. Man's Characteristics in a Group
4. Optimization of Machine Characteristics to Match Man's Characteristics
5. Optimization of Environment to Match Man
6. Extracted Output from Man
7. Unusual Input to Man
8. Handbooks on Human Factors, Engineering, Etc.
9. Bibliographies
10. Miscellaneous

Most of the documents were found through the DDC system, and were selected from their official abstracts. Those documents found through other media were usually selected by their titles alone, and the titles were often found to be misleading. Naturally, documents that were found to be not germane were deleted from the study and from this report.

Following most of the references in the bibliography is either a short quotation from the reference or my opinion of the contents of the reference. There are neither quotes nor comment where the title fully describes the work and the conclusions are obvious.

Two books, The Machinery of the Brain and Biotechnology: Concepts and Applications were deemed to be of sufficient interest to merit comment and abstraction of their tables of contents. These reviews are in Appendix A and B respectively.

The information collected on color vision theory was both interesting and contradictory. Color is a highly useful tool in human factors work, and

therefore a knowledge of color theory is an essential part of human factors work. The inplications of two-color theory and a possible need for a six-color theory are discussed in Appendix C.

I cannot conceive of non-fiction writing which would not have some bearing on a man/machine interface, which is the ultimate working ground of human factors information. Therefore, no attempt was made to be all-inclusive or to plumb specific areas to their maximum depth. Only those items which seemed to be of immediate value to the project were included, with the exception of a few reports which were so unusual as to merit interest on their own.

In the bibliography,documents are listed by author, within each general group. Anonymous documents are listed first, in alphabetical form by title. Those showing author's names are listed alphabetically by author.

Documents received from DDC are filed by DDC accession number; other documents are filed by arbitrary file number. A SPACO cross-referencing system enables document selection by author or group number.

The literature disclosed in this search confirmed the need for work in the particular areas specified in SPACO's proposal in response to RFQ-1-4-60-01024. These documents show that our anticipated experiments will not duplicate previous experiments. However, the information in these documents will be useful in planning of our experiments.

Copies of all listed documents are filed at SPACO's main facilities in Huntsville. After completion of the contract and the final project report, these files will be disposed of in accordance with the contracting officer's request.

GROUP 1.
MAN'S BASIC CHARACTERISTICS

Basic Research in the Field of Vision, Instituto Nazionale di Ottica, Arcetri-Firenze, Italy, (October 1960)(AD 251 238).[1]

The following seven subjects are discussed:

1 - Disappearance of a stabilized image with intermittent illumination
2 - Influence of a vibrating movement on the vision of an image with fuzzy contours
3 - Some methods for improving the perception of signals in extrafoveal vision
4 - Is the pulsating illumination actually advantageous, in practice, with respect to steady illumination?
5 - Blue-green interaction at mesopic levels
6 - Blue-green electroretinographic responses
7 - The perception of size ambients of different color and by correcting the chromatic aberration of the eye.

Effects of Acceleration on Pilot Performance, U.S. Naval Air Development Center, Pennsylvania, (March 1963)(AD408 686).

The data not only covers physical effects, but also shows a reduction in immediate memory and information processing capabilities due to acceleration.

Long Term Skill Transfer and Feedback Conditions During Training and Rehearsal, Behavioral Sciences Laboratory, Wright-Patterson Air Force Base, Ohio, (December 1963)(AD 431 222).

Nothing was proven.

PWI (Pilot Warning Instrumentation) Requirements Study, Sperry Gyroscope Company, (AD 418 306).

Subjects looked for a moveable, sometimes visible "intruder". Intruder warning without directional information did not help. Optimum directional information was accurate to 1.5° or less. Intruders which can be seen nearly 100% of the time when fixated are seen only about 5% of the time in free search.

Relative Effectiveness of Presenting Information to Selected Sense Modalities, Human Engineering, U.S. Naval Training Device Center, New York, (AD 251 450).

Subjects tried to count visual flashes, audible clicks, or tactile pressures. Data is presented for number of stimuli vs. rate vs. number of stimuli counted. The higher rates consistent with accuracy were obtained with audible clicks.

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[1] The AD numbers in parentheses are Defense Documentation Center accession numbers.

Study of Creature Communications, Armour Research Foundation of Illinois, Institute of Technology, Chicago, Illinois, (June 1963)(AD 407 950).

Biological phenomena were examined for techniques that could be used for data processing. Some success was noted.

A Study of Factors Influencing the Judgement of Human Performance, Human Factors Research, Ind., (AD 401 677).

Judges rated the performance of subjects from movies of the subjects performing the same repetitive task. Unusually good performance was overly weighted by the judges for first or last trials. Unusually poor performance was overly weighted only on first trials.

Term Expectation and Uncertainty in Human Decision Behavior, Behavioral Sciences Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (November 1963) (AD 431 634).

Term expectation does not heavily influence decisions.

Vision Research Reports, Edited by E. Porter Horne and Milton A. Whitcomb, Armed Forces NRC Committee on Vision, (No Date) (AD 252 513).

This is a collection of 19 papers from the 36th, 37th, and 39th Annual Meetings of the Armed Forces - NRC Committee on Vision. Three-color theory is thoroughly explained by D. B. Judd.

Allison, Roger B., Jr., Learning Parameters of Human Abilities, Princeton University, (AD 418 235).

Four separable factors involved in learning were found: a Conceptual Process Factor, a Rote Process Factor, a Mechanical Factor, and a Psychomotor Coordination Factor.

Arbib, Michael A., Brains, Machines and Mathematics, University of New South Wales & Massachusetts Institute of Technology.

This book covers such things as cybernetics, information theory, Godel's theorem, McCulloch-Pitts neurons, finite automata, Turing machines, the von Neumann approach, Shannon's communication theory, the Cowan-Winograd theory of reliable automata, Norbert Wiener's cybernetics, and the brain-machine controversy.

Arkadyevskiy, A. A., Combined Effect of Vibration and Noise on the Human Organism, Translation Division of Foreign Technology Division, Wright-Patterson Air Force Base, Ohio, (AD 415 672).

The effects of vibration and noise disappear in about 3 minutes.

Baker, James D.; Organist, Walter E., Short-Term Memory; Non-Equivalence of Query and Message Items, Decision Sciences Laboratory, Deputy for Engineering and Technology, Electronic Systems Division, Air Force Systems Command, United States Air Force, L. G. Hanscom Field, Bedford, Massachusetts, (February 1964)(AD 437 917).

Subjects were periodically given messages to remember and queries about prior messages. A query intervening between a specific message, and a query about that message, tended to degrade memory more than a message intervening between a related message and query.

Berbert, John H., Visual Acuity as a Function of Intensity for Different Hues, Electronics Branch Sound Division, (May 1958) (AD 162 689).

Resolution is best with luminous flux distributions centered on the visible spectrum.

Berg, S; Forkner, J., "Note on Recent Demonstrations of Color Mechanisms", Journal of Optical Society of America, Vol. 50, page 394, (1960).

This letter to the editor reports experiments which verify Land's work.

Bittini, M.; Ercoles, A. M.; Fiortini, A.; Ronchi, L., Research on Retinal Mechanisms and Responses, Office of Scientific Research, Instituto Nazionale di Ottica, Arcetri-Firenze, Italy, European Office, United States Air Force, (October 31, 1963)(AD 429 779).

This report covers six experiments. These experiments are so specific as to preclude their use in human factors work.

Castruccio, Peter A.; Loats, Harry L., Jr., Training and Training Equipment Requirements for Ground Operator and Maintenance Personnel of Advanced Systems, (July 1963)(N63-21366).

"A formal analogy was noticed between automatic maintenance procedure and the mathematics employed in logic-circuit design. If this analogy were extended, application of the algorithms of algebraic logic to the maintenance precedures will be a powerful analytic tool."

Chawalow, M. L. E.; Amsterdam, M. F., Seeing at Low Levels of Illumination, Fire Control Branch, Development Division Research and Development Group, Frankford Arsenal, Philadelphia, Pennsylvania, (August 1958)(AD 202 386).

This is a study of image intensification for military fire-control.

Craik, K. J. W.; Vernon, M. D., "Nature of Dark Adaptation", British Journal of Psychology, Vol. 32, pp. 62-81.

Crawford, B. H., "The Scotopic Visibility Function," Proceedings of Psychology Society of London, Vol. 62, pp. 321-324, (1940), National Physical Laboratory.

Scotopic (rod only) vision is thoroughly discussed.

Crook, Mason N.; Bishop, Harold P.; Freeher, Carl; Wade, Edward A., Luminance Reintensification at Frequencies from 40 to 300 Cycles Per Second as a Factor in the Reading of Simulated Visual Displays, Institute for Psychological Research, Tufts University, Medford, Massachusetts, (October 1960) (AD 255 556).

"It can be concluded that reintensification above the critical frequency of fliker creates no significant problem for the reading of visual displays."

Elliot, Lois L., Ph.D., Apparent Change of Repetitive Noise Bursts, USAF School of Aerospace Medicine, Brooks Air Force Base, Texas, (AD 429 966).

This report discusses the phenomenon that noise bursts which are presented at constant, slow rates through wide range earphones appear to change in rate and loudness.

Fry, G.A., Fusion of the Lines of a Television Display, For Rome Air Development Center, By the Ohio State University Research Foundation, Ohio, (September 1960) (AD 251 460).

The optimum way of fusing the lines of a television raster is to blur the lines perpendicular to the scan.

Gastaut, H.J., Evoked Visuals Responses in Man During Auditory Stress, Office of Scientific Research, European Office, Marseille, France, (October 1963) (AD 428 239).

Loud sounds effect the visual portions of the brain as shown by electroencephalographic recordings.

Glanzer, M., Processing of Perceptual Information, Department of Psychiatry, University of Maryland, (June 1961)(AD 261 002).

This tachistoscopic study proves that the total amount of information transferred improves with the number of possible characters in the system e.g. decimal is better than binary, alphabetic is better than decimal, etc.

Gogel, Walter D., The Perception of Depth from Binocular Disparity, Aeromedical Research Division, Oklahoma, (AD 429 827)

Binocular disparity is not a reliable source of distance information.

Gottdanker, Robert, Senders, John, Reactions to Sequences of Signals, Minneapolis-Honeywell Regulator Company, Aeronautical Division, Minneapolis, Minnesota, (AD 234 167).

Responses to discrete signals in quick succession or continuously varying signals were studied.

Granit, R., "The Color Receptors of the Mammalian Retina", Journal of Neurophysiology, Vol. 8, pp. 195-210, (1945).

"On the basis of the known modulators it would be necessary to develop a 6- or 7- colour theory, based on one red and one yellow modulator, two or three green modulators, and two blue ones."

Judd, Deane B., Dr., "Appraisal of Land's Work on the Two-Primary Color Projections", Journal of Optical Society of America, Vol. 50, pp. 254-268.
Judd doesn't like Land.

Karten, Harvey J., M.D., Studies on the Evolution of Nervous Control, Washington School of Psychiatry, (AD 433 153).
The avian and mammalian nervous systems have followed similar patterns of development.

Land, E.H., "Color Vision and the Natural Image Part I", Proceedings of the National Academy of Sciences, Polaroid Corporation, Cambridge, Massachusetts, Vol. 45, pp. 115-129, (1959).
This is Land's original paper on two-color theory.

Land, E.H., "Color Vision and the Natural Image Part II", National Academy of Sciences, Vol. 45, pp. 636-644. (1959).
This is the second part of the original paper.

Land, E.H., "Colors Seen in a Flash of Light", National Academy of Sciences, Vol. 48, pp. 1000-1008, (1962).
This study proves that the two-color theory cannot be explained in terms of accommodation.

Land, E.H., "Some Comments on Dr. Judd's Paper", Journal of Optical Society of America, Vol. 50, p. 268, (1960).
Land doesn't like Judd either.

Machol, Robert E., Information and Decision Processes, Purdue University, McGraw-Hill Book Company.
This book is a collection of 12 papers.

McGlothlin, William H.; Cohen, Sidney; McGlothlin, Marcella A., Short-Term Effects of LSD on Anxiety, Attitudes, and Performance, (June 1963) (AD 412 561).
The use of d-lysergic acid diethelamide (LSD) in humans was found to have no appreciable effect on performance. While inconclusive, the tests did indicate lower anxiety and decreased dogmatism.

Melton, C.E., Neural Control of the Ciliary Muscle, Aviation Medical Service, Aeromedical Research Division, Civil Aeromedical Research Institute, Oklahoma, (March 1963)(AD 413 392).
The ciliary muscle is responsible for focusing the eye.

Miles, Walter R., "Effectiveness of Red Light on Dark Adaptation", Journal of Optical Society of America, Vol. 43, No. 6, pp. 435-441.

The presence of red light has no effect on securing and retaining dark adaptation.

Mitchell, R. T.; Mitchell, Rhonda, Visual Acuity Under Blue Illumination, Massachusetts Institute of Technology, Lincoln Laboratory, Massachusetts. (AD 251 570).

Visual acuity is not as good under blue illumination as under white illumination. The axial chromatic aberration of the eye due to blue illumination requires about -0.60 diopter corrective lenses for acuity correction.

Moorell, Roger M., New Concepts in Monitoring of Astronaut Brain Function. (January 16-18, 1962).

The electroencephalographic (EEG) output from an astronaut's brain is probably amenable to data processing prior to transmission.

Murphy, Donald G.; Myers, T.I.; Smith, S., Pioneer VI - Reported Visual Sensations as a Function of Sustained Sensory Derivation and Social Isolation, U.S. Army Leadership Human Research, Presidio of Monterey, California, (November 1963)(AD 439 431).

The results were inconclusive.

Nagle, Francis J.; Balke, Bruno; Ganslen, Richard; Davis, Audie J., The Mitigation of Physical Fatigue with "Spartase", Civil Aeromedical Research Institute, Oklahoma City, Oklahoma, (AD 429 001).

Spartase had no effect on individuals in good physical condition. Spartase was effective in mitigating physical fatigue in untrained individuals engaging in strenuous work. (Spartase is a drug.)

Ogle, K. N., "On the Limits of Stereoscopic Vision", Journal of Experimental Psychology, Vol. 44, pp. 253-259, (1952).

There is a limited visual area in which stereoscopic fusion can occur. There is no stereoscopic vision outside of this area.

Rouse, Richard O., "Color and the Intensity-Time Relation", Journal of the Optical Society of America, Vol.42, No. 9, pp. 626-630, (September 1952).

Flicker fusion frequency and flash duration effects were found to be independent of color.

Schiffman, Harold, A Mathematical Analysis of the Impact of the Source and Content on the Evaluation of a Message, Office of Naval Research, (June 1963) (AD 413 348).

Experiments showed a precise relationship between the evaluation of a message and the subjects' like for the sender and estimate of the sender's competence.

Svaetichin, C.; McNichol, E. F., "Retinal Mechanisms for Chromatic and Achromatic Vision", Annals of New York Academy, Vol. 74, pp. 385-404, (November 1958).

There is a strong analogy between color TV and the chromatic retinal response of a fish.

Swets, John A., Signal Detection and Recognition by Human Observer, Cambridge, Massachusetts.

This book applies modern detection theory to human observers.

Szafran, Jack, Age Difference in Choice Reaction Time and Cardiovascular Status, (November 1963).

Maximum information rate appears to decrease with age.

Tramontano, R., The Contribution of Education to the Performance of Airmen Electronic Technicians, The American University, Washington, D. C., (AD 410 165)

Performance was unaffected by aptitude, age, and marital status. Tenth to twelfth grade educations were superior for this task.

Veynik, A., Training the Mind for Science and Creativity, USSR, (June 1963) (AD 410 628).

People can be trained to be creative in the same fashion as they are trained for other purposes.

Wernik, Joel S.; Tobias, Jerry V., A Central Factor in Pure Tone Auditory Fatigue, Civil Aeromedical Research Institute, Oklahoma City, Oklahoma, (September 1963) (AD 428 757).

The degree of effect of a fatiguing tone is a function of the listeners' activity during stimulation.

Wooldridge, Dean E., The Machinery of the Brain.

This book is reported in the Appendix.

Young, Laurence R., A Sampled Data Model for Eye Tracking Movements, (1963).

Equations for eye tracking motion. A sampled data model is required for adequate description.

GROUP 2
MAN'S CHARACTERISTICS AT AN INTERFACE

First Congress on the Information System Sciences Session 5 - Man-Computer Information Transfers, Directorate of System Design, Air Force Systems Command, L. G. Hanscom Field, Bedford, Massachusetts, (January 1964) (AD 428 931).

This is a collection of 3 papers, dealing with graphical languages for optimized man-computer communications.

Human Engineering Investigation of Aircraft Cockpit Visual Displays: The Effects of Contrast, Color, and Viewing Illumination on Scale Reading, Pennsylvania State University, Department of Psychology, (AD 129 108).

"Under daylight viewing conditions no consistent difference was related either to contrast or to color".

Human Performance in Information Transmission Part III, Flash Recognition of Familiar Displays, Staff and Consultants, Bio-Systems Group, Control Systems Laboratory, University of Illinois, Urbana, Illinois, (January 1956) (AD 83 017).

"... if maximum information transmission per glance is desired, then it can be best achieved by a balanced stress in both span of absolute judgment and order of complexity."

Human Performance in Information Transmission Part IV, Flash Recognition of Familiar Displays, Staff and Consultants, Bio-Systems Group, Control Systems Laboratory, University of Illinois, Urbana, Illinois, (January 1956) (AD 89 543).

Short-term human brain storage appears to be about 19 bits.

Information Transfer Display - Control Systems, Applied Psychological Services, (AD 404 732).

A formalized display rating system (Display Evaluation Index-DEI) is suggested as a means of numerically evaluating equipment design from an information transfer point of view.

Simulation of Human Problem - Solving Methods, Department of Electrical Engineering, University of Washington, Seattle, (AD 428 649).

This paper covers three subjects: problem solving and learning, computer game playing with a tree-pruning learning method, and human attitudes toward the man-machine relationship.

Tech Memo: Persistence of Training Effects Noted in the Listen Study, Systems Development Corporation, Santa Monica, California, (June 1963) (AD 410 790).

The skills developed in the first study had deteriorated due to lack of continued training.

Bekey, George A., An investigation of Sampled Data Models of the Human Operator in a Control System, University of California, (AD 273 347).

A human operator is best simulated by a sampled data model.

Bergum, Bruce; Lehr, Donald J., Vigilance Performance as a Function of Task and Environment Variables, (AD 404 212).

"The results for the optimization study suggest that significantly high levels of performance can be maintained over fairly extended time periods, with careful selection of conditions."

Briggs, G. E.; Cosgriff, R. L., Accomplishments in Human Operator Simulation (AD 245 125).

This report utilized non-linear transfer functions to simulate a human operator.

Crannell, C. W.; Topmiller, D. A., Effect of Grouping on the Time Required to Locate and Respond to the Elements of a Large Control Panel, Miami University, Behavioral Sciences Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (May 1963) (AD 410 998).

This is an interesting report, but some of the conclusions seem questionable.

Dale, H. C. A., The Effect on Performance of Variations in Certain Spatial and Temporal Properties of a Multi-Dial Display, Medical Research Council, Applied Psychology Research Unit, Cambridge, Massachusetts, (AD 221 700).

The results were ambiguous. They showed that (a) the use of a display consisting of a number of scattered units led to performances which were inferior to those obtained with displays consisting of a compact group of units; (b) a display involving a mixture of fast and slow units led to overall performances of the same quality as that obtained with a display consisting of units which rotated at similar speeds (the number of signals presented per minute being the same in each case). No interaction of the two variables was obtained.

DeSocio, Elizabeth; Walker, Norman K., The Effect of a Particular Stress on One Man's Performance of Various Tracking Tasks, Washington School of Psychiatry, (September 1963) (AD 428 112).

This progress report concerns a tracking task while repeating words heard in the subject's earphones. This repeating of words causes the subject to divide his attention between tracking and repeating, resulting in "catastrophic degradation in performance ...."

Foley, John P., Jr., Performance Testing: Testing for What is Real, Maintenance Training Branch, Training Research Division, Behavioral Sciences Division Laboratory, (June 1963)(AD 412 776).

Considerations in constructing valid written tests to test for performance capability are discussed.

Garfinkle, D. R.; Smith, R. L.; Lyman, J.; Groth, H., Performance Studies on the NOTS-UCLA Tracking Simulator: Effects of Error Magnification, Field of View, Proprioceptive Cues and Control Dynamics, University of California, Los Angeles, (April 1963)(AD 428 183).

Error magnification and proprioceptive cues improved tracking, while displacement aiding control dynamics produced better tracking scores than unaided velocity control dynamics.

Gottsdanker, Robert, Reaction Time: The Time to Initiate a Response, Minneapolis-Honeywell Regulator Company, Aeronautical Division, Minnesota (December 1958)(Ad235 166).

This is a theortical treatise on the definition of reaction time.

Jerison, H. J., Experiments on Vigilance: Duration of Vigil and the Decrement Function, Fourth in a Series, Antioch College, (December 1958)(AD 155 722).

"... Monitoring tasks should be kept short if optimal performance is required."

Johnson, D. L.; Kobler, A. L., Man-Computer Interface Study, Department of Electrical Engineering, University of Washington, (AD 416 612).

Kasten, Duane F., Human Performance in a Simulated Short Orbital Transfer, (AD 400 484).

The orthogonal-axes thrust control system produced better performance than the pitch attitude and one-axis thrust control system.

Katz, Aaron; Helme, William, Prediction of Success in Automatic Data Processing Programming Course, (October 1962)(AD 412 850).

The General Technical Aptitude Area test was the most effective in predicting students' grades.

Krendel, E. S.; Bloom, J. W., The Natural Pilot Model for Flight Proficiency Evaluation, Engineering Psychology, Franklin Institute, (April 1963) (AD 410 805).

This report attempts to derive a "Natural Pilot Model" to explain human behavior.

Loveless, N. E., Flying Personnel Research Committee, Attention to Individual Channels in a Bisensory Presentation, Nuffield Department of Industrial

Health, University of Durham, Kings College, Newcastle-on-Tyne, Air Ministry, England, (September 1959)(AD 237 772).

"The results showed . . . that seeing and hearing were just as efficient when the subjects were forced to attend to both channels as when they attend to one only."

Myera, L. B.; Carter, R. G.; Stover, R. E., The Evaluation of Trouble Shooting Strategies, HRB-Singer, Inc., State College, Pennsylvania, U. S. Naval Training Center, (January 1964)(AD 438 924).

Half-Split and Bracketing strategies are superior to Signal Tracing strategy.

Pfeiffer, M. G.; Clark, W. C.; Danaher, J. W., The Pilot's Visual Task: A Study of Visual Display Requirements, Courtney and Company, Pennsylvania, (March 1963)(AD 407 740).

Time-sharing of a pilot's attention between cockpit emergency detection, formation flying, and intruder detection can be taught effectively in a simulator.

Reed, J. B., The Speed and Accuracy of Discriminating Differences in Number and Texture Density, Mount Holyoke College, Psychological Research Unit, (AD 140 735).

A graphical coding technique for visual displays is presented.

Rogers, James G., The Effects of Target Distance and Direction on Maximum Velocity of the Rolling Ball Control, Hughes Aircraft Company Systems Corporation.

A rolling ball control system is described.

Rogers, James G., A New Method of Aiding for Discrete Manual Tracking, Thesis for Master of Science degree in Engineering, (June 1963).

Adaptive aiding provided a small gain in system capacity.

Siegel, Arthur I.; Wolf, J. J., Computer Simulation of Man/Machine Systems, (1963).

Digital simulation technique for one-and two-operator man/machine systems was developed.

GROUP 3
MAN'S CHARACTERISTICS IN A GROUP OF PEOPLE

Perception of Leadership in Small Groups, Office of Naval Research, (February 1963)(AD 411 376).

Thirty-five (35) leaderless four or five man groups discussed a human relations case. In 33 cases the participants and observers rated the same individual as the natural leader of the group. Apparently a small leaderless group of peers can capably select its own leader.

Christal, Raymond E., JAN: A Technique for Analyzing Group Judgement. (AD 403 813).

Judgement ANalysis is a technique for obtaining a consensus of humans by statistical analysis.

Doll, R. E., Peer Rating Validity as a Function of Rater Intelligence and Rating Score Received, Bureau of Medicine and Surgery, U. S. Naval School of Aviation Medicine, U. S. Naval Aviation Medical Center, Florida, (March 1963)(AD 410 352).

"... There is little practical reason to take into consideration rater intelligence when concerned with the validty of the ratings he gave..."

Fiedler, F. E., A Contingency Model for the Prediction of Leadership Effectiveness, University of Illinois, (AD 410 126).

The natural leader of a group for one type task is not necessarily the natural leader of the same group for a different task.

Izard, C. E., Affect, Person-Perception, and Behavior, Vanderbilt University, (April 1963)(AD 407 852).

Conclusion of this neuro-psychological treatise: Affect controls Perception controls Behavior controls Affect, etc.

Klaus, Davis J.; Glaser, L., Team Learning as a Function of Member Learning Characteristics, (AD 403 525).

"... Team learning can be specifically related to the proficiency which team members attained during prior individual learning".

Peters, J.; Benjamin, F. B.; Helvey, W. M.; Albright, G. A., Study of Sensory Deprivation, Pain and Personality Relationships for Space Travel, Republic Aviation Corporation, Farmingdale, Long Island, New York, (October 1962).

The evidence of the present study suggests that subjects who were able to endure pain and reduced sensory input conditions suffered less anxiety with

attendant headaches and nausea and remained in good functional condition for longer periods of time than those who were least able to endure pain and reduced sensory input conditions.

Ziller, Robert C., The Newcomer's Acceptance in Open and Closed Groups, Behavioral Sciences Division, (AD 407 716).

The knowledgeable newcomer to a group is welcomed only if he was expected or if the group has a poor record of success.

GROUP 4
OPTIMIZATION OF MACHINE CHARACTERISTICS TO MATCH MAN'S CHARACTERISTICS

Advanced Army Aircraft Instrumentation System, Douglas Aircraft, (AD 404 780).

This is a progress report on a new complete instrumentation panel.

Design of Visual Displays, Colgate University, Department of Psychology, (December 1 to March 1, 1953)(AD 9793).

The relative legibility of three type-faces was determined.

Electroluminescent Ferroelectric (ELF) Solid State Display, Bureau of Ships, Department of Navy, Westinghouse Electric Corporation, (30 June 1963) (AD 411 785).

This report covers the theory and construction of a panel utilizing electroluminescence with ferroelectric control.

Feasibility Study of Data Presentation Configurations for Real Time Flight Test Display, Raytheon Company, Equipment Division, Massachusetts, for Air Force Flight Test Center, Air Force Systems Command, Edwards Air Force Base, California, (July 1963)(AD 413 065).

Two display screens are the minimum required for a complex data presentation.

Interim Development Report for Multi-Station Push-Button Switch, U. S. Navy Department of Ships, Electronics Division, (December 1963)(AD 428 438).

This is a progress report on a sealed-face, teaseproof, multi-station switch.

A Study of Methods of Coding Visual Information, University of Vermont, State Agricultural Information, (AD 283 658).

"... For rapid transmission of information, the number of symbols should be minimized while the uncertainty of each individual symbol should be maximized." Uncertainty is meant here in the sense of the number of quantization levels.

Bourne, Charles P., Research on Computer Augmented Information Management, Directorate of Computer Development, Electronic Systems Division, Air Force Systems Command, L. G. Hanscom Field, Bedford, Massachusetts, (November 1963)(AD 432 098).

This is an information retrieval system.

Bowen, Hugh M; Andreassi, John; Turax, Shaffer; Orlansky, Jesse, Optimum Symbols for Radar Display, Dunlap and Associates, Inc., Stanford, Connecticut,

This study examined 20 arbitrary symbols.

Bowen, H. M.; Gradijan, J. M., Graphical Display of Multiparametric Information Part II; Experimental Studies of Chart Design, Dunlap and Associates, Inc., Stanford, Connecticut, Behavioral Sciences Laboratory, (N63-22596).

This report summarizes eight experiments designed to optimize multiparametric information formats. Some of the factors investigated were optimum grid intervals, linear and non-linear functions and scales, and chart complexity.

Bradely, J. V., Desirable Control-Display Relationships for Moving-Scale Instruments, Aeromedical Laboratory, Wright Air Development Center, (September 1953)(AD 61819).

It is not possible to construct a moving scale instrument which incorporates all three desirable functions:

1. The scale should rotate in the same direction as the control knob.
2. The scale numbers should increase from left to right.
3. The control knob should turn clockwise to increase the setting.

Brown, L., The U. S. A. F. Vertical Instrument Program, Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, Paris, (May 1959)(AD 237 624).

This report summarizes the vertical scale instrument concept.

De Lateur, L. A.; Munger, M. R., Final Report, Data Presentation for Positional Representation of Space Vehicles, (Phase II), Lockheed Missiles and Space Company, Sunnyvale, California, (AD 408 358).

A display console using four 35 mm projectors simulated computer generated CRT displays.

Deininger, Richard L., Desirable Push-Button Characteristics.

This report details specifications for push-button arrangements, button shapes and identification, and force-displacement characteristics.

Fried, Charles, A Human Factors Evaluation of Seven Digital Readouts in Indicators, Ordnance Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, (July 1960)(AD 243 030).

The IEE projection display was superior.

Gottsdanker, Robert, Senders, John W., Compatibility of Display and Control, (February 1959)(AD 235 168).

Controls and displays should be compatible, and can be because any control is, in a sense, a display.

Gustafson, C. E., A Method of Estimating Surface Color Discriminability for Coding Training Equipment and Predicting Label Legibility, Behavioral

Sciences Laboratory, Aerospace Medical Division, Wright Air Development Division, (May 1960)(AD 243 721).

The luminous reflectance values for Federal Standard colors can be used to estimate surface color discriminability.

Halsey, Rita M., Factors Influencing the Legibility of SAGE Displays, IBM Command Control Center, Federal Systems Division, Kingston, New York, (November 1960) (AD 252 034).

See Mitchell et al. in Group 1 for a critique.

Havron, M. D.; Jenkins, J. P., Information Requirements Methods as Applied to Development of Displays and Consoles, Contract Nonr 2525-(00), Engineering Psychology Branch, Psychological Sciences Division, Office of Naval Research, Human Sciences Research, Inc., Virginia, (March 1961) (AD 257 609).

This report lists 50 steps from system concept to a tested operational console.

Jarman, D. R., The Display of Automatically Processed Radar Information, (December 1963).

A computer analyzes the radar data and generates a display using appropriate symbols for aircraft types, etc.

Kearns, J. H.; Warren, E., Vertical Instruments, (July 1962)(AD 410 322).

This report shows how the vertical instrument program was derived.

Mann, Jerre V., "Design and Application of Lighted Display and Control," IEEE Transactions on Aerospace, (August 1963), pp. 187-194.

This report discusses good practice in lighted displays and controls.

Mengelkock, R. F., Houston, R. C., Investigations of Vertical Displays of Altitude Information: Comparison of a Moving Tape and Standard Altimeter on a Simulated Flight Task, University of Illinois, (March 1958) (AD 130 828).

The standard altimeter was significantly superior to the vertical, moving tape altimeter.

Mengelkock, R. F.; Houston, R. C., Investigation of Vertical Displays of Altitude Information: II The Effect of Practice on Performance of a Simulated Flight Task Using a Moving Tape Altimeter, University of Illinois, (March 1958)(AD 130 829).

The standard altimeter was significantly superior to the vertical, moving tape altimeter.

Mengelkock, R. F.; Houston, R. C., Investigation of Vertical Displays of Altitude Information: III The Effect of an Expanded Scale on Performance of a Simulated Flight Task Using a Moving-Tape Altimeter, University of Illinois, (March 1958)(AD 142 042).

A moving tape altimeter with a scale factor of 2.375 inches per thousand feet has the same resolution as the standard altimeter.

Reinwald, F. L., Legibility of Symbols of the AND 10400, Machworth and Berger Type-Faces at Vertical and Horizontal Angles of Presentation and the Construction and Test of Legibility of a Revised Type-Face, Colgate University, Department of Psychology, Final Report, (No Date) (AD 75 629).

The standard type-faces were equivalent in legibility. The revised type-face elicited 10% fewer errors than the AND type-face.

Reinwald, F. L., Design of Visual Displays, Colgate University, Department of Psychology, (October 21, 1954)(AD 67 099).

This is a symbol-by-symbol error analysis of the letters in the type-faces listed in the previous article.

Starsel, Harold; Regan, Richard; Glaserm, Robert, Investigations of Machine-Assists to Operator Performance: II - An Illustrative Guide to the Application of Machine-Assist Principles, Engineering Psychology Laboratory, Department of Psychology, University of Pittsburg, Pennsylvania, (AD 273 438).

"The approach reflected by the current literature is directed toward the solving of immediate problems rather than toward the systematic development of a body of inter-related and substantiated data which could be applied as required to problems at hand and in the future."

Wassermann, M. S., A Solid-State Self-Scanning Display Device, General Telephone and Electronics Laboratories, Inc., (AD 402 886).

This display device uses acoustic waves in an electroluminescent panel for a two-dimensional display device.

Williams, A. C.; Adelson, M., A Program of Human Engineering Research on the Design of Aircraft Instrument Displays and Controls, Hughes Aircraft Company, University of Illinois, Wright Air Development Center, (December 1956)(AD 110 424).

A human engineered aircraft cockpit was formulated.

GROUP 5
OPTIMIZATION OF ENVIRONMENT CHARACTERISTICS TO MATCH MAN'S CHARACTERISTICS

Oxygen and the Eye, Aeromedical Reviews, USAF School of Aerospace Medicine, Aerospace Medical Division, Brooks Air Force Base, Texas, (February 1964)(AD 438 909).

Exposure to an oxygen atmosphere of greater than 160 mm. Hg. partial pressure causes a contraction of the visual field. Forty-eight hours of 760 mm. Hg. oxygen causes retinal detachment.

Hughes, R. D.; Chaillet, R. F., An Evaluation of the Operational and Psychological Effects of a Broad-Band Blue Illumination System in a CIC Mockup, CIC Facility Branch, Naval Research Laboratory, (May 1958)(AD 162 557).

See Mitchell et al. in Group 1 for a critique.

Senders, J. W., The Influence of Surround on Tracking Performance, Part I Tracking on Combined Pursuit and Compensatory One-Dimensional Tasks With and Without a Structured Surround, Aeromedical Laboratory, Wright Air Development Center, (February 1953)(AD 12 618).

No strong interaction between display illumination and surround illumination was found.

GROUP 6
EXTRACTED HUMAN OUTPUT

Barnet, Ann B., Maturation of Electroencephalographic Evoked Potentials, The Washington School of Psychiatry, Final Report, (31 October 1962 to 31 Octobober 1963)(AD 437 930).

The EEG response to light and sound stimulations have been correlated with the age of infants.

Bates, J. A. V., et al., Electroencephalography - A Symposium on its Various Aspects.

This 474-page book is a basic reference in the EEG field.

Bennett, Donald R., Capt., USAF, MC; Duvoisin, Roger C., M. D., The EEG in Aerospace Medicine, pp. 452-458, (May 1964).

The rejection of flight candidates on the basis of their electro-encephalographic recordings is discussed.

Burch, Neil R.; Childers, H.; Edwards, R., Automatic GSR Analyzer, USAF School of Aerospace Medicine, Brooks Air Force Base, Texas, (AD 430 921).

"Galvanic Skin Response is considered to be a sensitive indication of the activation of the automatic nervous system." This analyzer produces an automatic digital readout for later correlation studies.

Callaway, Enoch III, M. D., Behavioral Correlates of Human Electro-encephalographic Activity: Alpha Phase, Reaction Time, and Brightness Judgment, The Langley Porter Neuropsychiatric Institute & University of California, (June 21, 1963)(AD 411 317).

This study had eight conclusions:

1. Alpha Phase is related to threshold.
2. Alpha Phase is related to brightness judgement.
3. Brightness judgement and reaction times to the same stimuli are not regularly correlated.
4. There is a relationship between alpha phase and cardiac cycle.
5. The time of maximum alpha synchronization occurs just before the arterial pulse at the eyeball.
6. Reaction time is a function of cardiac cycle during the period when alpha tends to be synchronized with the cardiac cycle.
7. Alpha phase effects are not solely the result of cardiac cycle effects.
8. Changes in visual evoked response (VER) can be related to alpha phase at stimulation.

Four subjects provided all of the data for this study. A larger sample would have allowed meaningful statistical investigation.

Farley, B. G.; Frishkopf, L. S.; Clark, W. A.; Gilmore, J. T., Computer Techniques for the Study of Patterns in the Electroencephalogram, Research Laboratory of Electronics & Lincoln Laboratory, Massachusetts Institute of Technology, (November 6, 1957).

A brute force wave correlator was constructed.

Gibbs and Gibbs, Atlas of Electroencephalography, Volume One, Methodology and Controls.

This 293-page book consists almost entirely of EEG traces.

Kozhevnkov, V. A., Technical Procedures for Detecting Weak Bioelectrical Responses, Foreign Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (AD 438 783).

Various methods for identifying a signal lost in noise are discussed.

Krendel, E. S., "The Analysis of Electroencephalograms by the Use of a Cross-Spectrum Analyzer", IRE Transaction on Medical Electronics, ME-6, No. 3, pp. 149-156, (September 1959).

"Time lags between driving stimulus and response are potentially valuable parameters for EEG analysis."

Livshits, B. N.; Solov'yev, N. A., Recorders in Electromedical Diagnostic Apparatus, Foreign Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (AD 438 825).

Russian EKG and EEG recording equipment is described.

McGuire, Terence F., The Normal Human EKG and Its Common Variations in Experimental Situations, Aeromedical Laboratory, Wright Air Development Center, (July 1956).

"An attempt has been made to define as clearly as possible, within the limits of presently accepted knowledge, the boundaries of normal in electrocardiography."

O'Connell, D. N.; Tursky, B., Special Modifications of the Silver-Silver Chloride Sponge Electrode for Skin Recording, Massachusetts Mental Health Center and Harvard Medical School, (AD 429 771).

Salzburg, B.; Burch, N. R., "A New Approach to Signal Analysis in Electro-encephalography", IRE Transactions on Medical Electronics, PGEM-8, pp. 24-30, (July 1957).

"A system of signal analysis which may be implemented by measuring the location of zeros, extremals, and points of inflection results from treating the individual rectified sections of the EEG signal as statistical distributions."

Squires, Russell D., Electroencephalographic Changes in Human Subjects During Blackout Produced by Positive Acceleration, Bureau of Medicine and Surgery, Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pennsylvania, (6 April 1964)(AD 438 485).

"The best index of the level of consciousness appears to be the inverse relationship between the depth of blackout and the amplitude of EEG frequencies in the range of 5 cps." "Moreover, the 5 to 7 cps frequency band is associated with cerebral hypoxia which occurs during positive acceleration. This frequency band was also shown to be related to performance of specific performance tasks".

Wolff, Louis, M. D., Electrocardiography, Fundamentals and Clinical Application, Harvard Medical School.

This 333-page book thoroughly covers heart disease and electrocardiography.

GROUP 7
UNUSUAL INPUT TO MAN

Howell, W. C.; Briggs, G. E., The Initial Evaluation of a Vibrotactile Display in Complex Control Tasks, The OSU Laboratory of Aviation Psychology, The Ohio State University Research Foundation, (AD 230 472).

Vibrotactile displays in the frequency range of 0-5 cps, when driven by circuitry utilizing quickening or super-quickening, can be used as an effective "display" for complex control tasks.

Knowles, W. B.; Newlin, E. P., Coding by Groups as a Mode of Stimulus Presentation, Engineering Psychology Branch, Applications Research Division, Naval Research Laboratory, Washington, D. C., (September 1955) (AD 74 002).

It was concluded that reduction coding, or coding by groups, can result in performance which is superior to the self-paced, or item-by-item mode of operation, and that the amount rather than the rate at which information is presented is more critical in determining the temporal organization of the responses to grouped signals. These results were discussed in relation to conditions of the experiment which may influence their generality.

Licklider, J. C. R., Audio Warning Signals for Air Force Weapon Systems, Bolt Beranek and Newman, Inc., Medical Laboratory, Wright Air Development Command, Wright-Patterson Air Force Base, Ohio, (March 1961)(AD 258 530).

This study defines good practice for an audio warning system.

Pollack, Irwin; Troch, J., "Speech Annunciator Warning Indicator System: Preliminary Evaluation", Reprinted from the Journal of the Acoustical Society of America, Vol. 30, No. 1, pp. 58-61, (January 1958)(AD 110 088).

"The speech annunciator was clearly superior to the master warning indicator."

GROUP 8
HANDBOOKS ON HUMAN FACTORS, ENGINEERING, ETC.

Documentation Index and Bibliography for Study on Human Engineering of Control Systems, Minneapolis-Honeywell Regulator Company, Aeronautical Division, Minneapolis, Minnesota, (November 1959)(AD 235 165).

Human Engineering Principles and Specifications in the Design of Ground Support Equipment, Psychological Research Associates, Inc., (April 1959) (AD 248 558).

OGE/MGE and Airborne Equipment Human Engineering Compliance Review Equipment, Martin Company, (AD 405 384).

Standard for Human Engineering Design Criteria, George C. Marshall Space Flight Center, Huntsville, Alabama, (July 1963).

Carter, J. W., Some Select Physiological, Anthropometric, and Human Engineering Data Useful in Vehicle Design and Logistic Problems of Space Flight Operations, Future Projects Design Branch, Structures and Mechanics Laboratory, Development Operations Division, Army Ballistic Missile Agency, Redstone Arsenal, Alabama, (24 February 1960) (AD 438 231).

Dreyfuss, Henry, The Measure of Man, Human Factors in Design.

Lucier, R. O.; Parker, E. J., Human Factors Considerations in the Design of Electronic Computers, U. S. Army Signal Research Development Labs, New Jersey, (June 1960)(AD 243 632).

Matheny, W. G., Human Factors Program and Progress Report Army-Navy Instrumentation Program-Rotary Wing, Bell Helicopter Company, Fort Worth, Texas, Office of Naval Research, (January 1961)(AD 250 052).

Price, Harold; Crain, C. L.; Siciliani, F. A., A Survey of Human Factors Engineering Problems in Firefighting Equipment, Office of Civil Defense, (February 1963)(AD 438 209).

Woodson, Wesley E., Human Engineering Guide for Equipment Designers, University of California Press, Berkeley, (1957).

GROUP 9
BIBLIOGRAPHIES

A Bibliography of Bibliographies (Supplement), (DDC)(AD 410 397).

A Bibliography of the Effects of Temperature on Human Performance, Behavioral Sciences Laboratory, (AD 404 913).

Display Systems-A Report Bibliography, (DDC)(AD 265 432).

Program Notes, Listings, and Flow Diagrams for Human Factors Engineering Studies, Human Factors Engineering Department, IBM Command Control Center, Federal Systems Division, Kingston, New York, (November 1960)(AD 252 990).

Teaching Machines - A Report Bibliography, (DDC)(AD 271 150).

Gonon, J. P., Capt., Bibliography of Human Factors Research with Abstracts, 1954 through 1962, Decision Sciences Laboratory, Deputy for Engineering and Technology, Electronic Systems Division, Air Force Systems Command, L. G. Hanscom Field.

GROUP 10
MISCELLANEOUS

A Classification of Learning Tasks in Conventional Language -Final Report, (July 1963).

There are five general classifications of learning: perceptual-motor, discovery, understanding, perceptual judgment, and memorizing.

Matrix Controlled Display Device, Navy Department, Bureau of Ships, Electronics Division, General Electric, Syracuse, New York, 1 July to 16 September 1963)(AD 418 684).

A surface deformable medium (thermoplastic or oil) on the reflecting surface of a total internal reflection prism allows modulation of the light passing through the prism. The reflecting surface must be a focal plane.

Measurement of the Heartbeat of a Bird Embyro with a Micrometeorite Transducer, Ames Research Center, Moffett Field, California, Technology Utilization Report, NASA SP-5007.

"A new ultrasensitive momentum transducer has been successfully adapted as a ballistocardiograph to measure the heartbeat of avian embryos."

Solid-State Panel Display, Air Force Avionics Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (December 1963)(AD 431 822).

A piezoelectric sheet, when driven by synchronized acoustic transducers, drives an electro-luminescent panel.

Technical Report on Electro-Optical Display Surface, Rome Air Development Center, Air Force Systems Command, Griffiss Air Force Base, New York, (November 1963)(AD 429 522).

"Magnetically polarized spheres or elements which are light reflecting (white) on one side and light absorbing (black) on the other are selectively scanned and rotated by the influence of individual, surrounding, magnetic fields. The elements are mounted behind a transparent panel where their light reflecting or light absorbing surfaces are used to form alpha-numeric characters, symbols or lines in response to electronic input signals."

Bullock, Theodore H.; Moore, George P.; Perkel, Donald H.; Schulman, J. H.; Segundo, Jose P., Stable Modes of Activity in Pacemaker Neurons with "Open-Loops" Synaptic Input, National Institutes of Health, The Rand Corporation, Santa Monica, California, (February 1964)(AD 431 869).

"The consequences of inhibitory or excitory interactions between pacemaker neurons were predicted mathematically and through digital-computer simulations, and were then confirmed experimentally in abdominal ganglia of Aplysia californica and in stretch receptors of Procambarus clarkii."

Edwards, Ward, Probabilistic Information Processing by Man, Machine, and Man-Machine Systems, University of Michigan, System Development Corporation, (August 1963)(AD 428 727).

Bayes' theorem of personal probability is discussed.

French, John W.; Ekstrom, Ruth; Leighton, A. P., Manual for Kit of Reference Tests for Cognitive Factors, Educational Testing Service, Princeton, New Jersey, (June 1963)(AD 410 915).

Tests for 24 factors (such as memory span) are discussed.

Herner, Saul, Deciding When to Establish Your Own Storage and Retrieval System, Herner and Company, Washington, D. C., (AD 432 518).

The conclusion of this report is relatively inconclusive.

Laemmel, Arthur E., Final Report-Pattern Recognition and Detection by Machines, (8 March 1963).

Pattern recognition systems are discussed.

Lawrence, John H., Semiannual Report-Biology and Medicine, Tove Neville, Associate Editor, Donner Laboratory and Donner Pavilion, University of California, Lawrence Radiation Laboratory, Berkeley, California, (December 1962)(UCLR-10683).

18 Projects are summarized.

Lecznar, William B., Years of Education as a Predictor of Technical Training Success, 6570th Personnel Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Lackland Air Force Base, Texas, (February 1964)(AD 437 940).

Aptitude tests were a better predictor of successful course completion than educational background.

Mandler, George; Kessen, William, The Language of Psychology.

"This (281-page) book offers an analysis of scientific language in psychology . . ."

Maron, M. E., On Cybernetics, Information Processing, and Thinking, Rand Corporation, Santa Monica, California, (AD 435 484).

This paper is an appraisal of Dr. Norbert Wiener's cybernetics theories.

Mesarovic, Mihajlo D., Views on General Systems Theory, Systems Research Center, Case Institute of Technology.

This is the proceedings of The Second Systems Symposium at Case Institute of Technology.

Miller, George A., Mathematics and Psychology, Harvard University.
This book deals with the special forms of applied mathematics used in the field of psychology.

Oldenburger, Rufus, Adaptive and Self-Optimizing Control, Purdue University, Purdue Research Foundation, (February 1964)(AD 429 297).
This is a brief summary of Oldenburger's previous work.

Scodel, Alvin A., Formal and Behavioral Factors in Decision Processes, Air Force Office of Scientific Research, (AD 428 235).
This is a behavioral report on subjects playing newly devised games.

Smith, Raphael F., The Wolff-Parkinson-White Syndrome as an Aviation Risk, U. S. Naval School of Aviation Medicien, Pensacola, Florida, (28 May 1963)(AD 428 966).
The W-P-W syndrome apparently does not constitute an aviation risk, but subjects with paroxysmal tachycardia should be prohibited from piloting aircraft.

Smode, Alfred F.; Gruber, Alin; Ely, Jerome H., Human Factors Technology in the Design of Stimulators for Operator Training, Dunlap & Associates, Inc., Stamford, Connecticut, Prepared for: U. S. Naval Training Device Center, (18 December 1963)(AD 432 028).

Standlee, L. S.; Hooprich, E. A.; LaGaipa, John, Programmed Instruction in Basic Electricity, Bureau of Naval Personnel, (August 1963)(AD 429 508).
"The programmed method of instruction tended to be slightly superior (to conventional instruction) in . . . objective tests of student achievement. . ."

Tang, P. C., Dille, J. R., Inflight Loss of Consciousness-A Case Report, Civil Aeromedical Research Institute, Oklahoma City, Oklahoma, (September 1963)(AD 430 394).
An EEG from a pilot who lost consciousness while flying is analyzed.

Voskrenskiy, A. D.; Prokhorov, A. I., Problems of Cybernetics in Medicine, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (December 1963)(AD 430 544).
Keeping up with modern medical advances requires the application of information theory.

Williams, J. D., Toward Intelligent Machines, Research Council, The Rand Corporation, (AD 432 330).

This article discusses the philosophic importance of machine intelligence.

Williams, Marian, PhD.; Lissner, Herbert R., Biomechanics of Human Motion, (1962).

APPENDIX A
THE MACHINERY OF THE BRAIN[1]

By Dr. Dean E. Wooldridge

Dr. Wooldridge originally intended to call this book "A Primer for the Nonbiologist". It is a travelogue through the modern theories of brain function for technical people in general, but with specific reference to digital computers. This book correlates hundreds of technical reports on brain theory and research, and combines them into a unified theory of the operation of the brain. Therefore there is no one passage that summarized the scope of the book. A listing of chapter headings and subheadings indicates the all-encompassing nature of the book.

Chapter 1 THE ELECTRICAL PROPERTIES OF NERVES

The "All-or-Nothing" Nature of Nerve Signals
Nature's On/Off Switch: The Neuron
Nature's Input/Output Devices: Receptor and Effector Neurons

Chapter 2 THE "SCHEMATIC DIAGRAM" OF THE NERVOUS SYSTEM

The Input/Output Cable: The Spinal Cord
Keeping the Wires Straight
The Equipment Organization of the Central Data Processor
Cerebral Terminations of the Peripheral Nerves

Chapter 3. PERIPHERAL DATA PROCESSING IN THE NERVOUS SYSTEM

The Beetles of Reichardt and Hassenstein
The MIT Frogs
The Harvard Cats

Chapter 4. AUTOMATIC CONTROL CIRCUITS IN THE NERVOUS SYSTEM

Control Loops Not Involving the Brain

[1]New York: McGraw-Hill Book Co., Inc., 1963

APPENDIX B
BIOTECHNOLOGY: CONCEPTS AND APPLICATIONS[1]

By Lawrence J. Fogel

This book is a collection of data grouped for ready, but not for casual, reference. Much of the data is so specific that it is difficult to apply, e.g., Table 6-1, Distribution of Pain Sensitivity, catalogs the number of pain receptors per square centimeter for 14 exterior areas of the body.

The book is too long due to the great amount of specific data; however, it does fairly completely represent the field of human factors. The following list of chapter headings and sub-headings indicates the scope of the book:

SECTION A: THE SCIENTIFIC METHOD

Chapter 1. MATHEMATICAL MODELS AND SCIENTIFIC METHOD

1.1 Fundamental Considerations
1.2 The Purpose of Mathematical Models
1.3 The Semantic Link
1.4 Analogic Descriptive Models
1.5 Analogic Constructive Models
1.6 Symbolic Descriptive Models
1.7 Symbolic Constructive Models
1.8 The Syntactic Link
1.9 The Pragmatic Link

Chapter 2. SOME USEFUL MATHEMATICAL MODELS

2.1 Introduction
2.2 Existence, Entity, and Class
2.3 Expressing Order Relations
2.4 About Numbers
2.5 Matrix and Vector
2.6 Transformation and Function
2.7 Limit, the Calculus, and Differences
2.8 The Spectral Model
2.9 Probability and Strategy

1. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963

SECTION B: THE HUMAN INFORMATION INPUT CHANNELS

Chapter 3. THE VISUAL CHANNEL

3.1 The Visual Stimulus
3.2 Aspects of Eye Movement
3.3 Optical Properties of the Eye
3.4 Neural Encoding of the Light Energy
3.5 The Effect of Binocular Vision
3.6 Visual Illusions

Chapter 4. THE AUDITORY CHANNEL

4.1 The Auditory Stimulus
4.2 The Sensing Mechanism
4.3 Theories of Audition
4.4 The Psychoacoustic Capability

Chapter 5. THE POSITION-AND-MOTION-SENSING CHANNEL

5.1 The Sensing Mechanism
5.2 The Sensing Position
5.3 The Sensing Acceleration
5.4 Illusory Effect Due to Acceleration
5.5 Motion Sickness

Chapter 6. THE SOMATIC CHANNEL

6.1 The Sensing Mechanism
6.2 Complex Somesthetic Perception
6.3 Artificial Somatic Communication

Chapter 7. THE TASTE AND SMELL CHANNELS

7.1 Introduction
7.2 The Taste Sensing Mechanism
7.3 Taste Perception
7.4 The Smell Sensing Mechanism
7.5 Olfactory Perception

Chapter 8. SUMMARY OF THE SENSORY CHANNELS

8.1 Introduction
8.2 Protensity, the Sensing of Time
8.3 The Sensing of Probability

APPENDIX C
COLOR VISION THEORY

By Dr. Edwin H. Land

Dr. Edwin H. Land's work [1, 2, 3, 4] on a two-color theory of human color vision has caused renewed interest in color theories in general. Under some conditions, projection of red light through one negative and simultaneous projection of essentially white light through a second negative, when the images are superimposed on a screen, will give the illusion of full color projection. From the classical laws of color addition, only red, white, and shades of pink should be seen. However, audiences saw a whole gamut of colors, from red to purple, including brilliant yellows, blues and greens.

Dr. Deane B. Judd is one of the leading authorities on three color theory.[9] The Helson-Judd Tri-stimulus Formulation is the best mathematical treatment of three color theory. After a review[5] of Land's work, Judd has written:

> "The color constancy hypothesis really states simply that it is hard to fool an observer even though incomplete information is provided him for the object-color perception; similarly, Land's hypothesis that we need chiefly to consider the information in the long-wave and middle wave records states that it is hard to fool an observer even though no short-wave information is given him. The hypothesis that middle-wave and long-wave information provides all the information necessary to determine the object-color perception is obviously doomed to failure; but like the equally untenable hypothesis of absolute color constancy of visual objects it has obviously been very fruitful in the sense of suggesting valuable experiments, and we are indebted to Land for pointing out how much can be learned from object-color perception simply from two-color projections of middle wave and long-wave records. We are indebeted to him even more for presenting the phenomena so clearly

> and dramatically in a series of demonstrations involving simply two-primary color projection. By these demonstrations thousands of people have been introduced to the fascinating facts of object-color perception previously hidden from all but a few score students of this specialized subject, and scores of researches that otherwise would never have been undertaken at all will undoubtedly use Land's techniques." "The fact that such pictures can be produced without substantial change by a wide variety of choices of pairs of projecting lights can be derived from the accepted principle of object-color perception, and, indeed, by means of formulas which I myself developed; but I did not recognize this implication in my own formulas, and would never have thought to search for it within them, had I not seen the Land demonstrations."

While Land still believes that two-color theory represents the real world for humans,[6] an interesting paper has been found which possibly explains how both a three-color and two-color theory can exist for the same phenomena. Ragnan Granit of the Neurophysical Laboratory, Karalinska Institute, Stockholm, Sweden, published a report[7] detailing at least six different spectral responses that could be found in the human eye. He performed tests on the eyes of snakes (cone receptors only) and rats and guinea pigs (rod receptors only), which show that the Purkinje Shift in spectral response must be caused by the difference in rod and cone spectral responses. In addition to the photopic (cone) ... "dominator there are, in the light adapted eye, narrow bands of sensitivity, called modulators. These occupy three preferential regions, red-yellow 0.580-0.0600 microns, green 0.520-0.540 microns, and blue 0.450-0.470 microns. In some light adapted rod eyes, there was also a narrow band, placed with its top in 0.500 microns, and thus suggesting a narrow visual purple curve."

Granit utilized a micro-electrode in the optic nerve inserted through the space normally occupied by the corners to make his measurements. Based upon 3988 observations, he proved that the eye has separate adaptation characteristics in various spectral regions. "On the basis of the known modulators it would be necessary to develop a 6- or 7-color theory, based on one red and one yellow modulator, two or three green modulators, and two blue ones. But considering that the modulators are centered around three spectral regions

it may be worthwhile to adhere to the structure of the trichromatic theory and find three fundamental sensation curves centered in these regions."

It may well be that Land's dichromatic theory groups the six or seven curves into two meaningful groups, and that at least some of the deficiencies of Land's demonstrations are due to the absence of portions of the visible spectrum, thereby not stimulating a particular response.

The human nervous system has been found to be a highly developed system utilizing all of the techniques of information theory, e.g., multiple level control loops, multiple level data processing, etc.[8] Conversely, an information theory study concerning color vision might resolve the color theory question.

1. Land, E. H., "Color and the Intensity Time Relation", Journal of Optical Society of America, Vol. 43, pp. 435-551, (1953).

2. Land, E. H., "Color Vision and the Natural Image Part I", Proceedings of the National Academy of Sciences, Vol. 45, pp. 115-129, (1959).

3. Land, E. H., "Color Vision and the Natural Image Part II", National Academy of Sciences, Vol. 45, pp. 636-644, (1959).

4. Land, E. H., "Color Seen in a Flash of Light", National Academy of Sciences, Vol. 45, pp. 1000-1008, (1962).

5. Judd, Deane B., Dr., "Appraisal of Land's Work on the Two-Primary Color Projections", Journal of the Optical Society of America, Vol. 50, pp. 254-268.

6. Land, E. H., "Some Comments on Dr. Judd's Paper", Journal of the Optical Society of America, Vol. 50, p. 268.

7. Granit, R., "The Color Receptors of the Mammalian Retina", Journal of Neurophysiology, Vol. 8, pp. 195-210, (1945).

8. White, C. E., A Study of Trends in Space Vehicle Digital Information Transfer Systems, SPACO, INC., October, 1963.

9. Judd, Deane B., "Color Vision Theory-Implications and Applications" Vision Research Reports, Armed Forces NRC Committee on Vision (No date) (AD 252 513).