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DEPARTMENT OF THE NAVY · O. N. R. LONDON BRANCH

OFFICE OF NAVAL RESEARCH

BRANCH OFFICE LONDON ENGLAND

INTERNATIONAL CONFERENCE ON PSYCHOLOGICAL RESEARCH IN DEEP DIVING
Office of Naval Research Branch Office, London
22-26 May 1967

Captain John E. Rasmussen

17 August 1967

UNITED STATES OF AMERICA

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INTERNATIONAL CONFERENCE ON PSYCHOLOGICAL RESEARCH
IN DEEP DIVING
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INTRODUCTION

The conference reported here represents somewhat of a departure from the traditional role and activity of ONR London. For over 20 years this office has had a major U.S. Government responsibility for scientific information exchange between the United States and Europe. While the missions of information exchange and fostering of advances in basic and applied sciences have been accomplished through a number of means, the primary mechanism has been through visits of ONRL liaison scientists to European universities and institutions, with the subsequent preparation of a report to the U.S. scientific community.

The meeting herein reported constitutes a new and different ONRL approach to enhancing information exchange and cooperative research activity. An attempt was made to bring together as many investigators as possible from various countries of the world who are working in a narrow, confused, but increasingly important research area -- the psychological aspects of deep diving.

The first papers reporting formal, systematic investigation in this area by psychologists were published less than ten years ago. Even though there has been a rapid expansion of deep diving activity within the past few years, both military and commercial, psychological research efforts have not developed at a commensurate rate. This is true even though it long has been known that humans may experience gross performance decrement and behavioral aberrations at depth. In fact, surprisingly little is known of the basic psychological variables involved, their interaction with physiological variables, or the specific limitations which they may place on man living and working at depth. The state of the art at present with regard to the psychological parameters of diving is such that there is confusion at even the most fundamental of issues, such as definition of key terms.

This Conference was organized and sponsored by ONR London with a multifold purpose:

(1) To exchange information on past, current, and planned psychological research activity in the area of deep diving.

(2) To give a broad perspective to this area of research and set forth goals which legitimately may be established. Here, it was hoped to identify and reach agreement on major variables and parameters as well as their fundamental definition.

(3) Consider basic problems of experimental design, methodology, criterion measure, etc., in the context of the research limitations imposed by the underwater and/or hyperbaric environment.

(4) Explore the possibility of an international cooperative effort in the development and standardization of instrumentation and measurement techniques.

(5) Develop uniform procedures for reporting data and experimental conditions in diving research.

(6) Explore the possibility of establishing an international data exchange program.

Invitations were extended to all known individuals from military, civilian, and industrial laboratories in the U.S. and Europe working on psychological problems associated with deep diving or hyperbaric atmosphere. A total of 12 persons, from three countries, accepted the invitation and participated in the Conference. When considered on an international basis, the participants represented approximately 90% of all psychologists identified with diving. A list of the participants, their addresses, and areas of research interest is contained in Appendix A.

PLAN OF CONFERENCE

Because of the nature of the meeting, no formal papers were prepared or presented, but each participant was requested to bring such data, reports, or other backup material he considered necessary to support technical positions which he might take during the course of the discussions. Four days were devoted to informal, semistructured discussion, with one day being set aside for a recap and summary. An agenda was prepared to serve as a general guideline for the discussion and to orient participants in their preconference planning and preparation. It was clearly understood, however, that the topics or issues set forth in the agenda were not intended to restrict the discussion. No rules were imposed beyond remaining reasonably well within the boundary of the general topic under consideration at the moment.

The meeting was opened by Captain C. T. Froscher, USN, Commanding Officer of ONR London, who made a few brief remarks welcoming the participants. Captain J. E. Rasmussen, MSC, USN, the psychology liaison officer at ONRL, served as general chairman and moderator for the meeting. It was planned that each session would be chaired by a different participant, but the plan was not followed throughout the Conference as some felt that this role limited their freedom of discussion. However, each of the predesignated session chairmen was responsible for preparing a general summary of the discussion immediately after his session was concluded. The agenda items included in each session and a summary of the general discussion are set forth below:

SESSION I -- PROBLEM DEFINITION

> "Conceptually, what are the goals or aims of psychological research in this area? What parameters are relevant to psychological study and diving performance? What is the role of psychological methodology in physiological studies of diver performance? What purely psychological problems are raised by diving? What are the relative priorities in this research area? What are the research payoffs? Are there other 'neglected' problems in this research area which should be considered?"

The session began with an attempt to identify the goals of psychological research as they relate to underwater activities. It was decided that one of the major aims initially should be to identify those psychological parameters which are unique, or highly accentuated, in the underwater environment. Some of these parameters will be discussed later.

A second major goal is the development of suitable psychological experimental methods for measuring performance in the rather diverse and difficult situations encountered. As will be discussed subsequently, some of the standard techniques, both experimental and statistical, are not readily adaptable to underwater work.

Another goal is the application of laboratory results to field situation and the identification of basic problems in the field which can result in redirecting the course of laboratory studies.

It was also emphasized that inasmuch as it is hard to separate psychological and physiological problems in diving research, an interdisciplinary approach is absolutely essential.

The following are not intended to represent a complete list, but these factors were considered by the group to be most relevant to performance and its measurement:

Environmental	Equipment	Psychological
Pressure	SCUBA	Experience
Buoyancy	Diving Mode	Team composition
Temperature	Mask	Task difficulty
Viscosity	Gas mixture	Potential danger
Water movement	Instrumentation	
Marine life	Diver communication	
Visibility		

In discussing the role of psychological methodology in physiological studies, the importance of an interdisciplinary approach again was emphasized. It also was stressed that "undersea" psychologists can provide some of the tools for gathering physiological data as well as suggesting what data need be collected. Likewise, diver performance cannot be understood without the basic data provided by physiological tests. This is true not only for research purposes, but also for planning and executing military missions involving diver skills.

Further discussion of underwater tests themselves led the group back to more fundamental questions: What do we want to measure? Why? What are the major research questions before us? What are the main areas in which psychologists can contribute? It was felt that a group should attempt an attack on these questions before involving itself with the details of tests and technique. In fact, it was felt that some preliminary answers to these more basic questions would provide a framework within which to discuss experimental techniques and their relative merits. Consequently, a list was generated of major psychological problem areas in diving. The areas included were:

(1) Cognitive behavior

(2) Motor behavior

(3) Individual differences (highlighting behavioral aberrations, apprehension, and experience)

(4) Social behavior

(5) Perceptual change

(6) Restricted sensory input

The research payoffs in diving research were considered fairly obvious. In addition to adding to our store of fundamental knowledge regarding human behavior, there are a number of specific ways in which the study of diver performance can be beneficial. Some of these are as follows:

(1) Increased overall performance effectiveness

(2) Improved equipment design

(3) Improved selection procedures

(4) Improved team effectiveness

(5) Advance scientific diver capabilities

(6) Increased sophistication of military missions involving divers

(7) Improved search, rescue, and salvage capability

(8) Modification of swimmer and diver training programs

A general discussion of stress ensued on the first day, ending in an attempt to identify stress factors which are unique or highly accentuated by the underwater environment. It was generally agreed that although there are unique factors contributing to stress underwater, i.e., marine life, gas mixture, etc., the overall problem is not basically different from other hazardous or difficult situations.

Throughout the discussion, several attendees cautioned the group about going "witch-hunting" with regard to looking for problems where, in fact, none existed. It is all too easy to assume that there will be difficulties in areas in which one's own interests lie. Along these same lines it was suggested that we examine problems, taking into account whether or not they are immediately solvable. Two examples given here were nitrogen narcosis, which can be avoided by using proper gas mixtures, and cold, which can be alleviated by heated suits. On the other hand, it was pointed out that although such solutions are technically available, they cannot always be used due to cost or equipment availability; and, in addition, certain penalties often are paid for such solutions. This led to some lengthy discussions of basic versus operational investigations.

A 25-minute film was then shown by Dr. Adolfson on the effect of nitrogen narcosis on behavior. In addition to demonstrating specific performance degradation, this film revealed a sharp contrast between the effects of narcosis(?) on an experienced person (the experimenter) and an inexperienced one (the subject). There was a remarkable difference in behavior (the experimenter being relatively unaffected) indicating a strong psychological component in narcosis or physiological response down to depths of 120 meters.

The discussion then shifted to the types of jobs that can best be done by divers as compared to operating from the surface or from submerged vehicles. The diver's contributions pointed out were scientific, such as studying marine animals, bottom-ripple observation, work tasks requiring fine manipulation, general flexibility, decision making, etc. It was emphasized that man's performance limitations must be established in order to determine the point at which submerged vehicles become more effective (cost and performance) than a free swimmer.

SESSION II -- RESEARCH METHODOLOGY

"What are the problems and pitfalls in the design of psychological research in diving, e.g., interaction, asymmetrical transfer, and learning effects, adaptation, etc.? What techniques can be devised to deal with the logistic constraints in diving? What is the role of the experimenter or investigator in diving research, e.g., problems of experimental participation versus nonparticipation? Is it possible to develop a sequence of designs of decreasing complexity to meet unexpected changes in operational conditions during the course of the experiment? What are the methodological problems associated with: (a) precise experiments aimed at testing theory; and (b) field experiments concerned with establishing performance limits?"

Two types of experimental task were distinguished, those concerned with the more immediate task of establishing performance limits in practical situations, and those concerned with more theoretical questions. It was agreed that applied experiments should be concerned only with major effects. In the more theoretical studies small effects may be important, and here experimental design (which is always important) is likely to be even more crucial.

Two major problems of design were discussed: (1) Problem due to the subject's expectations. Dr. Greenwood reported a study replicating the results of Kiessling and Maag on impairment at pressure, but showing that no impairment occurred (even at 300 ft) when subjects were not aware of the depth. Dr. Baddeley reported a study showing significant impairment at normal atmospheric pressure when subjects believed themselves to be at high pressure, though this effect was significantly less than that shown at 4 atm. (2) Problem due to practice and transfer effects. Improvement due to practice during the experiment may complicate the picture, especially when transfer across conditions is not symmetrical. It was agreed that, where possible, subjects should be thoroughly practiced before starting the experiment.

The problem of producing robust experimental designs to allow for the contingencies of field experimentation was discussed. Suggestions included: (1) Collapsing a range of conditions, such as temperatures, into two classes; (2) Where the same subject is used in all conditions, checking for undesirable transfer effects by comparing the general pattern of results with that based only on the first test from each subject; (3) Suggested rules for filling in incomplete data, e.g., from a partially completed articulation test; and (4) The value of having alternative experimental plans available.

There was considerable discussion on the role of the experimenter. Views differed, ranging from the contention that he should remain on the surface and never act as a subject in his own experiment to the view that his participation was highly desirable.

The question of whether subjects should always be experienced divers was raised. It was agreed that this is in general desirable, but that novices may be useful for some studies, e.g., training or looking at anxiety effects, though there was a suggestion that experienced divers showed a different pattern of anxiety than novices. The need for techniques to manipulate threat of danger was discussed and the resulting ethical problems considered.

A number of additional research problems were discussed. These included:

(a) Techniques for controlled observation of practical tasks. Dr. Miller outlined the salvage program planned for SEALAB III and various sampling and recording procedures were discussed.

(b) The performance of divers in pairs and in groups. It was agreed that this is an urgent and potentially fruitful problem, which, in turn, is crucially dependent on the next point.

(c) Communications between divers. The need for better voice communications is generally felt to be vital. It was pointed out that this, in turn, interacts with visibility.

(d) Visibility. More research is needed on the effects of poor visibility on performance. Possible techniques for experimental manipulation of visibility were discussed.

(e) What is the appropriate baseline condition? Opinions differed as to whether dry land performance was relevant or whether the baseline should always be performance in good visibility, warm, shallow water.

SESSION III -- EXPERIMENTAL TECHNIQUES

"Is it possible to develop: (a) an agreed-upon or standard battery of performance tests, and (b) a set of techniques for analyzing operational tasks? What criteria should be used (validity, reliability, learning effects, practicability, etc.) in the selection of experimental tasks? Is it possible to agree upon which variables should be controlled or at least recorded in experiments? What additional complications are introduced by open sea research?"

The session began with two demonstrations:

(1) Mr. Parker presented a film showing the usefulness of underwater problems for the solution of zero-gravity design problems in the aerospace program. The sequence of walking on the ocean (moon) bottom suggested particularly well the correspondence between the two situations, and the additional usefulness of this type of study in highlighting purely underwater problems. The transfer of aerospace technology to underwater work was discussed, and it was agreed that advantage could be taken of the physiological monitoring equipment developed in the space program. EEG measurement techniques and self-contained recorders were identified as potentially valuable. The space-diving trade-off was readily apparent in the discussion.

(2) A record was played demonstrating surface-to-diver and diver-to-surface voice communication over an Aquasonics communications system incorporating automatic gain control. Diver speech was fairly intelligible up to a range of 400 yards at a maximum depth of 45 feet. (Dr. Tolhurst reported that the word intelligibility for this system was about 64%.) It was agreed that there was room for improvement, and suggested that some improvement had been effected in more recent Aquasonic equipment.

Discussion of the session topic proper began with the consideration of test standardization. Several points were made, including the futility of standardization for its own sake. Dr. Bowen stressed the application of "on-line" tests to operational situations, a technique he felt superior to "off-line," artificially imposed tasks. There was general agreement on this point.

A major share of the day's discussions was devoted to an exploration of the six psychological problem areas outlined in the first session of this report.

COGNITIVE BEHAVIOR - It was recognized that many aspects of cognition exist -- judgment, memory, reasoning, information processing.

Dr. Baddeley described a test based on linguistic concepts which he had just recently applied. In it a sentence describes a relationship between a pair of letters, and the subject marks the sentence true or false. This test aims at the same general area of cognition as the set exceptions test subsequently described by Dr. Bowen, but may prove more sensitive. Dr. Adolfson exhibited a Swedish version of the Stroop word-color test, a cancelling test and the Wechsler-Bellevue digit-symbol test currently being used in SEALAB III training.

It was accepted that tests should not be used because they are easy to administer -- often a temptation -- and that attempts should be made to devise cognitive tests more closely related to and integrated with the operational situations. Tests of practical diving judgments were identified as particularly important.

In finishing the discussion on cognition, a survey was made of the cognitive functions that are important in diving and which have not yet received much research attention. Further development is desirable in the fields of:

(a) Sequentially dependent tasks (i.e., each succeeding subtask is defined, at least in part, by the nature of the previous subtask).

(b) Adaptive flexibility, particularly in the sense of coping with unexpected or contingency situations.

(c) Group/individual self-assessment; a checklist approach was thought to offer promise.

(d) Attentional proneness; vigilance, scanning, time-sharing, etc., as a function of task multiplicity, load, environmental or physiological stress, etc.

(e) Memory; short-term and long-term memory. (It is noted that some observational and experimental data presently exist but are far from being definitive.)

MOTOR BEHAVIOR - This area was separated into several subareas: (a) mobility, (b) work position in the water, (c) manual dexterity, and (d) work output. A number of influential variables were identified. These included water factors (such as cold, buoyancy, visibility, movement, viscosity), respiratory and circulatory chemical factors, and experiential factors.

Because quite a few of the participants are active in the investigation of fine manual dexterity in diving, this subarea was discussed in some detail. Several tests for the measurement of fine dexterity were presented and commented upon. A good test should be simple, "captive" or resistive to gross failure (such as dropping parts in the water), and insensitive to learning effects. It was generally agreed that if some defects could be eliminated, particularly the tendency to drop and lose nuts, the screw plate test (a test requiring subjects to reverse nuts and bolts) might well provide a form of international basic standard, even though other tests would still be used for special problems.

Gross motor behavior presents a more complicated investigative picture because it involves both diverse aspects (carrying, force application, assembly, etc.) and finer elements (for example, it is hard to imagine a practical gross motor activity which does not also require fine motor activity, major perceptual activity, and so forth). Dr. Weltman described a pipe-assembly task now under development that utilizes flanged 2-inch pipe which can serve as an experimental vehicle for the examination of motor activity and team effort. Dr. Miller reported some preliminary work by Dr. Streimer of North American Aviation in the field of underwater force application.

Criteria guiding the selection or development of psychomotor tests were discussed. The following five criteria seemed most critical to satisfy:

(1) Simplicity of administration -- both in terms of the experimenter's tasks and the subject's tasks.

(2) Reliability in terms of avoiding variability in subject's method of doing the task or strategy for approaching the task.

(3) Sensitivity in differences to stimulus in terms of subject.

(4) Minimum of training time and learning time.

(5) Validity, through use of "job sample" types of tests.

The group further agreed that, where possible, psychomotor test equipment might be modified in order to find better methods and equipments.

INDIVIDUAL DIFFERENCES - A number of related topics were subsumed in the discussion under this broad heading. They ranged from identification of behaviors important in diving performance, through personnel selection, emotional and intellectual function problems related to hyperbaric atmospheres, to diving training. Three major points emerged early in the discussion and set the tenor of the whole session. In and of themselves these points are rather obvious and certainly not remarkable. On the other hand, it was equally apparent that in spite of their fundamental importance those points had not been clearly verbalized or explicitly set forth previously in connection with this research area. They may be summarized as follows:

To date, minimum attention has been given to personnel selection in diving research. "Self-selection" has been the means through which individuals become involved in diving activity. However, it is anticipated that selection programs will be required in the very near future because of the greatly increased use of divers, both commercial and military. Before a meaningful selection program can be developed, it is necessary to obtain an understanding of and factual knowledge about individual differences which are important in diving performance.

Considerable time was devoted to the discussion of two major determinants of individual difference in diving which are of paramount importance, although almost completely neglected to date: the type and extent of diving experience, and the nature and degree of diver apprehension or anxiety. It was the consensus among the participants, who themselves are experienced divers, that these two factors probably contributed the largest sources of unaccountable variance in diving research reported to date. That view was reinforced by recalling the movie shown by Dr. Adolfson on the first day of the meeting which revealed extreme behavioral differences between experimenter and subject at 10 atm.

This discussion led to the third major point: the need for agreement regarding the descriptive information or data which should be recorded on all subjects and reported in the literature. In essence, the issue here is determination of the nature and amount of information on subjects which is required to interpret and compare research findings meaningfully.

It was proposed that a standard form should be devised to record specific descriptive information to include: body fat, ponderal index (height, weight), physical defects, age, sex, visual acuity, vital capacity, education, occupation. It was agreed that diving experience should be recorded in a standard fashion. Information in this area would include: total number of dives, number of dives in the situation under investigation, accident history (bends and other types of diving accidents), and a judgment as to the relevance of past experience to the present situation. Further, because of extreme individual differences frequently encountered in this research area, it was agreed that investigators should report both the range and standard deviation (where applicable) of test scores.

In discussing anxiety or apprehension, it was agreed that all experimenters should be encouraged to obtain some index of the diver before, during, and after dives. A major problem here is the fact that techniques for evaluating apprehension are markedly dependent upon the capability of each research establishment. Among objective techniques considered to be of possible value are physiological measures such as heart rate, tachycardia, and hypergranulation. In addition, the possibility of using ratings or scaling procedures was discussed. Particular note was taken of the desirability of involving specialists in clinical psychology and psychiatry in this aspect of diving research.

The participants considered the separation of selection and training to be unrealistic. Moreover, there was a general feeling that training programs probably serve as the best selection devices obtainable at present. While most persons in practice select themselves in or out of diving programs, it was hoped that data on expressed attitudes would be collected whenever possible. Of more immediate concern is the problem of group composition where limited populations are available. Selection in terms of commonality of motivation, professionalism, and skill level, should be studied. In fact, group selection was considered sufficiently important to constitute a separate broad research area

SOCIAL BEHAVIOR - In the general discussion of group behavior, Dr. Rasmussen mentioned the importance of distinguishing between active and passive groups in terms of the social interaction that takes place. Thus, group problems in SEALAB-type programs may differ markedly from those in salvage diving. There was a general feeling that we should observe groups of divers going about the natural tasks that may come about in the course of doing experimental studies. Some special group tasks were discussed, and the possibility of using underwater search problems for groups was mentioned. This would require each member to coordinate his activities with others in the group to avoid redundancy and ensure complete coverage.

The various special issues for study were defined as:

(a) Work effectiveness

(b) Compatibility

(c) Cohesiveness

(d) Professionalism

(e) Team organization in terms of:
supra and subordinate relationships
decision making processes
optimal networks
amount and kind of work
training as a social unit
communication processes

There was considerable discussion of each of these topics. It was the general feeling that because diving is essentially a group activity, studies of group behavior should be a prime target of research.

PERCEPTUAL CHANGE - Since almost every perceptual mechanism is affected by submergence, it is important to consider not only physical changes underwater but also the effect of the diver's adaptation to these changes. The group identified three main areas of research needed in perceptual change in diving. These are:

(a) Basic sensory performance. It was agreed that information presently available on basic sensory ability underwater is inadequate for human factors design needs. This situation cuts across many sensory modalities: vision, hearing, tactile sensation, middle ear sensation, etc. It was agreed that when sufficient data become available, a handbook for underwater use, similar to the Bioastronautics Data Book, would be highly useful.

(b) Spatial perception. Discussion centered around the many variables involved, such as vision (including color, distance, and acuity), hearing, and geographic orientation. Dr. Ross pointed out that water cloudiness and light effects tend to offset the apparent shortening of distances due to refraction and frequently cause the diver to assume that objects are farther away than they actually are.

(c) Perceptual narrowing. This phenomenon, observed by Dr. Weltman and others in laboratory settings, appears to have significance in practical diving situations. Dr. Vaughan mentioned an instance of its apparent occurrence in control of a swimmer delivery vehicle. In discussing the methodology of measuring perceptual narrowing, several areas of cross applicability were discovered among different projects, and it was agreed that those involved would individually explore these further.

It was agreed that time perception is affected possibly by cold as well as inactivity. Some possible methods of offsetting the deleterious effects of this phenomenon were mentioned.

Social perception also was mentioned. SCUBA equipment imposes severe limitations on team cooperation and nonverbal communication, making it difficult to recognize emotions in teams and groups. Discussion revealed that while this is an interesting factor, it is probably not of paramount significance, and also is likely to improve along with auditory communications.

ENVIRONMENTALLY RESTRICTED SENSORY INPUT - It was recognized that the water environment is different from the terrestrial environment in many particulars and has the effect of decreasing the richness and variety of one's knowledge about the environment. When, as is often the case, relative sensory invariance is present, boredom and monotony may be prime determinants of behavior. Cold, in particular, is a primary cause (but not the only cause) of subjective time distortion.

Another feature of the diving environment is that it generally impoverishes and/or changes normal sensory feedback and knowledge of results. To the extent that this impairs performance, tasks and procedures may have to be designed to provide amplified feedback.

This problem area is not unique to diving, research is going on elsewhere. While building on such studies, diving experiments should attend to the unique causative factors which bring about these effects in the diving situation.

<u>HUMAN ENGINEERING</u> - The group did not address itself specifically to human engineering or man/machine system issues. However, there were frequent references to present inadequacies in equipment design and the lack of studies through the sequence of donning equipment, preparing to dive, diving and performing tasks, ascending, and cleaning up. Some incidents and accidents were thought to have been due to equipment inadequacies in terms of the human interface with the equipment, rather than simply to equipment malfunction. The penalty that is incurred by the need for overtraining on poorly designed equipment was also mentioned. Among the pressing problems is the development of equipment, communication equipment in particular, to allow groups to be more work-effective. While little was specifically said about man/machine system development, Dr. Vaughan mentioned that poor layout of displays on a manned prototype submersible caused impairment of navigation.

It was agreed that at the next meeting the topics of equipment design, human engineering and man/machine system development should be included in the agenda.

<u>SESSION IV -- ESTABLISHMENT OF DATA EXCHANGE PROGRAM</u>

Because so few psychologists are working in the area of diving research and because data are so difficult and expensive to collect, there is a critical need for expedient exchange of information among active investigators. This need was considered to be of sufficient magnitude to justify devoting a specific session of the Conference to discussion of problems in information and data exchange.

Dr. J. W. Miller volunteered the services of his office in ONR, Washington, as a data and information exchange center. One of the major tasks of this center will be to accumulate test data on instruments used in diving research with a view toward obtaining samples of sufficient size to develop norms.

The idea of a newsletter as a mechanism to exchange information evolved during the course of the discussion. Dr. Miller agreed to publish such a newsletter with the understanding that material would be submitted in a form which could be reproduced and published with a minimum of editorial effort.

The following types of information will be included in the newsletter: summaries of partially completed studies, abstracts of studies which produce negative results, abstracts of research which is proposed but not yet under way, information on equipment and tests currently being developed, and new developments in research technique and methodology.

Distribution of the newsletter will not be restricted, and copies will be sent to anyone working in psychological problems associated with diving, at their request. It was agreed that the deadline for the first issue will be 1 October 1967 and that all contributions should be forwarded to Dr. James Miller, Head, Engineering Psychology Branch, Office of Naval Research, Department of the Navy, Washington, D.C. 20360.

At the suggestion of Dr. Adolfson, Dr. Miller agreed to use his office as a center for exchanging documentary films made during the course of research activities.

SESSION V -- CONFERENCE SUMMARY AND CONCLUSIONS

As the Conference progressed, discussion became more active and the meetings actually continued one day beyond the time which had been planned. The final summarizing session was probably the most active of all. In fact, the agreements reached during this session were so numerous that they are difficult to record. Although the author has served for three years as a liaison scientist in the London Branch of the Office of Naval Research, the spirit of international cooperation and agreement shown during the last day of this meeting exceeds anything witnessed to date.

It was agreed that the only logical means of progressing in this research area is by close cooperation, adaptation of common or standard experimental procedures, and standardization of test instruments. In this connection, the participants considered it desirable that two manual dexterity tests, one using tools and the other fingers, be recommended for use in diving research. Standardized conditions of administration should be developed for these tests and appropriate norms devised. The Bennett Hand-Tool Test was selected as one instrument. Standardized drawings and instructions for this test will be distributed to participants by Dr. Miller. He will coordinate the development of norms using data collected under standardized conditions by various investigators.

A modified version of the screw-plate test was selected for the manual dexterity instrument involving use of fingers. Mr. Parker agreed to ask engineers at General Electric to prepare drawings and specifications for a modified screw-plate test. Dr. Adolfson indicated that it would be possible to fabricate several of the tests in the Swedish Navy instrument shops, and Mr. Bowen of Dunlap will develop instructions and standardized conditions for administration of the new tests.

The Wechsler-Bellevue Digit Symbol Test, now being used in SEALAB III, appears to be useful in diving research. In order to be utilized, the test must be embossed on plastic sheets. Dr. Miller agreed to provide the basic stimulus materials and Dr. Wilton-Davies indicated that the Royal Naval Physiological Laboratory could fabricate a number of sample sets.

Several general conclusions were reached on experimental technique and methodology. It was generally agreed that nonparametric statistics are preferable in diving research because of the small number of subjects and sampling difficulties encountered in this area. It was further agreed that extreme care should be utilized in interpreting results of research in the literature, where small samples are involved and decisions and interpretations are made on the basis of evidence which might not be particularly solid. It was agreed that extreme cases should be reported because of the significance of individual differences in diving research. Moreover, this field is still in a sufficiently early stage of development that single case observations are worth reporting.

A number of points were agreed upon in considering criterion problems. Test/re-test reliability should always be ascertained and reported before an attempt is made to utilize newly developed test instruments. Strange as it may seem, this practice has not been followed in much of the diving research published to date. Further, pilot study data should always be reported on new tests. In the same vein, learning effects and information regarding training on new test instruments should appear in any reports of studies utilizing instruments. It was agreed that particular emphasis should be given to the accumulation of information on the validity of tests using diving.

The participants requested that the Office of Naval Research sponsor another conference, patterned along the lines of the one reported here, in approximately one year to 18 months. It was agreed that plans will be made to hold such a meeting in the fall of 1968. Dr. Adolfson indicated that the Royal Swedish Navy may wish to serve as host for the next meeting. It further was agreed that the agenda should cover the same topics as at this Conference, although an additional session should be added to cover the area of Human Engineering.

A list of the Conference participants is contained in Appendix A. Appendix B sets forth references to tests used in diving research. One of the final decisions of the meeting was that the participants would forward such references as they may have to the Conference chairman so that they could be appended to the report. The material contained in Appendix B was received from Drs. Miller and Baddeley.

APPENDIX A

INTERNATIONAL CONFERENCE ON PSYCHOLOGICAL RESEARCH IN DEEP DIVING
22-26 May 1967

PARTICIPANTS	RESEARCH INTERESTS
Dr. John A. Adolfson Royal Swedish Navy Långa Raden 2 Stockholm 100 Sweden	"Nitrogen" narcosis and its effect on performance using air to depth of 120 meters. Dr. Adolfson pointed out the necessity for such studies because of the unavailability of helium in Sweden
Dr. Alan D. Baddeley M.R.C. Applied Psychology Research Unit Cambridge, England	Experimental design for studies of performance both in chambers and in the open sea. In particular the study of diver tasks encountered during scientific diving operations at depths less than 200 feet on air
Dr. Hugh M. Bowen Dunlap & Associates Darien, Conn., U.S.A.	The development and administration of motor and cognitive performance tests to study the effect of cold water
Mr. M. Greenwood Deep Submergence Systems Project Technical Office 139 Sylvester Road San Diego, Cal., U.S.A.	The study of diver performance in real life situations such as Sealab, salvage, etc.
Dr. James W. Miller Code 455 Office of Naval Research Department of the Navy Washington,D.C., U.S.A.	The administration of a contract program on diver performance and the conduct of the diver performance for the Sealab program
Mr. Fred Parker General Electric Co. MSD-UFSTC P.O. Box 8555 Philadelphia, Pa., U.S.A.	The use of underwater simulation as a means of studying extra-vehicular activities during space-flight. In particular physiological responses such as EEG and EKG are of interest and how these, such as oxygen consumption, as well as other measurements, using micro miniaturized sensing and recording techniques, may be applicable to deep diving research

PARTICIPANTS (Contd)	RESEARCH INTERESTS (Contd)
Dr. Helen E. Ross Department of Psychology University of Hull Hull, England	The visual processes as affected by the underwater environment such as depth perception, distance judgment, adaptation and visual acuity
Dr. G.C. Tolhurst Code 454 Physiological Psych.Branch Office of Naval Research Department of the Navy Washington, D.C., U.S.A.	Diver communication and general psychophysiological problems
Dr. W.S. Vaughan Whittenburg, Vaughan Associates Alexandria, Va., U.S.A.	The measurement of diver performance in operational settings, particularly during the operation of wet (water filled) swimmer delivery vehicles
Dr. Gershon Weltman University of California, Los Angeles Dept. of Engineering Los Angeles, Cal., U.S.A.	Development of methodology for measuring performance underwater both in tanks and open sea, with emphasis on perceptual narrowing over psychophysiological measurements
Mr. Colin Wilton-Davies Royal Navy Physiological Laboratory Alverstoke, Hants. England	Underwater telemetry of physiological responses, particularly with regard to developing techniques for obtaining such data on a non-interference basis

Chairman: Captain J.E. Rasmussen, MSC, USN
Office of Naval Research Branch Office, London

APPENDIX B

References for Tests Used in Diving Research

Screwplate Test

A. D. Baddeley, "The influence of depth on the manual dexterity of free divers," J. appl. Psychol. 50, 81-85 (1966)

Addition Test

A. D. Baddeley, "The relative efficiency of divers breathing air and oxy-helium," Underwater Assoc. Symp. 1, 13-19 (1965)

Digit Copying Test

D. Legge, "Analysis of visual and proprioceptive components of motor skill by means of a drug," Brit. J. Psychol. 56, 243-254 (1965)

Sentence Checking Test

A. D. Baddeley, J. W. De Figueredo, J. W. Hawkswell-Curtis, and A. N. Williams, "Nitrogen narcosis and performance underwater," Ergonomics (In Press).

Tests of Perceptual-Motor Skills

The following list of tests of perceptual-motor skills contains (a) test names in alphabetical order, (b) factor names on which the tests load, (c) one or more factor loadings reported in the literature, and (d) associated literature references.

A

TEST	FACTORS, LOADINGS, AND REFERENCE
Aerial Orientation*	Spatial Orientation (SO) (.61, 4) (.52, 18)
Aiming (Ai)*	Aiming (Ai), (.63, 2)(.36, 7) (.57, 9) Finger Dexterity (FD) (.12, 2) (.35, 7) (.30, 9) Wrist-Finger Speed (WFS) (.45, 2) (.52, 9)
Analog Addition Electronic (AAEl)	Control Precision (CP) (.31, 17) Movement Analysis (MA) (.22, 17) Single Integration/Differentiation Specific (.23, 17)
Analog Addition Mechanical (AAMech)	Ability to Deal with Rotational Magnitudes (.33, 17)
Analog Addition Pr. (AAPr)*	Ability to Deal with Linear Extents (.57, 17)
Arm Drift	Arm-Hand Steadiness (AHS) (.31, 5)
Arm Tremor	Arm-Hand Steadiness (AHS) (.36, 5)
Athletic Experience Scale*	Athletic Experience (General) (.89, 8) Athletic Experience (Specific)(.32, 8)
Athletic Versatility Index*	Athletic Versatility Index (.64, 8) Athletic Experience Specific (.45, 8)
Auditory Reaction Time (ART)	Reaction Time (RT) (.68, 2) (.63, 6) (.68, 12 (.51, 18)

B

TEST	FACTORS, LOADINGS, AND REFERENCE
Bimanual Matching (BM)	Control Precision (CP) (.37, 18)

C

TEST	FACTORS, LOADINGS, AND REFERENCE
Choice Reaction Time (CRT)	Response Orientation (RO) (.39, 18)
Circle Dotting (CD)*	Aiming (Ai) (.69, 15)

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* Signified a printed test.

TEST	FACTORS, LOADINGS, AND REFERENCES
Compensatory Balance (CB)	Rate Control (RaC) (.39, 11) Control Precision (CP) (.32, 11) Manual Dexterity (MD) (.31, 11)
Complex Coordination (CC)	Multilimb Coordination (MC) (.30, 6) (.38, 18) Response Orientation (RO) (.44, 3) (.43, 4) (.09, 6) (.22, 11) (.23, 18) Spatial Orientation (SO) (.13, 3) (.40, 4) (.45, 12) (.34, 18) (.46, 7) (.39, 10) (.16, 11) Control Precision (CP) (.36, 2) (.45, 3) (.35, 6) (.44, 7) (.47, 10) (.50, 11) Speed of Arm Movements (SAM) (.09, 2) (.37, 3) (.21, 6) (.09, 7) (.37, 10) (.09, 18)
Complex Movements, Printed*	Visualization (V) (.32, 11) (.34, 18) Integration (.30, 18)
Complex Multiple Reaction	Response Orientation (RO) (.41, 11)
Control Adjustment (CA)	Control Precision (CP) (.46, 6)
Control Movement, Estimate	Position Estimation (.48, 5)
Control Movement, Respond	Position Reproduction (.32, 5)
Controls Orientation	Visualization (V) (.36, 11) Spatial Orientation (SO) (.46, 11)
Control Sensitivity (CS)	Control Precision (CP) (.38, 18)
Coordinate Movements, Printed*	Spatial Orientation (SO) (.36, 11) (.36, 18) Visualization (V) (.36, 11) Integration (.30, 18)
Coordination, Printed*	Perceptual Speed (PS) (.42, 11)
Cox Eye Board	Arm-Hand Steadiness (AHS) (.47, 15)
	D
Decoding*	Numerical facility (.35, 10)
Dial Setting	Control Precision (CP) (.40, 6) Response Orientation (RO) (.43, 6)
Dial and Table Reading*	Mechanical Experience (.30, 10) Numerical Facility (.60, 10) Perceptual Speed (PS) (.32, 10)

TEST	FACTORS, LOADINGS, AND REFERENCES
Direction Tracing*	Position Reproduction (.39, 5)
Direction Control	Spatial Orientation (SO) (.34, 4) (.39, 11) (.24, 18) Response Orientation (RO) (.58, 4) Visualization (V) (.44, 11) (.34, 18)
Directional Control (DlCPr)*	Integration (.30, 18) Spatial Orientation (SO) (.38, 11) (.34, 18) Visualization (V) (.34, 11)
Discrimination Reaction Time (DRT)	Manual Dexterity (MD) (.10, 2) (.34, 11) (.01, 18) Response Orientation (RO) (.28, 3) (.53, 4) (.67, 6) (.50, 11) (.29, 18) Spatial Orientation (SO) (.38, 3) (.38, 4) (.72, 7) (.52, 10) (.37, 11) (.33, 12) (.14, 18) Speed of Arm Movement (SAM) (.05, 2) (.46, 3) (-.03, 6) (.25, 10) (.07, 18) Visualization (V) (.16, 3) (.23, 10) (.10, 11) (.34, 18)
Discrimination Reaction Time (Pr)*	Manual Dexterity (MD) (.26, 2) (.34, 9) (.04, 11) (.15, 18) Perceptual Speed (PS) (.35, 10) (.14, 18) Response Orientation (RO) (.42, 4) (.52, 6) (.41, 11) (.38, 18) Wrist-Finger Speed (WFS) (.14, 2) (.30, 9)
Double Differentiation (El)	Movement Analysis (.22, 17)
Double Differentiation/Integration (Mech)	Movement Prediction (.43, 17)
Dowel Manipulation	Manual Dexterity (MD) (.60, 1) (.40, 15)
Dynamic Balance (DB)	Control Precision (CP) (.35, 2)

E

(none)

F

Following Directions*	Preceptual Speed (PS) (.31, 18)
Forced Landings*	Mechanical Experience (.35, 18) Response Orientation (RO) (.36, 18)
Formation Visualization*	Spatial Orientation (SO) (.51, 4) Visualization (V) (.58, 4) (.61, 18)

TEST	FACTORS, LOADINGS, AND REFERENCES
	G
General Mechanics*	Mechanical Experience (.64, 3) (.81, 7) (.62, 10) (.47, 18) Visualization (V) (.09, 3) (.06, 10) (.38, 18)
	H
Hand Precision Aiming (Corrects)	Speed of Arm Movement (.14, 2) (.56, 9)
Hand Precision Aiming (Errors)	Speed of Arm Movement (.01, 2) (-.51, 9)
Height	Athletic Experience Spec. (.32, 8) Dynamic Strength (-.39 ,8) Static Strength (.42, 8) Trunk Strength (-.31, 8)
Hex-Nut Steadiness	Arm-Hand Steadiness (.42, 15)
	I
Instrument Comprehension*	Mechanical Experience (.19, 3) (.41, 7) (.16, 10) (.16, 18) Perceptual Speed (PS) (.29, 3) (.15, 7) (.35, 10) (.15, 18) Spatial Orientation (SO) (.49, 3) (.69, 4) (.50, 7) (.46, 10) (.37, 12) (.47, 18) Verbal Comprehension (.36, 12) (.24, 18) Visualization (V) (.38, 18)
Irregular Dotting Pursuit	Aiming (.82, 15)
	J
Jump Auditory Reaction Time (JART)	Reaction Time (RT) (.64, 6) (.70, 12) (.48, 18) Speed of Arm Movement (SAM) (.44, 6) (.31, 18)
Jump Visual Reaction Time (JVRT)	Speed of Arm Movement (SAM) (.73, 2) (.54, 6) (.73, 12) (.52, 18)
	K
Knob Positioning Estimate	Position Estimation (.42, 5)
Knob Positioning Respond	Position Reproduction (.34, 5)

TEST	FACTORS, LOADINGS, AND REFERENCES
	L
Large Tapping*	Speed of Arm Movement (SAM) (.21, 2) (.39, 9) Wrist-Finger Speed (WFS) (.74, 2) (.75, 9)
Log Book Accuracy*	Numerical Facility (.31, 10)
	M
Marble Board	Manual Dexterity (MD) (.51, 15)
Marking Accuracy*	Aiming (.37, 2) (.40, 7) Spatial Orientation (.35, 10) (.34, 18)
Mechanical Comprehension*	Mechanical Experience (.61, 3) (.49, 10) Visualization (V) (.38, 18)
Mechanical Principles*	Mechanical Experience (.61, 3) (.49, 10) Verbal Comprehension (.43, 12) Visualization (V) (.40, 3) (.41, 4) (.41, 10)
Minnesota Rate of Manipulation (Placing)	Aiming (Ai) (.34, 9) Finger Dexterity (FD) (.31, 2) (.37, 9) (.36, 18) Manual Dexterity (MD) (.73, 1) (.32, 2) (.53, 9) (.38, 18) Speed of Arm Movement (SAM) (.36, 2) (.24, 9) (-.13, 18)
Minnesota Rate of Manipulation (Turning)	Finger Dexterity (FD) (.34, 2) (.34, 9) (.27, 18) Manual Dexterity (MD) (.61, 1) (.38, 2) (.52, 9) (.40, 18)
Motor Judgment	Rate Control (.40, 6) Control Precision (.40, 6)
Multidimensional Pursuit Bank and Altitude	Rate Control (RaC) (.37, 6) Control Precision (.32, 6)
Multidimensional Pursuit Bank and Air Speed	Response Orientation (RO) (.31, 6)
Multidimensional Pursuit Banking and Heading	Response Orientation (RO) (.41, 6) (.23, 11)
Multidimensional Pursuit Banking, Heading and Air Speed	Response Orientation (RO) (.33, 6)

TEST	FACTORS, LOADINGS, AND REFERENCES
Multiplication by a Constant (PR)*	Ability to deal with linear extents (.60, 17)
Multiplication by a Constant (Mech)	Ability to deal with rotational magnitudes (.45, 17)
Multiplication by a Constant (Electronic)	Movement Analysis (.21, 17) Multiplication by a constant specific (.41, 17)
	N
Nut and Bolt	Finger Dexterity (FD) (.39, 15) Mechanical Experience (.32, 10)
Numerical Operations II*	Numerical Facility (.66, 10)
	O
O'Connor Finger Dexterity (OFD)	Finger Dexterity (FD) (.53, 2) (.59, 9) (.49, 18) Manual Dexterity (MD) (.50, 1) (.25, 2)
	P
Pattern Comprehension (PC)*	Spatial Orientation (SO) (.31, 3) (.40, 4) (.33, 10) (.24, 12) Perceptual Speed (PS) (.36, 3) (.23, 10) Verbal Comprehension (.46, 12 (.16, 18)
Pattern Discrimination (Pr)*	Aiming (Ai) (.36, 15)
Pin Moving	Manual Dexterity (MD) (.32, 1) Visual Feedback (.31, 1)
Pin Stick	Finger Dexterity (FD) (.19, 2) (.34, 9)
Plane Control	Control Precision (CP) (.38, 3) Multilimb Coordination (MC) (.41, 6) Speed of Arm Movement (SAM) (.49, 3)
Precision Steadiness (Errors)	Arm-Hand Steadiness (AHS) (.50, 2) (.56, 5) (.43, 6) (.34, 18)
Punch Board*	Arm-Hand Steadiness (.30, 2) (.05 right hand, 15) (.10 left hand, 15)
Purdue Pegboard (PP) (Sum of scores on the four variables)	Finger Dexterity (FD) (.43, 18) Manual Dexterity (MD) (.33, 18)

TEST	FACTORS, LOADINGS, AND REFERENCES
Purdue Pegboard (Assembly)	Finger Dexterity (FD) (.55, 2) (.43, 7) (.59, 9) (.35, 12) Manual Dexterity (MD) (.21, 2) (.32, 9) Perceptual Speed (PS) (.31, 7)
Purdue Pegboard (Both hands)	Finger Dexterity (FD) (.61, 2) (.66, 9) Manual Dexterity (MD) (.63, 1) (.21, 2)
Purdue Pegboard (Left hand)	Finger Dexterity (FD) (.58, 2) (.55, 9)
Purdue Pegboard (Right hand)	Finger Dexterity (FD) (.46, 2) (.60, 9)
Pursuit Aiming I (3/16th" diameter)	Aiming (Ai) (.68, 2) (.63, 9) Wrist-Finger Speed (WFS) (.50, 2) (.52, 9)
Pursuit Aiming II (1/8th" diameter)	Aiming (Ai) (.63, 2) (.63, 9) Wrist-Finger Speed (.48, 2) (.54, 9)
Pursuit Confusion (PC) errors	Arm-hand Steadiness (AHS) (.36, 6) (-.04, 18) Control Precision (CP) (.04, 6) (.37, 18) Pursuit Confusion Doublet (.31, 18)
Pursuit Confusion (PC) time on target	Control Precision (CP) (.04, 6) (.37, 18) Arm-Hand Steadiness (AHS) (.36, 6) (-.04, 18) Rate Control (RaC) (.30, 6) (.72, 7) (.58, 11) Pursuit Confusion Doublet (.35, 18)

Q

(none)

R

TEST	FACTORS, LOADINGS, AND REFERENCES
Rate Control (RaC)	Control Precision (CP) (.30, 6) (.01, 7) (.24, 11) Rate Control (RaC) (.30, 6)(.72, 7) (.58, 11) Spatial Orientation (SO) (.17, 7) (.47, 18)
Restricted Manipulation	Finger Dexterity (FD) (.35, 15)
Rotary Aiming (RAi)	Aiming (Ai) (.22, 9) (.38, 15) Speed of Arm Movement (SAM) (.46, 2) (.38, 6) (.53, 7) (.02, 18) Wrist-Finger Speed (WFS) (.36, 2)
Rotary Positioning	Position Estimation (.45, 5)

TEST	FACTORS, LOADINGS, AND REFERENCES
Rotary Pursuit (RP)	Control Precision (CP) (.26, 3) (.49, 7) (.60, 18) Manual Dexterity (MD) (.17, 2) (.35, 11) (-.06, 18) Speed of Arm Movement (SAM) (.22, 2) (.47, 3) (.17, 6) (.20, 7) (.34, 10) (-.02, 18)
Response Orientation (RO) Test 0°	Perceptual Speed (PS) (.47, 4)
Response Orientation (RO) Test 45°	Perceptual Speed (PS) (.40, 4) Spatial Orientation (SO) (.34, 4)
Response Orientation (RO) Test 90°	Spatial Orientation (SO) (.69, 4)
Response Orientation (RO) Test 135°	Response Orientation (RO) (.37, 4) Spatial Orientation (SO) (.48, 4)
Response Orientation (RO) Test 180°	Response Orientation (RO) (.40, 4) Spatial Orientation (SO) (.40, 4)
Response Orientation (RO) 225°	Response Orientation (RO) (.30, 4) Spatial Orientation (SO) (.35, 4)
Response Orientation (RO) 270°	Spatial Orientation (SO) (.30, 4)
Response Orientation (RO) 305°	Perceptual Speed (PS) (.36, 4)
Rudder Control (RC)	Control Precision (CP) (.45, 2) (.44, 6) (.52, 17) (.40, 18) Movement Prediction (.23, 17) Multilimb Coordination (MC) (.48, 6) (.36, 17) (.40, 18) (.52, 6) Single Integration/Differentiation Specific (.21, 17)
	S
Santa Ana Finger Dexterity	Aiming (Ai) (.17, 7) (.33, 15) Finger Dexterity (FD) (.16, 2) (.42, 7) (.46, 12) (.06, 15) Manual Dexterity (MD) (.47, 2) (.38, 11) (.28, 15) Spatial Orientation (SO) (.39, 7) (-.07, 11) (.20, 12)
Santa Ana Peg Turning	Arm-Hand Steadiness (.05, 2) (.32, 15) Aiming (Ai) (.17, 7) (.36, 15) Finger Dexterity (FD) (.16, 2) (.42, 7) (.46, 12) (.06, 15) Manual Dexterity (MD) (.47, 2) (.38, 11) (.28, 15) Spatial Orientation (SO) (.39, 7) (-.07, 11) (.20, 12)

TEST	FACTORS, LOADINGS, AND REFERENCES
Signal Discrimination*	Perceptual Speed (PS) (.40, 11) Response Orientation (RO) (.52, 11) Spatial Orientation (SO) (.35, 11)
Signal Interpretation*	Response Orientation (RO) (.30, 18) Spatial Orientation (SO) (.45, 18)
Single Differentiation/Integration (Electronic)	Control Precision (CP) (.40, 17)
Single Differentiation (Electronic)	Movement Analysis (.60, 17)
Single Dimension Pursuit Meter	Rate Control (RaC) (-.06, 6) (.64, 7) (.55, 11)
Spatial Orientation*	Spatial Orientation (SO) (.35, 10) (.34, 18) Perceptual Speed (PS) (.45, 10) (.30, 18)
Spatial Visualization*	Perceptual Speed (PS) (.35, 4) Visualization (V) (.73, 4)
Speed of Identification*	Spatial Orientation (SO) (.37, 3) (.32, 7) (.35, 10) (.16, 12) Finger Dexterity (FD) (.33, 7) (.10, 18) Perceptual Speed (PS) (.46, 3) (.43, 4) (.45, 7) (.47, 10) (.53, 18) Verbal Comprehension (VC) (.37, 12) (.20, 18) Visualization (V) (.38, 3) (.29, 10) (.06, 18)
Speed of Manipulation (Removing)	Aiming (Ai) (.32, 15) Finger Dexterity (FD) (.45, 15)
Square Marking*	Aiming (Ai) (.30, 2) (.31, 9) (.71, 15) Wrist-Finger Speed (WFS) (.29, 2) (.46, 9)
Steadiness (Printed)*	Arm-Hand Steadiness (AHS) (.31, 12)
Steadiness Aiming	Arm-Hand Steadiness (AHS) (.60, 2) (.40, 18)
Steadiness Tremor	Arm-Hand Steadiness (AHS) (.63, 5)
Stick and Rudder Orientation	Spatial Orientation (SO) (.53, 18) Visualization (V) (.57, 18)
	T
Ten Target Aiming (TTAi) corrects	Aiming (Ai) (.66, 2) (.31, 9) Speed of Arm Movement (SAM) (.72, 9) (.50, 18) Manual Dexterity (MD) (.05, 2) (.42, 18)

TEST	FACTORS, LOADINGS, AND REFERENCES
Ten Target Aiming (TTAi) errors	Speed of Arm Movement (SAM) (-.35, 2) (-.70, 9) (.63, 18) Manual Dexterity (MD) (.43, 2) (.35, 18)
Time Sharing (Electronic)	Movement Prediction (-.30, 17)
Time Sharing (Mechanical)	Control Precision (CP) (.26, 17) Time Sharing (.79, 17)
Time Sharing (Printed)*	Time Sharing (.71, 17) Single Integration/Differentiation (.21, 17)
Tool Functions*	Mechanical Experience (.83, 7)
Track Tracing (errors)*	Arm-Hand Steadiness (AHS) (.61, 2) (.61, 5) (.50, 6) (.42, 18) Finger Dexterity (FD) (.21, 2) (.35, 7) (.18, 13) Control Precision (CP) (.16, 2) (.29, 6) (.42, 7)
Two Hand Coordination (printed)*	Aiming (Ai) (.58, 15)
Two Hand Coordination (THC)	Control Precision (CP) (.25, 6) (.46, 11) Rate Control (RaC) (.32, 6) (.17, 11) Multilimb Coordination (MC) (.33, 6) (.30, 18)
Two Hand Matching	Response Orientation (RO) (.61, 3)
Two Plate Tapping	Control Precision (CP) (.41, 18) Manual Dexterity (MD) (.24, 12) (.35, 18) Speed of Arm Movement (SAM) (.54, 2) (-.05, 18) Wrist-Finger Speed (WFS) (.36, 2)
	U
Unidimensional Matching	Response Orientation (RO) (.61, 3)
	V
VDL Rings	Manual Dexterity (MD) (.44, 15)
Visual Coincidence	Response Orientation (RO) (.36, 6)
Visual Pursuit*	Control Precision (CP) (.24, 3) (.36, 7) (.20, 10) Perceptual Speed (PS) (.46, 3) (.28, 7) (.50, 10) (.35, 18) Spatial Orientation (SO) (.17, 3) (.22, 7) (.35, 18)

TEST	FACTORS, LOADINGS, AND REFERENCES
Visual Reaction Time (VRT)	Reaction Time (RT) (.56, 6) (.72, 12) (.48, 18)
Visualization of Maneuvers*	Spatial Orientation (SO) (.46, 18) Visualization (V) (.47, 18)
	W
Weight	Static Strength (.70, 8) Dynamic Strength (-.43, 8)
Word Knowledge (Vocabulary)*	Verbal Comprehension (.78, 12) (.67, 18)

References for Loadings in Appendix B

1. G. L. Bourassa and R. M. Guion, "A factorial study of dexterity tests," J. appl. Psychol., 43, 199-204 (1959)

2. E. A. Fleishman, "Dimensional analysis of psychomotor abilities," J. exp. Psychol., 48, 437-454 (1954)

3. E. A. Fleishman, "A comparative study of aptitude patterns in unskilled and skilled psychomotor performances," J. appl. Psychol., 41, 263-272 (1957)

4. E. A. Fleishman, "Factor structure in relation to task difficulty in psychomotor performance," Educ. psychol. Measmt., 17, 522-532 (1957)

5. E. A. Fleishman, "An analysis of positioning movements and static reactions," J. appl. Psychol., 55, 13-24 (1958)

6. E. A. Fleishman, "Dimensional analysis of movement reactions," J. exp. Psychol., 55, 438-453 (1958)

7. E. A. Fleishman, "Abilities at different stages of practice in rotary pursuit performance," J. exp. Psychol., 60, 162-171 (1960)

8. E. A. Fleishman, "The structure and measurement of physical fitness," Englewood Cliffs, New Jersey: Prentice-Hall, 1964

9. E. A. Fleishman and G. D. Ellison, "A factor analysis of fine manipulative tests," J. appl. Psychol., 46, 96-105 (1962)

10. E. A. Fleishman and W. E. Hempel, "Changes in factor structure of a complex psychomotor test as a function of practice," Psychometrika 19, 239-252 (1954)

11. E. A. Fleishman and W. E. Hempel, "Factorial Analysis of complex psychomotor performance," USAF Personnel Train. Res. Cent. res. Rep., No. 54-12, 1954.

12. E. A. Fleishman and W. E. Hempel, "The relation between abilities and improvement with practice in a visual discrimination reaction test," J. exp. Psychol., 49, 301-312 (1955)

13. E. A. Fleishman and W. E. Hempel, "Factorial analysis of complex psychomotor performance and related skills," J. appl. Psychol., 40, 96-104 (1956)

14. E. A. Fleishman and G. N. Ornstein, "An analysis of pilot flying performance in terms of component abilities," J. appl. Psychol., 44, 146-155 (1960)

14a. J. W. French, "The description of aptitude and achievement factors in terms of rotated factors," Psychometric Monographs No. 5, 1951

14b. J. W. French, "The factorial invariance of pure-factor tests," J. educ. Psychol., 48, 93-109 (1957)

15. W. E. Hempel and E. A. Fleishman, "A factor analysis of physical proficiency and manipulative skill," Skill Components Research Laboratory, Lackland AFB, Texas, Research Bulletin, Report AFPTRC-TR-54-34, 1954.

16. M. J. Herbert, "Analysis of a complex skill: vehicle driving," Psychol. Monogr., 5, 363-372 (1964)

17. J. F. Parker, "Use of an engineering analogy in the development of tests to predict tracking performance," The Matrix Corporation under Office of Naval Research Contract Nonr-3065(00), 1964

18. J. F. Parker and E. A. Fleishman, "Ability factors and component performance measures as predictors of complex tracking behavior," Psychol. Monogr., 74, 1-36 (1960)

Factors in Primary Perceptual-Motor Test Literature
(excluding Physical Proficiency Tests)

Ability to deal with linear extents (tentative)*
Ability to deal with rotational magnitudes (tentative)
Aiming*+o
Arm-Hand steadiness*+o
Control precision +o
Finger dexterity +o
Integration (tentative)*
Manual dexterity +o
Movement analysis
Movement prediction
Multilimb coordination +o
Multiplication by a constant
Numerical facility *#
Perceptual speed *+#
Position reproduction*
Pursuit confusion doublet
Rate Control +o
Reaction time +o
Response orientation *+o
Spatial orientation *+#
Speed of arm movement *+o
Time sharing*
Verbal comprehension *+
Visual feedback
Visual sensitivity
Visualization *+#
Wrist-finger speed *+o

+ relatively more established factors
* measured by printed tests
o tests that relate to man-machine tasks and account for ability requirements in many systems
while these are not perceptual-motor factors, they represent cognitive and perceptual factors commonly associated with the perceptual-motor abilities required by many man-machine tasks

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13. ABSTRACT

The meeting herein reported constitutes a new and different ONRL approach to enhancing information exchange and cooperative research activity. An attempt was made to bring together as mahy investigators as possible from various countries of the world who are working in a narrow, confused, but increasingly important research area -- the psychological aspects of deep diving.

Invitations were extended to all known individuals from military, civilian, and industrial laboratories in the U.S. and Europe working on psychological problems associated with deep diving or hyperbaric atmosphere. A total of 12 persons, from three countries, accepted the invitation and participated in the Conference. When considered on an international basis, the participants represented approximately 90% of all psychologists identified with diving.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Military Science						
Deep-diving						
Psychology						
Human Engineering						

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