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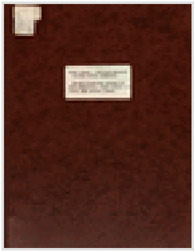

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Review of Wartime Studies

of

Dark Adaptation, Night Vision Tests, and Related Topics

Armed Forces–NRC Vision Committee

DECEMBER 1, 1949

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MEMORANDUM

June 22, 1953

TO: Members of the Armed Forces-NRC Vision Committee

FROM: H. Richard Blackwell, Executive Secretary

SUBJECT: Visibility -- A Bibliography
Compiled by M. Leikind and J. Weiner
Edited by J. R. Gibson
Library of Congress Reference Department
Washington, D. C. 90 pp. July 1952

The subject publication has been prepared by the Reference Department, Technical Information Division, of the Library of Congress, at the request of the Armed Forces-NRC Vision Committee and the Office of Naval Research. It provides a survey of the literature published from 1925 to 1950 inclusive on the subject of visibility as influenced by the various physical, physiological, and psychological factors inherent in the observer, target, background and atmosphere, and the engineering applications of visibility data. The plans for the publication of this bibliography were announced in the Minutes and Proceedings of the Thirtieth Meeting of the Vision Committee, April 4-5, 1952, page 99.

One copy of the bibliography is being sent herewith to each member of the Vision Committee. Additional copies are available upon request to the Secretariat, 3433 Mason Hall, University of Michigan, Ann Arbor, Michigan.

~~CONFIDENTIAL~~ Classified in error.

THE ARMED FORCES

NATIONAL RESEARCH COUNCIL VISION COMMITTEE

Review of Wartime Studies of Dark Adaptation, Night Vision Tests, and Related Topics

by

WILLIAM BERRY, Ph.D.

* * * *

Historical Foreword

WALTER R. MILES, Ph.D., Yale University

Some Comments on Night Vision Selection Tests and Procedures

WILLIAM S. VERPLANCK, PH.D., Indiana University

PUBLISHED BY

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PREFACE

H. Richard Blackwell
Vision Committee Secretariat

It is by now common knowledge that an impressive number of scientific and technical reports were prepared during the war years which record the intense, often frantic, efforts of scientists and technicians to satisfy the demands of the military machine. The reports were issued in part by permanent scientific and technical institutions, but in large number by military units enlarged to meet the wartime demand and by temporarily established scientific and technical groups. The reports were nearly all classified since they represented significant military resources. The issuance of the reports served to disseminate information among military and civilian scientific and technical organizations, thus permitting a maximum of research coordination and planning.

At the close of active hostilities, the military and special civilian research groups underwent gross reduction in scope or were terminated and the scientists and technicians returned to their permanent occupations. With them went their knowledge and special experience gained from wartime service, but in most cases, due to classification difficulties, the scientists were unable to take with them their research data or even copies of the research reports they had prepared while engaged in wartime duties. Except in rare cases, the wartime reports were stored in a few permanent libraries, but they were barred from the usual scientific publication because of classification. Not only are the full implications of wartime research hidden from the general scientific community, but the status of the report files makes it difficult for military personnel and for civilian scientists cleared for classified material to enjoy the full benefits of the wartime research. Since the termination of hostilities, the Vision Committee has attempted to make available the results of wartime research in vision in every way possible. Immediately following cessation of hostilities, attempts were made to obtain declassification of all possible vision reports. Reclassification of the "Bibliography of Visual Literature 1939-1944 Supplement" to Restricted was arranged.

The Committee has maintained a lending library of the wartime reports in vision, available to military personnel and civilian scientists who have appropriate clearances. The logical next step is for the Committee to prepare reviews of the wartime reports to be circulated as widely in the scientific community as classification will permit.

The present review of the wartime reports of dark adaptation, night vision tests, and related topics was undertaken as the first in a proposed series of such reviews. Dr. William Berry, working for the Vision Committee, undertook the tedious task of locating, reading, and abstracting the wartime reports. He has prepared tabular summaries and a topical index of the reports. In addition, Dr. Berry presents his general reaction to the research programs in night vision and related topics undertaken during the war years as obtained by examination of the reports.

In order to supplement Dr. Berry's review, the Committee arranged for two of its members who were intimately concerned with night vision research during the war years to prepare general comments on the status of night vision research. The comments prepared by Dr. Walter R. Miles assumed the form of an historical foreword. Anyone who was concerned with night vision problems during the war years will recognize how eminently appropriate are such comments. Dr. Miles represented the Committee on Medical Research of the Office of Scientific Research and Development on the Vision Committee from the latter's inception in 1944. In addition, Dr. Miles was a member of the Committee on Aviation Medicine of the National Research Council.

Dr. William S. Verplanck has taken the opportunity afforded by Dr. Berry's preparation of the review to reconsider general aspects of the night vision selection program undertaken during the war years. Dr. Verplanck, formerly a naval lieutenant at the U. S. Submarine Base, New London, Connecticut, was personally in the forefront of the Navy selection program, and he is, therefore, eminently qualified to take stock of the program from the detached point of reference afforded by five years separation from the problem.

The review takes the form, therefore, of a series of informative abstracts, indexed and summarized. General comments are presented by Drs. Berry, Miles, and Verplanck. The review

[redacted]

centered on the influence of vitamin A on the dark adaptation capacity of the eye. Several pieces of equipment, notably the Hecht-Shlaer Adaptometer, had been used by several scientists. Also the effect of anoxia on vision, including dark adaptation, had received recent scientific attention, particularly at the hands of Drs. E. Gellhorn and R. A. McFarland. Of special importance for our military considerations was the experience of British and Canadian colleagues. It must be remembered that the war between Nazi Germany and Great Britain began September 3, 1939. The Flying Personnel Research Committee of Great Britain had been created in January of 1939 and had set up a night vision subcommittee in February of 1941. The latter Committee was composed chiefly of civilian scientists. Military and civilian liaison kept the American group informed about what was going on in this field outside the United States. Furthermore the National Defense Research Committee, in 1941 appointed a technical aide, Dr. Charles W. Bray, to coordinate the results of visual research (including night vision) in progress under civilian auspices.

The first activities of the U. S. group concerned with night vision war-work partook of the nature of surveys in field tests on military personnel. The objectives here were: (1) to discover if the incidence of night blindness was considerable or negligible; (2) to compare the findings with previous laboratory studies; and (3) to get the feel of conducting such examinations and to educate military personnel in reference to them. The first seven abstracts in Dr. Berry's report relate primarily to this orientation objective. The results of these several field studies were considered at a conference on night vision held at Wright Field on August 18, 1941. The conference was very representative and several recommendations resulted from it, including the following: the size of the test target should be 2^0 of visual angle, both flash and form targets should be used in taking thresholds, light of daylight quality should be employed, thresholds should be expressed in log units of micro-microlamberts, and that further comparison should be made of scores for flash thresholds and form thresholds on actual lookout performance under field conditions. The results of the Wright Field conference were presented later in August at a meeting of the Committee on Aviation Medicine in Washington, attended by several military representatives including Colonel David N. W. Grant, Air Surgeon, and Captain John R. Poppen, Naval Bureau of Aeronautics, the former having recently returned from an observational tour of military preparations and activities in Great Britain. It seemed now possible to draw up a summary in reference to night vision requirements and objectives which would meet the approval of the military representatives. Thus summary is important in connection with Dr. Barry's report because it tends to set the stage for future work. The report was widely distributed to our Army and Navy activities, and contained the following statements: (1) night vision is not a pressing problem, since few military personnel examined have fallen in the category of clinical night blindness; (2) we are not prepared at the present time to eliminate applicants on the basis of a single measurement of thresholds for either flash or form; (3) we are not prepared at the present time to categorize personnel for night duty on the basis of a single test; (4) the improvement of illumination in cockpits as to color and intensity is of practical importance; (5) preliminary dark-adaptation of the eyes before night missions is important; (6) the prime need is a rough screening test which can be used on large numbers of personnel. No specific assignments for research were made in view of this outline. Each research worker or team it was assumed would push ahead in terms of opportunity and interest and would supply interim reports to be circulated usually as classified material.

The hundred abstracts which are necessarily brief and mostly represent reports which were gotten out promptly for circulation in mimeographed form can be best understood and their significance estimated in reference to the above terms of reference. It is safe to say that probably almost without exception those who produced this quick mimeographed war-literature on night vision knew about the conferences that had been held and the general points of view on prospective needs that had been put forward. Therefore, the abstracts give evidence of efforts to (a) design and re-design test equipment appropriate for large duplication and use in many centers by personnel who had not had the advantage of a considerable amount of laboratory training, (b) efforts to improve the scoring of night vision test results and their statistical treatment, (c) development of means (goggles) for economizing time in securing and retaining the dark-adapted condition in the eye, (d) improvement of illumination in cockpits for sparing the dark-adapted state of the pilots, (e) efforts to discover and improve the validity of night vision ratings in relation to field operation performance, and (f) development of equipment for group training in night seeing.

The early recognition of the importance of night vision by officers in the U. S. Submarine Service, particularly at the Submarine Base in New London, operated to speed up these research efforts. An observer from the Base while with the British Submarine Service had found them using a military adaptometer developed by Mr. R. W. Cheshire at the British Admiralty Laboratories.[1] The observer brought back a blueprint of this adaptometer and on June 3, 1941, Rear Admiral Edwards, then in command at the Submarine Base in New London, issued an order for the dark-adaptation and night blindness testing of the men and officers of the entire command. The order went to Lieutenant-Commander C. W. Shilling and included a request for a report on these observations by July 1, 1941. This order, which is believed to be the first military order in reference to night vision examinations in the military services of the United States, exercised a very immediate and continuing influence on the activities of the Medical Research Division at the Base and elsewhere, an influence that was indeed important in shaping the formation of the Armed Services-NRC Vision Committee, under the aegis of which the present report has been prepared.

Dr. Berry at the request of the Committee has performed a valuable service in producing this report. He has endeavored to compile informative abstracts providing condensed statements for the data, findings and suggestions included in the many rapidly executed studies of the period 1941-1946. Some readers will, no doubt, wish for more detailed statements concerning some of these investigations, which can, of course, be supplied through correspondence with the Committee or some other organization that has maintained files.

A review of such materials arranged chronologically and representing the efforts of a considerable number of workers in several widely-distributed centers, conveys an impression of lack of coordination in research effort. Under conditions of war this is surely to be expected. Ordi arily research has a large element of trial and error in it, especially in earlier phases. When striving for an applied goal that cannot be very specifically defined the handicap is even greater. Such considerations must not be permitted to frustrate research efforts or to constitute a council of despair. The reader of this report will bear in mind that scientific efforts, to build a classification test that is highly reliable, highly valid, simple, brief, and fool-proof, usually fall somewhat short of the ideal goal. Furthermore it must be remembered that when the efforts of the United States group, concerned with night vision and its military applications, turned their attention toward training methods and procedures rather than short classification tests, the results achieved proved to be highly important and practical for our Armed Services and form a basis on which to build for the future.

SOME COMMENTS ON NIGHT VISION SELECTION TESTS AND PROCEDURES

William S. Verplank

Dr. Berry is to be congratulated on his careful and thoughtful analysis of the literature on night vision testing which accumulated during the recent war. The mass of the literature, the variations in procedures, both experimental or statistical, the frequently conflicting findings and recommendations, and the inaccessibility of the reports themselves would discourage all but the most patient, and make impractical, if not impossible, a treatment of a type other than that made by Dr. Berry. Dr. Berry's review and abstracts not only ably and fairly summarize the contents of these reports, but also draws conclusions from them with which the writer is in almost complete agreement.

The most serious omission of the review is that it was evidently impossible or inadvisable to incorporate summaries of the work performed in Canada and England, even though it is likely that there was not anything contributed by our late allies which might lead to any important change in the conclusions which have been drawn from the work incorporated in the survey. Nevertheless, the British and Canadians explored a few blind alleys which we did not. A similar review of

[1] See Abstracts Nos. 3 and 5 where the term "British Device" is used to avoid the complications of British classified reports.

their work might save some future investigator the trouble of pursuing a promising line of research, to find that it is a cul de sac at the end of which the Union Jack has already been planted and waves in futility. I shall, therefore, take the liberty of referring to some of their material in the following comments.

With a perspective given by five years away from the topic, one can observe some general characteristics of the research performed on night vision selection during the recent war.

The most conspicuous characteristic is the devotion of almost all who worked in the area to an equivocation. If we worked at levels of illumination below a certain value, we were working with "night vision," (or synonymously "night visual performance"), which was usually treated as a unitary and measurable property of the individual. Some people, we expected, should have "good night vision," and others "poor night vision." And our job was to find out "how much," or "how good" "night vision" various individuals had. By and large, our efforts were limited to a search for the best "test" of this "capacity." Some of us, at intervals, or should one say, at lucid intervals, would question this assumption of a unitary capacity, and point out the obvious fallacies involved. But such intervals were brief, the search for a test was resumed, and the experimental analysis of visual behavior which should have been made, never appeared. Back we went to the development of "a test of night vision," which would have been accepted as satisfactory, if only it gave statistically reliable results. If a reliable test was obtained, validation tests were planned, but there were questions as to the necessity of such a step.

A second characteristic of the efforts was the variety of purposes with which different laboratories concerned themselves. Some sought the quickest and easiest method of eliminating the "night-blind". Others sought the most reliable test for grading the whole population, from "best" to "worst", without regard to cost, in personnel, time, or money, of the procedures of selection. Some tests were designed for use by field-hands in the woods on a reasonably dark night. Others required administration by the test designer himself—no one else would, or could, for that matter, do. Each felt free to investigate someone else's test, which was designed for one purpose, with respect to its usefulness for his own quite different purposes, and, finding that it did not meet his own criteria, concluded that it was worthless for any purpose whatsoever. Such criticism worked both ways; advocates of simplicity damned the complex tests with the same conviction that the apparatus-specialists displayed in describing the shortcomings of the simple devices. And in the cross-current of critical comparisons, it was not always clear that the tests were administered according to the procedures for which they were designed.

With variety in purpose went variety in design,—a variety just great enough to produce a maximum of confusion of results with a simultaneous minimum possibility of turning up a test sufficiently different from the rest to offer a fresh approach to the problem. Almost all the tests incorporated an acuity figure, a Snellen T or a Landoldt ring. But the sizes employed varied. Sources of illumination and brightness levels varied. Viewing distances varied. Number of trials, and other details of procedure varied. The effort was not characterized by a multiplicity of approach, but of detail. Differences among tests there were, great enough to make comparison difficult, but small enough to ensure that many visual functions went uninvestigated.

Just as the purposes and methods of the various tests differed, so too did the types of analyses performed on the data. Split-half reliabilities and test-retest reliability studies were performed; 'r', rho, tetrachoric "r's", eta's, epsilons, and Chi Squares were all computed in the effort to determine whether a particular test gave consistent results. Lack of homogeneity of reliability data, does not provide a satisfactory basis for the comparison of tests with one another. That it was often forced by differing test methods does not help any.

It is, then, not surprising that the concrete results of the various research programs add up to so little for so much effort, and that the conclusions are conflicting. Some found learning highly important in the test situation, and urged repeated retests before disqualification of an individual for one or another duty because of "Defective Night Vision" was recommended; others found tests sufficiently reliable to give useable results with one administration. One test was considered just as highly acceptable by some as others considered it worthless. Yet there is a sort of homogeneity in the results obtained with various tests. General conclusions which can stand scrutiny may be drawn. One generalization is, unfortunately, that tests of night vision are not very reliable. Indeed, one looks with extreme doubt on data showing reliability coefficients

(or inter-correlations) higher than .80, although, to be sure, there are a few such scattered through the data summarized by Dr. Berry. Still another generalization which may be reached, although it is not justifiable on the basis of any systematically collected data is that any of the tests, no matter how administered (within wide limits) will suffice to identify the very few cases of clinical night blindness which may be found in the service population.

More interesting than what was done on various night vision programs is, perhaps, what was not done, or was done but rarely, and inadequately. The most conspicuously missing class of activities has already been suggested—that is, the investigation of a wide variety of tests and instruments under comparable conditions. Only the Weddell experiment (abstract no. 73) incorporated a very great variety of tests. The results showed that none of the tests were very satisfactory, but continuing efforts at further development were restricted to the more conventional instruments, those involving acuity figures.

The second missing class of investigations is those which might yield comprehensive sets of validation data. To be sure, a few sets of such data appear, but the criterion performances employed too often approximated the performance in the laboratory. The most "naturalistic",—or "face-valid" criterion performance, that of the Weddell experiment, yielded data which indicated, not the validity of one or more of the tests studied, but the unreliability of the criterion performance (and hence the less valid as a criterion) the higher the predictive value of the test. Most such validation studies check performances on only one occasion, or over a very short period; they further seemed to assume that men were performing at their asymptotes. In only one laboratory was an effort made to measure the reliability, over a period of time, of a criterion performance. Evelyn, in Canada, collected such data over several months on a group of men. But his criterion performance duplicated closely, in the field, the performances typical of the tests to be validated. His reliabilities, incidentally, were not very high.[1]

Third among the missing is an extensive analysis of the statistical logic of the tests, e.g. of the role of chance in determining the scores obtained on tests employing forced guessing. The assumption that a "correction for guessing", such as the "R-1/3 W" employed in the four-choice tests, is adequate to assure that a valid measure of frequency of seeing is obtained was seldom questioned, despite the fact that such a correction is justifiable only when the number of guesses is very large. In very few cases indeed was this variable taken into account as significant for the determination of cutting scores, or of brightness levels at which testing was to proceed.

Finally, there is almost a complete absence of data on the actual utility of the various tests in practice. This is perhaps crucial to the usefulness of any test, however reliable, and however well validated. If a test lends itself to abuse in practice, and is such that uninterested, not to mention unskilled, personnel can produce unreproducible results, then that test is not a useful one, and may even do more harm than good. Hearsay evidence indicates that even those tests designed for administration by the most simpleminded were subject to abuse once distributed to the field and put into operation in a large-scale testing program.

There is doubt, then, that the work on night vision testing during the war has led to very useful results with respect to the selection of personnel for night visual duties, and it may follow that, if it is still considered desirable to develop such tests, a fresh start will prove more fruitful than the further investigation of tests now existent. Present test methods seem to assure the elimination of the clinically night blind, and any of them may be used for that purpose, but a continuing need for positive selection procedures can only be served by further, and novel research.

The basic fact is that we do not know very much about seeing at night. Seeing at night is probably also dependent upon a variety of non-visual psychological and physiological factors, such as fatigue, motivation, nutrition, situational variables and possibly others which we have not considered involved. Visual acuity, contrast sensitivity, absolute sensitivity, and movement sensitivity of all parts of the retina, which have not yet been convincingly demonstrated as co-varying,[2] presumably contribute to night seeing, as do ocular tremor and habitual eye-movement patterns. At a more complex level, so do training in the detection and recognition of objects under various conditions. Visual performance seems to show itself, both within the individual, and among

[1] A result also obtained in the field tests on binoculars, to be reported soon.
[2] Indeed, there is some evidence that such visual functions are only slightly correlated.

individuals as extremely variable, although there is some statistical evidence that there exist small individual differences in performance with respect to which individuals might be selected for night duties. It may be by no means an impossible task to select men for night duties. But it is a task which might be begun from a rather different point of view than that which has been taken so far.

Specifically, it is suggested that the most useful program for the development of useful tests should begin with a survey, in the field, of the visual performances which are required by military personnel, that is, of lookout duties, of night infantry patrolling, and of night flying. On the basis of such initial surveys relevant performances may be isolated and studied at experimental stations.

The second phase of such a program would investigate the variability of the selected performances among individuals, over a relatively long period of time. Measures of the appropriate performance may be obtained on relatively large numbers of untrained servicemen (unselected except for the usual physical and psychological examinations) over a period of months. Not only performance on military night duties should be measured, but data on a wide variety of visual functions and on many other physiological and psychological variables also may be collected. Correlational analyses within individuals, and among individuals may be expected to reveal the stability of the performance, the visual determining variables, and the non-visual determining variables. The first data should clearly establish whether or not night visual performance is sufficiently stable to predict the performance of an individual at one time and on one task from his performance at another time, and at another job. If it is found that individuals vary unpredictably in performance from day to day, it is clear that selection is futile. If the data show that criterion performances are reliable, and hence that it should be possible to select men with respect to them, then, using our second set of data, we may investigate correlations of these measures of these performances with the other measures obtained in the hope that one or more may be found to have some merit for prediction of the criterion performances. Thus a test or battery of tests, incorporating those variables which have been found predictive, may be developed. Such a battery, experimentally developed, should do what, in the recent war, we attempted to do with a single selection procedure, measuring a single visual function over a limited range of values.

The final step in such a program should aim at the use of this battery to predict the performance of another group of unselected men, and to procede to obtain measures of their performance so that a final determination of the validity of the procedures developed may be made.

Whether such a program, lengthy and expensive as it would be, is worth embarking upon, is another matter, which will depend upon the judgment of non-scientific personnel. The writer would contend, however, that <u>nothing less</u> is worth doing: The present tests eliminate night blinds, and there is no evidence that they do, or could do, more.

REVIEW OF WARTIME STUDIES OF DARK ADAPTATION, NIGHT VISION TESTS AND RELATED TOPICS

William Berry

INTRODUCTION

The initial plan of the project was to make a comprehensive report of the articles prepared under the stimulation of military requirements by military and civilian personnel during the years 1941-1946. It was assumed that it would be possible to work up the report in a manner comparable to the reviews of scientific literature which appear from time to time in various sicentific journals. During the development of the project, it became apparent that the initial plan would have to be modified, and the decision was made to prepare the report in such a way that it would consist, primarily, of informative abstracts of the original articles arranged in chronological order of their appearance.

The considerations which led to the decision may be summarized as follows:

1. The task of condensing the rather large and heterogenous mass of material into the limits of the conventional type of review of literature proved to be an insuperable one. The articles and reports are largely individual in nature, non-sequential and unprogrammatic. Several attempts were made to schematize them under obvious categories, as, for example, the specific types of adaptometers used, those used by the Army, the Navy and the Air Force respectively, those which were designed to establish cut-off points in selection, and those which were designed to classify distributively all the personnel tested. It was found that the heterogenous material did not readily or adequately lend itself to such treatment, due to the inherent variability in it, not only with respect to the topics covered by the individual reports, but also with respect to such details as the brightness levels of screen and target, the character and complexity of the targets or test objects, the experimental and test procedures used, and statistical methods of treating the data obtained.

2. In every case, the form of presentation of the results of experiments, test procedures, etc., was prescribed by the regulation military practice, for reasons which are clearly evident. Consequently, the reports were, and still are, official documents. In this respect they are quite unlike the scientific articles, monographs and books which normally constitute the source material of reviews. The latter are available to scientists through the conventional media of exchange of technical information, and hence are sources which can be shared by reviewers and readers of reviews alike.

3. A considerable amount of data and information is contained in the reports, and it is of such a nature that its appraisal for scientific merit and usefulness should be made by a wide circle of competent scientists. Such an appraisal requires as much documentary evidence as possible. Since this is the case, it seemed that about the only way in which an approximately adequate and objective presentation could be made would be to let the reports, in sequence, tell their own story. Obviously this could be done only by abstracting them in such a way as to provide "informative" rather than "indicative" abstracts. In this connection, use was made of definitions adopted at the Paris Conference of UNESCO, 1948. Briefly stated, an indicative abstract is usually short and designed primarily to serve as a bibliographical reference. An informative abstract is designed to cite not only the bibliographical data, but also to contain all the essential and relevant data together with conclusions contained in the source material which may be significant to specific readers, at least to the extent that the abstractor can make such judgments of significance.

This report, therefore, consists primarily of a series of abstracts, 106 in number, to which have been added three tabular summaries of the reported data on the reliability of the several adaptometers and test devices, their intercorrelations, the data derived from validation studies, an index of the topics treated in the reports, and an evaluation of the work done and the results achieved.

EVALUATION OF THE WARTIME LITERATURE

In the course of reading the original reports and preparing the abstracts, it was inevitable that many impressions would be made, some of them confusing and contradictory, especially to one who did not participate in the research work during the war years. On the one hand the reviewer cannot fail to note the impression made by the evidence of strong and immediate practical motivation in the research, and the relatively large number of scientists who were engaged in the task of finding as quickly as possible the answers to the problems posed by the necessity of selecting men to engage in military operations in conditions of low illumination.

On the other hand, mention must be made of what seems to be lack of evidence of a systematic and co-ordinated research attack by the Armed Forces upon the unprecedented undertaking of night vision testing on a very large scale. The reports put out are quite diverse in character, some of them seeming to be somewhat inconsequential both with respect to the immediate problems and as contributions to visual science. In all probability there is reflected in the majority of the reports the conditions under which they were produced. Compliance with directives calling for information and recommendations was the controlling factor, rather than the degree of thoroughness and inclusiveness characteristic of normal scientific investigations carried on in well organized laboratories. Although a considerable body of laboratory and clinical data on the functions of the eye in conditions of low illumination was in the scientific literature, there was very little or none at all which could be applied immediately in the technical and procedural problems of mass testing for night vision ability. It is true, of course, that a beginning had been made in Great Britain and Canada to devise Adaptometers and night vision Test Devices, and to use them in the selection of military and civilian personnel engaged in night operations. However, it cannot be said that much progress had been made in the formulation of definitive procedures, or in the interpretation of the results which were obtained by the time the problem became an acute one in the United States. To all intents and purposes, it was an unique situation which confronted the military authorities. In the light of this fact, and from the standpoint of a later date, it is amazing to note that the research was carried on in an uncoordinated manner. Solely on the basis of the reports as they are read in chronological order, it is difficult, if not impossible, for one to avoid the impression that the work was carried on by individuals or small groups, often in more or less isolation from each other and in pre-occupation with respect to their own problems. The actual facts may have been quite otherwise, and by visits of personnel of the several services to laboratories and stations, the exchange of reports, personal and official communications, etc., there may have been a lively flow of ideas back and forth. Assuming this to have been the case there were undoubtedly advantages derived. How much more advantage would have accrued from systematic and coordinated experimental design and techniques within each of the services, to say nothing of all the services combined, is a matter of guesswork. However, it may be surmised that had such been the case the resultant outcome would have been more satisfactory than it now appears to be.

Although developmental trends are not clearly distinguishable in the literature there are indications that the initial assumptions on which mass night vision testing was begun were more or less rapidly shown to be inadequate. The first tests used were based on clinical practice of undoubted scientific merit and they were the logical ones to use in the emergency. Implicit in their use was the identification of final rod threshold (for light) with night visual ability in outdoor situations and at various levels of illumination within the scotopic range. However, the promise of usefulness contained in the tests was by no means fulfilled. Being essentially individual tests and time consuming in their administration it became apparent that insuperable operational difficulties made them impracticable. Furthermore, it became clear that something more than a patch of light as a test object was necessary if a test had to have even a modicum of meaning as an indicator of night visual ability. From this point on, the development of an amazing variety of test devices proceeded apace. Two objectives apparently were dominant in their influence. One was the development of a test which would involve the minimum of time and effort in its administration. The other was the development of a test which, by its structural characteristics and facile operation would yield a compact index of night vision ability, reliable enough for use in the prediction of performance in a wide variety of situations. It may be conceded that the first objective was achieved, at least in part, in a number of the test devices. With respect to the second objective the situation is quite different. The trend of the evidence is in the direction of the conclusion that the objective was not achieved during the war years and remains unrealized at the present time.

The appraisal of the scientific merit and the functional usefulness of the work performed in the research investigations is by no means a simple task. In the last analysis it will have to be made by the competent scientists who have occasion to study the records. With respect to the question—how successful were the various test devices and procedures in selecting personnel on the basis of their night vision ability?—the tabular summaries contained in this report may provide, in part, the basis for an answer. The writer has to state that after diligent study of the reports he is unable to add anything new to what has already been written in several places, including the Minutes and Proceedings of the Armed Forces-NRC Vision Committee. In short, it appears that the reliability of the tests is not too impressive, varying for the most part from .60 to .80 with occasional unreproduced examples of higher co-efficients. They correlated with each other either indifferently or badly. Their validity was investigated in a relatively limited number of cases, with the paradoxical result that it was as open to doubt as were the criteria.

If any positive conclusion can be stated on the basis of the results of the investigations it is that night vision is much too complex for it to be assayed by any single type of test such as was used. Although the phrase "one shot test" has been used in an entirely different context it may be applied in this connection. There is something perennially attractive in the notion of a single test, easy to administer, which will serve as the basis of prediction of human behavior in any number of complex situations. Unfortunately the data of experience in many cases are in conflict with the notion. Such has been the case in the history of testing in other fields and it appears to have been so in this field. To be sure men were selected, either in the simplest possible dichotomy of pass or fail, or on the basis of grades from superior downwards to fail, the grades depending on the instrument used and the procedure followed. Furthermore, true "night blinds" were eliminated by any test developed, although the same result could have been secured by far less costly methods. To the extent that this is true it cannot be said that night vision testing during the war years was an unqualified failure. Indeed, it might be possible to argue that, under the circumstances of the war situation, empirical standards of functional value of the tests were far more pertinent than rigorously derived scientific standards, and that on the whole the tests did exactly what they were required to do, namely separate men with functionally inferior night vision from those with functionally adequate night vision. The essential weakness of the argument is found in the fact that the test results did not furnish any satisfactory basis for prediction and there were far too many incongruities, published and unpublished, of service men who "failed" the tests and yet performed altogether adequately in exacting night operations of all types. At best, the result of the entire business of night vision testing during the war years can be regarded as a useful, perhaps necessary, first approximation. Viewed in this light it takes on the character of a large trial and error experiment which has set the stage for a considerable amount of adequately designed and executed scientific experimentation.

At this point a distinction of some significance must be noted. In the first place it is well known that basic research in the complex variables of night vision is now being carried on and will be considerably accelerated as time goes on. Investigations of scotopic acuity in various retinal regions, of the characteristics of the scotopic luminosity curve, of scotopic sensory thresholds, of the detection of targets under conditions of low illumination, and of electrical recordings from the retina in dark adaptation are but a few examples of the varied phases of the basic research. On the other hand the question whether it should be closely, remotely, or not at all associated with research in the development of adequate night vision tests is a debatable one. If the available data concerning the necessity or the irrelevancy of night visual ability in time of war were unequivocal in nature, the answer to the question of the necessity or irrelevancy of night vision tests would be readily forthcoming. On purely prudential grounds the position can be taken that the time may come when men will again be required to carry on vastly complicated military operations, both in daylight and in darkness. In such a contingency tests of night vision ability would be needed. Obviously, if the only ones available were those which were used hitherto their usefulness would be no greater than has been shown to exist. In the face of such a contingency as total mobilization it is hardly conceivable that research in night vision tests should be neglected. Experience has shown that war time conditions are not always conducive to the optimal development of a device or technique to be used in war time.

TABULAR SUMMARY

In the following tables are brought together data in the reports abstracted. They include: (1) data on reliability, (2) data on intercorrelations between the several Adaptometers and Night Vision Testers, and (3) data on the relation between performance in outdoor tests, and other criteria adopted, on the one hand and scores on the Adaptometers and Night Vision Testers on the other hand. In cases where the available information does not lend itself readily to tabular presentation, references have been made to the Abstracts where it may be found.

TABLE 1.

DATA ON RELIABILITY OF ADAPTOMETERS AND NIGHT VISION TESTERS.
COEFFICIENTS CITED ARE PRODUCT-MOMENT EXCEPT WHERE OTHERWISE NOTED.

Abstract No.	Test	Reliability	N
41	AAF-Eastman NV Tester Model 1	Varied target sizes, brightness levels, viewing distances Test 1 vs 2: r = .82 2 vs 3: .87 3 vs 4: .70 4 vs 5: .80 5 vs 6: .65 6 vs 7: .76 7 vs 8: .75 8 vs 9: .77 9 vs 10: .62	33
	AAF-Eastman NV Tester	Tests 1, 2, 3 vs Tests 4: r = .70 to .78 5: .80 to .80 6: .55 to .65 7: .46 to .63 8: .50 to .57 9: .43 to .47 10: .63 to .64	33
47	AAF-Eastman NV Tester Model 2	2^{o} target r = .78	44
64	AAF-Eastman NV Tester	Test 2 vs Test 4 r = .797	85
66	AAF-Eastman NV Tester Model 1	Varied target sizes, etc. r = .81 to .91	24
	Model 2	2^{o} target. Average of 3 Tests r = .68	24
78	AAF-Eastman NV Tester	Average of 4 Tests r = .852	20
86	AAF-Eastman NV Tester	1^{o} target r = .68	200
		2^{o} target r = .76	16

			N
38	Adactometer	Total letters read: r = .901, eta = .940 "Adaptacuity": .878, .915	(Approx.) 100
50	Adactometer	See the abstract for statement	
78	AeroMedLab Radiant Plaque NV Tester	5 Tests: r = .631 to .765 Average of Tests: .68	54
86	AeroMedLab RPNV Tester	r = .54 r = .89 r = .85	200 16 34
94	AeroMedLab RPNV Tester	r = .54 to .89	
71	Army Night Vision Tester (Rostenberg)	NVX-13 r = .88 (Predicted from 40 trials to 80) NVT-15 r = .91 NVT-15 (First trial vs Second trial) r = .74	99 709
84	Army Night Vision Tester (Rostenberg)	NVT-15 r = .91 NVT-R 2 (Radium) r = .91 NVT-15 P Odd-even r = .89 Test-retest r = .80	
100	Modified Rostenberg Tetrachoric	Tests: 1 vs 2, 2 vs 3, 3 vs 4, 1 vs 3, 1 vs 4, 2 vs 4 r = .66, .72, .78, .72, .64, .77	115
73	Clockface Adaptometer	r = .266	150

~~RESTRICTED~~

						N
27	Hecht-Shlaer	(See the Abstract for statement.)				
35	Hecht-Shlaer	Day 1 vs Day 2	5 Tests Day 1 vs Means	Complete data		
		r = .637	.753			
		eta = .765		.781	(Approx.)	90
38	Hecht-Shlaer RCN Model	r = .636				108
50	Hecht-Shlaer RCN Model	(See the Abstract for statement.)				
66	Hecht-Shlaer Portable	Light r = .64	Form .48			24
73	Hecht-Shlaer RCN Model	r = .422				150
19	Hopkins Test	r = .61				38
37	Hopkins Test (Radium)	r = .78				43
66	Johnson Found. Luminous Plaque	r = .61				24
19	Luckiesh-Moss Contrast Card	r = .67				38
66	Luckiesh-Moss Contrast Card	r = .81				24
78	Luckiesh-Moss Contrast Card	4 Tests r = .630 to .893		Average of Tests .806		20
27	Miles 4-Plaque	(See the Abstract for statement.)				

~~RESTRICTED~~

			N
45	Miles 4-Plaque	r = .57	28
50	Miles 4-Plaque	(See the Abstract for statement.)	
103	NavMedResInst NNMC, Bethesda Tetrachoric	4 Tests 1 vs 2 · 2 vs 3 · 3 vs 4 · 1 vs 3 · 1 vs 4 · 2 vs 4 · Average r = .82 · .60 · .57 · .62 · .67 · .56 · .64	115
65	Navy Radium Plaque Adaptometer	Chi square = 2.93	22
73	Navy Radium Plaque Adaptometer	Score in terms of per cent correct 50% · 60% · 80% Chi square = 24.17 · 31.16 · 33.69 Significant at 1%, or better, level	150
74	Navy Radium Plaque	(See the Abstract for statement.)	
75	Navy Radium Plaque	4 Tests Test 1 vs Test 2 · Test 2 vs Test 3 · Test 3 vs Test 4 r = .63 · .75 · .69	234
77	Navy Radium Plaque	Split-half · "Standard score" · "Raw score" Uncorrected r = .82 · .80 Corrected (Spearman-Brown) r = .90 · .89	100

87 Navy Radium Plaque (N: —)

I.	Test 1 vs Test 2	Test 2 vs Test 3	Test 1 vs Test 3
Chi square =	61.2	21.6	102.3
p =	.000---	.000---	.000---

II.	50 trial method N 499	20 trial method N 503	20 trial method vs 50 trial method
Chi square =	50.14	91.47	0.448
p =	.0000--	.0000--	.90

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97 Navy Radium Plaque

(See the Abstract for statements.)

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99 Navy Radium Plaque — N: 57

Test given at

	5 feet distance	6 feet distance	7 feet distance	9 feet distance
r =	.56	.52	.77	.54

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100 Navy Radium Plaque

Tetrachoric — N: 115

	Test 1 vs Test 2	Test 2 vs Test 3	Test 3 vs Test 4	Test 1 vs Test 3	Test 1 vs Test 4	Test 2 vs Test 4
r =	.65	.66	.52	.43	.52	.47

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104 Navy Radium Plaque

(See the Abstract for statements.)

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105 Navy Radium Plaque — N: 24

	Test given at 5 feet distance	Test given at 7 feet distance	5 feet distance vs 7 feet distance
r =	.815	.821	.729

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106 Navy Radium Plaque

(See the Abstract for data and conclusions.)

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50 Navy Tele-silhouette

(See the Abstract for statement.)

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27 OSRD-NDRC Model II

(See the Abstract for statement.)

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31 OSRD-NDRC Model II

r = .63. Corrected by S-B formula r = .77 — N: 19

			N
35	OSRD-NDRC Model II A	Day 1 vs Day 2: r = .674; eta = .779 5 Tests Day 1 vs Means: r = .814 Complete data: eta = .778	(Approx.) 90
46	OSRD-NDRC Model II A	Low Group: r = .339 High Group: r = .484 All Cases: r = .581	92
58	OSRD-NDRC Model III	First 10 trials vs Second 10 trials (N 253): r = .56 Second 10 trials vs Third 10 trials (N 68): r = .64	
73	OSRD-NDRC Model III	Cutting score per cent correct 20%: Chi square = 7.39 30%: 16.46 50%: 16.20 Significant at the 1%, or better, level	150
27	Pensacola (Pensad)	(See the Abstract for statement.)	
73	Purkinje Test (Adaptation time)	r = .534	150
50	Rotating Silhouette	(See the Abstract for statement.)	
86	School of AvMed SAM Portable	r = .29	200
35	Self-Luminous Telesilhouette	Day 1 vs Day 2: r = .669; eta = .572 5 Tests Day 1 vs Means: r = .808 Complete data: eta = .727	(Approx.) 90

						N
38	Self-Luminous Telesilhouette	r = .761				
46	Self-Luminous Telesilhouette	r =	Low Group .347	High Group .633	All Cases .734	205
73	Tufts-SDS	r = .190				150
44	Wright Adaptometer	r = .33				27
50	Wright Adaptometer	(See the Abstract for statement.)				

TABLE 2.

DATA ON INTERCORRELATIONS BETWEEN ADAPTOMETERS AND NIGHT VISION TESTERS. COEFFICIENTS CITED ARE PRODUCT-MOMENT, EXCEPT WHERE OTHERWISE NOTED.

Abstract No.	Test	Intercorrelation			N
66	AAF-Eastman NV Tester	(See the Abstract for statement.)			
78	AAF-Eastman NV Tester	Correlated with	AeroMedLab RPNVT	r = .789	125
	"	"	" (Ave. of 4 tests)	r = .905	25
86	AAF-Eastman NV Tester 1° Target	Correlated with	AeroMedLab RPNVT	(a) r = .78	16
				(b) r = .82	66
				(c) r = .55	200
	AAF-Eastman 1° Target	Correlated with	SchAvMed SAM Portable	(a) r = .20	200
				(b) r = .29	5000
	AAF-Eastman 2° Target	Correlated with	AeroMedLab RPNVT	r = .85	16

					N
94	AAF-Eastman NV Tester	Correlated with	AeroMedLab RPNVT	r = .52 to .82	
38	Adactometer "Adaptacuity"	Correlated with	Self-Luminous Telesilhouette	r = .385	108
78	AeroMedLab RPNVT	Correlated with	AAF-Eastman NV Tester	r = .789	125
	"	"	" (Ave. of 4 tests)	r = .905	25
86	AeroMedLab RPNVT	Correlated with	AAF-Eastman NV Tester 1° Target.	(a) r = .78 (b) r = .82 (c) r = .55	16 66 200
	"	"	" 2° Target.	r = .85	16
	AeroMedLab RPNVT	Correlated with	SchAvMed SAM Portable	r = .26	200
94	AeroMedLab RPNVT	Correlated with	AAF-Eastman NV Tester	r = .52 to .82	
102	AeroMedLab RPNVT	Correlated with	Army Night Vision Tester ANVT-1	r = .67	32
71	Army NV Tester Various models	Correlated with	Army NV Tester Various models	(See the Abstract for data.)	
100	Army NV Tester Modified Rostenberg	Correlated with	Navy Radium Plaque (Tetrachoric) r =	Average of 4 Tests .565	115
102	Army NV Tester ANVT-1	Correlated with	AeroMedLab RPNVT	r = .67	32
103	Army NV Tester Modified Rostenberg	Correlated with	NavMedResInst. NNMC, Bethesda (Tetrachoric) r =	Average of 4 Tests .72	115
73	Clockface	Correlated with	Several Instruments	(See the Abstract for statements.)	

27	Hecht-Shlaer Model 2	Correlated with	Pensacola	(See the Abstract for statement.)
35	Hecht-Shlaer	Correlated with	OSRD-NDRC Model II A	Means of scores r = .449
	Hecht-Shlaer	Correlated with	Self-Luminous Telesilhouette	Means of scores r = .413
38	Hecht-Shlaer RCN Model	Correlated with	Self-Luminous Telesilhouette	r = -.555
73	Hecht-Shlaer RCN Model	Correlated with	Several Instruments	(See the Abstract for statements.)
86	Hecht-Shlaer Model 3	Correlated with	SchAvMed SAM Portable	(See the Abstract for statement.)
99	Hecht-Shlaer	Correlated with	Navy Radium Plaque	r = -.67
66	Johnson Found. Luminous Plaque	Correlated with	AAF-Eastman NV Tester	(See the Abstract for statement.)
23	Miles 4 Plaque	Correlated with	Hecht-Shlaer	(See the Abstract for statement.)
55	Miles 4 Plaque	Correlated with	OSRD-NDRC Model III	(a) r = .45 (b) r = .60
73	Navy Radium Plaque Cutting score 60%	related with	OSRD-NDRC Model III Cutting score 20%	
		Chi square = 19.86 1% or better level of confidence		

					N
77	Navy Radium Plaque (a) Standard score (b) Raw score	Correlated with	Col. Univ. Motion Acuity Test " "	 r = .93 r = .90	100
99	Navy Radium Plaque	Correlated with	Hecht-Shlaer	r = -.67	28
100	Navy Radium Plaque	Correlated with	Army NV Tester Modified Rostenberg (Tetrachoric) r =	Average of 4 Tests .565	115
103	Navy Radium Plaque	Correlated with	NavMedResInst NNMC, Bethesda (Tetrachoric) r =	Average of 4 Tests .65	115
27	OSRD-NDRC Model II	Correlated with	Pensacola	(See the Abstract for statement.)	
35	OSRD-NDRC Model II A	Correlated with	Hecht-Shlaer	Means of scores r = .449	90
	OSRD-NDRC Model II A	Correlated with	Self-Luminous Telesilhouette	Means of scores r = .848	
55	OSRD-NDRC Model III	Correlated with	Miles 4 Plaque	(a) r = .45 (b) r = .60	22 22
73	OSRD-NDRC Model III Cutting score 20%	related with	Navy Radium Plaque Cutting score 60%		
		Chi square = 19.86 1% or better level of confidence			150
86	SchAvMed SAM Portable	Correlated with	AAF-Eastman NV Tester 1° Target	(a) r = .20 (b) r = .29	200 5000
	SchAvMed SAM Portable	Correlated with	AeroMedLab RPNVT	r = .26	200

					N
35	Self-Luminous Telesilhouette	Correlated with	Hecht-Shlaer	Means of scores r = .449	90
	Self-Luminous Telesilhouette	Correlated with	OSRD-NDRC Model II A	Means of scores r = .848	
38	Self-Luminous Telesilhouette	Correlated with	Adactometer	r = .385	108
	Self-Luminous Telesilhouette	Correlated with	Hecht-Shlaer RCN Model	r = -.555	108
73	Purkinje Test Smith Vis-Motor Test Tufts SDS	Correlated with Correlated with Correlated with	Various Instruments	(See the Abstract for statement.)	
9	Wald Adaptometer	Correlated with	"British Device"	r = .40	

TABLE 3.

DATA ON VALIDITY DERIVED FROM STUDIES OF COMPARISONS OF ADAPTOMETER AND NIGHT VISION TESTER SCORES WITH SCORES OBTAINED IN OUTDOOR TESTS AND OTHER CRITERIA ADOPTED. COEFFICIENTS CITED ARE PRODUCT-MOMENT.

Abstract No.	Test		Validity			N
78	AAF-Eastman NV Tester	Correlated with	ArmoredMedResLab (AMRL Field)			
				Average of 4 groups (a) r = .60		158
				Average of 4 tests (b) r = .769		20
86	AAF-Eastman NV Tester 1° Target	Correlated with	ArmoredMedResLab Field Test	r = .83		16
38	Adactometer	Correlated with	Night Lookout Training. NLO	Test	Retest	108
	"Adaptacuity"	"	NLO(A) Spotting objects	r = .028	-.074	
	"Adaptacuity"	"	NLO(B) Identification	r = .016	-.055	

					N
78	AeroMedLab RPNVT	Correlated with	ArmoredMedResLab (AMRL Field)	Average of 5 Tests r = .597	64
86	AeroMedLab RPNVT	Correlated with	ArmoredMedResLab (AMRL Field)	r = .64	16
94	AeroMedLab RPNVT	Correlated with	Field Tests	r = .55 to .64	
71	Army NV Tester NVT-15	Correlated with	Outdoor "Courses"	TC 44-I: r = .39; TC 44-II: .63; TC 44-Z: .41	
	Army NV Tester NVT-15	Correlated with	Observation Test II	Perception Distance: r = .73; Recognition Distance: .71	48
	(See the Abstract for details of other models of the instrument and for statements of the validity of other instruments.)				
27	Hecht-Shlaer	Correlated with	Outdoor Tests	(See the Abstract for statement.)	
73	Hecht-Shlaer	Correlated with	Night Lookout Performance	(See the Abstract for statement.)	
19	Hopkins Test	Correlated with	Road Test	r = .28 to .58	38
19	Luckiesh-Moss Contrast Card	Correlated with	Road Test	r = .19 to .38	38
71	Luckiesh-Moss Contrast Card	Correlated with	Various Outdoor Tests	(See the Abstract for statement.)	
78	Luckiesh-Moss Contrast Card	Correlated with	ArmoredMedResLab (AMRL Field)	Average of 4 Tests (a) r = .709	20
				Average of 4 Groups (b) r = .40	158

							N
27	Miles 4 Plaque	Correlated with	Outdoor Tests	(See the Abstract for statement.)			
73	Navy Radium Plaque	Correlated with	Night Lookout Performance	(See the Abstract for statement.)			
74	Navy Radium Plaque	Related to	Night Lookout Training	(See the Abstract for statement.)			
91	Navy Radium Plaque	Related to	Night Lookout Performance	(See the Abstract for statement.)			
97	Navy Radium Plaque	Related to	Evelyn Trainer	(See the Abstract for discussion.)			
99	Navy Radium Plaque	Correlated with	Outdoor Test	Perception Scores	Recognition Scores	Combined Scores	
	At 5 feet		r =	.38	.40	.41	
	At 6 feet		r =	.33	.45	.43	
	At 7 feet		r =	.39	.52	.50	
	At 9 feet		r =	.31	.40	.38	
	At all distances		r =	.42	.52	.51	56
27	OSRD-NDRC Model II	Correlated with	Outdoor Tests	(See the Abstract for statement.)			
73	OSRD-NDRC Model III	Related to	Night Lookout Performance	(See the Abstract for statement.)			
27	Pensacola	Correlated with	Outdoor Tests	(See the Abstract for statement.)			
78	SchAvMed SAM Portable	Correlated with	ArmoredMedResLab (AMRL Field)	Average of 4 Tests r = .508			20
38	Self-Luminous Telesilhouette	Correlated with	Night Lookout Training. NLO	Test	Retest		
			NLO (A) Spotting objects	r = .157	.074		
			NLO (B) Identification	r = .020	.043		108

					N
78	Purkinje Test Smith Vis-Motor Tufts-SDS	Related to	Night Lookout Performance	(See the Abstract for statements.)	
19	Battery of Tests (a) Moving target (b) Hopkins Test (c) Luckiesh-Moss	Correlated with	Road Test	r = .66	38

ABSTRACTS OF REPORTS ON STUDIES OF DARK ADAPTATION, NIGHT VISION TESTS AND RELATED TOPICS

The numbers in parenthesis following the titles refer to the serial order of two bibliographical sources, as follows:

A. Numbers 3348-4886 are included in:
A bibliography of Visual Literature 1939-1944 Supplement, compiled by J. F. Fulton, D. G. Marquis, H. T. Perkins, and P. M. Hoff.

B. Numbers 4887-5180 are included in:
Reports in the Army-Navy-NRC Vision Committee Files not listed in the volume cited in A above.

Editor's note: The Fulton bibliography has been bound with Publication No. 11 from the Historical Library, Yale Medical Library entitled: "A Bibliography of Visual Literature, 1939-1944." Since the Supplement is Restricted, the composite volume is not available through normal channels. Both the Fulton Supplement and the bibliographical material cited in B above may be obtained from the Executive Secretary, Armed Forces-NRC Vision Committee. In addition, copies of all reports abstracted are in the library files of the Vision Committee and may be borrowed by military personnel or civilian scientists possessing adequate clearance.

1. E. A. PINSON. Dark adaptation in army air corps pilots. U. S. AAF-ATSC. Experimental engineering section. March 17, 1941. (3820) (O)

The Hecht-Shlaer Adaptometer was used with 30 subjects whose average age was 20-50 years. The mean threshold in log units, micromicrolamberts, for the age groups was as follows: 3.20 for the 20-25 year group, 3.25 for the 26-30 year group, 3.27 for 31-35 year, 3.22 for 36-40 year, 3.45 for 41-45 year, 3.73 for the 46-50 year group. The mean threshold for 30 subjects was 3.37. None of the 20-25 year group was night blind. About 6 per cent of the 25-40 year group showed dark adaptation deficiency. Fifty per cent of the 40-45 year group showed diminished night visual efficiency and the other 50 per cent were on the borderline. All the men in the 45-50 year group were definitely below the men in the other groups in night visual efficiency. An inability to perceive a light intensity of less than 3.5 log units at the end of 30 minutes of dark adaptation was considered to indicate deficiency in dark adaptation.

2. E. LILJENCRANTZ. Dark adaptation study, U.S.S. Enterprise. U. S. Navy. Bureau of Aeronautics. May 17, 1941. (3849) (C)

One-hundred subjects were tested, with the Hecht-Shlaer instrument, to obtain the curves of the course of dark adaptation. Fifty subjects were enlisted men, 25 were naval aviation officers, and 25 were officers. The lowest rod threshold reached was 2.6 log units. The highest terminal rod threshold was 3.8 log units. No gross night blindness was found, but differences were said to be evident between subjects older and younger and, also, between officers and men. Intelligence and training were regarded as factors in the latter difference, and in favor of the officers. The question of Vitamin A in the diet of navy personnel was briefly commented upon.

3. ANON. Adaptometers for use in testing night vision. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. June 28, 1941. (3858) (C)

Notes on the use of an adaptometer made at New London. Probably developed from an unnamed "British Device." No quantitative data.

4. E. C. HAMMOND and R. H. LEE. A method of scoring dark adaptation tests. U. S. National institute of health. Division of industrial hygiene. June 30, 1941. (3843) (C)

An equation for the treatment of the data in individual dark adaptation curves obtained in the standard Hecht-Shlaer adaptometer procedure was developed and its use illustrated in typical examples. The equation is $\text{Log } I = a + b/t^2$ where Log I = the intensity of the barely perceptible test flash, a = a constant representing the asymptote of the curve or the log value about which readings would fluctuate after a long period of time, b = a constant indicating the rapidity with which the eye is approaching the log value of the constant a, t = the time in minutes from the termination of the preadapting light. The equation was said to fit the rod portion of the curve quite satisfactorily.

A set of 31 multilithed curves, with values of the constant b ranging from 80 to 500, was provided. The procedure suggested was to fit by visual inspection a given individual curve to one of the b curves and from it derive the value of a. The criteria of "best" scores will depend on the purpose for which tests of dark adaptation are made.

5. W. C. IVES, C. W. SHILLING and S. H. BARON. Preliminary report on 365 subjects tested for night vision. U. S. Navy. Submarine base, New London, Conn. Medical Research Laboratory. July 1, 1941. (4958) (C)

Two adaptometers were used, the Wald and one constructed from a description supplied of a "British Device." Fairly normal distributions of scores were obtained. The average score on the Wald instrument was 2.5 log units with a standard deviation of .27 log units. The classification proposed was: Excellent for scores below one S.D. from the mean, good for scores between plus and minus one S.D., and poor for scores above one S.D. from the mean. The correlation between scores on the Wald and the "British Device" (light flash) was r = .40.

6. E. C. HAMMOND and R. H. LEE. Criteria for scoring dark adaptation tests. U. S. National institute of health. Division of industrial hygiene. July 10, 1941. (3844) (C)

The individual dark adaptation curves obtained by means of the Hecht-Shlaer adaptometer from 23 subjects were analyzed. The equation previously reported by the authors was used (cf. Abstract no. 4). The purpose of the investigation was to make a comparison of the several factors in the equation for the degree of dependence or independence of each other. The data were given in 13 scatter diagrams and 2 tables.

The conclusions stated included the following:

1. The lowest level (rod) of dark adaptation reached is independent of the rate of dark adaptation, i.e., the constant "a" correlates slightly negative with the constant "b", r = -.06.

2. At 10 minutes in the dark adaptation period the correlation between Log I values and rate of adaptation, i.e., "b" values, is r = .76.

3. A prediction of Log I values at 40 minutes from those at 10 minutes would be dubious since the correlation r = .39.

4. If a given Log I value is selected, for example, log 4.0, the correlation between "a" values and "t" is r = .55. The correlation between "b" values and "t" is r = .69. Although some of the factors are definitely related to each other, they do not measure the same things. The criteria for the selection of the best men for a task must be obtained from a complete analysis of all the factors in dark adaptation.

7. E. A. PINSON. Dark adaptation in army air corps personnel. U. S. AAF-ATSC. Experimental engineering section. August 28, 1941. (3821) (O)

Eighty-nine officers and 115 men were tested by the Hecht-Shlaer adaptometer. The average subject over 40 years of age was from 30 to 60 per cent less efficient than the average subject under 35 years of age. However, the size of the difference is small when compared with the variability from one person to another. The Hecht-Shlaer instrument was not considered satisfactory for mass testing of subjects.

8. S. HECHT. The design and construction of a threshold meter for measuring the visual threshold during dark adaptation: progress report. U. S. OSRD-NDRC. Division 16, Optics and camouflage. September 22, 1941. (3878a) (O)

The desirable characteristics of an instrument were listed as follows: (1) It should be portable and self contained. (2) It should be simple and fool-proof in operation. (3) There should be an intensity scale for the direct reading of brightness in log micromicrolamberts. The instrument should be capable of covering a range of 1 log unit above and 1 log unit below the normal mean threshold. (4) There should be a standard lamp for the control of the working lamp. (5) The instrument should be capable of measuring the threshold under controlled conditions of fixation, exposure, color and size of field, as well as form threshold and the entire course of rod dark adaptation. A detailed description of the developmental stages was given along with specifications and a schematic diagram.

9. W. C. IVES, C. W. SHILLING and W. H. CURLEY. Final statistical report on the use of the Wald adaptometer. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. October 18, 1941. (4957) (R)

There were 1481 officers and men tested for night vision during the period June 10 to October 1941. The mean final rod threshold score was 45.76 scale units with a S.D. of 5.44. The mean is equivalent to 2.41 log units, microlamberts. Between plus and minus one S.D., there were 75.1 per cent classified good, 10.6 per cent were classified excellent, and 14.3 per cent were classified poor.

Six hundred fifty-four subjects indicated some previous night lookout duty prior to the test. Of these, 57 per cent had scores which were average or better than average and 43 per cent had below average scores. There were 616 men who had no lookout duty prior to the test. Of these, 47 per cent had average or better scores and 52 per cent had below average scores. It was concluded that lookout experience had increased the efficiency, not physiologically, but through learning to observe and report more accurately.

The age range of a sample population of 1265 men was 17 to 52 years. A table shows the per cent of men with scores average or better, and below average, for age groups. (Table on page 30.)

A sugar solution drink was given to 544 subjects prior to the test. Compared with a control group of 1040 men, there were no appreciable differences in the scores.

Age range	Per cent with average or better	Per cent with below average
17-22 years	59.5	40.5
22-27 years	52.9	47.1
27-32 years	53.2	46.7
32-37 years	47.8	52.2
37-42 years	36.2	63.8
42-52 years	23.8	76.2

10. W. C. IVES and C. W. SHILLING. Night adaptation after exposure to various colored lights. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. November 13, 1941. (3602) (C)

A study of the final thresholds in dark adaptation following exposures to white and to ruby lights was made. Eight hospital corpsmen were tested with the Hecht-Shlaer adaptometer under the following conditions: (1) The thresholds were obtained in the usual manner, the average being 2.44 log units. (2) The following day the men were tested after 20 minutes' exposure to the light of a bright ruby lamp. The average threshold was 2.48 log units, or a difference of .04 log units. (3) Several days later the thresholds were obtained in the usual manner, the average being 2.64 log units. (4) Following an hour in the sunlight the men were exposed to the light of the bright ruby lamp for a period of 20 minutes. The average threshold obtained was 2.62 log units. The results indicated that the red light of the ruby lamp did not affect terminal thresholds.

Reference was made to a communication from Dr. Walter R. Miles concerning the use of red goggles in his studies of dark adaptation. He stated that subjects who wore them in a room lighted with about 6 millilamberts of light intensity while reading or doing other visual work gave terminal threshold values closely similar to those obtained after adaptation in a completely dark room. Suggestions were given concerning the practical use of the method in submarine operation. It did not appear necessary for an observer to be in a dark room to achieve the requisite sensitivity of the rod mechanism. He could, by the use of red light, continue with his task while becoming rod adapted.

11. W. R. MILES. Development of adaptometer for night vision; interim report. U. S. OSRD-NDRC. Division 16, Optics and camouflage. December 9, 1941. (3878b) (R)

The objective of the research was the development of an instrument to make possible rapid and easy measurement of the threshold of night acuity (silhouette vision) and the threshold of light (flash). A device had previously been made by the author and this with some modifications became the working model. Conferences were held with scientific workers and representatives of the Armed Forces in different parts of the country. Subsequently the model was turned over to a manufacturer for construction. Reference was made by the author to the exploration of the possibility of the use of self luminous material to serve as an accessory to the device.

12. C. W. BRAY. Desirable characteristics for adaptometer tests of night vision. U. S. OSRD-NDRC, Applied psychology panel. December 13, 1941. (4960) (C)

A memorandum prepared following a conference between the members of the Committee on Aviation Medicine, Vision Section, and representatives of the Air Corps Medical Group, the A.G.O., and the Navy Bureau of Aeronautics. Essential requirements listed are: the instrument must definitely eliminate the night blind and provide some categories for the classification of the normal group; the instrument must be standardized, simple in construction and fool-proof for use in all sorts of places; the factor of "face validity" in the test situation must be taken into account in order to minimize the boredom experienced by subjects in otherwise "meaningless" procedures to them.

13. W. C. IVES and C. W. SHILLING. Object identification with the Hecht-Shlaer adaptometer plus visual targets or silhouettes devised by Dr. Walter R. Miles of Yale University. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. December 26, 1941. (3864) (C)

By means of a slide containing 4 silhouette figures and 1 circular field the instrument was modified in order that both "flash" and "object" perception could be tested under low illuminations. The figures were a modified Snellen T placed in the positions up, down, right, left, respectively. Tests were given to 189 men. It was found that approximately 1 log unit more light was necessary for the identification of the object than was necessary for the perception of the faintest flash of light.

14. W. C. IVES, C. W. SHILLING and S. R. BARON. Comments regarding the findings of other boards for the determination of night vision. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. 1941. (3865) (C)

Comparison of reports from several stations where studies and tests of night visual efficiency have been made brought out the fact that there was a decided lack of uniformity in the procedure of testing, in the evaluation of results, and in the statistical treatment of the data. A recommendation was made that a directive be issued setting up more uniform procedures for use at Naval stations.

15. A. P. WEINBACH, R. H. LEE, B. F. JONES and F. S. BRACKETT. Preliminary report on the influence of brightness and color of preadapting lights on the course of dark adaptation. U. S. National institute of health. Division of industrial hygiene. January 5, 1942. (3587) (C)

A study of the dark adaptation curves obtained from 1 subject when the test fields were violet, sextant green, jena green, red, and white, respectively. The preadapting lights were white and red used through a considerable range of brightness values. Among the conclusions given are the following: after exposure to a low brightness preadapting light less time is required to reach the threshold than after exposure to a high brightness preadapting light. Less time is required to reach the threshold after exposure to red light than to exposure to white light of the same brightness (cone). This was also the case when the preadapting light was photo flood seen through red goggles as compared with an exposure to normal white light. In a test of reading in a normally illuminated room with and without red goggles the time required to reach the threshold was considerably less when the goggles were worn than it was when they were not used. Four figures (curves) were given.

16. E. A. PINSON. Dark adaptometer. U. S. AAF-ATSC. Experimental engineering section. January 8, 1942. (3823) (R)

A detailed description and two diagrams of the NDRC portable adaptometer, instructions for use and a photograph of the T forms used in the test for form perception under low illuminations were given. The instrument and the standard Hecht-Shlaer adaptometer were used in a test of 12 men. The mean threshold was 2.43 log units, micromicrolamberts, for the NDRC portable and for the Hecht-Shlaer, it was 2.45 log units. Thresholds for form perception are more difficult to obtain than for light only.

17. E. A. PINSON. Dark adaptometer. U. S. AAF-ATSC. Experimental engineering section. January 29, 1942. (3824) (O)

The author reported on the results of a conference with Eastman Kodak Co. staff members relative to the design and development of an instrument for the mass measurement of night visual efficiency. Previously, he had made a pilot sketch embodying his concept of a suitable type of instrument which was made the basis of the discussions.

In an appendix to the report there is a discussion of the factors which appear to be essential in order to enhance the validity of such an instrument. The most important one is the perception of form at low levels of illumination in which are involved contrast between an object and its background, the size of the object, the distance from which it is viewed as well as the angle of viewing. Binocular vision should be used in the test situation and the illumination of the background should be such that it simulates the night sky. Relatively large test forms requiring visual acuity of 20/150 or 20/200 are desirable. Physical conditions in the test situations should be reproducible and under control.

The design of the proposed instrument was given in a blueprint diagram and the details discussed. The source of light is an ordinary lamp bulb operated on 60 volts. A constant density filter (blue) and a rotating variable-density filter are inserted between the lamp and viewing screen. A film carrying black silhouettes of a broken ring moves across the screen presenting to the subjects the image of the ring with its break oriented in one of eight possible positions for a period of 15 seconds. A shutter cuts off the light in the intervals between the presentation of the ring in one position and the movement of the film to present the ring in another position. The brightness values of the background could be varied through 4 levels from .35 to 1.0 microlamberts.

The subjects record their responses by writing on suitable paper forms the symbols for the compass points judged to correspond with the orientations of the break in the ring.

18. R. H. LEE and A. P. WEINBACH. Binocular adaptation—the independence of the state of adaptation of one eye upon that of the other eye. U. S. National institute of health. Division of industrial hygiene. January 30, 1942. (3586) (O)

The authors referred to some data concerning the slight effect of red light on the rods of the eye, drawn from Hartline's work and from their own study (cf. Abstract no. 15). They also referred to data drawn from Southhall's work on the independence of one eye upon the other in the matter of dark adaptation. If such independence existed it would be possible to use one eye for high intensity work as in reading, etc., while the other eye is maintained in a state of dark adaptation by means of a cup or patch worn over it.

The hypothesis was tested, the adaptometer used being the Hecht-Shlaer. First, a normal dark adaptation curve for the right eye was obtained and used for comparison with the curves obtained in the subsequent tests. Both eyes were dark adapted for 30 minutes, then the left eye was exposed for 3 minutes to a light of 1800 millilamberts intensity. Another test was made on the right eye following a period of one hour during which it was protected and the left eye used for reading in full room illumination. In another test both eyes viewed the test flash from a distance of six feet and a normal dark adaptation curve obtained. Then the left eye was light adapted and the right eye dark adapted for a period of 30 minutes and a curve obtained. It was concluded that the darkened eye is many more times sensitive than the light adapted eye at the instant of exposure, and that the state of adaptation in one eye is largely independent of that in the other.

19. ANON. Validation of night vision tests. U. S. ASF. Adjutant general's office. n.d. (3835) (R)

The following data were obtained from Abstract Series No. 6, February 3, 1942. An attempt was made to develop a night vision test which would predict the ability of truck drivers to see during blackouts. Five laboratory tests and one road test were used with 38 subjects.

1. Moving target test: Three targets at the end of a long box viewed under low illumination. The subject indicated by pressing a button when he could detect which target was moving.
2. Hopkins test: A white target background on which were 1, 2, 3, or 4 black bars. From blackness the illumination was gradually raised until the subject named correctly the number of bars on the target.
3. Daytime visual acuity: Snellen letters read in daylight.
4. Nighttime visual acuity: Snellen letters read in low illumination.
5. Luckiesh-Moss Low Contrast Chart.
6. The road test was used in a clearing in a woody section. The test objects were illuminated traffic sign buttons (radium), white striped targets, logs, and black discs.

Correlation coefficients for test-retest with four days' intervals were reported as follows:

1. Moving target test	r = .33
2. Hopkins test	r = .61
3. Daytime acuity test	r = .68
4. Nighttime acuity test	r = .35
5. Luckiesh-Moss Chart	r = .67
6. Road test	r = .52

Considerable variability was found in the correlations between the laboratory tests and the road test. Four correlations were made in each case.

1. Moving target	vs	Road test	r ranged from .31 to .55
2. Hopkins test	vs	Road test	r ranged from .28 to .58
3. Luckiesh-Moss	vs	Road test	r ranged from .19 to .38

Between the road test and a battery of tests made up of the moving target, the Hopkins and the Luckiesh-Moss Chart, a correlation coefficient r = .66 was reported.

20. ANON. Summary of night vision studies. U. S. ASF. Adjutant general's office. Personnel research section. March 2, 1942. (3839) (O)

Although this report is dated March 2, 1942, it contains data from a report on validation of night vision tests (cf. Abstract no. 19) and a report on night vision and its relation to race and blood sugar (cf. Abstract no. 24). The data were used in the discussion of the problems arising in the selection of men as drivers who must operate under blackout conditions. Conclusions reached include the following: Measurement of night vision should be made since there are individual differences sufficiently large enough to warrant it. To a certain extent the ability to see at night can be predicted from laboratory tests. Simple tests appear to be as valid as the more elaborate ones, but the usual acuity test gives little indication of night seeing ability. The ingestion of a sugar solution does not affect the night vision. The data on the relative ability of white and colored soldiers to see at night are conflicting. If a difference does exist it is not likely to be great enough to be of much practical importance.

21. ANON. Dark adaptation study, U.S.S. Enterprise. U. S. Navy. U.S.S. Enterprise. March 23, 1942. (3876) (O)

This report contains data additional to those previously given in May, 1941 (cf. Abstract no. 2). Measurements were made to determine the thresholds for "circle perception" and "flash perception." Officers and men were used as subjects. The mean thresholds for circle and flash perception were approximately the same for the officers and the men although there was a mean age difference of 7.8 years between them. The question was raised concerning the factor, or factors, which operated to offset the age difference, i.e., older officers and younger men. It was surmised that "intelligence and training play a more important part than was previously recognized." Night vision is defined as the combination of biochemical and psychophysical responses. The latter include judgment, ability to make decisions, consistency of responses, etc. The data were analyzed in order to determine if a significant difference existed between form perception (circle) and flash perception. It was found that the threshold for the former was higher than the latter. "The perception of a circle has more of the psychophysical in it than does the perception of a flash."

A section of the report deals with the difference found between vitamin A treated officers and men and untreated officers and men. Explanation of the difference was found to be quite difficult.

22. A. P. WEINBACH and R. H. LEE. Report on the influence of brightness of red and white preadapting lights on the course of dark adaptation for various colors of test fields, and tests of specific goggles submitted by the Medical research section, Bureau of aeronautics. U. S. National institute of health. Division of industrial hygiene. March 25, 1942. (3588) (C)

A series of reports on tests made with goggles designed to transmit only those wave lengths which do not appreciably affect rod vision but which permit the reading of fine print illuminated by white light of 40-50 foot candles. Report one is identical with the report dated January 5, 1942 by Weinbach, Lee, Jones, and Brackett (cf. Abstract no. 15). Report Nos. 2, 3, and 4 were devoted to specifications of various goggles.

23. F. C. KEIL. The comparison of the Hecht adaptometer and the Miles illuminous disc adaptometer. U. S. AAF. School of aviation medicine, Randolph Field, Tex. March 31, 1942. (3826) (C)

Tests with both instruments were given to 191 men, 122 air force cadets and 69 other personnel. The data were presented in scatter diagrams. No correlation figures. It was indicated that the form threshold does not correlate with the light threshold and that persons with low thresholds do not necessarily have good form perception under low illumination. The explanation of this fact is not easy but the suggestion was made that training in rod vision may improve them. The diagrams were said to indicate absence of correlation between age of subjects and scores on both the Hecht and Miles adaptometers, between the color of eyes of the subjects and the scores on both instruments, and between the instruments themselves. Reference was made to the factor of the size of central scotoma in night vision and to the phenomena of fading which takes place when seeing with rod vision in connection with testing for night visual efficiency. The factor of fading, which has also been observed by British investigators, apparently is not due to any breathing rhythm on the part of the subjects.

24. ANON. Night vision and its relation to race and blood sugar. U. S. ASF. Adjutant general's office. Personnel research section. April 2, 1942. (3837) (O)

In this report are included data from tests given at Fort Knox in 1941 and from tests given at Fort Bragg. The objectives of the study were to determine: (1) the effect on night vision of taking a sugar solution, (2) the difference in night vision between colored and white soldiers, (3) whether or not night vision scores are distributed normally.

The number of men tested at Fort Knox was 1889. Of these, 949 were given a sugar solution just before entering the dark room and 940 men were not given the solution. All were white soldiers. The Wald adaptometer was used. The mean scale reading on the instrument for the men given the solution was 33.99, and for the others without the solution it was 33.84. The critical ratio of the difference between means equals .82 with a probability of 42 times in 100 of a difference as large as the one obtained occurring by chance. It is concluded that the taking of a sugar solution does not affect night vision as measured by the Wald adaptometer.

The data on racial difference in night vision are ambiguous. At Fort Knox, 921 white soldiers and 51 colored soldiers were tested. Of these, 429 white and 21 colored were given sugar solution, 492 white and 30 colored soldiers did not receive sugar. At Fort Bragg, 236 white soldiers were not given sugar and 167 colored soldiers were given sugar solution. The data as given indicate that at Fort Knox the white soldiers had a slightly lower mean threshold than the colored soldiers, 30.9 against 32.06 or a difference of 1.16. At Fort Bragg the colored soldiers had a siightly lower mean threshold, viz., 31.68 against 33.72 or a difference of 2.04. No conclusion can be drawn from the data. The distribution of 1889 scores showed more scores clustered near the mean and a few more very poor scores than would be the case in a normal curve of distribution.

25. E. A. PINSON. Night vision. U. S. AAF-ATSC. Experimental engineering section. April 7, 1942. (3545) (O)

A report of a trip by the author to Randolph Field in order to initiate studies in the School of Aviation Medicine on night vision and night vision testing, to acquaint the personnel with the methods of procedure used in studies of dark adaptation and night vision, and to accumulate data on air corps personnel which could be used for the purpose of classifying them with respect to night visual efficiency.

26. E. A. PINSON. Night vision tester. U. S. AAF-ATSC. Experimental engineering section. May 29, 1942. (3825) (O)

The report contains the details of certain modifications proposed and made in the AAF-Eastman night vision tester (cf. Abstract no. 17). In Appendix 1 are the suggestions for improvement based on experience gained in tests with the instrument at Kelly Field. In Appendix 2 are the minutes of a conference held at Rochester, New York at which the decisions on the changes to be made were adopted.

The changes included the provision of a viewing screen 18 inches in diameter, subtending a visual angle of 4°, and a test character varying in size up to 2° mounted on a rotating turret for placement in any one of 8 compass points. The latter change eliminated the use of the film with silhouette forms thereon moving across the viewing screen. The procedure was modified to provide for five presentations at each one of 8 levels of illumination for 7 seconds duration of each presentation and an interval of 10 seconds between presentations. The range of illumination adopted was 1.75 log units with step intervals of .25 log units. A change in the recording system was effected by the use of a Veeder counter electrically activated to record only correct responses. With this device from 6 to 10 subjects could be tested simultaneously.

27. R. H. PECKHAM. Tests of night vision. U. S. Navy. Naval air training base. Dispensary. Research section. Pensacola, Fla. June 6, 1942. (3855) (O)

In the investigation both indoor and outdoor tests were made. The adaptometers were the Hecht-Shlaer, model 2; the NDRC, model 2; and the 4 plaque radium (Miles). Two devices were developed for outdoor tests. One was made up of 6 discs each painted gray and having a T shaped object placed on it. The discs varied in reflection value from 38.5 per cent to 6.3 per cent. The black T had a reflection value of 3.7 per cent. This device was named the Pensacola Adaptometer. It was also tried out in the laboratory under the name of Pensad, but was later discarded as impractical for use indoors. The other device for use outdoors consisted of two wheels each 4 feet in diameter. On each was mounted a smaller disc 12 inches in diameter, tangent to the inner edge of larger wheel. The larger wheels were painted gray, one with 64.5 per cent and the other with

38.6 per cent reflection value. The former was named the dark wheel and the latter was named the light wheel. The smaller discs had a reflection value of 3.7 per cent. The subjects were required to approach from a distance at which a wheel could not be seen and to stop when they could determine with confidence the direction of its rotation.

In the treatment of the data the chi square formula was used in connection with the hypothesis that the tests being compared distributed the population tested according to chance interrelationship. Three tables were prepared on reliability, intercorrelation and validity respectively. Due to the lack of data in the extremes of scores some computations could not be made. The tables showed definite scattering of instances of chance relationship. In other instances there appeared to be probability on the 5 per cent, 2 per cent, and 1 per cent levels of confidence contra the hypothesis. The tables as presented do not lend themselves readily to an interpretation of the data.

The conclusions stated may be arranged as follows:

1. Reliability—The Hecht-Shlaer Adaptometer showed good reliability in the center portion of the data, but none or very little at the extremes where most needed. (47 subjects). The NDRC, model 2, showed good reliability for the selection of superior and above average men (45 subjects). The Pensacola (Pensad) was consistently reliable in the data of 25 subjects. The 4 plaque radium was consistently unsuccessful in use.
2. Intercorrelations—There was slight correlation for the median subjects with the Hecht-Shlaer and Pensacola, and with the NDRC and Pensacola.
3. Validity—For the NDRC there was consistent validity for all subjects. It was shown for Pensacola with median subjects only. It was not shown for the Hecht-Shlaer and for the 4 plaque radium adaptometers.

28. C. SHEARD, J. W. BROWN and K. G. WILSON. Dark adaptation. I. Apparatus and methods. U. S. Mayo aero-medical unit. Rochester, Minn. June 15, 1942. (3583) (C)

The apparatus, used in conjunction with a low pressure chamber in a number of studies of dark adaptation under various conditions, was described. It was external to a chamber in which the subject was placed and consisted of an optical bench carrying a suitable light housing, a preadapting light field, and a metal plate pierced with apertures. The whole was aligned in front of the window of the chamber, through which the stimuli were presented to the subject. The preadapting light field was illuminated with 600 millilamberts for 4 minutes. This unit was then replaced by the metal plate. Four small apertures provided red fixation points situated at the macula and 5, 8, and 10 degrees, vertical, in the paramacula region of the retina. Directly aligned with the light source was an aperture 3 cms. in diameter over which could be placed caps perforated so as to provide visual targets of 1/4, 1/3, 1/2 and 1 degree subtense to the eyes of the subject. Movement of the light source along the optical bench brought about variations in the intensity of the light thrown on the targets. The inverse square law was employed to calculate the intensity of the light which could be just perceived by the subject. An intercommunication system provided for instructions to the subject and for the subject to report to the operator. The studies in which the apparatus was used are reported elsewhere.

29. ANON. Reliability of Ft. Belvoir night vision tests. U. S. ASF. Adjutant general's office. Personnel research section. June 26, 1942. (3838) (O)

The Hopkins Night Vision Test was given to 266 men during the period April 20-June 13, 1942, on the first day they joined the Motor Transport Company for training in truck driving. Data given are of 230 cases, 36 cases being eliminated because of an extreme difference in test or procedure. Split-half (odd-even) reliability for six groups tested ranged from .95 to .99. For the same groups the reliability of the whole test ranged from .97 to .995. No test-retest correlation figures were given. The correlation of age with the scores for 92 white men was -.31 and for 63 colored men it was -.25.

30. W. M. ROWLAND. A small light threshold meter. U. S. AAF. School of aviation medicine, Randolph Field, Tex. July 22, 1942. (3827) (O)

Design and construction of light threshold meter with a self contained source of light. This instrument was the precursor of the SAM portable adaptometer. A small area of material was covered with luminous paint which in turn was covered with a sheet of exposed photographic film whose density was approximately .95. A disc was provided to place silhouette figures in front of the light surface. Mounted on a rotating device were filters providing for a brightness range from 4.07 to 1.84 log units micromicrolamberts. Instructions for the test procedure were given.

31. C. W. SHILLING. Report on reliability test of NDRC adaptometer, Model II, conducted at Submarine base, New London. U. S. Navy. Submarine Base, New London, Conn. Medical research laboratory. July 28, 1942. (3862) (C)

Tests were given to 19 men at 24 hours interval. Motivation was facilitated by giving cigarettes to the men and a bonus for the best performance. The test-retest coefficient of correlation was .63 and by application of the Spearman-Brown "prophecy" formula for a test twice as long the coefficient became .77.

32. E. A. PINSON. Night vision tester. U. S. AAF-ATSC. Experimental engineering section. August 22, 1942. (3818) (O)

The author reported the results of a conference held at Rochester to consider additional modifications of the AAF-Eastman night vision tester (cf. Abstract no. 17). Appendix 1 contains the details of the changes made. Aside from purely structural and operational features, the changes in the instrument were: (1) the adoption of a 90 mm Landolt Ring test character with provision for the use of a T figure subtending a visual angle of 2° if deemed necessary, (2) the provision for a maximum brightness of 10 microlamberts for the test field with two neutral filters to permit tests at two distinct brightness levels, one fairly high and the other one low. With each level there are to be arrangements to allow 8 brightnesses at step intervals of .25 log units, the median brightness for use with the Landolt Ring to be .30 microlamberts, and for use with the T figure the median brightness to be .008 microlamberts. (3) An imitation screen and dummy recorder for the purpose of pretest instruction of the subjects to be provided.

33. L. S. BEALS and W. S. ADAMS. Comparative night vision rating; a preliminary report on 600 tests. U. S. Navy. Naval air station, Coco Solo, Upham, Canal Zone. September 1942. (3853) (O)

A detailed description of the development and the specifications for the construction of the Adactometer. The device was designed to test not only dark adaptation but also visual acuity and the rate of recovery from a moderate degree of glare effect. The test objects were letters of the Snellen type viewed through a layer of material varying in opacity from top to bottom of a drum-like structure. Scores were obtained from the total number of letters read, partial recovery time from the glare effect and full recovery time. The term "adaptacuity" refers to a composite score to which are contributed percentage values from the scores listed.

34. R. C. ARMSTRONG. Night vision tests. U. S. AAF-ATSC. Experimental engineering section. October 17, 1942. (3819) (O)

Tests were given to 18 men with the Hecht-Shlaer portable adaptometer. Thresholds for both light and form perception were obtained. These were within the normal range.

35. W. S. VERPLANCK. Report; comparative study of adaptometers. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. December 1, 1942. (3861) (O)

The adaptometers used in this extensive comparative study were the NDRC, Model II-A, the Hecht-Shlaer and the Self-luminous Telesilhouette. Modifications were made in the instruments in order that they would be relatively comparable with respect to the size and nature of the test objects, the fixation points and the levels of illumination. Tests on each instrument were given on 5 successive days, in each test there being 48 presentations of the stimulus. The data were given in 12 distribution and scatter diagrams and 11 tables, and were analyzed for information on the test-retest reliability of the instruments, their intercorrelations, the correlation between Otis IQ scores and adaptometer scores, the effect of the hours of sleep obtained in the night preceding the test on the scores, the difference between city-bred men and country-bred men, the relation between eye color and scores on the adaptometers.

Reliability, Test-Retest		NDRC, Model II	Self-luminous Telesilhouette	Hecht-Shlaer
Day_1 vs Day_2	r =	.674	.669	.637
Day_1 vs Means	r =	.814	.808	.753
Day_1 vs Day_2	eta =	.779	.572	.765
Complete Data	eta =	.778	.727	.781
<u>Intercorrelations</u>		NDRC vs Self-lum.	NDRC vs Hecht-Shlaer	Hecht-Shlaer vs Self-lum.
For the means of the scores	r =	.848	.449	.413

The number of cases included in the correlations varied from 90 to 102. Practically zero correlation was found between Otis scores and the adaptometer scores. No significant difference was found between scores preceded by 5 hours or less of sleep and those preceded by more than 5 hours of sleep. The same was true in the cases of city-bred men versus country-bred men and in the cases of brown-eyed versus blue-eyed men.

The author concluded that all the instruments were satisfactorily reliable, that the variability of individuals is such as to preclude reliability coefficients higher than .70. In the matter of intercorrelations the Self-luminous and the NDRC adaptometers were consistently higher than their own test-retest correlations and they were assumed to measure the same variable. However, the variable undergoes diurnal changes in the individual. The Hecht-Shlaer did not correlate significantly with the other instruments. All the conclusions are to be regarded as tentative in nature since data concerning the validity of the instruments are not available.

36. F. C. KEIL. Visual fields in the dark adapted state. U. S. AAF. School of aviation medicine, Randolph Field, Tex. December 7, 1942. (3547) (R)

That there is a central scotoma in the visual field when low levels of illumination prevail is a well known fact. However, not much is known about the variability in its size under different levels of illumination and at different periods in the course of dark adaptation. The purpose of the investigation was to measure central scotomata with two types of scotometers, one described as a dark field and the other described as a bright field.

The dark field consisted of a tangent black screen with a central red fixation light used at a distance of 75 cm. The test object subtending a 45-minute angle was the luminous end of a 14-inch Lucite rod containing a small light source at the other end. Neutral filters and instrument control of the current to the light bulb provided for differential levels of test object brightness. Three levels were selected for the experiment: 4.3, 4.9, and 5.2 log units micromicrolamberts. The scotomata were plotted with chalk directly on the screen. The bright field consisted of a tangent screen of opal glass illuminated from the rear with a light source place 1 meter from it. A small red fixation light was used. The test object was circular and subtended a visual angle of 45 minutes. Four photographs of the experimental set up were provided.

The tests were given with both scotometers following 25 minutes of dark adaptation. The data were given in 1 table, 2 threshold gradient curves and 2 field charts. The average sizes of the scotomata for the different brightness levels were:

Brightness Levels (Log units)	Average size of Scotomata (Degrees)	No. of Cases
Dark Field:		
4.3	9.2	20
4.9	3.9	22
5.2	2.0	22
Bright Field:		
4.3	10.0	1
4.9	9.2	5
5.2	5.0	5

Dark adaptation thresholds were obtained from 17 subjects by means of the Hecht-Shlaer adaptometer, 3° test field. The range of the thresholds was from 3.43 to 2.2 log units with an average of approximately 2.75 log units. One conclusion stated was that the size of the central scotomata for a given illumination varies with the light threshold of the individual, those individuals with high thresholds having large scotomata.

Two subjects were tested along the horizontal meridian with the Hecht-Shlaer, 1° white light test field. The intervals selected were at $2\frac{1}{2}°$ to 20° nasal and temporal fields. The curves indicated that testing the threshold in one isolated area of the retina would not give an accurate estimate of true sensitivity to light.

The general conclusions drawn from the experiments were that the size of the central scotoma normally present in the dark adapted eye increases with decreasing illumination. However, the size decreases with the time allowed for dark adaptation, for a given brightness. The small differences in light thresholds in a normal group are associated with central scotomata of sizes sufficiently different as to be of considerable importance in rating their night visual efficiency. The size of the scotoma for a lighted test object on a dark field is approximately one-half the size of the scotoma for a dark object against a bright field when the brightnesses are approximately equal.

37. ANON. Hopkins night vision test (with radium illumination). U. S. ASF. Adjutant general's office. Classification and replacement branch. December 15, 1942. (3836) (O)

For this test the Hopkins adaptometer was modified by the substitution of light from 4 radium buttons instead of from a battery powered unit. The buttons were mounted on a movable slide inside the viewing box between the subject and the target. The brightness values of the illumination were not measured but were estimated to range from log intensity 4.0 to 1.71 according to the distance of the slide from the target. The latter consisted of 4 black stripes on a white ground. Tests were given to 124 men being trained as truck drivers at Fort Belvoir. The test-retest reliability was reported as .78, for an interval between tests of 21 minutes, and 43 cases.

38. L. S. BEALS and W. S. VERPLANCK. Further report on the testing of efficiency of night vision; comparative reliability and validity measures on the adaptometer and the self-luminous telesilhouette adaptometer. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. January 1943. (3863) (C)

Three adaptometers were used in this investigation to ascertain the relationships between the scores obtained with each instrument, and the kind of effect specific training in night lookout had upon adaptometer scores. The instruments were the Adactometer, the Self-luminous tele-silhouette and the Hecht-Shlaer, R.C.N. model. From the night lookout training two types of scores were obtained: (1) NLO(A), the intensity of the light at which the subjects "spotted" an object on the horizon. (2) NLO(B), the intensity of the light at which the subjects were able to "identify" the object.

The data (condensed) were as follows:

Reliability Test-Retest	Adactometer		Adaptometers	
	Total letters read	"Adaptacuity"	Self-luminous Telesilhouette	Hecht-Shlaer (R.C.N. model)
r =	.901	.878	.761	.636
eta =	.940	.915		

Intercorrelations	Self-lum. Telesilhouette vs Hecht-Shlaer	"Adaptacuity" vs Self-lum. telesilhouette
r =	-.555	.385

The term "adaptacuity" refers to a composite score on the adactometer to which are contributed certain percentage values derived from the other scores obtained by the device (cf. Abstract no. 33).

In the validation phase of the investigation the data were obtained by the interposition of a session of night lookout training between the test and the retest sessions. Correlation coefficients were computed between the scores on the several instruments, test and retest, and the training scores.

Validation Coefficients	Self-luminous Telesilhouette scores vs NLO(A) Scores Test	NLO(B) Scores Test	NLO(A) Scores Retest	NLO(B) Scores Retest
r =	.157	.020	.074	.043

	Adactometer "adaptacuity" scores vs NLO(A) Scores Test	NLO(B) Scores Test	NLO(A) Scores Retest	NLO(B) Scores Retest
r =	.028	.016	-.074	-.055

The conclusion drawn was that the results were entirely negative with respect to the question of the relationship between night lookout training and the results of testing with the adaptometers. The authors stressed the point that the problem of validation of the adaptometers was wide open since it was not at all clear what was being tested by them. Equally negligible were the correlations between adaptometer scores on the one hand and the Otis scores, neuro-psychopathic classification and "emotionality" scores on the other hand.

39. H. K. HARTLINE and R. MCDONALD. Frequency of seeing at low illumination. U. S. NRC-CAM. January 1943. (3553) (O)

The authors referred to the well-known fact that faintly illuminated objects are intermittently seen during a given period of observation. Theories have been advanced to explain the fact, such as fluctuations in the ability of the observer to see, fluctuations of quanta about a mean emitted by light of low intensity, the indeterminate absorption by the retinal elements of the quanta emitted. Whatever the explanation the fact that seeing is uncertain over a range of intensity of approximately one half of a log unit must be taken into account in the determination of a visual threshold. An average of many repeated trials is necessary if any sort of accuracy is to be obtained. An investigation of the frequency of seeing was carried on to determine thresholds for (a) light, (b) large forms, bright, (c) large forms, silhouette, (d) small forms, silhouette, (e) large forms of low contrast. The range of intensities used provided for 100 per cent seeing at one extreme and for 0 per cent seeing at the other extreme. Eleven subjects were tested in 50 experiments. A formula was theoretically developed for the treatment of the data to obtain the "mean threshold." For a given routine of test procedure the standard deviation from the mean threshold can be computed from the "seeing curve" and makes possible the design of test procedures to yield whatever accuracy of measurement may be required.

40. W. M. ROWLAND. A small light threshold meter. U. S. AAF. School of aviation medicine. Randolph Field, Tex. January 23, 1943. (3828) (O)

To facilitate the use of the instrument previously described in a report dated July 22, 1942 (cf. Abstract no. 30), small changes in construction were made. They consisted of the addition of a notched marker with which the operator could determine with accuracy the position and orientation of the target object. Also added was a string to be looped around the neck of the subject in order to maintain constant the test distance of 13 inches from the instrument to the eye of the subject.

41. E. A. PINSON and A. CHAPANIS. Form discrimination at low illuminations. U.S. AAF-ATSC. Engineering division. Aero medical laboratory. February 5, 1943. (3813) (O)

A study was made of the test-retest reliability of the AAF-Eastman Night Vision Tester (model 1). The instrument was described in a report dated January 29, 1942 (cf. Abstract no. 17). The test object was a Landolt ring which was presented in one of eight positions. A complete test consisted of 32 stimulations, i.e., 8 at each of 4 levels of brightness. Thirty-three subjects were employed in the investigation, each being given 10 tests separated on the average by approximately 3 days. The interval between the first and the tenth tests was almost exactly a month. The variables in the experiment were listed in the following table:

Test	Size of Test object	Viewing Distance	Levels of Illumination Log units micromicrolamberts			
1	37½'	20 feet	3.6	2.0	1.0	.43
2	37½'	20 feet	3.6	2.0	1.0	.43
3	37½'	20 feet	3.6	2.0	1.0	.43
4	30'	24 feet	3.6	2.0	1.0	.43
5	30'	24 feet	3.6	2.0	1.0	.43
6	1°	12 feet	.6	.33	.165	.07
7	1°	12 feet	.6	.33	.165	.07
8	2°	9 feet	.07	.035	.016	.008
9	2°	9 feet	.07	.035	.016	.008
10	37½'	20 feet	3.6	2.0	1.0	.43

The data were contained in 3 tables. Product-moment correlations between scores with the different sizes of test objects and different illumination were computed. In condensed form the correlation coefficients were as follows:

	TESTS									
Reliability	1 vs 2	2 vs 3	3 vs 4	4 vs 5	5 vs 6	6 vs 7	7 vs 8	8 vs 9	9 vs 10	1,2 & 3 vs 10
r =	.82	.87	.70	.80	.65	.76	.75	.77	.62	.63 to .64

To account for the smaller correlations between the first three and the tenth tests, it was conjectured that there were unequal effects of training in the intermediate six tests, together with manifested boredom on the part of the subjects doing the same tests over and over again. The coefficients of correlation between the first three and the fourth through the ninth tests showed the following ranges:

Reliability	Tests 1, 2, and 3 vs Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Range of r =	.70 to .78	.80 to .80	.55 to .65	.46 to .63	.50 to .57	.43 to .47

The correlations between scores obtained with various sizes of test objects were all positive and significant. For practical night vision testing the size appears to make but little difference. An individual who makes a score good or inferior on one test under the conditions of the experiment would be likely to make a similar score on another test under the same conditions.

42. F. C. KEIL. Use of red light to facilitate dark adaptation. U.S. AAF School of Aviation Medicine, Randolph Field, Texas. February 19, 1943. (3579) (R)

The purpose of the study was to discover if illumination of ready rooms with red light was a simpler method of shortening the time required for dark adaptation than the use of red adaptor goggles. A 40-watt ruby bulb was used with the light reflected down to a white surface 36 inches square. Each subject was required to read printed material for 20 minutes. The rate of dark adaptation was measured with a Hecht-Shlaer adaptometer, 3^{o} test field, violet light.

Six subjects were tested and a composite curve of the data given. The average time required to adapt to within .2 log units micromicrolamberts of the threshold to light was 6 minutes following 20 minutes exposure to the red light. This did not differ materially from the time required when red goggles were worn. It was concluded that goggles have no advantage over red illumination. They are expensive to produce and cause discomfort in wearing. For these reasons the use of red illumination instead of red goggles is suggested.

43. W. S. VERPLANCK and D. T. REED. A report on the test-retest reliability of the Admiralty Mark I adaptometer. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. March 1943. (3872) (C)

Twenty-seven men, restricted to quarters at the time, were tested and retested with an interval of 48 hours in between. The correlation obtained was .63. A brief description of the instrument was given. It was judged to be an awkward device to use and too much time was consumed in giving the test.

44. W. S. VERPLANCK and D. T. REED. A report on the test-retest reliability of the Wright adaptometer. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. March 1943. (3874) (C)

In this study the subjects were the same as those used in the study of the Admiralty Mark 1 adaptometer (cf. Abstract no. 43). The test objects were cards of different degrees of reflectance viewed from a distance. The score was the number of the card of lowest reflectance seen three out of four trials. A correlation of .33 was obtained between test and retest with 48 hours' interval. The instrument did not yield the desired spread of scores and was judged to be unreliable.

45. W. S. VERPLANCK and D. T. REED. A report on the test-retest reliability of the Miles four-plaque adaptometer. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. March 1943. (3873) (C)

Tests with this adaptometer were given to 28 men and retests were made after an interval of 48 hours. The mean score for test one was 35.7 and for the retest it was 38.9. The correlation obtained was .57.

46. W. S. VERPLANCK. A rapid procedure for testing night vision. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. March 5, 1943. (3869) (C)

Implicit in the use of adaptometers for the purpose of selecting personnel with respect to night vision is the question of how the scores are to be used. Among other methods employed have been the determination of final rod thresholds, the frequency of seeing distributions, etc. The author argued against the idea of the necessity and desirability of distributing the scores of a population on the ground that the tests had not been validated, at least with respect to naval night lookout efficiency. Only scores indicating high thresholds of night vision have functional significance since they indicate men with inferior night seeing ability. Furthermore, the Service requirements, especially on submarines, make it imperative that almost every man in the crew be available for lookout duty. The problem of selection therefore becomes one of the determination

48\. R. TOUSEY. Effectiveness of photoflash lamps for destroying dark adaptation. U. S. Navy. Naval research laboratory. March 30, 1943. (3599) (C)

The problem was to ascertain the duration of the blinding effect of flashes of light produced by 25 photoflash bulbs (No. 50 G.E.) placed in a compact square pattern, 14½ inches side dimension. Three black paper plane silhouettes were placed on a white screen, simulating the tail view of a 70-foot bomber. Viewed from a distance of 12 feet the sizes of the silhouettes corresponded to the appearance of the bomber at 300, 150, and 75 yards respectively. The illumination on the screen was varied from 2.5 through 2.0, 1.5, and 1.0 log units millimicrolamberts simulating conditions of rather dark moonlit sky, clear starlit sky, dark overcast sky, and very dark sky backgrounds. A red fixation light was provided for the flash exposures but no fixation points were provided for viewing the target (plane) figures. Binocular vision was employed by the 8 subjects used in the investigation. Measurements of the time required for the subjects to see the three target figures in succession following the flash exposures were made.

The following data indicate the blinding times, i.e., the recovery times from the effect of the flashes when the background was log 2.0 (clear starlit sky).

Distance to plane	Distance to the flash		
	75 yards	150 yards	300 yards
Yards			
300	9 secs.	3.75 secs.	Less than 1 sec.
150	5 secs.	2 secs.	Less than 1 sec.
75	3 secs.	1 sec.	Less than 1 sec.

The average recovery times were longer at the shorter distances to the flash for all the distances to the plane figures, and the three curves of recovery times for the several distances to the plane end practically at the same point, i.e., less than 1 second. When the distances to flash and plane figures were equal the data on the recovery times for the several brightnesses used were as follows:

Log brightness	75 yards	Distance 150 yards	300 yards
2.5	1.75 secs.	.3 secs.	.2 secs.
2.0	3.0 secs.	2.0 secs.	.25 secs.
1.5	4.5 secs.	4.0 secs.	
1.0	12.0 secs.	8.0 secs.	

49\. E. O. HULBERT. Report on dark adaptation; time to become dark adapted after stimulation by various brightnesses and colors. U. S. Navy. Naval research laboratory. March 30, 1943. (3600) (R)

The investigation was planned to ascertain the times required to become dark adapted after exposure to various colors and brightnesses. The experimental set up consisted of 2 white screens of approximately 70 per cent reflectivity and 2 sources of illumination. One of the screens was designated the stimulation screen and was about 3 feet square. The other was about 4 feet square on which were 2 circular black spots with diameters of 16 and 6 cms respectively. This was designated the sky screen. The stimulation screen was illuminated with various colored lights at 2 brightness levels, viz., 1 foot candle and 6 foot candles, and the illumination on the sky screen was 8 milli-micro-lamberts. The observer, after becoming dark adapted, was stimulated by light from the screen at a distance of about 1 foot for 3 minutes. He then extinguished the light and shifted his gaze to the sky screen which was 10 feet distant. He was required to indicate the time in which he saw the screen and the larger and the smaller black spots on the screen. At the prescribed distance of 10 feet the angles subtended by the screen and the black spots were about 24, 3 and 1 degrees respectively.

The data reported are for one observer:

Color	Wave Length	Brightness level 1 foot candle 24°	3°	1°	6 foot candles 24°	3°	1°
		Time (Seconds)			Time (Seconds)		
Red	650	25	80	230	65	110	260
Red	630	30	90	240	70	120	270
Yellow	589	40	100	250	90	160	310
Green	546	70	180	320	130	300	450
Blue-green	520	95	310	460	180	430	580
Blue	436	250	500	650	285	650	800
White		70	180	320	130	300	450

The values in seconds for the mercury green light, wave length 546, are identical with those for the white tungsten light. It was noted that the time to become dark adapted increased with the progressively shorter wave lengths used. When ultra-violet light of 366 wave length was used the time required to see the screen and the black objects at both 1 and 6 foot candles levels was given as 5 to 10 seconds. A comparison was made between the dark adaptation times following stimulation with equal illuminations of white tungsten light and red light, wave length 650, through a series of stimulating light levels from .1 foot candle to 1000 foot candles. A complete table of data showing the times required for the observer to see the 24, 3 and 1 degree targets after stimulation by white light and red light was given. The data below are for the 1 degree spot target only:

Foot candles	White light Seconds	Red light Seconds	White minus Red Seconds
.1	230	210	20
1.0	320	230	90
2.0	360	240	120
4.0	410	255	155
6.0	450	260	190
10.0	570	280	290
14.0	720	290	430
20.0	1080	305	775
120.0	21 minutes	7 minutes	14 minutes
1000.0	40 minutes	—	—

The difference in time required to see the 1 degree spot was relatively slight for the lowest level but it increased quite rapidly in favor of red light over white light as the stimulating illumination increased in intensity.

The author pointed out that the course of dark adaptation following the stimulation was not always smooth. After images and nebulous clouds made the detection of the 3 degree spot target difficult, although the 24 degree screen target came into view rather steadily. The values in the tables were averages of those observations which seemed to be free from too great disturbances due to optical spasms, after images, and floating clouds.

50. R. H. PECKHAM. Report on analysis of reliability of various adaptometers. U. S. Navy. Naval air training base. Pensacola, Fla. April 5, 1943. (3854) (O)

Data obtained at New London and Pensacola were analyzed to determine the proportions of men failing a second test who had either passed a first test or had failed a first test. Eight adaptometers had been used in the accumulation of the data. The instruments were classified with respect to reliability as follows: The adactometer, the Navy Telesilhouette, the Hecht RCN Model and the Wright adaptometers were stable. The Hecht-Shlaer and the Admiralty, Mark 1, were promising. The Miles four-plaque and Rotating Telesilhouette were unstable. The Adactometer, scores in terms of the total number of letters read, showed the most reliable selection possibilities. The next best instrument was the Navy Telesilhouette.

51. R. H. LEE. Growth curve of light adaptation. U. S. National institute of health. Division of industrial hygiene. April 8, 1943. (3585) (R)

The purpose of the investigation was to measure the change in the state of adaptation after exposure to white light 50 millilamberts brightness value for various periods of time. Four subjects were tested twice at each of the exposure periods: .5, 1, 3, 4, 6, 8, 15, 30 minutes. Curves of dark adaptation were drawn in the usual manner by plotting log intensity values against time in the dark. Those obtained from the .5 and the 1 minute exposure periods started lower, dropped more sharply and reached lower threshold values than the others. The curves of light adaptation were obtained from the data by plotting log I minus log thresholds against the exposure durations. They show a sharp rise for the range .5 to 6 minutes durations followed by a slower rise through the 8 and 15 to the 30 minutes exposure durations. The state of adaptation depends on the duration of exposure to a light source as well as on the brightness of the source.

52. A. P. WEBSTER. The measurement of thresholds of perception and discrimination. U. S. Navy. Bureau of medicine and surgery. April 19, 1943. (3555) (O)

In studies involving the use of stimuli of various types the determination of the thresholds of response is of great importance. A threshold was defined as that value, in the appropriate physical units, which will just produce perception or discrimination in 50 per cent of the presentations of the stimuli. An implication of the definition is the "frequency of seeing" curve and methods of deriving from it the required data on the threshold. A formula for the correction of forced guessing in responses was given. $C = R - p/qW$, where "C" means the correct number, "R" means the number of right responses at a given level, "p" means the probability of correct responses by chance, "q" means the probability of wrong responses by chance, and "W" means the number of incorrect responses. The percentage of discrimination or perception was expressed by the formula: $P = c/f\ 100$, where "f" means the total exposures made at a given level. The procedure of determining thresholds in several different fields of sensory perception was illustrated. Two methods were used, the double integral method and the single value method, the appropriate formulae being given for each method.

53. W. M. ROWLAND and L. S. ROWLAND. Aspects of night visual efficiency. U. S. AAF. School of aviation medicine, Randolph Field, Tex. May 1, 1943. (3830) (C)

The purpose of the investigation was to ascertain the relationships between (a) the ability to perceive light, (b) the ability to locate an object viewed against a dimly illuminated background, and (c) the ability to locate and identify an object under the same conditions. The instrument used throughout the experiments was a projection lantern provided with neutral filters and a series of slides. The test field was either a light square subtending a visual angle of $9^{\circ}\ 10'$ or a similar square containing a silhouette image of an airplane. Brightness values of the test field ranged from 5.75 to 2.75 log units micromicrolamberts. The viewing distance was 10 feet and 103 subjects were used.

The data were given in 1 figure and 5 tables. The average minimum light intensities required by the subjects were as follows:

	To "see" light square	To "detect" object in the square	To "identify" detail, i.e., direction of the air plane.
Mean thresholds (log units)	3.25	4.25	4.50
S.D.	.30	.28	.36

A comparison was made between these data and some data on night sky brightnesses. On clear or moderately cloudy moonless nights the latter range from 4.4 to 5.2 log units. According to the results of these experiments the majority of normal subjects could detect or locate the object in the brightness of 4.4 log units and discriminate details in the brightness of 5.2 log units. However, since the sky brightness on moonless nights with clouds or fog is approximately 4.1 log units, the majority of the subjects in the experiment would be unable to detect the object and very few would discriminate details of direction in the object in such a brightness.

Retests were given to 39 subjects. The results were given in terms of the mean thresholds:

Mean thresholds (log units)—39 subjects			
	To "see" light square	To "detect" object	To "identify" direction
Test 1.	3.26	4.30	4.95
Test 2.	3.28	4.23	4.81

No evidence of improvement due to practice was evident, but it was noted that the responses of the subjects were made more rapidly in the second test than in the first.

The relationship between the three tests was shown in terms of correlation coefficients. There were two extreme cases included in the group of subjects and the figures given are for the entire group and for the group minus the two cases:

Coefficients	Light threshold vs Location (Form)	Light threshold vs Discrimination (Form)	Location (Form) vs Discrimination (Form)
N = 103 r =	.51	.40	.70
N = 101 r =	.29	.22	.63

It was concluded that the light threshold was not as closely related to either location or discrimination thresholds as were the latter to each other.

54. R. H. LEE. Determination of effect on dark adaptation of varying intensities of illumination in ready rooms. U. S. Navy. Naval medical research institute. June 2, 1943. (3596) (R)

To determine the effectiveness of goggles for the restoration of dark adaptation which has been lost, a study was made with 4 subjects under the following conditions: Red goggles were worn for 10 minutes and an additional 10 minutes spent in complete darkness. The room was then lighted at the desired level and printed material read for 30 minutes. Then red goggles were worn and reading continued for 30 minutes (first series) and 45 minutes (second series).

The light was then extinguished, the goggles removed and the course of dark adaptation measured. In series one, the room brightnesses were 50.0, 20.65, 12.50, 5.50 millilamberts. With 30 minutes exposure while wearing the goggles the time required to reach .2 log unit above the final threshold was in the order of 16 minutes, 12 minutes, 10 minutes and 7 minutes for the corresponding order of decreasing room brightness. In series two, the room brightnesses were 50 and 20.65 millilamberts respectively. The time required to reach .2 log unit above the final threshold was 9 minutes and 2 minutes, following 45 minutes exposure while wearing the goggles.

The data presented led to the conclusion that the only combination giving adequate visibility and rapid recovery of dark adaptation is that in which the goggles are worn for 45 minutes in a room brightness of 20.65 millilamberts. Three recommendations were made: (a) that ready rooms be lighted to an average of 20-30 foot candles, (b) or that a lower intensity supplemented by local lighting be used, where needed, and (c) that goggles be worn for a minimum of 45 minutes to ensure a state of proper dark adaptation. Note: The third recommendation was revised in a subsequent report (cf. Abstract no. 62).

55. R. H. LEE and M. B. FISHER. Physical and physiological calibration of NDRC model III adaptometer. U. S. Navy. Naval medical research institute. June 4, 1943. (3856) (R)

A complete examination was made of several instruments of this model with respect to the design and the degree of deviations from the specifications provided. They were not recommended for use except in situations where the necessary facilities for the control of calibrations were available.

A performance comparison between the NDRC model III and the Miles 4-plaque adaptometer was made with 22 subjects. The correlations between the scores on the two instruments were:

Intercorrelations	NDRC Model III (3.7 log units) vs Miles 4 Plaque (3.6 log units)	NDRC Model III (3.7 log units) vs Miles 4 Plaque (3.9 log units)
r =	.45	.60

The conclusion was stated that the correlations were not high but they indicated that the two tests were measuring substantially the same function.

56. W. S. VERPLANCK. A report on the NDRC model III adaptometer. U. S. Navy. Submarine Base, New London, Conn. Medical research laboratory. June 7, 1943. (3870) (C)

Several copies of this model were used in a program of night vision testing of personnel of the U.S.S. New Jersey. On the basis of extensive experience with the adaptometer a comprehensive report was made of its general characteristics, both with respect to its design and to its use as a testing device. Several mechanical defects and problems of calibration were described in detail.

57. C. W. SHILLING and W. S. VERPLANCK. Night vision testing of the crew of the U.S.S. New Jersey. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. June 25, 1943. (3867) (C)

As a part of a full scale program of personnel classification provision was made for an extensive program of night vision testing of the crew. A primary purpose was to select personnel with superior night vision for the L division, which had cognizance of all surface and horizon look outs. Another purpose was to disqualify, for night duties, those men in the Gunnery Department whose night vision did not meet certain minimal standards.

For the L division 54 men had already been assigned, but not on the basis of the 3 criteria set up as desirable for test purposes, which were superior visual acuity, superior night vision, and intelligence as measured by G.C.T. scores in the lower middle range, approximately in the IQ range 85-105. In a night vision test of the 54 men by means of the NDRC model III adaptometer the final classification was:

41 men classified as superior,
7 men classified as passed,
6 men classified as disqualified.

Another group of 772 men in other divisions of the ship's complement was tested with the same instrument. The final classification was:

288 men classified as superior,
347 men classified as passed,
137 men classified as disqualified.

The 288 men classified as superior with respect to night vision were further classified with respect to visual acuity and intelligence. When the three criteria were used as the basis of selection, it was found that 95 men out of the 288 were qualified for inclusion in the L division, i.e., for night lookout duties.

The authors concluded that a night vision testing procedure was feasible, that retests were desirable, and that better methods of testing visual acuity were necessary.

58. C. W. SHILLING and W. S. VERPLANCK. Report on night vision testing of the crew of the Battleship New Jersey,—incidental data of interest. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. July 3, 1943. (3868) (C)

The data given in the report supplemented those previously given in a report dated June 25, 1943 (cf. Abstract no. 57).

In the course of night vision testing the subjects were questioned as to their general feeling of fitness, the amount of sleep obtained in the night preceding the test and alcohol consumption. The answers given by the men were negative with respect to the classifications given them on the basis of adaptometer scores. The table below is an example of the results obtained:

Classification	"Feeling well"		"Not feeling well"	
	N	%	N	%
Superior	278	96.5	10	3.5
Pass	340	98.1	7	1.9
Disqualified	133	97.1	4	2.9

A comparison was made between measurements of visual acuity by means of standard charts and NDRC model III adaptometer scores, or classifications made on the basis of the scores. The data were presented in a condensed table as follows. The results were said to be only suggestive since a chi square test for significance showed one chance in two that the relationship indicated between visual acuity and night vision is significant.

Classification	VA 20/15 or better Both Eyes		VA 20/20 or less Either Eye		Total	
	N	%	N	%	N	%
Superior	240	43.7	30	32.3	270	42.1
Pass	226	41.2	38	40.9	264	41.1
Disqualified	83	15.1	25	24.8	108	16.8

During the course of testing, it became clear that a modification of the test procedure should be made. At first a brightness level of 4.08 log units micromicrolamberts was used. Those men who obtained complete correct scores at this level were further tested at two lower levels, approximately 3.85 and 3.70 log units respectively. It was at the lowest level that the men ceased to make perfect scores as a general rule. The modified procedure provided for a routine schematized as follows:

Cumulative no. of trials	Score obtained	Classification group	Additional trials to be given
10	10	Superior	None
10	Below 10		10
20	16 to 19	Pass	None
20	13 to 15		10
20	Below 12	Disqualified	None
30	23 or more	Pass	None
30	Below 22	Disqualified	None

The reliability of the procedure was determined by means of the product-moment correlation technique. The results obtained were as follows:

Correlation	Number correct First 10 trials vs Second 10 trials N = 253	Number correct Second 10 trials vs Third 10 trials N = 68
r =	.56	.64

The conclusions indicated that the procedure was entirely adequate for the purpose of disqualifying men whose visual performance at low brightnesses is not good. Some men who can perform satisfactorily might be disqualified but the "waste" would not be prohibitive. Obviously it would be desirable to retest all subjects making low scores on the initial test. The procedure was not too satisfactory as a means of picking a superior group.

59. ANON. Night vision testing. U. S. Navy. Atlantic Fleet. Amphibious training base, Camp Bradford, Norfolk, Va. August 23, 1943. (3848) (C)

On the basis of the recognized importance of the selection of men with superior vision a Board was authorized and set up to prescribe and standardize night vision tests for personnel in Amphibious training bases and for landing craft operations. Specifications for the construction of test chambers, clock dial test, and the illumination of the test objects were described in detail.

Instructions on the test procedure, including a lecture on the necessity of learning to use the eyes properly to secure the maximum night visual efficiency, were also given. It was indicated that the visual problems of the amphibious forces differed markedly from those in other commands. Only a small number of men with the keenest night vision were to be selected for special duties. For other types of work, including submarine duty, the test should be made easier by increasing the amount of illumination falling on the test objects. As described, the test was said to pass over 75 per cent of the men tested.

60. C. W. BRAY. Report on the use of selective tests aboard the U. S. S. New Jersey. U. S. OSRD-NDRC. Applied psychology panel. August 31, 1943. (3877) (R)

This was a complete account of the program of personnel classification of the ship's complement. Section IV, pages 11-12 contain data substantially identical with those reported by Shilling and Verplanck. (Cf. Abstract no. 57).

61. W. M. ROWLAND. A small light threshold meter. U. S. AAF. School of aviation medicine, Randolph Field, Tex. September 13, 1943. (3548) (R)

A description of a revised model of an adaptometer previously described (Cf. Abstract no. 30). The recommendation was made that it be called the SAM Portable Night Vision Tester.

62. R. H. LEE, M. B. FISHER and J. E. BIRREN. Determination of effect on dark adaptation of varying intensities of illumination in ready rooms: newly discovered fluctuations of periodic nature occurring in dark adaptation thresholds. U. S. NRC-CAM. September 24, 1943. (3589) (R)

To confirm or disprove a previously made recommendation that dark adaptation goggles be worn for a period longer than 30 minutes an experiment was carried on with 6 subjects (cf. Abstract no. 54). During the evaluation of data obtained in this experiment, and in the previous one, the occurrence of certain wave like fluctuations in log intensity readings were noted. The fluctuations had a periodicity of 3 to 7 minutes during the course of dark adaptation and an irregular amplitude from .05 to .25 log units. They were found in all dark adaptation thresholds below the highest levels. They make the quantitative treatment of data very difficult and may account for the conflicting reports of dark adaptation measurements. In the light of the new data the authors concluded there was no advantage to be gained by wearing dark adaptation goggles longer than 30 minutes.

63. E. A. PINSON. Night vision testing program. U. S. AAF-ATSC. Engineering division, Aero medical laboratory. September 29, 1943. (3815) (O)

A report of official visits made by the author to several centers where night vision testing was being carried on. Data given indicated that approximately 50,000 potential aviation cadets and gunners had been tested by means of the AAF-Eastman night vision tester. Percentage distributions in the classification system showed the following: (Table on page 53). The breakdown of the data for the several classification centers and gunnery schools showed general comparability of results obtained with the exception of one station, where a considerably higher percentage of men were classified unsatisfactory than was the case at the other stations. It was also noted that there was a higher percentage of "unsatisfactory" in the gunnery schools than in the

Classification	Cadets %	Gunners %
Above average	18.0	15.6
Average	50.0	45.6
Below average	30.1	32.6
Unsatisfactory	1.9	6.2

classification centers. The reason for the difference was said to be due to variable motivating factors. It was surmised that the gunners, not being volunteers, had little or no desire to do well on the night vision test. Mechanical difficulties in the operation of the instruments were described.

64. P. R. MCDONALD. The reliability of the AAF night vision tester. U. S. AAF. School of aviation medicine. Randolph Field, Tex. November 10, 1943. (3831) (R)

In a study of the reliability and the practice effects in tests with the AAF-Eastman night vision tester, 85 subjects were given 4 tests each. The mean difference between test one and test two was 3.72 and that between test one and test four was 4.4. The correlation between test two and test four was r = .797. The practice effect was greatest between tests one and two. Subsequent tests are of little value. It was recommended that individuals who fail the first test with the AAF-Eastman night vision tester be given a second test.

65. W. S. VERPLANCK, G. E. WATSON and D. T. REED. Field tests of the radium plaque adaptometer. U. S. Navy. Submarine base, New London, Conn. Medical research laboratory. November 26, 1943. (3875) (O)

Two radium plaque adaptometers were used in tests given to 491 subjects. Trials were made according to the 10-20-30 procedure of administration. The percentage distribution was 78.2 per cent of the men passed, 9.3 per cent were doubtful, and 12.5 per cent failed. The results were said to be closely comparable to those obtained with other adaptometers where the same brightness level and the same test procedure were used. A retest was given to 22 men who failed in the first test. A chi square of 2.93 was obtained but an estimate of the probability of chance occurrence was not given.

66. E. A. PINSON and A. CHAPANIS. Tests of dark adaptation and night vision: their reliabilities and intercorrelations. U. S. AAF-ATSC. Engineering division. Aero medical laboratory. December 17, 1943. (3816) (O)

This report was an extension of an earlier one dated February 5, 1943 (Cf. Abstract no. 41). There were available for this investigation 24 men who had previously been tested 10 times with the AAF-Eastman, Model 1, night vision tester and they were given an additional series of nine tests with the same instrument. The same subjects were given 2 tests each with the Johnson Foundation Luminous Plaque, the Luckiesh-Moss Low Contrast Test Chart and the Hecht-Shlaer (NDRC) Portable Adaptometer. An entirely different group of 24 subjects was tested 3 times with the AAF-Eastman Model 2 night vision tester which had a 2° Landolt-ring test object.

The data were contained in 8 tables in terms of test-retest correlations and intercorrelations between the instruments. The results which are shown in the following table were derived from the scores made by the first group of 24 subjects. It should be noted that the size of the test object in the AAF-Eastman night vision tester varied from $30'$ through $37\frac{1}{2}'$ to 1° and 2°, with variable viewing distances and different levels of illumination. The several correlation coefficients obtained were:

Reliability Test-Retest	Size of Test Object			
	30'	37½'	1°	2°
r =	.81	.90	.91	.81

The intervals between tests and retests were not of uniform duration. When the interval was approximately 1 month the coefficients ranged from r = .60 to r = .76, average r = .66. When the interval was approximately 2 months they ranged from r = .58 to r = .70, average r = .64. The reliabilities of the other instruments used in this part of the investigation were reported as follows:

Reliability Test-Retest	Luckiesh-Moss Chart	Hecht-Shlaer Portable (Light)	Johnson Foundation Luminous Plaque	Hecht-Shlaer Portable (Form)
r =	.81	.64	.61	.48

Because of the small number of cases involved it was stated that the differences between the coefficients cannot be considered significant.

The other group of 24 subjects tested 3 times in succession with the AAF-Eastman, Model 2, gave scores which averaged 25.5, 24.9 and 27.7 for tests 1, 2, and 3 respectively. The coefficients of correlation were:

Reliability	Test 1 vs Test 2	Test 2 vs Test 3	Test 1 vs Test 3	Average 3 Tests
r =	.76	.76	.53	.68

On the basis of the results the size of the test object in the Model 2 was reduced from 2° to 1°.

The instruments did not correlate highly with each other. The closest relationship found was between the AAF-Eastman and the Johnson Foundation Luminous Plaque. One conclusion stated was to the effect that agreement can be expected between tests of rod vision and between tests of cone vision but not between the former and the latter.

67. R. H. LEE. Comparison of rates of dark adaptation under red illumination and in total darkness. U. S. Navy. Naval medical research institute. December 20, 1943. (3598) (O)

The investigations reported in this article were designed to check the validity of conclusions stated by Miles (Fed. Proc. 2 1943) and in British sources that red light has an accelerating effect on the rate of dark adaptation, and that terminal thresholds are lower after a period of exposure to red light than they are after a similar period spent in complete darkness.

Two series of experiments were made. In series one, 4 subjects gave dark adaptation curves under normal conditions. These curves served as control data. The subjects were then given intermittent exposures to red light of .87, .28, and (approximately) .001 millilamberts respectively, following which the dark adaptation curves were obtained. The data were presented in terms of the mean performance in both control and experimental tests, i.e., log intensity red minus log intensity control. In series two, 6 subjects were tested under control conditions and also with continuous exposure to red light of .3 millilamberts. In series one, the results indicated that the thresholds were appreciably higher with red light of .87 and .28 millilamberts, and very slight negative values were found with red light of approximately .001 millilamberts. In series two, the results indicated that mean thresholds were higher following continuous exposure to red light of .3 millilamberts, i.e., the red light delayed the recovery of dark adaptation. No measurable accelerating effect of exposure to red light was discovered.

68. W. M. ROWLAND. The SAM portable night vision tester. U. S. AAF School of avaiation medicine. Randolph Field, Texas. January 14, 1944. (3829) (O)

Instructions on the use of the instrument. They consisted of the details of setting up the device on a rigid box and a method of determining the position to which the test object was rotated when in use in the test situation.

69. R. H. PECKHAM, H. WEST and C. E. HENRY. Methodology in determining scotopic flash limens. U. S. Navy. Naval air training base. School of Aviation medicine. Pensacola, Florida. January 18, 1944. (3556) (O)

The primary objective of the investigation was to ascertain which one of the currently used psychophysical methods was most applicable to the determination of scotopic flash limens. The authors discussed in some detail the problem of the limen and indicated that it is by no means a simple one. The definition of the limen depends on the properties of the retina in response to very dim illumination. It can be assumed that there will be failure to respond when brightnesses of very low value are used and that response is practically certain when higher brightnesses are used. However, there will be a brightness which yields equal probability of response or no response. This is defined as the 50% limen. A method of depicting the probability of seeing given brightnesses is available in the cumulative frequency curve. If the curve is the integral of a normal distribution curve it will be symmetrical about its point of inflection coincident with the 50% ordinal value. In addition to the definition of the limen the following factors are indispensable in comparisons of absolute liminal values; retinal area stimulated, photopic color of the stimulus, duration of the stimulus, form of the stimulus.

In the experimental part of the investigation the Hecht-Shlaer model 1 adaptometer was used with the T forms removed. Forty-one subjects in groups of from 9 to 13 were examined for their scotopic flash limens. The stimulus was given within the liminal range in three methods designated 1, the method of random stimuli (mutable method), 2, the method of constant differences (method of limits), 3, the method of constant stimuli (single brightness). The data obtained were presented in 24 tables and 4 figures. The methods of treating the data included the analysis of the frequency of seeing curve for the single brightness method, and the use of graphic solution, the use of arithmetic probability scales and the use of computation from formulae for the multiple stimulus level methods.

On the basis of the results it was concluded that the method of limits has the superiority over the others. Its advantages are ease of application, greater symmetry and highest test-retest reliability, rho = .63. The single brightness method showed poor test-retest reliability, rho = .31, and the mutable method had a test-retest reliability of rho = .55. The mutable method has an advantage in that it "supplies asymmetry for study of quantum theory, especially when modified." The single brightness method cannot be used except for gross classification and even this use is dubious.

70. W. M. ROWLAND and J. MANDELBAUM. A comparison of night vision testers. U. S. AAF School of aviation medicine. Randolph Field, Texas. January 26, 1944. (3832) (R)

A comparative study of three adaptometers was made. They were the AAF-Eastman, the SAM portable and the Hecht-Shlaer, model III. The objective of the study was to define scores for the instruments so that classification on one would be comparable to the results on the others.

Initial standards for classification as superior, satisfactory and unsatisfactory, for each instrument, were used for the classification of over 200 men tested. Considerable discrepancy was noted although the largest number of the men were placed in the satisfactory or average group. For example, it was found that of 55 cases classified unsatisfactory by the AAF-Eastman adaptometer, with a 1 degree object and a brightness of 6.25 log units micromicrolamberts, 2 were classified unsatisfactory, 48 were satisfactory and 5 were superior by the SAM portable adaptometer. From this it was concluded that the 1 degree Landolt target and the maximum brightness level of 6.25 log units made a test too difficult for many subjects with normal vision and hence were classified as unsatisfactory. The results of a test made with the target changed in size from 1 degree to 2 degrees, the maximum brightness changed from 6.25 to 5.7 log units and a modification made of the classificatory standards were more commensurate with the results from the other instruments. A revised scoring system for each adaptometer was worked out and recommended for adoption.

71. L. O. ROSTENBERG. Night vision studies. U. S. AGF. Field artillery school, Fort Sill, Oklahoma. Department of gunnery. February 17, 1944. (3834) (R)

The voluminous report, consisting of 120 pages, covered the period August, 1943 to February 10, 1944, during which time several series of investigations were carried on to determine the most efficient means whereby personnel in Field Artillery units could be classified with respect to their ability to see at night and appropriate assignments made for night operations and night combat. A preliminary survey which was made failed to disclose a satisfactory night vision test for field troops. Inasmuch as the problems encountered in the Field Artillery and other Ground Forces were materially different from those in other branches of the Armed Forces not too much reliance could be placed on studies made elsewhere.

An experimental night vision tester was made and designated NVX model. Variants of the model were used in a series of tests, numbered NVX1 through 16, in which the size of test object, the character of test object, the character of test object and brightness levels of illumination were changed in accordance with the design of the specific test being investigated. Throughout this series the source of the illumination was a light bulb connected with an ordinary line current through appropriate control instruments. In another series of investigations a battery operated night vision tester was used to determine its effectiveness for use in the field. The series was designated NVT 14, NVT 15, NVT FS and NVT PB. The characteristic of NVT FS was a projector attached to the device to explore the practicability of film strip. NVT PB was made up of a salvaged packing box. Another variant of the tester was developed in which the source of illumination was a radium plaque. This was named NVT R2. In the descriptions of the several tests given by means of the variants of the tester full details of the size and character of the test objects are given along with details of test procedure used. The levels of illumination in terms of foot lamberts for all observations made in all series were listed in an appendix. In addition to the above mentioned night vision tester, and its variants, tests were made with the Feldman Adaptometer and the Luckiesh-Moss Low Contrast Test Chart. All were indoor or laboratory tests.

For the purpose of testing men outdoor and to obtain data on criteria for validation three tests were used. The first was one described in Training Circular 44-1942. With two modifications of it made for experimental purposes the series was designated TC 44-I, TC 44-II, and TC 44-Z. The essential features in each case were a black background and a white target placed thereon, the whole being set up in a grove of trees. The score was the distance from the target at which the position or orientation of the white form against the black ground could be just identified. The other two outdoor tests were designed and built by the research staff. In the first of these a walking obstacle course in the shape of a horseshoe containing 30 objects was set up and named Validity Test Course, Observation Test I. The second was also a walking obstacle course set up in a natural terrain area, indeterminate in shape and containing 10 objects placed at irregular distances from arbitrarily chosen starting points. This test was named Observation Test II. The scores were the total yardage necessary to perceive an object and also to recognize or identify it.

A large quantity of data was obtained in the entire series of investigations and presented in tables and figures. Considerations of space forbid the inclusion of more than a few examples in this abstract.

Reliabilities	NVX-1 vs NVX-1	NVX-2 vs NVX-2	NVX-3 vs NVX-3	NVX-4 vs NVX-4	NVX-13 vs NVX-13	NVX-16 vs NVX-16	NVT-15 vs NVT-15
r =	.85	.85	.84	.93	.90	.90	.91

The correlation coefficients between the several items in the NVX series, 1, 2, 3, 4, 13, 16 ranged from r = .46 to r = .93, average r = .83. A comparison of NVT-15 with other tests yielded the following:

Reliability				NVT-15 vs			
	NVX-1	NVX-2	NVX-4	NVX-13	NVX-16	NVT-FS	NVT-PB
r =	.75	.87	.83	.85	.75	.74	.76

One group of 99 men was tested with NVX-13 and retested after an interval of approximately 3 days. Forty presentations of the stimulus were given in each test. The reliability coefficient computed from this and then predicted for an 80 - presentation test was r = .88. A table of reliabilities, split half, was given and is shown rearranged below. The computations were for 40 trials tests and the Spearman-Brown formula used to predict the reliabilities of the 80-trial tests, split-half, reliabilities.

		Test					
		NVX-1	NVX-2	NVX-4	NVX-13	NVX-16	NVT-15
40 trials	r =	.85	.85	.93	.90	.90	.82
80 trials	r =	.92	.92	.97	.95	.95	.90
1st trial vs 2nd trial	r =	.83	.82	.92	.87	.86	.74
Number of cases	N =	100	312	70	98	71	709

The following data have been selected as typical examples and show the relationships found between the indoor laboratory tests and the outdoor tests: (Table on p. 57). A large group of correlation coefficients between the several tests and criteria I, II, and III, were given in a table. However, no adequate description was given of the criteria. Two quotations from the discussion may be given. First "on the basis of the outdoor tests used as validity criteria, NVX-2, NVX-4, NVX-13, NVT-14 and NVT-15 possessed equal validity." Second, "Tests NVX-3, NVX-16, the Feldman Adaptometer, Luckiesh-Moss, TC 44-1, TC 44-2, and TC 44-Z were definitely inferior" to the above mentioned. It was also pointed out that the number of cases in the investigations was small and did not justify too sweeping conclusions even though the figures obtained were higher than those previously recorded.

The conclusions given in a section of the report included:

1. There has been developed a test which seems the best available at this time for classifying the night vision abilities of personnel in the field. It is the FAS Mass night vision test

Validation Outdoor tests		Laboratory Tests NVX-1	NVX-2	NVX-4	NVX-13	NVX-16	NVT-15
TC 44-I	r =	.49	.49	.44	.70	.43	.39
TC 44-II	r =	.41	.53	.50	.65	.50	.63
TC 44-Z	r =	.39	.36	.49	.45	.31	.41
Observation Test II							
(a) Perception distance	r =		.65		.67	.56	.73
(b) Recognition distance	r =		.70		.65	.53	.71

described in the report as NVT. Of all known tests it most closely fulfills the requirements which are listed.

2. For immediate use by units in the field the NVT-15 is the design best suited for troops to build. However, it would be more satisfactory if the NVT were built in a central place and distributed. In this case the radium activated or film strip type NVT is to be preferred.

72. R. H. PECKHAM. The course of readaptation after exposure to white light. U. S. Navy. Naval air training base. School of aviation medicine. Pensacola, Florida. February 23, 1944. (3595) (O)

Data were presented to show the probability of seeing at time intervals between 2 and 176 seconds following exposure to light of 6.6 effective foot candles for periods of 1, 4, 8, seconds respectively. The NDRC model II adaptometer was used with 2 subjects.

A three dimensional figure was drawn to show the planes in which frequency curves were determined in establishing the course of readaptation. The probability of response in percentage was represented by the vertical ordinate, time was represented by the horizontal ordinate and brightness was represented by the oblique ordinate. The theoretical considerations involved in the selection and use of this method of presentation were discussed. Conclusions reached indicated it is probable that light one log unit above limen can be seen within 10 seconds following exposure to light which is high enough to allow instrument or map reading for less than 8 seconds, and that if short intervals of loss of dark adaptation are required they can be controlled both in degree and time by the use of dis-adapting light.

73. C. H. WEDDELL. A study of the prediction of night lookout performance. U. S. OSRD-NDRC. Applied psychology panel. March 15, 1944. (3959) (O)

The purpose of the investigation was to give tests and retests of night vision to a group of Navy men and to compare the results with scores obtained in a situation which would closely duplicate the conditions under which actual night lookout duties are performed. Two objectives were: (1) to obtain a measure of the reliability or dependability of night vision tests, (2) to determine the predictive value of the tests with respect to the night lookout ability of the men tested. The instruments used were the Navy Radium Plaque, the Clockface adaptomer, the Smith Test of Visual-Motor Coordination, the Tufts-SDS Test of Night Vision, the Hecht-Shlaer adaptometer (RCN model), the NDRC adaptometer model III, and the Purkinje Test. Complete details of the characteristics of the instruments and the methods of administering tests with them were given. In addition, there were 4 personality tests used together with the verbal scores obtained on the Navy General Classification Test. The Field or Criterion tests were carried on aboard a ship adapted for the purpose. The men were posted as lookouts and provided with telephone connections with a central recording room. They were advised of the time when a target ship began its "run" toward the ship they were on and were required to scan 180° of the horizon, report the bearing of the target as soon as it appeared, and continue the reports of estimated bearing at one minute intervals. Various types and sizes of target craft were used, approaching on various bearings and at different speeds. Data on the actual ranges and bearings were obtained by radar and used as the basis of the evaluation of the performance of the men. The score was in terms of the greatest distance, to the nearest 100 yards, at which a subject was judged to have seen the target.

The group tested consisted of 150 seamen not experienced in night lookout. Included was a group of 20 men who had been tested previously with the Radium Plaque and classified as failures. Each man was given tests with the 7 instruments and then put through a regular course of night lookout training three times. Then each man was retested with the 7 instrument tests following which he was tested in the Field or Criterion situation. An interval of one week occurred between the tests.

The data were given in the form of scatter diagrams, chi square cells, tables and distribution curves. The correlation coefficients of test-retest reliabilities of the instruments were as follows:

Reliability Test-Retest	Clockface Adaptometer	Purkinje Test (Adaptation Time)	Tufts-SDS	Hecht-Shlaer
r =	.266	.534	.190	.422
E.1.2 =	.180	.506		.416
E.2.1 =	.343	.498		.381

The product moment coefficients on the Radium Plaque, NDRC, and Night Lookout Training were not computed because of the skewed distributions. There were no data on the reliability of the Smith Visual-Motor Test, the scores on the first test being discarded because of instrumental difficulties.

The chi-square technique was used to estimate the reliability of the Radium Plaque and NDRC scores with these results:

	Radium Plaque Score in terms of per cent correct		
	50%	60%	80%
Chi square =	24.17	31.16	33.69
	NDRC Model III Cutting score per cent correct		
	20%	30%	50%
Chi square =	7.39	16.36	16.20

All the chi squares given above were said to be values significant at the 1% or better level of confidence. In the case of the scores on the night Lookout Trainer (NLOT) the chi square technique was used in a comparison of first and second tests only. The order of scores was 1 through 5, the better scores being the smaller ones. For the cutting scores as indicated the results were:

	NLOT Cutting score 4	NLOT Cutting score 3	NLOT Cutting score 2
Chi square =	.4948	17.0766	.7658

Only the second of the three chi squares had a value significant at the 1% or better level of confidence.

The intercorrelations between 5 of the night vision tests were quite low. The correlation coefficients between the second tests with the instruments ranged from r = -.19 to r = .26 for the Clockface, the Purkinje Test, the Smith Visual-Motor Coordination Test, the Tufts-SDS, and the Hecht-Shlaer Adaptometer. The relationship between the NDRC and the Radium Plaque was determined by means of the chi square formula since it was not possible to compute a product-moment or "r" coefficient. Taking cutting scores which cause approximately the same number of men to fail each instrument, viz., 20% on NDRC and 60% on Radium Plaque, the chi square was 19.86, which has a value on the 1% or better level of confidence. A study was made of the performance of the 20 men who were included in the group of 150 and who had been classified as failures in a prior test with the Radium Plaque. The mean score of the small group was compared with the mean score of the larger group in each of the 7 night vision tests. The results showed that there was a significant difference between mean scores on the 5% level of confidence for the Radium Plaque and the Hecht-Shlaer instruments, a significant difference on the 1% level of confidence for the Clockface instrument and no significant difference for the Purkinje, the Smith, the Tufts-SDS, and the NDRC instruments.

The relationship between Test Scores and the Field or Criterion Scores was either absent or was very slight. The data were summarized and indicated that the Purkinje, the Smith, the Hecht-Shlaer, the NLOT, the 4 personality tests and the verbal scores on NGCT (navy general classification test) did not predict night lookout performance. The Clockface and the Tufts-SDS showed validity only at levels which would fail more than 20% of the population. The Radium Plaque did not show any significant relationship to night lookout performance and the NDRC model III showed a relationship to the criterion at two cutting scores. However, both were said to be poor predictors of performance. All conclusions were regarded as tentative inasmuch as they were to be considered in the light of the question, how dependable is the score on night lookout performance?

74. J. E. WILSON. Field study of navy radium plaque adaptometer. U. S. Navy. Naval Academy, Annapolis, Md. April 1, 1944. (3852) (O)

A group of midshipmen, first class, were given tests with the Navy Radium Plaque Adaptometer. A high group of 66 men who scored in the range 140-150 and a low group of 111 men who scored below 50 were retested after an interval of approximately 5 days. In the retest, 51 of the 66 men in the high group remained in the score range of 140-150, 14 men scored in the range 90-139, and 1 man scored in the range 60-89. Of the 111 men in the low group, 1 was placed in the 140-150 range, 16 scored between 90-139, 53 men scored between 40-89, and 41 were placed between 0-39. Using the score of 90 as a point of dichotomy in the retest, 64 men of the high group were above and 1 below. Of the 111 men in the low group 17 were above and 94 below. Since there was 89.8% agreement and 10.2% disagreement between test and retest it was concluded that a measurement of night vision was being made.

A group of 636 men were tested and retested on the night lookout training table for contact only. The results indicated 52% agreement and 48% disagreement. A comparison of scores of 917 men tested with the Radium Plaque and on the night lookout table for contact only was made. The dichotomy points were score 90 on the adaptometer and illumination number 1 on the night training table. The results showed 52.3% agreement and 47.7 disagreement, which closely approach the proportions of 50-50. A further comparison was made of scores of 917 men with the adaptometer and their night lookout recognition scores. In this case the dichotomy points were score 90 for the adaptometer and the illumination grade 3 for the table. There was 54% agreement and 46% disagreement.

It was concluded that the adaptometer had high validity (reliability?), the night lookout training table when used as a test for night vision showed low validity since there was a lack of correlation between those scores and the adaptometer scores.

75. J. B. MACMILLAN and B. COMMONER. Field study of navy radium plaque adaptometer. U. S. Navy. Naval air training center. Corpus Christi, Tex. April 15, 1944. (O)

The objectives of the investigation were (1) to establish a reliable cutoff point for rejects, (2) to study variability in operators who gave the tests. Two hundred thirty-four cadets were given 4 tests each. The means, standard deviations and correlation coefficients obtained were:

	Navy Radium Plaque			
	Test 1	Test 2	Test 3	Test 4
Mean	95.5	100	117	120.5
S.D.	34.5	31.7	31.1	30.1

	Test 1 vs Test 2	Test 2 vs Test 3	Test 3 vs Test 4
r =	.63	.75	.69

In no case was the correlation high enough to satisfy requirements for test-retest reliability. It was noted that there was considerable learning indicated from test to test. A table was given showing the shifts in the percentages above and below a given score:

Test	Per cent above 100	Per cent below 100
1	56	44
2	65	35
3	75	25
4	83	17

Four operators gave the tests but the differences which appeared in the results were slight and not greater than could be expected by chance.

It was stated that the Navy Radium Plaque Adaptometer does not give sufficiently consistent results to warrant its use as a selective device. A cutoff point for rejects on a single test is not justified. If the instrument is to be used for purposes of selection all subjects should be given sufficient practice to reach their level of performance before being passed or failed. The instrument might have limited use as a device for preliminary training in night vision.

76. L. D. CARSON. Recommended modifications in radium plaque adaptometer. U. S. OSRD-NDRC. Division 16. Institute of optics, Rochester, N. Y. April 19, 1944. (3878)

A description was given of a method of modifying the adaptometer by means of a "tell tale" phosphor disc placed on the radium plaque. The disc would indicate whether or not the plaque had been exposed to light at a time sufficiently close to the time of use to cause inaccuracies in its brightness value. In addition, a filter system was described in which day or artificial light could be used to quench undesirable after glow quickly in cases where the plaque had been accidently exposed to unwanted light.

77. C. J. WARDEN. An investigation of motion acuity under scotopic conditions at various retinal positions. U. S. NRC-CAM. April 30, 1944. (3625) (O)

This report is one of a number bearing the same title. In the study covered by the report the purpose was to make a check of the Navy Radium Plaque Adaptometer as a test of scotopic form acuity and the Columbia University Motion Test as a test of scotopic motion acuity. The latter was described in detail in a previous report dated August 6, 1943 (Fulton, Bibliography of Visual Literature, Index number 3624) and also in articles in preparation for publication.

For the purpose of the investigation some modifications of the apparatus in the motion test were made. A radium plaque figure T with the appropriate filter was fitted to the driving shaft which could be rotated clockwise and counter clockwise. The motion perception threshold was determined by the psychophysical method of adjustment. The general speed level of the target was set well above the threshold and the subject reduced the speed by means of a rheostat to a point below the threshold and then increased the speed by small steps until the criteria of the threshold were satisfactorily met. The threshold value was defined as the speed of rotation at which the subject could see definite motion with absolute certainty. The standard requirement was a judgment of "good motion" in 3 successive exposures at the accepted threshold speed. The range of speed, expressed in seconds per 30 degrees of central angle, was from 12.64 to .62 with a median of 3.81.

The test with the Radium Plaque Adaptometer was administered according to standard procedure including 50 presentations of the stimulus. One method of scoring used was to take the number of correct responses multiplied by 3 minus the number of wrong responses. This was designated "standard". A second method used was to count only the number of correct judgments made. This method gave what was called the "raw" score. The subjects were 75 students from Barnard College and 25 from Columbia College, the age range being 17-25 years. A requirement for selection as a subject in the investigation was the possession of photopic form acuity as indicated by a Snellen Index of 20/20 or better in each eye.

The split-half reliability of the Navy Radium Adaptometer was given in terms of the correlation coefficients between the first 25 trials and the second 25 trials.

		"Standard" Score	"Raw" Score
Uncorrected	r =	.82	.80
Corrected (Spearman-Brown)	r =	.90	.89

The reliability of the Motion Acuity Test was determined by two methods. Correlations were made between the threshold values obtained, viz., between first and second, first and third, second and third. The coefficients ranged from r = .97 to r = .99. The other method used was to convert the correlation coefficients into Z scores and average them. The result obtained was .98. This was said to be the best estimate of the reliability of the three determinations of threshold values. The relationships between the results of the three tests, viz., 1 photopic test (Snellen) and 2 scotopic tests (Adaptometer and motion acuity) were stated as follows:

	Snellen vs			Motion Acuity vs	
	Adaptometer	Motion Acuity		Adaptometer (Standard Score)	Adaptometer (Raw Score)
r = (Biserial)	.02	.04	r =	.93	.90

The relationship between photopic form and scotopic form and motion is practically negligible whereas that between scotopic form and motion is quite high. The relationship holds for each of the two methods of scoring the Adaptometer test and is in conformity with the correlation between standard scores and the raw scores which was r = .98.

A determination was made of the relationship between motion acuity threshold value and motion acuity score. The motion apparatus was set up as a test device in which the standard was the median threshold value, derived from a group of 100 subjects, of 3.81 secs/30 degrees of central angle. To each of 25 subjects there were given 50 presentations of the stimulus at this speed with some interspersed "no motion" presentations. The correlation between the number of correct responses made and the threshold value was r = .85.

A comparison was made of the standard method of scoring the Radium Plaque Adaptometer with the short form designated the 10-20 method. In the following table are shown the classification of subjects, in terms of percentages, according to the Manual of Instructions and the corresponding classification of the test group of 100 subjects:

Standard Classification	Manual of Instructions	Test group 100 subjects
Rejected	6%	4%
Acceptable	53%	43%
Passed or Superior	61%	53%

However, when the criteria of the 10-20 method were applied it was found that 73% failed and 27% passed on the basis of 16 correct responses out of 20 trials.

The conclusions drawn from the data were to the effect that no significant relationship existed between photopic form acuity and either scotopic form acuity or scotopic motion acuity on the basis of the Snellen Test, the Radium Plaque Adaptometer and the Columbia Motion Apparatus. On the other hand a high degree of relationship was found between the tests for scotopic form and scotopic motion perception. Both types of perception are apparently closely related visual functions at scotopic levels of illumination. With respect to the use of the Radium Plaque Adaptometer it was felt that the long or standard method of procedures with 50 presentations of the stimulus gave a superior measure or index of scotopic form acuity than the short 10-20 method of procedure.

78. L. B. ROBERTS and W. E. MANN. Comparison and evaluation of field laboratory methods of measuring night-seeing ability of ground troops. U. S. ASF. Armored medical research laboratory. Fort Knox, Ky. May 1, 1944. (3840) (O)

The laboratory tests used in this investigation were the AAF Night Vision Tester, the Luckiesh-Moss Low Contrast Chart, the S.A.M. Tester and the Luminous Plaque (Radium Plaque Night Vision Tester). Descriptions of the tests, with 8 photographs of the devices, together with the details of scoring the tests were supplied. The principal Field Test was one which involved tasks normally required of ground troops during night operations and was designated the AMRL Field Test. Essentially, the test situation consisted of 39 targets, including various geometrically shaped objects and vehicles, of different sizes and with various brightness contrast values, which were distributed at irregular distances from arbitrarily chosen starting points in 3 stations located in a large bowl shaped clearing. Complete details of the targets in terms of types, size and shape, brightness (foot lamberts) were given along with 4 photographs of the general test area and typical arrangements of the objects. Another field test was a Field Landolt-Ring target, 4 inches, painted on a white disc 22 inches in diameter and rotated in a random order to one of four positions.

The scoring method used in the AMRL Field Test provided for the assignment of points varying in number from 1 for the mere seeing of a target to 4 for the recognition of the kind and shape and full description of the characteristic central markings in the case of the geometrical objects, or, in the case of vehicles, from 1 for the mere seeing to 4 for the correct identification of the kind or type used as a target. For every three wrong answers, without regard to target or sequence, one point was deducted from the total score.

	AMRL Field Test (Average of 4) vs AAF Test (Average of 4)	Luckiesh-Moss (Average of 4)	SAM Test (Average of 4)	Field Landolt-Ring
r =	.769	.709	.508	.744

Part III. Radium Plaque Night Vision Tester vs AAF and Field Tests.

This part was devoted to the consideration of scores obtained with the RPNVT and with the AAF and Field Tests. To 54 men five successive tests were given with RPNVT. Test-retest correlations gave results as indicated in column 1 in the table below. Intercorrelations between RPNVT scores and field test scores, 64 subjects, and between RPNVT scores and AAF test scores, 125 subjects, are given in columns 2 and 3 of the table:

		Radium Plaque NVT vs RPNVT (N = 54)	Radium Plaque NVT vs AMRL Field (N = 64)		RPNVT (Test 1) vs AAF (Test 1) (N = 125)
Range of coefficients	r =	.631 to .765	.553 to .640	r =	.789
Average	r =	.68	.597		

The correlation between the average of four RPNVT tests and four AAF tests with 25 subjects was r = .905.

The authors concluded that the AAF night vision tester will enable the selection of men for night field operations with sufficient accuracy for practical purposes. However, the size and cost of the device, as well as the requirement of a special dark room, preclude its use in the field or away from well organized training stations. The Luminous Plaque, i.e., the Radium Plaque night vision tester will allow the selection of men on the basis of night seeing ability. It is a convenient and simple device to use. The SAM portable and the Luckiesh-Moss Low Contrast Chart were not satisfactory as tests.

79. W. M. ROWLAND and L. S. ROWLAND. Studies of a number of men reporting difficulty in night operations. U. S. AAF. School of aviation medicine, Randolph Field, Tex. May 10, 1944. (3550) (O)

A group of 12 men was referred to the School of Aviation Medicine because of histories of visual difficulties during night operations. They were given tests with the AAF-Eastman night vision tester, the Hecht-Shlaer Adaptometer, the SAM Portable Night Vision Tester and the Sloan Perimetric Light Sense Tester.

The results indicated that 3 subjects had normal night vision and 9 showed slight or marked defects. Of the latter sub group, 6 were given tests before and after vitamin therapy. At the time of the retests, 4 men had shown some improvement in night vision and 2 men had not.

80. ANON. Report of test of night vision of F.A. liaison pilot instructors. U. S. AGF. Field artillery school, Fort Sill, Okla. May 27, 1944. (3833) (O)

The object of the investigation was to determine the relation between scores made on the Rostenberg night vision apparatus by liaison pilot instructors and the proficiency of the pilots in night flying. Seventy-eight men were tested. The target was a rotatable silhouette of an airplane exhibited for 5 seconds in 8 randomly chosen positions for each of 6 levels of intensity of illumination. The brightness values were not stated. Each subject made his response to the stimulus by moving a rotatable arm on a control board in front of him to the same relative position in which he judged the nose of the airplane silhouette to be. After the test run of 48 presentations, each subject was exposed for 10 seconds to the light of 2 standard 60 watt electric lamps and required to indicate the position of the target, illuminated at "magnitude four," by moving the arm on his control board to the same relative position. This phase of the test was added to study the value of a simple adaptation test and to demonstrate to the subjects the value of dark adaptation.

The data were presented in histograms only, 6 figures. The average number of correct observations for the levels of illumination, 1 through 6, were 6, 6, 5, 4, 2, 1, respectively. The average "accomodation time" for 73 subjects was 60 seconds.

It was concluded that the number of tests given was inadequate for the development of a standard. Anomalies in the results cast doubt upon the practical value of the test. Some men made poor scores who were reputed to be satisfactory or superior night pilots, while others made satisfactory scores who were not so reputed as night pilots. It was felt that no practical value could be served by further application of the test, both on the ground of difficulty of interpretation of test results and also on the ground that administrative problems involved in its adoption would be insurmountable.

81. L. S. ROWLAND. Night visual efficiency in illuminations above the level of the cone threshold. U. S. AAF. School of aviation medicine, Randolph Field, Tex. May 31, 1944. (3551) (O)

The purpose was to investigate the need for tests of foveal acuity at low intensities of illumination. Since night flying involves vision sometimes above and sometimes below the cone threshold, the question has been raised about the use of tests of night vision efficiency to include tests at photopic levels as well as at scotopic levels. If a test of cone function in low illumination is needed in addition to a test of rod function in order to rate individuals adequately with respect to night vision the two functions should be tested independently.

Data were obtained on the normal variation in foveal visual acuity at low intensities. They showed that the measurement of visual acuity at a single low level of brightness indicates adequately the visual performance in brightnesses ranging from just above cone threshold to about .04 ml. Acuity ratings for low brightness levels agree somewhat with ratings on standard measurements at about 10 ml. Poor acuity at high illumination levels seems to go with poor acuity at low levels, but better than average acuity at high levels may not be associated with better acuity at the low levels. An independent test of foveal acuity in low illumination would provide a better basis for rating this aspect of night vision efficiency than can be obtained from measurements of acuity at relatively high levels of illumination.

82. F. N. LOW. Studies and investigations in connection with a test for peripheral visual acuity: technique applied to night vision; results of early experiments. U. S. NRC-CAM. May 31, 1944. (3554) (O)

The problem was stated in the form of two questions: (1) Is the Landolt-circle method used for testing peripheral daylight acuity adaptable to conditions of night vision? (2) Can night vision be trained by a technique of controlled practice similar to that applied to day vision?

Twenty-four subjects were used in the experiment. The data presented are based on results obtained from 23 subjects. One subject was revealed as night blind on the basis of his failure to identify the largest size of target. The apparatus used had been previously described in Am. Jour. Physio. 140 83-88, October, 1943, and the details given in this report referred only to modifications made for the experiment. They consisted of a change from a black on white fixation button to one of orange self-luminous material. A small pencil-type flashlight fitted with a red filter was used as a check in fixation when deemed necessary. A low degree of luminosity was maintained. The brightness value was not given but it was such that the position of the break in a medium sized circle could not be seen with central vision. The 14 points tested were at 30° in two paracentral vertical meridians, right and left, upper and lower, at 30° and 60° along the horizontal meridian, right and left, at 30° in the upper right and left quadrants along the 45° meridians, and at 30° and 60° lower right and left quadrants along the 45° meridians.

Data were given in 3 figures and 1 table. The average score of 23 subjects was 65.4 for night vision and was compared with an average score of 47.9 for day vision of 100 subjects. The spread of the night vision scores was said to be considerably less than that of day vision scores. In a study of learning 2 subjects were given 11 trials each. Both started with approximately the same scores, in both cases the learning curves show irregular but definite improvement in the scores, but one of the subjects showed decidedly more improvement than the other. Compared with curves of learning for day vision the night vision curves of learning indicate that night vision performance is apparently more sluggish and irregular than day vision. The potentiality of improvement seems to be less for the former than for the latter, nevertheless it probably represents, in itself, a large quantitative range. An improvement of peripheral night vision to any degree ought to raise the total efficiency of night vision to the same degree.

83. W. S. VERPLANCK. Adaptometers for night vision selection and classification. U. S. ANOSRD vision committee. Minutes 3rd meeting. June 16, 1944. (3841) (R)

A review of the development and the up to the date status of night vision tests, based on experience at the Submarine Base, New London and on available reports from other places. The selection of personnel on bases of their night vision became a problem quite early in the war period. The tests sought were those which met purely physical criteria of reliability and could be used to determine visual thresholds, absolute or form. They were developed without much difficulty and yielded test-retest reliability coefficients ranging from .60 to .80. With additional experience in large scale testing, it became clear that the reliability coefficients obtained were rather misleading. High scores were found to be quite reproducible but not the low scores. Learning was clearly indicated in successive tests.

The absence of high intercorrelations between tests assumed to measure the same function, and evidence of gross changes in test scores due to non-visual factors, gave rise to doubts concerning the validity of the tests, the doubts being confirmed by field validation studies. The difficulty of selecting a single retinal function as an index of night visual performance emerged. However, tests had a basic value in that men whose field performance was poor enough to warrant classification as "night blind" could not pass any one of them in which the statistical basis was sound.

The Navy adopted the Radium Plaque Adaptometer for use only in screening the men with inferior night vision. The passing score is based on the statistics of small samples and the percentage of men failed, or passed, is determined by the chosen brightness value of the test patch, i.e.,.3.9 log micromicrolamberts. As now employed the procedure makes it impossible to pass a subject who has zero probability of discriminating the .025 visual acuity figure. Thus men who are "night blind" are being disqualified but there is also the possibility that other men are being disqualified whose performance at night might be satisfactory. The procedure is probably expensive in terms of personnel but the selection made has, presumably, been regarded as worth the cost involved.

In the light of all the evidence it appears that adaptometers now available have been developed as far as their results warrant. New lines of developing selection devices should be explored.

84. E. R. HENRY. Camp Blanding study of night vision tests. U. S. ANOSRD vision committee. Minutes 3rd meeting. June 16, 1944. (3842) (R)

The primary purpose of the investigation was to secure cross-validity data on the night vision tests developed at the Field Artillery School, Fort Sill, Oklahoma (Cf. Abstract no. 71).

Two tests were used, NVT-15 and NVT-R_2. Both had a circular light field subtending 4° at 20 feet distance. A 2° test object was mounted in front of the light field in such a way that it could be oriented in any one of 8 positions. The tests differed in terms of source of illumination, brightness levels used, and in the type of test object. In NVT-15 there were three 3 c.p. lamps with appropriate control instruments. The brightness values ranged through 5 levels from 1.7 x 10^{-4} to 5.0 x 10^{-6} foot lamberts. A sixth level was made up of a combination of stimulus presentations at level 4 and at level 3. The test object was a Landolt-Ring. In NVT-R_2 the illumination was from a radio-active plaque, the brightness values ranged through 6 levels from 1.1 x 10^{-4} to 7.0 x 10^{-6} foot lamberts and the test object was a T figure. Each test included 8 presentations of the stimulus in each of the 6 levels, or a total of 48 stimulations. Following the test there was a rest interval of 2 minutes after which there was a retest. Four hundred ninety men formed the group of subjects.

The immediate test-retest reliability for both NVT-15 and NVT-R_2 was r = .91. The mean scores were 14.6 and 15.2 with standard deviations of 4.3 and 4.5. Both distributions were said to be skewed towards the lower scores.

A revision of the test procedure was made involving a slight increase in brightness levels, the introduction of a practice series and the use of a mechanical-electrical method of recording scores. It was not stated if NVT-15 or NVT-R_2 or both were revised. At all events it was stated that a test designated NVT 15 P was used together with an outdoor test in a cross validation study. The latter consisted of Course A and Course B, both made up of standard vehicles and field pieces placed at irregular distances from chosen starting points. Two groups of subjects were used. One was a battalion of Parachute Field Artillery men with service experience of approximately 1 year. The other group was a company of Infantry Trainees at the end of their basic training.

The data presented were said to be tentative in nature pending further statistical analysis.

	Outdoor Criterion			
	Course A		Course B	
	Perception	Recognition	Perception	Recognition
Odd-even reliability r =	.85	.70	.75	.70

NVT-15 P

	Odd-even Reliability	Test-retest (2-day interval. Reliability small no. of cases)
r =	.89	.80

The mean of the distribution was 25.6 with a standard deviation of 4.2.

85. J. MANDELBAUM and L. S. ROWLAND. Central and paracentral visual acuity at different levels of illumination. U. S. AAF. School of aviation medicine. Randolph Field, Tex. June 23, 1944. (3549) (O)

In the investigation an image of a Landolt-Ring was cast upon a white screen. Three sizes were used, viz., 2, 6, and 12 mm. respectively. The size of the projected image could be varied from 12.5 to 24.5 mm. by means of slides each giving presentations of the ring in 4 positions, and by the variable magnification of the projector. The background was varied by neutral filters from 9.0 to 4.3 log units micromicrolamberts. One subject was tested, each "run" consisted of determinations for the entire range of intensities at one retinal position. The measurements were made in the horizontal meridian.

The data were presented in 4 figures and 1 table. The curves show acuity thresholds along the meridian for 8 brightness levels 9.0 to 4.6 log units. Those of the higher brightnesses, viz., 9.0 to 7.0 log units show peaks at the fovea and fall off rapidly out to 10°, and slower from there to 30° temporal. With brightnesses of 6.3 log units and lower the paracentral acuity exceeded that at the fovea. For the one subject tested it appeared that fixation at 4° temporal to the object viewed was most favorable for form discrimination at scotopic levels. Whether this feature of a 4° peak in efficiency was due to an innate anatomical factor or was due to habituation in using that retinal region in scotopic vision could not be determined. It was proposed to study many subjects in order to ascertain if the 4° retinal region is most efficient under similar conditions.

86. A. CHAPANIS. Night vision tests and the night vision testing program in the Army Air Forces. U. S. AAT-ATSC. Engineering division. Aero medical laboratory. July 20, 1944. (3817) (O)

The purpose of the report was twofold. First, to point out some errors in the statistical analysis of night vision test data reported on January 26, 1944 by the School of Aviation Medicine, Randolph Field, Texas (Cf. Abstract no. 70). Second, to summarize the night vision data collected by the Aero Medical Laboratory and to show that these data and the S.A.M. data are actually in essential agreement.

In a critical analysis of the School of Aviation Medicine report reference was made to the conclusion reached by the authors that agreement between three types of adaptometers, namely, the Hecht-Shlaer, Model 3, the School of Aviation Medicine (SAM) Portable Night Vision Tester and the AAF-Eastman, Model 2 could be greatly enhanced provided the size of the test object in the AAF-Eastman was increased from 1° to 2°, and the maximum brightness reduced from 6.25 to 5.7 log units. The author pointed out that the accumulated experience with the instrument on the part of the Aero Medical Laboratory staff was at variance with the conclusion and that the discrepancy indicated might be due to the difference in statistical methods used by the Aero Medical Laboratory and the School of Aviation Medicine, the latter being inadequate for the purposes intended. Exception was taken to what was regarded as the criterion used by S.A.M. in judging the sets of ratings of subjects tested by the several adaptometers. The criterion was said to be, the higher the percentage of men receiving the same classification on two tests the better is the agreement between the tests.

To test the validity of the criterion, the School of Aviation Medicine data, given in the form of contingency tables showing the number of men assigned to classifications of superior, satisfactory and unsatisfactory, were recalculated to show the numbers for corresponding cells which could be expected by chance. The results showed that the predicted frequencies for cells of identical classification, i.e., superior, satisfactory, unsatisfactory respectively, on the SAM and the AAF 1° tests exceeded in number those actually obtained. The sum of the predicted frequencies was 139.1 out of 238 whereas the sum of the obtained frequencies was 152 out of 238 cases. A similar procedure was used with the School of Aviation Medicine data from tests with the Hecht-Shlaer and the SAM Adaptometers. The sum of the predicted cell frequencies for identical classifications was 164.5 and the sum of the obtained frequencies was 165 out of 204 cases. Conclusions drawn from the statistical analyses were made to the effect that some degree of correlation exists between the ratings assigned by means of the AAF-Eastman 1° Model 2 and the SAM Portable Adaptometers, whereas, the ratings assigned by means of the Hecht-Shlaer Model 3 and the SAM Portable Adaptometers are correlated about as well as ratings by means of SAM and any arbitrarily chosen serial sequence would be. The alleged erroneous conclusions contained in the School of Aviation Medicine report were the result of a failure to use one or more of the statistical techniques developed to estimate the amount of correlation between the test scores or ratings.

This report contains the results of two studies. In the first study a group of 5245 men was tested with the Navy Radium Plaque Adaptometer and the 10-20-50 method of administration of the test. However, apparently only a small percentage of the men were given 50 trials and "all present data are based on the first 20 trials." The second study was made by R. H. Peckham and the results given in a report titled: "Report of five hundred subjects tested and retested for 50 trials each on the Navy Radium Plaque Adaptometer," dated March 8, 1944 and designated Appendix B in the report cited at the head of this Abstract.

I. The results of the testing of the group of 5245 showed that 4320 men were graded pass and 925 were failed. There were available for a second test, approximately five weeks later, 202 men of the 925 in the first failure group. In the second test the results showed that 117 men now passed with 85 again failing. An hypothesis that the 202 men out of the first failure group was a random sample of the whole was checked by means of the chi square formula. A prediction based on the proportions of those passed and those failed in test one indicated that by chance 168 of the 202 men would pass and 34 would fail. The actual numbers of pass and fail in test two were 117 and 85. The magnitude of the difference between the actual and predicted numbers expressed in terms of chi square was 92.3 with p = .0000. This result indicated that the hypothesis could be rejected with a high degree of confidence and an assumption made that selection had occurred in the first test. An estimate of reliability is to be found in the chi square procedure, taken in conjunction with the percentages of failures in a retest, and its use is based upon the highly tenable hypothesis that an individual once passed in a test by the Radium Plaque Adaptometer will continue to do so on successive tests. A third test was given to 56 of the 85 men in the second failure group with the results that 17 were passed and 39 remained in the failure group.

In terms of percentages, pass and fail in the successive tests, of the entire group of subjects the data are as follows:

	Per cent Pass	Per cent Fail	Number
Test 1	82.4	17.6	5245
Test 2	57.9	42.1	202
Test 3	30.3	69.7	56

A table was given in which it was shown that the final pass percentage was 94.9 and the final fail percentage was 5.1 of the entire population, the table having been set up on the assumption that the men retested are a random sample of all men failing each test.

Chi square tests of significance of alteration in population with the successive tests yielded the following results:

Test 1 vs Test 2	Chi square = 61.2.	p = .000---
Test 1 vs Test 3	Chi square = 102.3.	p = .000---
Test 2 vs Test 3	Chi square = 21.6.	p = .000---

The author concluded that the report indicates the feasibility of large scale "one shot" programs of night vision testing. Of those failing a first test approximately 60 per cent will pass a second test. In the event a third test is given approximately 30 per cent of failures in the first two tests will pass a third. Since a large learning factor is indicated, a second test should be given to all who fail a first test. The saving in personnel would be approximately 7 per cent. However, such a procedure may be considered unnecessary in view of the limited application of test results. Learning does not play a marked role in tests beyond the second.

II. In the study reported by R. H. Peckham, a group of over 500 men was tested and retested for 50 trials each with the Navy Radium Plaque Adaptometer. The data were presented in two scatter diagrams and 4 tables. The first diagram shows the arrangement of 503 scores by a 20-trial method and by a 50-trial method. The second diagram shows the arrangement of 499 scores test-retest in terms of 50 trials. The data so displayed were reduced to double dichotomies.

1. Double dichotomy
   20 vs 50 trials. N = 503. Chi square = 300.0. p = .0000---
2. Double dichotomy—Test-retest
   50-trial method. N = 499. Chi square = 50.14. p = .0000---
3. Double dichotomy—Test-retest
   20-trial method. N = 503. Chi square = 91.47. p = .0000---

For the test-retest 50-trial method vs the test-retest 20-trial method, the chi square = 0.448 with p = .90, indicating an excellent result in a test for "goodness of fit."

An analysis of the data of the test-retest by the 20-trial method gave the following results: the scores of 10/10, 16/20 or better being regarded as passing and 15/20 or less regarded as failing:

			Test 2					
	Test 1		10/10		16/20 or better		15/20 or less	
Scores	No.	%	No.	%	No.	%	No.	%
10/10	306	(61)	232	(76)	66	(21)	8	(3)
16/20 or better	125	(25)	74	(59)	42	(34)	9	(7)
15/20 or less	72	(14)	23	(32)	21	(29)	28	(39)
Totals	503		329		129		45	

The data were said to indicate definitely that classification was successful.

The author discussed the statistical considerations involved. It was stated that the score 10 out of 10 equals pass will exclude persons whose probability of seeing is 50 per cent or worse. The score 15 out of 20 excludes persons who are 29 per cent or worse and 91 per cent or better. The score 16 out of 20 or better will include men lower than average performance and can be expected to include all very superior and excellent persons in the passing group. The advantage of 50 over 20 trials is very slight and either method will yield an indiscriminate "doubtful" group.

The recommendation was made that the defined "pass" and "fail" scores be used for the classification of the "pass" and "fail" groups and that the "doubtful" category be eliminated. The recommended scores can be expected to fail about 15 per cent of the population on a single test. It is recognized that the effect of retesting is to decrease the number of failures. However, since retesting immediately is not practical, it becomes necessary to exclude by a "fail" category a larger portion of the population than was originally anticipated. The proportion may be reduced as Navy personnel become increasingly familiar with the test routine.

88. W. B. CLARK and M. L. JOHNSON. The course of dark adaptation after wearing orange dark adaptor goggles. U. S. Navy. Naval air training base, Pensacola, Florida. School of aviation medicine. August 31, 1944. (3594a) (O)

This report is number one of two reports bearing the same title. The date given in Fulton, Bibliography of Visual Literature is an error. The correct date is August 31, 1944. The date of the second report is February 19, 1945 (Cf. Abstract no. 95).

The purpose of the investigation was to study the course of dark adaptation when the subjects wore goggles of different types and to discover, if possible, a method of providing dark adaptation which would permit the reading of maps and the performance of other visual tasks. Eight subjects were employed.

Preliminary to the main experiment each subject was light adapted for 30 minutes in ordinary room illumination and then dark adapted by wearing Navy red goggles for 20 minutes, followed by

10 minutes in darkness. By means of the Hecht-Shlaer adaptometer the threshold was determined by averaging 20 trials, 10 ascending and 10 descending. The experiment was in three parts. First, the course of dark adaptation was plotted after the subjects wore red goggles in room illumination for periods of 5, 10, and 15 minutes. Measures of adaptation were made at an interval of 15 seconds after exposure, an interval of 1 minute, and at intervals of $\frac{1}{2}$ minute thereafter up to 6 minutes. The intensity of the test patch was reduced in steps of .2 log units until 2 negative responses were obtained and then increased until 2 responses were given. This part of the experiment with red goggles was regarded as a control for the second part in which the subjects wore orange goggles for periods of 5, 10, and 15 minutes in room illumination. Each subject was tested twice. Measurements of dark adaptation were made as in the preceding part except that after the 5-minute exposure, they were taken for 20 minutes before all the subjects returned to their limens. In the case of the 10 and the 15-minutes exposure, additional measures were made at 25 to 30 minutes. In the third part of the experiment the subjects were exposed without goggles to room illumination for 5 minutes.

The data were presented in 6 figures showing the several curves of dark adaptation obtained. They show that the group limen was 2.76 log units. After exposure for 5 and 10 minutes, the limens were lifted to 3.55 log units. After 15 minutes exposure the limen was lifted to 3.69 log units. The recovery time following 5-minutes exposure was 10-20 minutes, for 10-minutes exposure it was 18-20 minutes and for 15-minutes exposure it was 28-30 minutes in duration. When red goggles were worn the results were markedly different. The elevation of the limens following exposure for 5, 10, and 15 minutes was to 3.08, 3.04 and 3.13 log units respectively. The recovery time was 2-2$\frac{1}{2}$ minutes. When no goggles were worn and the exposure time was 5 minutes the elevation of the limen was to 3.57 log units, approximately equivalent to the result with the orange goggles. The recovery time was slower than was the case for orange goggles during the first 8 minutes following exposure but thereafter the two curves show no significant difference.

The results of the experiment indicated that orange goggles are of no practical value in protecting dark adaptation in ordinary room illumination. Only slight loss of dark adaptation occurred when red goggles were worn and the recovery time was short, viz., within 2-2$\frac{1}{2}$ minutes. Inasmuch as orange goggles are not practical as dark adaptors or as preservers of dark adaptation another substitute for red goggles must be sought when interference with the performance of certain duties is brought about by their use.

89. R. H. LEE and E. M. FINCH. A method of curve fitting applicable to dark adaptation and similar data containing periodic fluctuations about a smooth curve. U. S. Navy. Naval medical research institute. September 11, 1944. (3557) (O)

The method discussed involves the use of the equation $y = a + be^{-cx}$ in which y is the dependent variable, a, b, and c are constants, e is the base natural logs, and x is the independent variable. Necessary assumptions were stated as follows: (1) The main tendency of the data must follow the law of the equation, (2) The data must be given in equal intervals of the independent variable x, (3) There must be no missing data between the first and last terms, (4) The data must contain enough terms to permit division into three groups and each group must contain an identical number of terms sufficient in number to average out random error or systematic fluctuations about the mean curve. An example of the equation fitted to dark adaptation data was provided.

90. R. H. LEE, M. PIJOAN, H. R. CATCHPOLE, and E. M. FINCH. Periodic fluctuations and threshold levels in dark adaptation and the effects produced by paredrine, oxygen, carbon dioxide and ascorbic acid. U. S. Navy. Naval medical research institute. September 12, 1944. (3597) (O)

In a previous report, dated September 24, 1943, reference was made to periodic fluctuations observed in the dark adaptation curves obtained from some subjects (Cf. Abstract no. 62). The fact that the fluctuations were not observed in the dark adaptation curves of all subjects gave rise to the suggestion that environmental factors might be involved in their causation. A study was made of some of the respiratory and dietary factors reported in the literature as influential in raising or lowering dark adapted thresholds. Six subjects were tested after (a) breathing room air through a mask, (b) breathing 100 per cent oxygen, (c) breathing 2 per cent mixture, (d) breathing 3 per cent mixture of CO_2 in air. Four subjects were given the juice of 15 oranges per day for 3 days and 2 subjects were given 1 gram of ascorbic acid per day for 4 days. One drop of 1 per cent solution of paradrine was placed in each eye of four subjects 5 minutes before light adaptation began and again ½ minute before the pre-adapting light was extinguished.

The curves obtained were treated by the use of an empirical formula, $\text{Log } I = a + Ce^{-kt}$ where Log I = the threshold at any time t, a = terminal threshold, C and k = numerical constants representing the starting point and the velocity of drop respectively. The smooth curve so obtained was used as a base and the differences between it and the raw data determined. The differences were smoothed by the formula $\frac{\log I_1 + \log I_2 + \log I_3}{4}$, where log I, subscripts 1, 2 and 3 represent any 3 sequential threshold readings. The resulting average was assigned to t, the time at which the reading of Log I_2 was obtained. The data were presented in 2 figures containing 5 curves and 3 tables.

The results showed that:

1. There were no significant differences between the control tests and those in which room air was breathed through a mask, 100 per cent oxygen and 2 per cent carbon dioxide. Neither threshold level nor fluctuations were altered. The breathing of a 3 per cent mixture of carbon dioxide elevated the threshold by about .16 log units but had no effect on fluctuations.

2. The thresholds were significantly lowered by the use of paradrine. If the course of dark adaptation is divided into 3 sections, namely, from ½ to 10 minutes, from 10½ to 20 minutes, and from 20½ to 30 minutes, the average differences between control thresholds and experimental thresholds were .24, .21, and .17 log units respectively. The probability of such differences occurring by chance is .05, and hence the differences were said to be significant. However, the subjects who normally showed fluctuations continued to do so under the influence of paradrine.

3. Thresholds were not affected by the use of orange juice or by ascorbic acid.

91. W. C. H. PRENTICE. A study of the performance of night lookouts aboard ship. U. S. OSRD-NDRC. Applied psychology panel. October 7, 1944. (3960) (O)

The primary purpose of the study was to obtain reliable quantitative data under wartime operating conditions upon the performance of lookouts. The subjects were those men on a convoy ship regularly assigned to the duty. Lookout watches of 1 hour on and 1 hour off through 4 hours were maintained. The men in the lookout stations were called on to make reports on the bearings of most distant craft visible in their respective sectors. By appropriate methods data on weather conditions, sea and sky brightnesses, and the actual bearings of the craft sighted were recorded.

In order to make comparisons between the performances of the men the raw data consisting of bearings and ranges of the ships visible to them at the time of their reports, were reduced to a unit designated ESF (Equivalent square feet). The corrections necessary for the derivation of the unit were described in detail and included those for target angle, the range and size of the sighted craft and the differentials in sea and sky background brightnesses. The resultant was a hypothetical target, visually equivalent to the one actually seen, silhouetted against a sky brightness of .05 foot lamberts at a distance of 1000 yards from an observer. The scores of 114 men were given in terms of distribution of single scores and also of the averages of the scores of the men. The range of the latter distribution was from 5 to 316 ESF, the lower scores being the better ones. The distribution was definitely skewed towards the lower scores, the mean being 60 ESF.

One phase of the experiment was to ascertain how well the Navy Radium Plaque Adaptometer predicts night lookout performance. Data on both ESF scores and Radium Plaque scores for 63 men were available. The alignment of the men in terms of Radium Plaque scores was 50 passed and 13 failed. The average ESF score for the pass group was 64.7, and for the fail group it was 43.92. The difference between the averages was said to be statistically insignificant. It was shown that 10 of the 13 men in the Radium Plaque fail group had better ESF scores than the mean of those who passed the Radium Plaque test. A further comparison was made between 2 groups of men, 12 in each, who were judged to be the best lookouts and the poorest lookouts, on the basis of their ESF scores. The means were 12 and 196 respectively. Scores on the Radium Plaque were available for 9 men in the best group and 8 men in the poorest group. In each group only 1 man was graded fail, with 8 in the best group and 7 in the poorest group graded pass. On the basis of the data it was concluded that the Radium Plaque Adaptometer did not predict night lookout performance. The latter contains many non-visual elements not measured by the Adaptometer. As it is now scored it may not be a reliable indicator of night blindness.

92. R. H. PECKHAM and H. J. OLDER. The effectiveness of colored versus neutral dark adaptation goggles. U. S. Navy. Naval air station. Anacostia, D. C. n.d. (3594) (O)

Although the report is undated there are indications that the study was done toward the end of 1944. Contrasting combinations of lenses were mounted in welding goggles in the order of right-left and left-right and worn as dark adaptation goggles. The combinations were:

(a) Red and neutral matched for cone transmission
(b) Red and neutral matched for rod transmission
(c) Red and orange matched for cone transmission

Six subjects were dark adapted for 20 minutes with standard red goggles, then light adapted for 10 minutes in room illumination of two 300 watt lamps. Then they were dark adapted with one of the experimental pairs of goggles for 20 minutes following which the goggles were removed, an Evelyn Trainer turned on and the subjects required to report any differences apparent to the two eyes. The scores were in terms of time required for equally good vision in both eyes after the differential dark adaptation. The results indicated marked individual differences. The averages for six subjects were as follows:

Combinations of lenses	Average time required for apparent equality	In favor of
(a) Red-neutral (cone trans.)	5 mins. 1 sec.	Red
(b) Red-neutral (rod trans.)	5 mins. 48 sec.	Neutral
(c) Red-orange (cone trans.)	3 mins. 32 sec.	Red

The red lenses were superior to both the orange and neutral (cone transmission). The fact that red was not as efficient as neutral of presumably equivalent rod transmission was said to be due to the fading of the red filters. It was stated that it would seem expedient to use red adaptation goggles for dark adaptation whenever possible and to use orange goggles when some color vision is necessary in the performance of duties during the acquisition of dark adaptation or to maintaining it.

93. R. H. LEE. Report on recheck for night blindness of officer candidates at Naval Reserve Midshipmen School, Columbia University. U. S. Navy. Naval medical research institute, Bethesda, Md. December 18, 1944. (O)

In a test with the Radium Plaque Adaptometer given to 1075 men there were 126 who were graded fail. Out of the fail group, 114 men were available for a second test. In this test, 44 men failed. A third test, in which the number of trials was increased from 20 to 48, was supervised by the author. For the test there were available 113 men who had failed the initial test. The number of failures was 23, including 17 men who fialed in all the tests.

Two men out of the 17 who failed in three tests had scores poor enough to warrant a classification of "functional" night blind. Tested by means of a multiple brightness adaptometer they were found to require 2 to 4 times as much light to obtain passing scores as that provided by the Radium Plaque Adaptometer. It was surmised that the remaining 15 men in the three-failure group could pass the Radium Plaque test provided they had more practice after a rest period from the visual strain of studies before their final examinations.

Night vision is so rarely used by civilized man that not only the seeing but also the interpretation of what is seen requires a technique which must be learned. Shifts in the thresholds are large and the normal daily variations probably account for the sizable amount even after learning has been accomplished. As now used the Radium Plaque separates men into two groups, passed or failed. Extreme fatigue, headache or a cold can put a man in a fail classification who really should be in a pass classification.

94. A. CHAPANIS and E. A. PINSON. A portable radium plaque night vision tester. U. S. AAF-ATSC. Engineering division. Aero medical laboratory. January 7, 1945. (4953) (O)

A description together with 4 figures (photographs) of the Aero Medical Laboratory Radium Plaque night vision tester was given. The device consists of a small case, 5 3/8" x 6 3/4" x 3/4", containing a glass cell filled with radium salts. The basic brightness value is .18 microlamberts. The test object is a broken circle, the dimensions not stated, superposed on the surface of the plaque. A slide provides for exposure of the test field and object when in use and for protection of the plaque when not in use. A test presentation consists of exposing the plaque with the break in the circle oriented in one of four positions, left, right, up, or down for ten seconds. The plaque is held at a given distance from the subject, 4 correct responses out of the first 4 positions shown being considered an indication of "seeing" it at that distance. If error or errors occur at the distance, 10 presentations are given with 8 correct responses being regarded as passing. A cord looped around the neck of the subject marks off distances of 5, 7, 9, and 11 feet from the plaque. The original classification of men on the bases of their scores was five fold:

Score (character seen at)	Classification
Less than 5 feet	Unsatisfactory
5 feet but not 7 feet	Below average
7 feet but not 9 feet	Average
9 feet but not 11 feet	Above average
11 feet	Superior

In an appendix to the report a proposed revision provided for:

Score	Classification
10 or more	Superior
5 to 9	Satisfactory
less than 5	Unsatisfactory

Test-retest correlations for the device were given, r = .54 to .89. Although not as high as might be desired they are as good as, if not better than, those obtained with other portable-type adaptometers. Coefficients of correlation, r = .55 to .64, between scores with the tester and field test scores were reported. Intercorrelation between the plaque and the AAF-Eastman night vision tester ranged from r = .52 to .82.

95. W. B. CLARK and M. L. JOHNSON. The course of dark adaptation after wearing orange dark adaptor goggles. U. S. Navy. Naval air training base, Pensacola, Florida. School of aviation medicine. February 19, 1945. (5059) (O)

This report is number 2 of two bearing the same title. No. 1 is dated August 31, 1944 (Cf. Abstract no. 88).

The purpose of the experiment was to find a substitute for the standard Navy red goggles which would protect dark adaptation and permit color perception at the same time. Eight subjects were employed. Prior to each experiment they were light adapted for 30 minutes in ordinary room illumination, then dark adapted by wearing red goggles for 20 minutes and in darkness for another 10 minutes. Limens were obtained by means of a Hecht-Shlaer Adaptometer and determined by averaging 10 descending and 10 ascending trials.

Part 1 of the experiment involved the use of (a) 50 per cent transmission orange Dark Adaptor Goggles, (b) 5 per cent transmission goggles of the same type. The subjects were exposed to room illumination for periods of 5, 10, and 15 minutes while wearing the goggles. Each subject was tested twice with the 50 per cent and also with the 5 per cent transmission goggles. Measures of dark adaptation were taken 15 seconds after exposure to the light at 1 minute, then at ½-minute intervals to 10 minutes, then at 1-minute intervals for the next 10 minutes and at 5-minute intervals for the next 10 minutes. Determinations of thresholds were made by the method of limits. Part 2 of the experiment was designed as a control and involved the use of (1) standard Navy red goggles, (2) 5 per cent transmission neutral goggles, (3) 10 per cent transmission neutral, and (4) no protective goggles. The procedure was identical with that in Part 1.

The data were presented in 6 figures and 1 table. The latter has been rearranged as follows:

Exposure Time	Elevation of limens in log units above the group limen (2.76 log units)					
	With Goggles					With no Goggles
	50% Orange	5% Orange	Standard Red	10% Neutral	5% Neutral	
5 minutes	.80	.44	.44	.68	.61	1.03
10 minutes	.80	.47	.36	.79	.57	1.09
15 minutes	.93	.57	.54	.68	.76	1.20
	Time required, in minutes, for return to the designated levels above limen. (A) to .05 log units:					
5 minutes	17.0	4.0	1.5	5.0	6.0	16.0
10 minutes	18.0	11.0	1.5	8.5	10.5	23.0
15 minutes	20.0	16.0	4.0	16.0	13.5	24.0
	(B) to .10 log units:					
5 minutes	9.5	3.0	1.2	3.5	4.2	9.5
10 minutes	13.0	3.5	1.2	6.5	4.5	21.0
15 minutes	19.5	4.0	2.5	9.5	8.0	22.5

Exposure Time	Time required, in minutes, for return to the designated levels above limen. (C) to .15 log units:					
	With Goggles					With no Goggles
	50% Orange	5% Orange	Standard Red	10% Neutral	5% Neutral	
5 minutes	7.5	2.0	1.0	3.0	3.5	7.5
10 minutes	8.0	2.5	1.0	3.5	4.0	13.0
15 minutes	15.0	2.5	2.0	8.5	4.5	21.0

Recovery of the original dark adaptation state was regarded as the return to the group limen or to a point within .05 log units of it. This was regarded as quite satisfactory for a laboratory situation, but may be too rigid for field requirements. The other two adaptation levels were included for the reason that they fall within the normal variability of subjects and, also, that they are probably effective for vision at starlight illumination as indicated by observations on the screen of an Evelyn Trainer.

The data show that the orange goggles with 50 per cent transmission have practically no value in protecting dark adaptation. In terms of elevation of limen and length of recovery time to all three adaptation levels they are only slightly better than no goggles. The 5 per cent transmission orange goggles are almost equivalent to standard red goggles in terms of elevation of limen but are quite dissimilar in terms of recovery time to the basic dark adaptation level. However, the difference between 5 per cent orange and standard red goggles in terms of recovery times to the other designated dark adaptation levels is small. On the assumption that these levels are adequate for the performance of some duties it would appear that the 5 per cent orange goggles may be satisfactory when conditions require the use of color vision and the loss of some efficiency in dark adaptation protection is of minor consequence. The standard red goggles are definitely superior to all the others under conditions which require swift recovery to the completely dark adapted level following exposure to ordinary room illumination.

96. L. S. ROWLAND and W. M. ROWLAND. Individual differences in the region of maximal acuity in scotopic vision: applications to night vision testing and training. U. S. AAF. School of aviation medicine, Randolph Field, Texas. February 19, 1945. (3549a) (O)

The purpose of the investigation was to determine the shape of the acuity gradient curve and the region or regions of maximal acuity, binocular vision. Reference was made to a previous report by Mandelbaum and Rowland, dated June 23, 1944 (Cf. Abstract no. 85) in which it was shown that for illumination intensities of 6.3 log micromicrolamberts, or lower, visual acuity was best at 4° in the temporal retina (nasal field) horizontal meridian for 1 subject tested. The study was made only on the right eye. If a similar maximum of acuity exists in the left eye for the nasal field, it could be expected that, in binocular vision, peaks in the acuity gradient curves on both sides of the fovea would occur unless the scotopic acuity of one eye exceeds that of the other.

I. In the report there were included data from studies carried on by J. Mandelbaum at Laredo Army Air Field, Texas, on the effect of using fixation lights on scores obtained in tests with the AAF-Eastman night vision tester. A red fixation light was placed 4° from the test object in the positions left, right, above and below. The subjects were encouraged to use one or more fixation lights in the test. Four hundred forty-two men were questioned as to the position found to be most helpful. The large majority (272) preferred the light in the right position. Sixty-four, 54 and 24 men preferred the upper position, the left position and the lower position respectively, while others said they used all four positions.

The scores of 612 men tested with 4 fixation lights were compared with the scores of 612 men tested without fixation lights. In the first group there were 9.65 per cent failed and in the second there were 12.9 per cent failed. It was conjectured that some of the men failed because they had not learned to maintain proper paracentral fixation. In a follow-up study, 28 men, who had failed the test twice in succession with standard procedure, were again tested with and also without fixation lights. Of this group, 11 again failed both tests, and 5 passed both tests. Ten men passed with fixation assistance and failed without it. The remaining 2 men barely passed without fixation lights but failed with them.

II. Inasmuch as the proper use of eccentric fixation is one of the most important aspects of night vision training it was felt desirable to obtain further information as to the most favorable direction and degree of such fixation and possible variations due to differences in levels of intensity and in individuals. The studies reported were carried on in the School of aviation medicine, Randolph Field, Texas.

Scotopic acuity in the central and paracentral retina, horizontal meridian was measured in 18 subjects. For the central measurements a fixation target of 4 self-luminous spots arranged in a square subtending a visual angle of 4° was used. Inside the square was placed a Landolt C. For the paracentral measurements one red fixation point was placed in relation to the Landolt C according to the design of the experiments. Eleven points were selected for fixation, namely 0° and 2°, 4°, 6°, 8°, 10° both right and left. The minimum size at which the subject could discriminate the opening in the test object 6 out of 8 presentations was determined for the 11 points. Exposures were 1/5 second in duration. The field brightness was held at 5.8 log units except as noted below:

The data were given in five figures and five tables. Summarized they show:

1. The range of maximal paracentral acuity for 17 subjects was from .113 to .050, decimal notation, corresponding to .7° to 1.7°. One subject had a maximum of .038 or 2.2° and was judged to be night blind on this test and also when tested by SAM Portable Adaptometer.

2. Ten subjects had maxima in acuity with fixation right, 4 had maxima with fixation left, 3 had both right and left maxima, 1 had double maxima with fixation left.

3. Rank order correlations between maximal acuity and acuity for 17 subjects:

		2°	4°	6°	8°	10°
Fixation right	rho =	.46	.93	.93	.79	.81
Fixation left	rho =	.70	.85	.88	.77	.80

rho = .48 for 0° fixation.

4. Acuity gradient curves in both vertical and horizontal meridians for 3 subjects showed similarities. No subject had higher acuity in the vertical than in the horizontal. One subject had equivalent maxima of .075 at 6° right fixation and 10° upper fixation.

5. Two subjects were tested at 5 levels of intensity illumination. The data are as follows:

	Regions of maximal acuity under different intensities (log units)				
	6.8	6.2	5.8	5.3	4.7
Subject 1	6° R	4° L	6° L	6° R	12° R
Subject 2	2° R & L	4° L	4° L	8° R	8° & 10° L

It was concluded that the region of maximal acuity under levels of illumination below cone threshold is somewhere between 4° and 12°, the precise location varying with the individual and the brightness of the background. The use of roving fixation should be emphasized in order that a subject may learn to use his region of highest acuity. However, there is no objection to the use of a fixation light since scotopic acuity at any one paracentral location shows a fairly close relation to the maximal scotopic acuity.

97. J. ORLANSKY. The effect of night vision training (Evelyn Trainer) on U. S. Navy radium plaque adaptometer scores. U. S. Navy. U. S. Naval air station. Quonset Point., R. I., April 16, 1945. (O)

The investigation was designed to ascertain if prior training on the Evelyn night vision trainer would cut down the number of men failing the radium plaque test. As a standard of comparison the data from a group of 4477 men who had been given routine RPA tests were used. One experimental group consisted of 434 men who were all given a training session of approximately 1 hour duration with the Evelyn Trainer. Two hundred seventy-six of the men were given the RPA test immediately following the training period and 158 were given the RPA test one week after the session. Among the subjects were 134 men who had previously passed the RPA and consequently the test following the training session was a second or retest on RPA. Another experimental group of 80 men who had passed a previous RPA test were again given the test but were not given the training session with the Evelyn Trainer.

The data were given in 3 figures and 2 tables. Comparative data for the group of 4477 men (control) and for the experimental group of 434, as a whole and also in two sub groups: (a) tested immediately after training, (b) tested one week after training are shown below:

	Control Group (Quonset) N = 4477	Experimental group Evelyn trained and RPA tested Whole Group N = 434	Sub-group (a) N = 276	Sub-group (b) N = 158
Median score	18.28	18.61	18.69	18.44
Percent fail	18.4	16.6	14.9	19.6
Percent 10/10 scores	41.4	45.2	46.0	43.6
Percent 0/20 scores	8.5	7.6	8.0	7.0

It was noted that the median score for the entire experimental group was better than that of the control group and the percent of fail was slightly lower.

By the chi square test the probability value for percent deviation of experimental group from the control group was .35. A comparison of the sub group (a) with the sub group (b) shows that the median score was higher and the percent of fail lower for (a) than for (b). The probability value for percent deviation from the control group was .75 for the sub group tested immediately after training, and .65 for the sub group tested after an interval of one week. If there are any effects of training that can be measured by RPA, it would appear that they are transient in duration.

The data below were derived from 134 men who had previously passed a RPA test, had been given Evelyn training and a RPA retest immediately after the training, and a group of 80 men who had passed a previous RPA, and were given a retest but no Evelyn training:

	Experimental Groups: RPA Test-retest Evelyn trained N = 134	RPA Test-retest N = 80
Median score	19.03	19.11
Percent fail	8.3	13.8
Percent 10/10 scores	51.5	56.3
Percent 0/20 scores	5.2	7.5

8.3 percent failed in the former group as compared with 13.8 percent in the latter. The respective probability values were .01 and .25.

The author urged caution in the interpretation of the results. With respect to the experimental group of 434 men Evelyn trained and then RPA tested, the difference between the percent of their fail and the percent of fail in the control group of 4477 men was only 1.8 percent, i.e., 18.4 percent minus 16.6 percent. The difference was slightly larger between the group tested immediately after training and the control group, i.e., 18.4 percent minus 14.9 percent or 3.5 percent. It should also be noted that there was a difference in the opposite direction, namely, an increase in the percent fail when a comparison was made between the control group and the sub group tested one week after training, i.e., between 18.4 percent and 19.6 percent or 1.2 percent.

With respect to the group of 134 men tested, trained and retested, there was a drop in the percent fail, 8.3 percent as compared with the 18.4 percent of the control group, which may have been due to the RPA retest as such, or to the Evelyn training, or to the selection of men who had previously passed. A suggestion as to the relative involvement of the factors might be obtained by comparison with the group of 80 men tested and retested but not trained. Here there were 13.8 percent failures, a drop of 4.6 percent from the control group, i.e., 18.4 percent minus 13.8 percent. With both groups identical except for the item of training the difference between 13.8 percent and 8.3 percent failures may well be an indication of the influence of training, while that between 18.4 percent for the control group and 13.8 percent for the retest group may be due partly to the retest.

A treatment of the data in such a way as to limit the percentage of failures in the 0/20 scores to 2 percent of the population with the elimination of all cases in excess was made with the result that no significant change was brought about in the trends indicated by the original data. The author briefly touched on the question of what the two and three dimensional trainers accomplish beyond demonstration. Although outside the scope of the study it was indicated that an investigation is imperative for testing the effectiveness of the devices, for establishing practice procedures and for the development of an inclusive curriculum. One session scarcely affords much practice in scanning or peripheral fixation. Additional training is necessary to establish working habits in the techniques.

98. S. HECHT, C. D. HENDLEY, S. ROSS and P. RICHMOND. Influence of exposure to intense sunlight on subsequent night vision. U. S. Navy. Naval medical field research laboratory. Camp Lejeune, N. C. April 26, 1945. (O)

The object of the study was to investigate the temporary and cumulative effects of exposure to bright sunlight on night vision. Reference was made to persistent reports from U. S. Armed Forces overseas which indicated deterioration in night vision after exposure to strong sunlight. A published report from a foreign source contained results of a study which gave support to the observations from the American sources.

The problem was threefold:

(1) is the onset of dark adaptation delayed after exposure to bright sunlight?

(2) is the process slowed up so that the threshold is still above normal even after an hour or two in darkness?

(3) is the effect of daily exposure cumulative? Data on phases 1 and 2 of the problem were available in the literature but not on phase 3.

Two experiments of a preliminary nature were done in which subjects were exposed to bright light for longer or shorter periods of time. In the first, 7 subjects were instructed to look at the sky which varied from 3,000 to 12,000 millilamberts in brightness. Monocular vision was used in the final stage of the exposures and the course of subsequent dark adaptation measured by the Hecht-Shlaer Model 1 Adaptometer (monocular test). Twelve curves were obtained showing both rod and cone thresholds. In the second, 5 subjects gazed at the sky which varied from 3,500 to 16,000 millilamberts for periods of 2 to 35 minutes. For comparison, dark adaptation curves were obtained after exposure to 5 and to 50 millilamberts for various short periods of time. The data were given in 1 table and 1 figure. Summarized they show that after 60 minutes exposure to 50 ml., recovery is complete after 40 minutes in the dark, but exposure for two minutes to 7,000 ml., prolonged the time of recovery up to approximately 40-60 minutes. Exposure for 15 minutes to 6,000 ml. and for 30 minutes to 3,500 ml., made the recovery times over 2 hours and over 5 hours respectively. The average elevations of thresholds were .48 log units after 30 minutes in the dark, .2 log units after 1 hour, and .1 log unit after 2 hours.

A third preliminary experiment was done in which 43 subjects were dark adapted for 1 hour and dark adaptation curves obtained. They then spent several hours in bright sunlight on an open beach, following which they returned to the laboratory for testing. Then they left the building, wearing red goggles and returned later for another test after a period of 1 hour dark adaptation. Some subjects were again tested the following morning. The elevations of threshold at 3/4 - 1 hour after exposure ranged from .25 to .12 log units with an average of .218. Some residual effect of exposure was apparent after several hours and perhaps overnight.

In the main experiments two groups of subjects were used in the roles of experimental and control groups and vice versa. One group of 20 men was kept at indoor tasks and required to wear red goggles when outdoors during the daytime. This was the control group. The other group of 31 men was taken to a sandy beach where they spent their time exposed to direct sunlight and reflected light from sand and water surfaces. This arrangement continued from the 5th to the 30th day of a month, whereupon the control group became the experimental group from the 30th day to the 10th day of the following month and the former outdoor group became the indoor group for the same period of time. For the purpose of taking measurements the two groups were each divided into 3 sub-groups and 3 paired control experimental sub-groups set up. Each pair of sub-groups was tested twice a week in a morning-afternoon-morning sequence. Measurements were made with the Hecht-Shlaer Adaptometer, Model 3 (binocular) and the data given were based on tests as given with "blue" light test flash. Five figures and 2 tables.

The results showed that:

1. The two groups began with approximately equivalent thresholds. They then diverged with the control group showing lowered thresholds, at first rapidly and then more slowly, and the experimental group showing rapidly rising thresholds to a level which was maintained.

2. When the reversal in roles took place the former control group showed thresholds rising by almost .1 log unit in 3 days followed by very slight additional rise. The former experimental group showed the elevated thresholds all through the period of 10 days spent indoors.

3. A comparison of means of the distribution of thresholds showed the experimental group lower by .02 log units at the outset, but higher by .12 log units after exposure. The change, amounting to .14 log units, was equal to 4.3 times the standard error of the difference between the means following exposure. The probability of such a difference occurring by chance was given as 2/10,000.

4. Measurements made through 9 days (overlapping the two periods of the experiment) at (a) morning, afternoon, early evening and next morning for the outdoor group, and (b) morning, afternoon and next morning for the indoor group, and following 1 hour of dark adaptation in each case, showed that the threshold was raised by .14 log units due to sunlight and that the effect did not disappear until some time later in the night.

Two conclusions were stated and their military significance discussed in some detail with illustrative examples:

1. Night vision is significantly but not drastically interfered with for several hours following a single prolonged exposure to sunlight.

2. There is a cumulative effect of daily exposures to sunlight upon night vision. After about 10 days it accumulates to about the same magnitude as that produced in the maximal temporary effect of a single exposure.

99. S. ROSS. An investigation of the effect of varying the test distance upon Radium Plaque scores. Report No. 1. April 27, 1945. (O)

S. ROSS. An investigation of the effect of varying the test distance upon Radium Plaque scores. Report No. 2. May 15, 1945.

S. ROSS and C. G. MUELLER. An investigation of the effect of varying the test distance upon Radium Plaque scores. Report No. 3. July 17, 1945.

C. G. MUELLER, P. N. RICHMOND and S. ROSS. An investigation of the effect of varying the test distance upon Radium Plaque scores. Report No. 4. November 21, 1945. U. S. Navy. Naval medical field research laboratory. Camp Lejeune, N. C.

I. The experiment was designed to study the effect on Standard Navy Radium Plaque Adaptometer scores of variations in the distance from the instrument to the subjects being tested. The officially prescribed distance was 5 feet, (60 inches). Fourteen experimental distances were chosen and for convenience in handling the data the magnitudes, in inches, were converted to log units by the expression $\log \frac{1000}{d}$.

No.	Distance (inches)	$\log \frac{1000}{d}$	No.	Distance (inches)	$\log \frac{1000}{d}$
1	48.0	1.32	8	84.0	1.08
2	57.0	1.24	9	88.5	1.05
3	61.5	1.21	10	93.0	1.03
4	66.0	1.18	11	97.5	1.01
5	70.5	1.15	12	102.0	0.99
6	75.0	1.13	13	111.0	0.96
7	79.5	1.10	14	120.0	0.92

There were 6 subjects who were qualified as operators of the instrument but not trained observers in psychological experiments. They were cognizant of the nature of the experiment and well motivated thereby. At each distance 20 trials were made and the score recorded on the number of correct responses given.

The data were presented in 4 figures and 1 table. In the latter were shown the number of correct responses and the average of percent correct for each subject and for each of the 14 distances. The percentages were based on 60, 80, or 100 judgments. Below are given the ranges of the average percentages and the means of the ranges.

Dist. No.	Range of average % correct 6 subjects	Mean of the range	Dist. No.	Range of average % correct 6 subjects	Mean of the range
1	95-100	97.6%	8	30-88	68.3%
2	85-100	96.3	9	27-80	58.8
3	55-100	87.0	10	25-72	55.0
4	57-100	89.0	11	22-90	47.3
5	48- 99	83.1	12	20-57	44.0
6	42- 87	74.3	13	15-56	31.5
7	32- 96	70.0	14	20-38	28.0

As the distance increased the average percent of correct responses decreased. The data indicate some individual variability especially at the distances 3 through 14. One subject had the lowest percent correct throughout the entire series. The individual curves of percent seen, corrected for chance, show the same variability. A generalized curve was made using as a basis the average distance at which occurred a given percentage of correct responses.

On the basis of the results it was concluded that the distance method of giving the test could be highly practical for purposes of classification. At distances, or a distance, greater than 60 inches (the standard distance) a wider classification might be made and the Radium Plaque

Adaptometer become a tool not only for screening the worst cases of night visual deficiency, but for classifying various degrees of ability in night vision.

II. In this part of the project the experiments were designed: (1) to test the night vision ability of 124 men by means of the Navy Radium Plaque at several distances, (2) to determine the reliability of the "distance method" and the relationship between RPA scores so obtained and threshold scores obtained by the Hecht-Shlaer Adaptometer. The distances were 5, 6 and 7 feet respectively, the instrument being mounted on a rack for the purpose. Twenty judgments were called for at each distance from 124 men and retests given to 57 of them after an interval of one week. The Hecht-Shlaer threshold values were obtained from 28 men.

The data on the RPA scores were given in 9 figures and 2 tables, and analyzed in terms of the histogram distributions of the number of correct judgments made. They show the following characteristics:

1. <u>At 5 feet distance</u>

The scores are piled up highest in the distribution intervals 20, 18 correct judgments and not quite as high in the intervals 16, 14, and 12. The remaining columns are quite low through the intervals 10, 8, 6, 4, and 2.

2. <u>At 6 feet distance</u>

The piling up of scores at the passing end is less marked than at 5 feet.

3. <u>At 7 feet distance</u>

This distribution is relatively flat topped from end to end excluding the extremes, and is said to be the most differentiating distance in terms of range of performance.

4. <u>At 9 feet distance</u>

The scores are piled up in the distribution intervals 8, 6, 4, and 2 correct judgments respectively.

The means of the number of correct responses for the distances were:

	5 feet	6 feet	7 feet	9 feet
Mean no. correct responses	17.86	15.72	12.26	7.89

The result of a retest made on 57 men was graphically shown in a histogram showing the percentages of men passing both tests at each distance. The precise figures were not given. The means of the number of correct responses were:

Retest: N = 57	5 feet	6 feet	7 feet	9 feet
Mean no. correct responses	17.98	16.05	13.25	8.21

The product moment correlation coefficients for test 1 vs test 2, turned out to be:

N = 57	5 feet	6 feet	7 feet	9 feet
r =	.56	.52	.77	.54

A comparison between the scores of 28 men on both RPA and the Hecht-Shlaer produced a negative correlation r = -.67 with a probable error of .07. Since the best scores on RPA are the highest and the best on the Hecht-Shlaer are the lowest, the correlation was regarded as evidence of a rather high degree of relationship.

In terms of the several distances, the correlation was r = -.57 for the 5 feet and approximately the same for 6 feet and 7 feet distances. For the 9 feet distance it was r = -.46.

Inasmuch as the RPA tests were initially given in a fixed order of 5, 6, 7, and 9 feet distances check was made on the possibility of practice and learning as factors influencing (1) the distribution of scores at the 7 feet distance, and (2) the larger coefficient of correlation at that distance. One hundred and six men were first tested at the 7 feet distance. No significant differences were found between the original distribution of the scores and the distribution of the scores of this group.

On the basis of the results it was stated that each of the distances used in the test with the Radium Plaque Adaptometer would have certain advantages. For the purpose of rejecting personnel with poorest night vision, the 5 feet test would be satisfactory. To classify personnel as good (upper 10%), fair, or poor (lower 10%) or, if only one standard test distance is prescribed for use, the 7 foot distance is the superior one. The test at the 9 foot distance can be used for the selection of persons with superior night vision.

III. A comparison of visual performance on the Radium Plaque Adaptometer and the ability to perceive objects in the field at night was made. The RPA tests were given at distances of 5, 6, 7 and 9 feet. The outdoor test consisted of 12 targets differing in size and nature set up in a cleared area. Reference was made to reports by L. O. Rostenberg (Cf. Abstract no. 71) and L. B. Roberts and W. E. Mann (Cf. Abstract no. 78) as sources of information in the construction of the test. A diagram showing the layout of the test and descriptions of the targets is included in the report.

The data were given in 4 tables and analyzed in terms of the efficiency with which the test at each distance as well as the test at the entire series of distances predicted the outdoor performance. The RPA tests were given during the week prior to the field test. The correlations between the RPA scores and the field scores were:

RPA Scores		Field Scores (Perception)	Field Scores (Recognition)	Combined perception and recognition
At 5 feet	r =	.38	.40	.41
At 6 feet	r =	.33	.45	.43
At 7 feet	r =	.39	.52	.50
At 9 feet	r =	.31	.40	.38
At all distances	r =	.42	.52	.51

The probable errors were either .07 or .08. The correlation between total perception and total recognition scores (field test) was r = .77 with a probable error of .04.

Another type of analysis was made using a two-way method. In the first place the classification of the subjects into good, fair and bad was made on the basis of their field test scores (total recognition) and a comparison made with their ratings on the RPA test.

		Radium Plaque Test		
Classification Field Test		At 5 feet	At 7 feet	At all distances
Good	N = 16	10	10	10
Fair	N = 25	12	12	12
Bad	N = 15	6	6	5
Total	56	28 (50%)	28 (50%)	27 (48%)

The men were then classified by their RPA scores and compared with their ratings on the field test. The percentages of agreement were found to be 52%, 50% and 50% respectively.

The Radium Plaque Adaptometer classifies correctly 50% of the men on the basis of the outdoor test. This degree of agreement is considerably above chance and supports the assumption of relationship between the two measures. However, it was stated that the inadequacy of an outdoor criterion provides a limiting factor to the establishment of a close relationship between an indoor and an outdoor test. Furthermore the RPA test measures retinal sensitivity, this being only one of the complex of physiological and psychological variables in night vision performance.

IV. In this part of the project the relationship between RPA scores and performance on the night vision trainer (Device 9-W) was investigated. The latter was a modification of the RCAF Night Vision Trainer developed by Wing Commander K. A. Evelyn and adapted for use as a test instrument in this experiment. The level of illumination was kept constant throughout. The subjects were required to describe the size, shape and features of the figures seen on a screen and to trace the course of moving images. The range of possible scores in the test was from 0 to 50.

Forty-four subjects were used of whom 18 had previously failed four consecutive standard RPA tests given at the distance of 5 feet. Twenty-six men had previously passed the test once and were given three additional RPA tests at the 5 foot distance. Each subject was also tested with the Hecht-Shlaer Adaptometer and with the RPA using the "distance method" described in 3 previous reports. Although the data of the latter tests were included they were not analyzed or discussed in this report.

The average score on the Night Vision Trainer for the 26 men in the RPA pass group was 32.7 and for the 18 men in the RPA fail group was 17.3. The distribution curves for the two groups shown in relation to Night Vision Trainer scores indicated some overlapping. 15% of the pass group and 94% of the fail group were reported as making night vision trainer scores below 25. Since the group of subjects was regarded as highly selected, further quantitative analysis of the data in terms of normal curve statistics was not made. However, it was affirmed that the facts of the two distribution curves pointed to a high relationship between the criterion of pass or fail on RPA and the scores on the Night Vision Trainer. The test could be used as a fairly good predictor of performance on the Trainer.

100. R. H. LEE and M. B. FISHER. Evaluation of the modified Rostenberg adaptometer. U. S. Navy. Naval medical research institute. Bethesda, Md. May 8, 1945. (O)

An investigation of the test reliability and ease of operation of the modified Rostenberg and the Navy Radium Plaque Adaptometers was made. The first named instrument was a modification of the adaptometer described in a report dated February, 1944 and titled "Night Vision Studies" (Cf. Abstract no. 71). The source of light was a radium plaque and brightness levels were varied by means of perforated slides placed in front of the plaque. The levels were 4.85, 4.30 and 3.85 log units micromicrolamberts respectively. Eight subjects were tested simultaneously at a distance of 20 feet. No fixation light.

Tests with the two adaptometers were given to 115 men at Camp Lejeune. There were 48 presentations of the stimulus in each case, and since 3 levels of brightness were used with the Rostenberg the presentations were 16 at each level. With the Radium Plaque test which has a single brightness level, the full series of 48 presentations was given at the level. All the men were tested 4 times with both instruments.

The data given in 3 tables reveal that the distributions of scores were skewed definitely toward the high scores in each of the 4 tests with each instrument. The passing score for 48 trials on the Radium Plaque was 39 or 75% seeing (48 trials) and for the Modified Rostenberg it was 38.

N = 115 48 trials	Navy Radium Plaque Test				Modified Rostenberg Test			
	1	2	3	4	1	2	3	4
Number passed	93	106	113	113	95	100	107	108
Number failed	22	9	2	2	20	15	8	7
Median score	45.6	47.6	48.0	48.0	46.0	47.3	47.6	47.4

The last 16 trials in each test were separately treated, a passing score being defined as 13 correct out of the 16.

N = 115 Last 16 trials	Navy Radium Plaque Test 1	2	3	4	Modified Rostenberg Test 1	2	3	4
Number passed	91	106	112	113	72	79	87	95
Number failed	24	9	3	2	43	36	28	20
Median Score	15.7	16	16	16	14.5	15.6	16	15.7

In the case of the Rostenberg test the last 16 trials were given with the lowest brightness level, viz., 3.85 log units.

The test-retest coefficients of correlation (tetrachoric) between the tests and for each adaptometer were:

	Test 1 vs 2	2 vs 3	3 vs 4	1 vs 3	1 vs 4	2 vs 4
Navy Radium Plaque:						
48 trials						
r (tetrachoric) =	.65	.66	.52	.43	.52	.47
Modified Rostenberg:						
48 trials						
r (tetrachoric) =	.66	.72	.78	.72	.64	.77
Last 16 trials r =	.72	.78	.79	.74	.67	.79

The intercorrelations (tetrachoric) of tests with the two instruments for 4 successive test days were .63, .51, .52, and .60 respectively.

Although the Rostenberg showed a slight superiority in test-retest reliability its size and the requirement of a relatively large space for testing purposes made it not altogether suitable for use afloat or in shore stations where dark room space was not available.

101. ANON. Constructing ANVT-1. U. S. AGF. Armored School. Fort Knox, Kentucky. May 18, 1945. (4955) (O)

This is a 35-page manual of instructions for the construction of the night vision tester developed at Fort Sill, Oklahoma by L. O. Rostenberg, and described in a report titled "Night Vision Studies" dated February, 1944 (Cf. Abstract no. 71). There are 72 figures and detailed specifications of the several parts in the assemblage.

102. A. CHAPANIS. Night vision testing and training in the Army ground forces. U. S. AAF-ATSC. July 1, 1945. (5001) (S)

The report, with 4 appendices, was devoted primarily to observations on the testing and training program carried on at Fort Knox, Kentucky, and also on certain devices and equipment in use during night operations. The period covered by the report was May 16-June 7, 1945.

The official test for the Army Ground Forces is the Army Night Vision Tester-Trainer ANVT-1 (Cf. Abstract no. 71). During the period covered by the report there was opportunity to test 32 men with ANVT-1 and with the AML Radium Plaque NVT (Cf. Abstract no. 94). The intercorrelation coefficient between scores with both instruments was r = .67.

Full details of the testing and training program were given in the text of the report and in appendix 1. It was felt that the testing part of the program could be improved and extended. The night vision training was complete and thorough and might very well be used as a model in other service branches.

103. R. H. DRAEGER, R. H. LEE, and M. B. FISHER. Design, construction and preliminary evaluation of a portable multiple brightness radium plaque adaptometer. U. S. Navy. Naval medical research institute, Bethesda, Md. August 11, 1945. (4956) (O)

The project involved (a) the construction of the adaptometer, and (b) the comparison of the performance of subjects when tested by the instrument and two other devices, namely, the Navy Radium Plaque Adaptometer and the Modified Rostenberg apparatus.

The NMRI portable adaptometer consisted essentially of a disc of radioactive substances with a surface brightness of 7.0 log units micromicrolamberts set in a framework. In front of the disc was a truncated cone arrangement with its base occupied by a rotating head device and containing a figure T test object. Light from the disc passed through a selected aperture and a diffusing surface to illuminate the field against which the T test object was viewed. The brightness levels were varied by means of 5 graduated apertures in steps of approximately .2 log units from 4.1 to 3.3 log units. Full details of the parts of the instrument together with a diagram and 2 photographs were provided. The Navy Radium Plaque was the standard instrument in use and the Modified Rostenberg apparatus was that described by Lee and Fisher, "Evaluation of the Modified Rostenberg Adaptometer," May 8, 1945 (Cf. Abstract no. 100).

The experiments were carried on at Camp Lejeune, N. C. in connection with those reported by Lee and Fisher, May 8, 1945. One hundred and fifteen subjects were used. Some data previously reported by Lee and Fisher were incorporated in this report for purposes of comparison of the three instruments, viz., the NMRI, the NRP (Navy) and the MR (Modified Rostenberg).

N = 115 48 trials	NMRI Test 1	2	3	4
Number passed	82	109	108	111
Number failed	33	6	7	4
Median Score	43.6	47.7	47.9	48.0

The passing score was set at 75% seeing or 38 correct responses out of 48 trials. The comparable data for NRP and MR are included in Abstract no. 100. All three distributions showed large skew characteristics. The majority of the errors were made when the lowest test brightnesses were used with NMRI, as was the case also with MR. With the NRP adaptometer the errors were approximately equally distributed through the 48 trials.

Reliability coefficients (tetrachoric) both split-half and test-retest, were given for each instrument.

The split-half reliability of the NMRI was said to be more consistent than those of the other two instruments which showed considerable variability from test to test (48 trials). In the case of NRP it was noted that the score on 16 trials had approximately the same reliability to be expected by the Spearman-Brown formula from reducing the test to one-third its original length. In the case of the NMRI and MR, the reliability of the last 16 trials was approximately that of the whole tests and the results are in harmony with the fact that relatively few errors were made and little discrimination produced by the 32 trials in which the higher brightness levels were used. The test-retest reliability coefficients were all fairly low and indicated considerable day-to-day variability. The MR instrument appeared in general to have the higher values.

The experiment was designed to test the effect of a level of brightness other than the standard single brightness used in the Navy Radium Plaque Adaptometer test of night vision. By means of suitable filters a level of approximately 3.7 log units was produced and used in conjunction with the standard level of approximately 3.9 log units. Group A (219 men) was tested first with the standard level (Level I) and immediately thereafter with the more difficult level (Level II). Group B (227 men) was first tested with Level II, followed immediately by a Level I test.

The data were given in 3 figures and 8 tables. The distributions of scores made by the two groups on Level I, 3.9 log units brightness and Level II, 3.7 log units brightness, are given below in condensed form:

	Distributions (condensed)							
	Group A				Group B			
Scores	Level I		Level II		Level I		Level II	
	F.	Cum. %	F.	Cum. %	F.	Cum. %	F.	Cum. %
10/10	132	60%	41	19%	123	45%	40	18%
19/20 to 16/20	59	to 87%	48	to 41%	63	to 82%	50	to 30%
15/20 and below	28	to 100%	130	to 100%	41	to 100%	137	to 100%
N =	219		219		227		227	

The same data were plotted in cumulative percentage curve, also, on a probability grid, and showed that the RPA scores followed a normal distribution. Variability was the same on both testing levels, Group B was slightly inferior to Group A in performance on Level I, due, it was surmised, to the fact that the more difficult test (Level II) was given first and it impaired the performance on Level I by "discouragement." A Chi square test of homogeneity of the men in Groups A and B yielded:

Level I. Chi square = 5.70
Level II. Chi square = 0.07

The chances that the performance of Group B on Level I differs from that of Group A were approximately 97 in 100. The chances that the performance of Group B on Level II differs from that of Group A fall between 50 in 100 and 5 in 100.

In a discussion it is pointed out that a test of the Radium Plaque type must be based on the statistical properties of small samples. Twenty trials provides the basis of an estimate of the probability of seeing by an individual at a fixed brightness level. To fail those persons whose probability of seeing is 30% or less (on the .001 level of confidence) a failing score of 15/20 is required. This holds good without regard to the brightness level at which the test may be run. In the experiment under discussion in which the difficulty was increased by reducing the standard brightness by .20 log units the percentage of men failing, provided the 30% frequency of seeing is desired as a cutting performance, is increased from 15.5% to 59.9%. On the other hand, if it is desired to eliminate those whose frequency of seeing is 0%, the percentage of failures must be increased from 4.9% to 28.8% in order to insure that no such person can pass. It may be asserted that the reliability of the RPA test at a lower level of brightness will be the same as it is at the standard level. It is further asserted that no significant purpose will be served by altering the difficulty of the RPA test. One result would be to fail a larger percentage of subjects which is of doubtful desirability in a test of undetermined validity.

105. J. H. SULZMAN. A study of the physiological blind-spot of the dark adapted fovea. U. S. Navy. Medical research department. Submarine base, New London, Connecticut. March 1, 1946. (4910) (O)

Three devices were used in this study. The first was the Livingston Test equipment consisting of a Bjerrum tangent screen of black cloth and 6 self-luminous targets. It was developed for the purpose of examination of the central visual field under scotopic conditions. The second was the Korb Diaphragm Shutter Scotometer. Both devices were designed to permit the measurement of central scotoma. The third device was the Navy Radium Plaque Adaptometer. Twenty-four subjects were given tests and retests with each device.

Reference was made to the results stated by Ross (Cf. Abstract no. 99) to the effect that tests with the RPA at a distance of 7 feet yielded a wider classification of subjects than was the case when the standard or prescribed 5-foot distance was used. In this study 20 trials with RPA were given at 7 feet and 20 at 5 feet. Reliability coefficients were given as follows:

Test retest	RPA 5-foot distance	RPA 7-foot distance	5 feet vs 7 feet
r =	.815	.821	.729

A comparison of scores based on 16 correct out of 20 as a pass-fail dichotomy for both the 7 foot and 5 foot distances follows:

Seven-foot distance	RPA Five-foot distance Pass	Fail	Total
Pass	7	0	7
Fail	9	8	17
Total	16	8	24

The relationships between the scotometers and the RPA were described and briefly discussed.

106. W. S. VERPLANCK. Reliability of the RPA over long test-retest intervals. U. S. Navy. Medical research department. Submarine base, New London, Connecticut. August 15, 1946. (O)

In the early part of 1944 a large group of men was tested with the Navy Radium Plaque Adaptometer. Toward the end of the year another large group was similarly tested. An examination of the data revealed that 777 men had been included in the earlier and the later studies. Inasmuch as several months had elapsed in the interval an opportunity was provided to make a statistical study of the relevant data on test-retest reliability. The problem was stated as follows: To what extent is the classification of personnel with respect to night vision by means of RPA test results reproducible over long periods of time?

The data were given in 1 figure and 8 tables under the following captions:

1. Reliability of classifications by first test only.
2. Reliability of classifications with systematic retest of failures.
3. Test-retest reliability within each testing series.
4. Adequacy of sample.

5. Stability of norms.
6. Reliability of tests given in December series (i.e., the later series).

The two tables below refer to items 1 and 2 respectively:

Test-Retest reliability.

1. Results on first administration of each series only considered.

Later test	Percentages Earlier Test Pass	Fail	Total	Tetrachoric
Pass	78.4	17.6	96.0	r
Fail	1.4	2.6	4.0	.72
Total	79.8	20.2	100.0	

2. Results on retests considered.

Later test	Percentages Earlier Test Pass	Fail	Total	Tetrachoric
Pass	92.5	4.5	97.0	r
Fail	1.3	1.7	3.0	.88
Total	93.8	6.2	100.0	

The test-retest reliability within each testing series (item 3) was investigated by means of two methods. The first was the Chi square procedure to test a hypothesis, which in this case was, the test is without reliability and does not select out a portion of the population differing from the rest with respect to night vision. The second method involved the use of the data derived from the larger groups, previously studied, in the construction of tables from which a coefficient of correlation could be obtained. The final results are summarized:

Earlier test:

(1) Chi square test of reliability of RPA Pass/Fail classification
Chi square = 70.4; p = less than .00001.

(2) 5% tetrachoric r = .76
1% tetrachoric r = .59

Later test:

(1) Chi square test of reliability of RPA Pass/Fail classification
Chi square = 458; p = less than .00001

(2) 5% tetrachoric r = .95
1% tetrachoric r = .91

The results were said to indicate that the pass/fail categorization preferred by the RPA test of night vision is highly reliable.

The analysis of the data with respect to the adequacy of the sample (item 4) showed the following:

	Chi square Test of Homogeneity Earlier Test 777 men out of 5750	Later Test 777 men out of 3256
Chi square =	4.26	14.4
p =	Less than 5 Greater than 1	.01

The probability is, as indicated, that the sample group of 777 men was representative of the earlier test population. However, it was not representative of the later test population. Only half as many of the retest group failed the test as predicted of the whole population. This was said to reflect the greater experience of the retest group with the test as well as improved operator skill.

The stability of norms (item 5) was investigated by means of cumulative frequency data (distributions and curves) and the Chi square procedure. Three large populations were involved; two of them being the total groups, 5750 men and 3256 men, from which the sample of 777 men was taken. A population of 3461 men tested routinely in the period intervening between what has been referred to above as the earlier and the later tests constituted the third group. The groups were designated populations A, B, and C respectively. Chi square tests of homogeneity on the percentages of men passing and failing the tests in each group were computed. A condensation of the table shows:

Chi square tests of homogeneity of three populations.

Population	Predicted by Population	Chi square	"p"
A	B	57.6	.00..1
A	C	269.0	.0001
B	A	29.0	.000..1
B	C	154.9	.0..01
C	A	194.0	.00..01
C	B	93.9	.00..01

It was noted that the norms were not stable. The scores on the later tests, i.e., population C, were better with a significantly smaller proportion of failures. Each series differed significantly from the other two. The reasons listed for the shift toward higher scores were (1) familiarity with the test, (2) more skillful operators.

The results of the investigation were discussed against a restatement of the principles upon which the RPA test was developed. The present results were stated as follows:

1. A progressive shift in the results obtained on large groups is found to have taken place over a period of several months. Associated with this is an increase in the estimated test-retest reliability over short intervals of time.

2. Despite the shift in performance of large populations the RPA classifications obtained on the early test series are reproducible after the passage of several months.

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