

LEVEL



ARI TECHNICAL REPORT
TR-79-A14

AD A071115

A Review of Selected Literature on Stresses Affecting Soldiers in Combat

by

Albert L. Kubala and William L. Warnick

HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street
Alexandria, Virginia 22314

May 1979

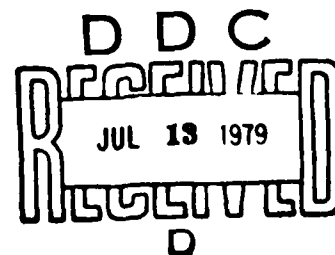
Contract DAHC 19-75-C-0025

Monitored by
ARI Field Unit at Fort Hood, Texas

Prepared for



U.S. ARMY RESEARCH INSTITUTE
for the BEHAVIORAL and SOCIAL SCIENCES
5001 Eisenhower Avenue
Alexandria, Virginia 22333



Approved for public release; distribution unlimited

79 07 12 010

DDC FILE COPY

U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the
Deputy Chief of Staff for Personnel

JOSEPH ZEIDNER
Technical Director

WILLIAM L. HAUSER
Colonel, US Army
Commander

Research accomplished
under contract to the Department of the Army

Human Resources Research Organization

NOTICES

DISTRIBUTION: Primary distribution of this report has been made by ARI. Please address correspondence concerning distribution of reports to: U. S. Army Research Institute for the Behavioral and Social Sciences, ATTN PERI-P, 5001 Eisenhower Avenue, Alexandria, Virginia 22333.

FINAL DISPOSITION: This report may be destroyed when it is no longer needed. Please do not return it to the U. S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

RECIPIENT'S CATALOG NUMBER

TR-79-A14

—

3. RECIPIENT'S CATALOG NUMBER

TITLE (and Subtitle)

A REVIEW OF SELECTED LITERATURE ON STRESSES AFFECTING SOLDIERS IN COMBAT

~~TYPE OF REPORT PERIOD COVERED~~

Technical Report
11 May 1977 - 11 May 1978

PERFORMING ORG. REPORT NUMBER
FR-WD-TX-78-6

AUTHOR(s)

/Albert L./Kubala and William L./Warnick

8. CONTRACT OR GRANT NUMBER(s)

DAHC19-75-C-0025

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Human Resources Research Organization
300 North Washington Street
Alexandria, Virginia 22314

10. PROGRAM ELEMENT, PROJECT, TASK
AREA & WORK UNIT NUMBERS

20763743A775

11. CONTROLLING OFFICE NAME AND ADDRESS

HQ, TCATA
Fort Hood, TX 76544

12. ~~REPORT DATE~~

May 1979

13. NUMBER OF PAGES

69

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

**US Army Research Institute for the Behavioral
and Social Sciences, 5001 Eisenhower Avenue,
Alexandria, Virginia 22333**

15. SECURITY CLASS. (of this report)

UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release: distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Monitored by Charles O. Nystrom, ARI Field Unit at Fort Hood, TX.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Combat Stress
Physiological Stress
Psychological Stress

Performance (human)

Stress Research

20. **ABSTRACT** (Outline on reverse side if necessary and identify by block number)

⚡ This report reviews selected literature on psychological and physiological stressors which affect the soldier in combat. The selections were oriented toward: (a) documents which describe the types of stressors which are likely to be encountered on the battlefield, and (b) documents which describe performance during or following stressful experiences.

Army Project Number
2Q763743A775

Human Performance
in Field Assessment
Contract No. DAHC19-75-C-0025

Technical Report TR-79-A14

A REVIEW OF SELECTED LITERATURE ON STRESSES
AFFECTING SOLDIERS IN COMBAT

Albert L. Kubala and William L. Warnick
Human Resources Research Organization

Submitted by:
George M. Gividen, Chief
ARI FIELD UNIT AT FORT HOOD, TEXAS

May 1979

Approved by:

Frank J. Harris, Acting Director
Organizations and Systems
Research Laboratory

Joseph Zeidner, Technical Director
U.S. Army Research Institute for
the Behavioral and Social Sciences

Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DDC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
A	Avail and/or special

Approved for public release; distribution unlimited

FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity; formerly called MASSTER--Modern Army Selected Systems Test Evaluation and Review). This support is provided by assessing human performance aspects in field evaluations of man/weapons systems.

A war using modern weapons systems is likely to be both intense and short. US man/weapons systems must be effective enough, immediately, to offset greater numbers of an enemy. Cost-effective procurement of improved or new combat systems requires testing that includes evaluation of the systems in operational settings similar to those in which the systems are intended to be used, with troops representative of those who would be using the systems in combat. The doctrine, tactics, and training packages associated with the systems being evaluated must themselves also be tested and refined as necessary.

This report presents the results of a review of selected literature on psychological and physiological stress. The literature selected was oriented toward: (a) documents which describe the types of stresses confronted by soldiers in combat, and (b) documents which describe performance during or following stress. Recommendations for further research are made.

ARI research in this area is conducted as an in-house effort, and as joint efforts with organizations possessing unique capabilities for human factors research. The research described in this report was done by personnel of the Human Resources Research Organization (HumRRO), under contract DAHC19-75-C-0025, monitored by personnel from the ARI Fort Hood Field Unit. This research is responsive to the special requirements of TCATA and the objectives of RDTE Project 2Q763743A775, "Human Performance in Field Assessment," FY 1978 Work Program.

A REVIEW OF SELECTED LITERATURE ON STRESSES AFFECTING SOLDIERS IN COMBAT

BRIEF

Requirement:

The work carried out in this study is that referred to in paragraph 2.2.7 of the Statement of Work dated 24 February 1977 under the title "Effects of Stress on Performance." The following objectives guided the study:

- To determine the nature and extent of the most prevalent psychological and physiological stresses confronting the soldier on the battlefield.
- To determine the extent of and the major factors which influence neuropsychiatric casualty rates.
- To determine the degree to which performance is affected by various types of stress.

Procedure:

Relevant literature was sought from a variety of sources. Searches employing several different combinations of key words were conducted through the Defense Documentation Center. Other materials were sought through personal contacts and searches in a large university library. The bibliographies or reference sections of every document obtained were also scanned in an effort to locate additional relevant literature. Literature reviews or bibliographies on stress were sought in particular.

The literature obtained was categorized into that dealing with: (a) the history of the problem in the US military, (b) stress concepts, (c) the extent of the stress problem, (d) stresses affecting soldiers in combat, and (e) effects of stress on performance. A report was written which discusses the literature in each of the five categories listed above. Recommendations for further research were made.

Principal Findings:

- Neuropsychiatric casualties were a major problem for US forces in World War II, a smaller problem in Korea, and a comparatively minor problem in Vietnam.
- A multitude of both physiological and psychological stressors confront the soldier in combat.
- Research on the performance effects of stress has been minimal, and the results contain apparent inconsistencies. Much of this work is probably not relevant to the combat situation.

- Wounding rates, cumulative time in combat, and frustrations resulting from a lack of purposeful activity have consistently been associated with increases in combat exhaustion rates.

Utilization of Findings:

This report attempted to summarize and synthesize the major findings concerning the various stresses that might affect soldiers in combat. As a result, major gaps in our knowledge concerning stress effects became evident. Therefore, this report represents a first and necessary step in planning future research on stress.

CONTENTS

CHAPTER	PAGE
1 Introduction	1-1
2 Historical Background, Definition, and Magnitude of the Problem	2-1
Historical Background	2-1
Stress Concepts	2-3
Magnitude of the Problem	2-7
Recapitulation and Comment.	2-13
3 Stressors Affecting the Combat Soldier	3-1
Stressors in the Physical Environment	3-1
Stressors in the Psychological Environment.	3-15
Stresses in a Chemical, Biological, and Radiological Environment	3-24
4 Performance Under Stress	4-1
Introduction.	4-1
Performance Under Various Stressors	4-4
Other Concomitants of Stress.	4-16
Coping With Stress.	4-17
Summary	4-21
5 Review and Comment	5-1
REFERENCES	R-1

Chapter 1

INTRODUCTION

The purpose of this report is to provide a current review of the literature on stresses as they affect the soldier in combat. Army authorities have long been concerned about stress and its effects on human behavior and mission accomplishment. The literature on the subject is voluminous. However, most of the research is concerned primarily with single stressors. The stresses faced by the soldier on the battlefield are many, and usually act in combination rather than singly.

Psychologists and psychiatrists have typically concerned themselves largely with "combat stress." However, a satisfactory definition of combat stress has proven to be elusive. Other stressors, such as heat, cold, and malnutrition, are seldom dealt with in any detail by behavioral scientists, and their specific effects on behavior and job performance are largely ignored in the literature on combat stress. Even largely psychological stressors such as isolation and confinement tend to be dealt with as isolated variables. This review was initiated as an attempt to place the various kinds of stressors into proper perspective, that is, to present the "big picture." Unfortunately, the body of literature dealing with the specific behavioral and performance effects of combinations of or interactions between stressors is indeed small. Nevertheless, it was felt that a single report which consolidated the major findings concerning the various stressors would be worthwhile. Such a survey should serve to point out the gaps in our scientific knowledge concerning the effect of stress on the job performance of the soldier in combat.

As mentioned earlier, the literature on stress is extensive. An adequate review of the entire subject would take volumes. Therefore, it was necessary to limit the scope of this literature review in some manner. This was done in part by treating only selected specific topics. For example, literature dealing with normal stresses of everyday living such as family problems and professional setbacks was rejected. It is not intended to imply that such stresses could not contribute to the problems faced by the combat soldier. The soldier concerned about promotion or other aspects of his professional career, or concerned about the fidelity of a wife or girlfriend, may well carry these stresses onto the battlefield. However, such stresses are not applicable to some soldiers, and affect those to whom they do apply to varying degrees. Furthermore, unless a soldier becomes severely maladjusted and is referred for a psychiatric evaluation, the existence of or contribution of such personal problems is likely to be unknown. Other topics which will not be covered, although part of the military stress literature, are: (a) problems in transitioning from civilian to military life, (b) variations in stress tolerance and response to stress as functions of cultural backgrounds, (c) readjustment to civilian life, (d) stresses

encountered by prisoners of war, (e) selection for military service and/or for hazardous duty, and (f) treatment of personnel referred for psychiatric reasons. The literature dealing solely with selection is in itself quite large. However, the soldier on the battlefield has already been "selected," so this literature is largely irrelevant to the topic at hand. The literature on the treatment of neuropsychiatric casualties is also quite extensive. But again, literature on methods, procedures, and results of treatment are not particularly relevant. Nevertheless, some of this literature was examined in hopes of gaining insight into the workings of stress on the battlefield. Other topics, such as the effects of psychological warfare will be dealt with only very briefly.

A review of the literature on battlefield stresses seemed appropriate at this time for two reasons. First of all, our armed forces are not at the present time engaged in any conflict, so there is opportunity to reflect on what is known about stress, and hopefully, to better prepare military personnel to cope with stress. Changes in organizational structure and modifications to equipment which may reduce stress can be considered. In brief, it is time to reflect on what is known and to prepare for the future. A second reason for a review at this time is that little research on stress is being conducted at this time. Furthermore, prospects for stress research in the immediate future are poor. This state of events is due in a large part to a concern for the rights of human subjects involved in experimentation, a concern which has been steadily growing since the early 1950s. This concern is probably only a part of a more encompassing concern for human rights which began to mushroom after WWII. This movement, especially where minority groups were concerned, received considerable attention and nurture from the news media. It has also lead to a volume of challenges and changes to existing laws. As a part of this movement, a number of groups have challenged traditional approaches to experimentation with human subjects. They were concerned with the ethics of placing subjects in stressful situations without their prior knowledge and consent. In the past, psychologists frequently deceived subjects by concealing the actual purposes and objectives of an experiment. They felt this was necessary if informing the subject of the true nature of the experiment would bias the results. However, recently this practice has been challenged even in the most harmless of experimental situations.

As a result of these developments, a number of guidelines concerning the use of human subjects in experimentation have been issued. One of the earliest¹ was issued by the American Psychological Association (APA) in 1963.¹ These were revised in 1965 and again in 1972. Another APA publication titled "Ethical Principles in the Conduct of Research with Human Participants" was issued in 1973,² and is one of the most

¹"Ethical Standards of Psychologists." *American Psychologist*, January 1963.

²"Ethical Principles in the Conduct of Research with Human Participants." American Psychological Association, 1973.

comprehensive guides on the subject available today. Anyone who believes that a psychologist's conduct of an experiment falls outside the principles outlined in the policy can refer the matter to the APA Ethics Committee. If the Committee determines the violation to be willful and/or flagrant, they can recommend expulsion from the Association. Expulsion from the Association drastically limits further professional opportunities for a psychologist. In addition, the individual psychologist and the institution he represents might be subject to civil suit for damages by the participants.

The Department of Health, Education and Welfare (DHEW) has also issued detailed guidelines for the protection of human subjects.^{3,4} Any institution or individual receiving funds from DHEW must adhere to these guidelines. The US Army has also developed guidelines which are similar to those adopted by DHEW. These are set forth in Army Regulation 70-25.⁵ Essentially, all of these guidelines set forth the doctrine of "informed consent." They state that a subject must be fully informed of the purposes and objectives of an experiment, the procedures that are to be followed, must freely consent to participation and be permitted to voluntarily withdraw at any time. Even with this oversimplified interpretation of the guidelines, it is obvious that the types of stress which can be used in research are severely limited. For example, it is not possible to place a soldier in the field on some pretext, and then stress him by informing him that he has been "inadvertently" placed in an artillery impact area. In most cases, if the subject is fully informed concerning the experiment, the proposed stressor may well cease to function as a stressor. Intuitively, subjects know that they will not be placed in any real danger by the experimenter. Therefore, unless the threat appears to be the result of an accident, they will realize that they are not in danger, so will not be placed under stress. However, the use of such "accidents" is considered unethical, as it violates the informed aspect of the doctrine of informed consent.

In addition to the guidelines listed above, most organizations conducting research with human subjects have developed internal policies to insure proper protection of subjects' rights. HumRRO has issued guid-

³"The Institutional Guide to DHEW Policy on Protection of Human Subjects. US Department of Health, Education and Welfare, Washington, D.C., December 1, 1971.

⁴"Protection of Human Subjects." *Federal Register*, May 30, 1974, 39(105), Part II, 18914-18920, US Department of Health, Education and Welfare.

⁵US Department of the Army. AR 70-25, "Use of Volunteers as Subjects of Research," Washington, D.C., 31 July 1974.

ance to the research staff in the form of memoranda at frequent periods over the years. A more formal and complete policy statement was issued in April 1974,⁶ and a review committee was established in November 1974.⁷ This committee is charged with the responsibility of insuring that all HumRRO research efforts comply with the guidelines of the sponsoring agency and the APA.

All of the guidelines issued indicate in one form or another that the subjects for experiments must be volunteers. If an individual is fully informed about an experiment, and still volunteers to participate, it seems safe to assume that he at least feels that the stresses involved will not exceed his tolerance. If an individual feels the stresses might become intolerable, he can simply refuse to volunteer. Therefore, individuals who volunteer for experiments involving stress are likely to be those with higher stress tolerance, at least for the experimental stressors. As a result, the generalizations of experimental results must be limited to volunteers, and cannot be extended to the entire population. If these biases obtain, the effects of the experimental stressor will likely be underestimated, as the segment of the population with the least stress tolerance will not volunteer to participate.

The limited options available to behavioral scientists interested in stress research have resulted in a rather marked decrease in stress research activity. Most of the work currently being done is probably of only marginal relevance to the military. The stressors employed are typically distractions such as loud intermittent noises, or, fear of failure. In studies employing fear of failure, the subject is given a virtually impossible task to perform but is lead to believe that most subjects can accomplish the task. While some will even question the ethics of this form of "fooling" subjects, in general, there has not been any indication of great concern on the part of sponsoring agencies. However, fear of failure is stressful only if the subject is concerned about failure. If failure in the particular task is not seen as a threat by the individual, he cannot be expected to evidence stress. Individuals who are ego-involved with a task may be severely threatened by the possibility of failure, and will exhibit a variety of behaviors

⁶"HumRRO Policy Statement Concerning the Protection of Human Subjects." Office of the President, Human Resources Research Organization, Alexandria, Virginia, April 15, 1974.

⁷"Implementing Guidelines for a General Institutional Assurance on Research Involving Human Subjects." Office of the President, Human Resources Research Organization, Alexandria, Virginia, November 13, 1974.

which can be interpreted as stress reactions. Lazarus, et al.⁸ feel that such variation in motivation is largely responsible for the inconsistent results obtained in laboratory studies of stress. Regardless of their validity as stressors, the stresses produced by distraction or fear of failure appear to be subjectively quite different from those produced by exposure to combat or other situations involving fear of death or mutilation.

It is for the reasons discussed above rather than a lack of interest in stress that has caused a curtailment in research relevant to the military. It would appear that research staffs have been unable to devise relevant stress situations which comply with the various ethical guidelines. Relevant research activity is likely to remain at a comparatively low level until useful stress situations can be devised, or until the guidelines are amended to permit researchers greater latitude in applying stress (at least in the military). Therefore, as mentioned earlier, the present seems an appropriate time to assemble, review, and reflect on the knowledge that is available about stress.

Relevant literature was sought from a variety of sources. Searches employing several different combinations of key words were conducted through the Defense Documentation Center (DDC). Other materials were sought through personal contacts and searches in a large university library. The bibliographies or reference sections of every document obtained were also scanned in an effort to locate additional relevant documents. A special effort was directed toward locating literature reviews or bibliographies on the various aspects of stress. Many of the documents sought were published during or shortly after WWII, or, during or shortly after the Korean Conflict. Copies of some of these documents were obtained through inter-library loan, but others simply could not be located from the sources queried. Many of the organizations which in the past have published relevant works are now defunct, or have changed their names (maybe more than once) and missions, and in some instances the name of the successor organizations could not be determined. Some attempts were made to locate the authors of older documents. However, the majority of these could not be located and are apparently retired or deceased. One organization, still in existence, was unable to locate any record of a particular publication.

All of the literature obtained was first reviewed for relevance to the topic. Documents considered to be of only marginal relevance were largely eliminated from further consideration. Others, though topically relevant, were eliminated as they contained material which was dealt with in greater detail in other documents. The vast majority of the

⁸R. S. Lazarus, J. E. Deese, and S. F. Osler. "The Effects of Psychological Stress Upon Performance," *Psychological Bulletin*, July 1952, 49(4), Part I.

literature cited was actually obtained and reviewed by the authors. However, some documents which could not be obtained were cited from secondary sources because of their high relevance. In each such case the document was cited in several of the other items of literature reviewed, and it was felt that failure to discuss the reported findings would detract significantly from this present review.

The reader may notice that most of the literature cited is comparatively "old"; i.e., it was published more than five years before this review was initiated in 1977. This is because, in the opinion of the writers, most of the more recent literature has only marginal relevance to the problems of the soldier in combat. This, it is believed, is due to the curtailment of stress research previously discussed.

The remainder of this report is organized into four chapters. Chapter 2 is intended to place the problem in perspective by providing a brief historical background, a review of wartime data on the magnitude of the problem, and a discussion of the problems in defining stress or developing conceptual models of behavior under stress. Chapter 3 discusses the types of stressors that are likely to affect virtually every soldier actually engaged in combat. Combat stress is emphasized, but other stressing aspects of both the physical and psychological environment are dealt with. Some of the effects of stress on behavior or performance are discussed, however, a more complete discussion of performance under stress is presented in Chapter 4. Finally, Chapter 5 provides a brief summary with comments and conclusions by the authors.

Chapter 2

HISTORICAL BACKGROUND, DEFINITION, AND MAGNITUDE OF THE PROBLEM

Historical Background

Stress in combat and the possibility of acute mental breakdown is not a recent phenomenon. As Glass¹ points out: "Even the Bible records the panic and paralyzing fright of participants in battle." Bourne^{2,3} provides a brief history of the problem in the United States Army. During the Civil War, the Surgeon General of the Union Army described a condition which he termed "nostalgia." This condition rendered men incapable of performing their duties even when there was no evidence of physical injury. The Union Army reported 5,213 cases of nostalgia during the first year of the Civil War, amounting to a rate of 2.34 cases per 1000 troops. In the second year of the war the rate rose to 3.3 cases per 1000 troops. In addition, through the course of the wars, the discharge rate for "insanity" was approximately 6 men per 1000. Also, an average of approximately 21 men per 1000 troops were discharged with paralysis. It is likely that many of these cases of paralysis had no organic basis, and the symptoms would be recognized today as hysterical symptoms. The Russo-Japanese War of 1904-1905 was the first conflict in history in which mentally ill military personnel were treated by psychiatrists. The Russian psychiatric casualties became so numerous that large numbers of patients were turned over to the Red Cross for treatment and final disposition.

Planning for psychiatric casualties was incorporated into the medical planning of the US Army for the first time during WWI. The etiology of the condition was not, however, well understood. It was noted that such casualties increased rather markedly during heavy artillery bombardments. As a result, it was assumed that the condition was organic in nature, resulting from damage inflicted by explosions of nearby artillery rounds. Hence, the term "shell shock" was coined. Beginning with "shell shock," Glass⁴ traces the history of the term-

¹A. J. Glass. "Combat Exhaustion," *US Armed Forces Medical Journal*, 1951, 2(10), 1471-1478.

²P. G. Bourne. "Military Psychiatry and the Vietnam War in Perspective," in P. G. Bourne (ed.), *Psychology and Physiology of Stress*, New York: Academic Press, 1969.

³P. G. Bourne. "Psychological Aspects of Combat," in H. Abram (ed.), *Psychological Aspects of Stress*, Springfield, Illinois: John C. Thomas, 1970, 70-85.

⁴A. J. Glass. "Introduction," in P. G. Bourne (ed.), *Physiology of Stress*, New York: Academic Press, 1969.

nology applied to wartime neuropsychiatric casualties. He points out that during the 1915-1916 time frame, it became evident that shell shock was entirely a psychological disorder. It was not until after WWI that the syndrome came to be called the "war neuroses" or "traumatic neuroses." However, there was still a wide spread belief that psychiatric casualties were found among only those individuals with personality defects or a low stress tolerance. Thus, the stresses of combat were considered to be only a precipitating factor rather than an ultimate cause of war neuroses. With this view, it was naturally assumed that the problem could largely be eliminated by careful psychiatric screening. Therefore, psychiatric rejection rates at the beginning of WWII were 3-4 times those of WWI. The futility of this approach became apparent after the first large-scale land combat during WWII. At this time the primary term utilized was psychoneurosis-anxiety, mixed or conversion types. Later the term "exhaustion" was adopted and was applied to all combat-related psychiatric disorders. Exhaustion was selected because it was descriptive of the appearance of the majority of psychiatric casualties, and also, because it did not connote a basic personality defect. Exhaustion was certainly understandable to any soldier who had been in combat, and therefore, the diagnosis did not carry the social stigma that any diagnosis beginning with the term (psycho) carried. The US Air Force frequently referred to the syndrome as "operational fatigue." During the Korean Conflict exhaustion was changed to "combat exhaustion" to differentiate the neuropsychiatric diagnosis from that of physical exhaustion. The term "combat fatigue" was adopted for Navy and Marine personnel and has survived until this time. During the Vietnam Conflict reasons for psychiatric breakdown were found in the environmental and situational circumstances of combat itself rather than in any innate predisposition to breakdown.

It is interesting that most of the literature, or at least the earlier literature, deals only with the extreme reactions to stress. Little seems to have been written concerning lesser reactions to combat stresses. Furthermore, the literature dealing with disorders primarily psychological in nature seems to be set well apart from that dealing with disorders primarily physical in nature. Yet, the battlefield has both a psychological and a physical environment. The fact that physical stressors play a role in psychological breakdown is certainly recognized, but the extent of their role has received little investigation. The role of psychological factors in the development of physical ailments is also recognized, but probably less well understood. This is perhaps due to the fact that reactions to physical stress, at least biological reactions, are much more predictable and have been studied for a much longer period of time. If an individual collapses on the battlefield under conditions of extreme heat, he is treated as having a purely physical ailment unless he also exhibits bizarre behavior. This tendency is probably due in part to the fact that physiological reactions to environmental factors such as cold, heat, and intense noises are present in the absence of combat, and affect civilians and soldiers

alike. However, the combat exhaustion syndrome is peculiar to the combat soldier. Regardless, this tendency to view ailments as either purely psychological or purely physiological has limited attempts to evaluate the separate contributions of combinations of stressors or causal factors in any ailment, either psychological or physiological.

Stress Concepts

Although much has been written about stress, a precise definition of the term has proven to be elusive. Weitz⁵ reviewed the literature in hopes of finding or developing an acceptable definition of stress. However, after reviewing a portion of what he described as a "mammoth collection" of the literature on stress, he felt that a precise definition of stress might be impossible. Weitz quotes a limerick attributed to H.D. Parsons which expresses his own feeling quite adequately. This limerick, as quoted by Weitz, is:

A wonderful concept is "stress" --
What it means is anyone's guess.
Though its fun to be clinical and
rude to be cynical, operationally
it is a mess!

Weitz points out that some writers think of stress as a stimulus, some as a response, some as both, some as a stimulus/response interaction, while others regard it as a state of an organism or an intervening variable. He further states that people identify stimuli as stressful on the basis of the responses to the stimuli. That is, we infer a state of stress resulting from some stimulus only if it affects response. He further points out that military concern probably centers on those stressful stimuli which result in a degraded performance. Weitz presents a model in which a "stimulus situation" impinges upon an organism which makes a "perceptual appraisal" (also referred to as a "cognitive appraisal"). The organism appraises the situation and considers the possible responses that might be made. Some responses are relevant to the situation and others are not. Finally, an "external or observable response" is made. In this model, Weitz views stress as an intervening variable and considers it as the interaction of response tendencies and the cognitive appraisal. The implications of Weitz' model are not completely clear to the present authors. For example, he views the potential responses as being arranged in hierarchical fashion, and if an appropriate response is higher in the hierarchy than an inappropriate response, a "coping" response will be made. Weitz does not make clear why a non-coping response would be higher in the hierarchy than a coping response.

⁵J. Weitz. *Stress*, Research Paper P-251, Institute for Defense Analysis, April 1966.

Weitz further hypothesizes "...that the stress state will occur when the outcome of the situation is important to the subject and there is an awareness on the part of the subject of the possibility of 'unpleasant' outcomes." He further states that these are necessary but not sufficient conditions. While these statements certainly seem acceptable to the present authors, they throw no further light on reasons why inappropriate responses occur.

Helmreich⁶ also states that psychologists have been unable to develop a generally accepted definition of psychological stress. However, Helmreich was less timid than Weitz, and provided definitions for his own use. He accepted Scott's⁷ definition of stressful situations as "...situations in which adjustment is difficult or impossible but in which motivation is very strong." The similarity between this and Weitz' statement concerning necessary conditions is evident. Helmreich goes on to define stress as "...the state resulting from exposure to a stressful situation." Beyond its circularity, there is nothing objectionable in Helmreich's definition, but it is inadequate for use in military research. As mentioned before, if stress is viewed as a "state" of an organism, it can only be inferred from behavior. In fact, in the military, behavioral changes are at the very core of the interest in stress. For the military psychologist, a "stressful situation" would be defined as one which has a reasonably high probability of resulting in a behavioral change. Behavior, or performance, might actually improve, and/or be effective or coping. However, the military psychologist is far more concerned with maladaptive behavior; i.e., behavior which is undesirable from the standpoint of mission accomplishment and/or involves unnecessary personal risks.

The need to anchor stress concepts to behavior seems to have been the impetus for Kern's⁸ attempt to develop a conceptual model of behavior under stress. Borrowing heavily on work by Swank and Marchand,⁹

⁶ R. L. Helmreich. *Human Reactions to Psychological Stress, Self-Esteem and Attitudes*, Technical Report 12, University of Texas, Austin, November 1970.

⁷ J. P. Scott. "Relative Importance of Social and Hereditary Factors in Life Adjustment During Periods of Stress in Laboratory Animals, *Life Stress and Bodily Disease*, Association for Research in Nervous Mental Disease, 1949.

⁸ R. P. Kern. *A Conceptual Model of Behavior Under Stress, with Implications for Combat Training*, Technical Report 66-12, George Washington University, Human Resources Research Office (HumRRO), June 1966.

⁹ R. L. Swank and W. E. Marchand. "Development of Combat Exhaustion," *Archives of Neurology and Psychiatry*, 1946, 55, 236-247.

Kern analyzes behavior under extreme stress into three stages. In Stage 1, the individual is oriented toward external cues associated with control or manipulation of the environment. A soldier in this stage would be learning how to apply much of the knowledge acquired in training and to differentiate between important and unimportant cues in the combat environment. In essence then, at this stage he learns how to perform as expected while minimizing exposure to danger. During this period the soldier reaches his maximum effectiveness. In Stage 2, the soldier attends to external danger stimuli and internal anticipatory damage stimuli. Upon entering Stage 2, the soldier begins to perceive himself as being in a situation over which he has little control. His behavior turns more and more towards self-preservation and away from job performance-centered activities. In Stage 3 the soldier responds almost entirely to internal stimuli. Attempts to control the environment and eliminate the bodily threat through job performance activities drastically declines. In fact, activities directed at self-preservation also decline. The soldier appears to withdraw totally from his environment and becomes apathetic to the point of failing to take cover during an attack. A soldier who slips into Stage 3 becomes a liability to his unit, and unless removed from combat, is very likely to become a casualty to enemy action. Kern goes on to state that these more or less observable reactions are the result of a "stress process" in which an attitude of situational-confidence erodes into an attitude of situational-despair. The implications of the model are obvious. An attitude of confidence must be developed, i.e., both confidence in self and confidence in equipment, through training.

The failure to derive a satisfactory "dictionary" definition of stress has led investigators to look not only at behavior, but also to attempts to delineate the characteristics of stressors or stressful situations. Intuitively, it has been known for some time that stress is created by the perception of the threat. Recently, experimental work was undertaken to demonstrate this point. Wherry developed the Anticipatory Physical Threat Stress (APTS) model.^{10,11} Wherry's model states that performance on any task is affected as a function of: "(a) the perceived proximity (closeness of the unpleasant event), (b) the perceived unpleasantness of the event if it occurs, and (c) the perceived probability that the unpleasant event will occur." For an event to be truly stressful, it must meet all three criteria. For example, if a soldier believes that an attack is imminent which will result in many

¹⁰R. J. Wherry and P. M. Curran. *A Study of Some Determiners of Psychological Stress*, US Naval School of Aviation Medicine, Pensacola, Florida, July 1965.

¹¹P. M. Curran and R. J. Wherry. "Measure of Susceptibility to Psychological Stress," *Aerospace Medicine*, October 1975, 36, 929-933.

deaths and serious injuries, and that there is a high likelihood of serious personal injury, then the situation will result in near intolerable stress. However, if the soldier feels invulnerable, it matters little if he assumes that the attack is certain and will occur in the very near future. In Kern's¹² terms, confidence rather than despair would lead to a prediction of reduced stress in Wherry's model. Wherry and his co-workers were able to validate the model in a laboratory setting employing anticipated electric shock as the stressor.

Berkun, et al.¹³ also developed criteria for determining the validity of presumed stressors. They were actually concerned with experimental stressors; hence, their criteria are stated in terms of response comparisons between experimental and control subjects. These criteria are:

1. Subjective self-report. A Thurstone-type scale known as the Subjective Stress Scale was employed to obtain self-reports. For a stressor to meet this criterion, subjects subjected to the stressor had to choose words which indicated more negative affect than those chosen by a control group.
2. Performance. Both control and experimental subjects were required to perform some situationally relevant task which could be scored quantitatively in terms of accuracy, completeness, or speed. To meet this criterion, the distribution of scores made by experimental subjects had to differ in either central tendency or in shape from the distribution of comparable scores by a control group.
3. Physiological response. To meet this criterion, experimental subjects had to show some measures of hyperactivity of the adrenal cortex.

It should be noted that the performance criterion requires only a difference in performance, and not necessarily a degradation. For example, mild stress has frequently been shown to enhance rather than degrade performance.

The foregoing sampling of stress-related concepts is by no means intended to be comprehensive. It is presented to illustrate the difficulties encountered in attempting to define a primarily mentalistic concept such as stress. The reader interested in further discussions of

¹²Kern, *op. cit.*

¹³M. M. Berkun. *Human Psychophysiological Response to Stress: Successful Experimental Simulation of Real-Life Stresses*, HumRRO Research Memorandum, George Washington University, Human Resources Research Organization, December 1959.

stress concepts as they might relate to the military is referred to Chiles¹⁴ or Walker, et al.¹⁵ For military usage, concepts anchored in job performance or other observable behaviors are preferred to dictionary type definitions. The military must of necessity be pragmatic. To properly utilize the concepts of stress, military authorities need to know: (a) what conditions are likely to result in degraded performance; (b) how long these conditions can exist before performance is degraded; (c) what percentage of the men are likely to be affected; and (d) how performance changes as a function of time under given conditions. The above should not be construed as implying that commanders have no concern for their men. It simply indicates a need to know what to expect of men in combat, so that realistic plans can be made.

Magnitude of the Problem

The actual magnitude of the effects of stress on the combat soldier cannot be ascertained. Stress may degrade, or in some instances enhance, the performance of all combat soldiers. However, the degree to which performance is affected would be extremely difficult to measure, and so far as is known, only one attempt has been made to measure the performance effects of combat stress under partially controlled conditions. This will be discussed at some length in Chapter 4. The notion that performance is affected at all by stress comes largely from clinical studies and observations of performance on the battlefield. Medical authorities are typically only aware of extreme cases of non-performance. In other words, soldiers are normally left in their assignments until either a complete physical or mental breakdown occurs, or, they are referred for treatment by a superior by reason of bizarre behavior or grossly ineffective job performance. Therefore, statistically, the effects of stress are judged on the basis of extreme cases. Yet, the evidence from clinical studies indicates that performance becomes degraded long before a breakdown occurs. For example, see Swank¹⁶ or Swank and Marchand¹⁷ for a detailed analysis of behavior and symptom

¹⁴W. D. Chiles. *Psychological Stress as a Theoretical Concept*, WADC Technical Report 57-457, Wright Air Development Center, Wright-Patterson AFB, Ohio, July 1957.

¹⁵N. K. Walker, F. Schectman, and E. DeSocio. *Further Work on the Use of Tracking Tasks as Indicators of Stress*, Washington School of Psychiatry, Washington, D.C., January 1964.

¹⁶R. L. Swank. "Combat Exhaustion," *Journal of Nervous and Mental Disease*, 1949, 109(6), Serial No. 810, 475-508.

¹⁷Swank and Marchand, *op. cit.*

Beebe and DeBakey,²⁴ Glass,²⁵ or Appel, et al.²⁶ As an indication of the strength of this relationship, Beebe and DeBakey report correlation coefficients between non-battle and battle attrition in the European Theatre during WWII ran from +.70 to +.80. Beebe and DeBakey also present data reported elsewhere which illustrate how casualty rates varied as a function of duty position. For clerk typists, the admission rates were .5 for battle and 2.0 for non-battle per 1000 men per day. Among riflemen, the battle admission rate was 12.2 and the non-battle admission rate was 10.7 per 1000 men per day. Certainly a strong relationship between battle and non-battle casualties might be expected. As Appel, et al. have stated: "The incidence of wounding is an index of the intensity of combat, which is thus shown to determine in large part the incidence of neuropsychiatric casualties in both wars."

Time in combat is a second factor which influences neuropsychiatric casualty rates. Time in and the severity of combat are frequently related. Vineberg, in his review of combat stresses, believes that cumulative stress, which is primarily a function of the duration of a man's exposure to battle, is the most important factor affecting the neuropsychiatric casualty rate. Beebe and Appel²⁷ examined the records of 2500 representative WWII infantrymen with high-risk assignments. Their data revealed with alarming clarity the significance of time in combat as a factor in NP attrition. Based on their data, which ranges up to 80 days of company combat, they estimate that 47% of the men would have become NP casualties had they not been removed from combat for other reasons. In extrapolating their data by actuarial methods, they estimate that 90% of the men would breakdown by day 210, and that after 260 days, 95% would become neuropsychiatric casualties. Rates of this magnitude have not actually been observed because other forms of attrition intervened too rapidly for NP attrition to reach these high levels. Fortunately, the majority of WWII soldiers were undoubtedly not subjected to such long periods of constant combat.

²⁴G. W. Beebe and M. E. DeBakey. *Battle Casualties-Incidence Mortality, and Logistic Considerations*, Springfield, Illinois: Charles C. Thomas, 1952.

²⁵A. J. Glass. "The Problem of Stress in the Combat Zone," *Symposium on Stress*, Walter Reed Army Medical Center, Washington, D.C., March 1953.

²⁶Appel, Beebe, and Hilger, *op. cit.*

²⁷G. W. Beebe and J. W. Appel. *Variation in Psychological Tolerance to Ground Combat in World War II*, National Academy of Sciences, April, 1958.

Experience in the Italian Campaign was somewhat different than that in North Africa. Appel and Beebe²⁸ report that the officers in Italy generally agreed that soldiers became ineffective after 140 to 180 days of combat. These same officers felt that the peak of combat efficiency was reached on approximately the 90th day of combat. Attrition during the Normandy Campaign was much more severe. Swank²⁹ reports that some units had lost all of their original men at the end of 45 days, while many of the other units, at least theoretically, reached 100% casualties in 110 to 130 days. Differences between the Italian and the Normandy campaigns are evident in the observations made by Swank and Marchand³⁰ concerning the Normandy Campaign. They state that the large majority of men achieved an adequate adjustment to the combat situation in approximately 5 to 7 days. Peak efficiency as a combat soldier was reached after 21 days and was maintained for approximately an additional week. After 25 to 30 days, symptoms of combat exhaustion appeared in most men. After 40 to 45 days severe symptoms began to appear. The men became hopelessly apathetic, and were sure they were going to be killed.

The differences observed in the North African, Italian, and Normandy campaigns are undoubtedly due to differences in the severity of combat. As Swank noted, in both the Italian and the Normandy campaigns, combat efficiency declined when approximately 65% of the original group of men became casualties. In Italy this occurred after approximately 90 days, in Normandy, it occurred after approximately 30 days.

The experience with NP casualties in Vietnam was quite different than it was in WWII. Data reported by Tischler³¹ indicate that casualties referred for psychiatric evaluation were highest during the first month and thereafter steadily declined over the entire 12-month tour. Approximately half the men referred were referred during the first three months, after which referral rates became markedly lower. The reason for this undoubtedly lies in the fact that there was no prolonged combat in Vietnam. Men with low stress tolerance broke early during their tours, and those with greater tolerance were simply never subjected to the cumulative stresses of incessant fighting which characterized WWII. The very low rates observed in the last months were probably in part due to the fact that men approaching the end of their tours were less likely to be sent out on patrols.

²⁸J. W. Appel and G. W. Beebe. "Preventive Psychiatry: An Epidemiologic Approach," *Journal of the American Medical Association*, 1946, 131.

²⁹Swank, *op. cit.*

³⁰Swank and Marchand, *op. cit.*

³¹G. L. Tischler. "Patterns of Psychiatric Attrition and of Behavior in a Combat Zone," in P. G. Bourne (ed.), *Psychology and Physiology of Stress*, New York: Academic Press, 1969.

The Vietnam experience coupled with the WWII experience suggests that the neuropsychiatric casualty rate as a function of time may actually be U-shaped. Initially high rates may be observed until those with extremely low tolerance are "weeded" out. Rates may then be lower, but increase with time as the cumulative effects of combat stresses take their toll.

The third factor which affects neuropsychiatric casualty rates will be referred to as the Relevant Activity to Inactivity Ratio. Stalemate situations, the inability to retaliate, and idleness have all been shown to be related to neuropsychiatric casualty rates even when wounding rates were comparatively low. Grinker and Spiegel³² report that flying personnel with the least amount of continuous work to do during a combat mission are the most susceptible to accumulations of anxiety and are more likely to experience "operational fatigue." WWII fighter pilots were the least susceptible, while radio gunners were the most susceptible. Glass³³ states that there are several means of reducing the crippling tension produced by battle fear. However, he states that "...the best antidote to the poison of fear is purposeful action. Even speech is helpful in battle, but aggressive action, as in firing and coordinated movement, gives the most relief from combat tension." Mericle³⁴ reports an incident during WWII when a gasoline shortage stopped aggressive action and the troops found it necessary to dig in and hold. The incidence of combat exhaustion casualties began to increase rapidly, and after some 12 days in Mericle's words, "reached an alarming figure." During a 15-day period, the instances of combat exhaustion were greater than they had been during the previous two months. Swank and Marchand³⁵ provide this description of an incident during WWII:

Near D+55 day static warfare was replaced by fluid warfare. The allied forces broke through the enemy's lines, and many units broke out into the open and made rapid and satisfactory progress. Under these conditions many men on the verge of breakdown appeared to improve, or merely carried on temporarily. When the enemy's resistance became organized again,

³² R. R. Grinker and J. P. Spiegel. *Men Under Stress*, Philadelphia: Blakiston, 1945.

³³ Glass, *op. cit.*, March 1953.

³⁴ E. W. Mericle. "The Psychiatric and the Tactical Situations in an Armored Division," *Bulletin of the US Army Medical Department*, 6(6), December 1946.

³⁵ Swank and Marchand, *op. cit.*

especially when these men were subjected to heavy artillery fire and were "pinned down," all symptoms of combat exhaustion flared up, and the long-awaited breakdown followed.

Garner³⁶ also reports that being "pinned down" by enemy fire increases neuropsychiatric casualty rates. However, he believes that being pinned down is just one of many possible terrifying experiences which are the immediate causes of acute psychological disturbances. Page, et al.³⁷ feel that the inability to retaliate while being pinned down produces combat exhaustion. The individual soldier has no means of counter-attacking the artillery which keeps him pinned down. The same reason has been cited for the unrealistic fear of the dive bomber by US troops in North Africa.³⁸ The dive bomber was feared out of proportion to its actual casualty-producing capability. But again, the individual soldier had no means of retaliation.

Whatever the reasons may be, there can be little doubt that neuropsychiatric casualty rates increase when aggressive action against the enemy decreases.

Recapitulation and Comment

Stress, at least in less severe forms than combat stress, is something most adults have faced many times in their lives. It is a concept most of us feel we understand. Yet, it has eluded precise definition. Reactions to stress are of great concern to military authorities. During extended and/or severe combat, caseloads of combat exhaustion cases reach alarming rates. However, it must be remembered that these cases of complete breakdowns may represent only "the tip of the iceberg." Degradation of performance undoubtedly occurs long before the final break. Many individual who never break may actually continue to function, but far below their potential. In other words, the toll stress takes on combat effectiveness is not fully known, but is suspected to be of gigantic proportions.

³⁶ H. H. Garner. "Psychiatric Casualties in Combat," *War Medicine*, 1945, 8, 343-357.

³⁷ M. M. Page. "Prior Art in the Psychological Effects of Weapons Systems," *Proceedings of the First Symposium on the Psychological Effects of Non-Nuclear Weapons, Vol I*, Eglin AFB, Florida, April 1964.

³⁸ J. C. Naylor. "A Proposed Method for Determining the Psychological Effects of Weapons," *Proceedings of the First Symposium on the Psychological Effects of Non-Nuclear Weapons, Vol I*, Eglin AFB, Florida, April 1964.

At least three major factors have been observed to be consistently associated with increases in combat exhaustion rates. These are wounding rates, cumulative time in combat, and the frustrations resulting from a lack of purposeful activity. Why these factors influence NP casualty rates is easily understandable. Nevertheless, it should be noted that cumulative time in combat is the only factor over which Army authorities can exercise much control. Even there, complete control may not be possible, as replacements simply may not be available. Also, setting rotation policies in a major conflict is not an easy task. As Swank³⁹ noted, combat exhaustion symptoms begin to increase markedly when approximately 65% of an original unit have become casualties. Depending upon the severity of combat this may occur in a few days, a few weeks, or even a few months. Therefore, a standard rotation policy based simply on days in combat is likely to be too early in some situations and too late in others.

³⁹ Swank, *op. cit.*

Chapter 3

STRESSORS AFFECTING THE COMBAT SOLDIER

The soldier in combat constantly faces the possibility of injury, maiming, extreme and protracted pain, or death. Fear of these possibilities is undoubtedly the most potent stressor on the battlefield, and the primary cause of NP casualties. However, the soldier faces a number of other hazards, both physiological and psychological, unrelated to direct enemy action. These hazards also impose stresses and, acting cumulatively, can cause considerable distress even in the absence of effective enemy action. The major stressors which are likely to affect virtually all soldiers at some time during combat even in conventional warfare are discussed briefly below. For purposes of this discussion, these stressors will be divided into those resulting from the physical environment and those resulting from the psychological environment. A third section will be devoted to a very brief discussion of the hazards affecting the soldier in case Chemical, Biological, or Radiological (CBR) agents are employed. Hopefully, soldiers will never face these latter mentioned hazards. However, just the potential for their use can create additional stress on the battlefield.

Stressors in the Physical Environment

Heat. Duke, Findikyan, Anderson, and Sells¹ conducted an exhaustive review of the literature on heat stress in 1967. They observed a remarkable consistency in the literature survey. Performance on almost all tasks became degraded when temperatures reached or exceeded 90°F, with the exception of reaction time, which was unaffected by considerably higher ambient temperatures. Results obtained in vigilance studies were somewhat inconsistent. Some investigators found that mild heat stress improved vigilance performance, while others found the opposite. Simple and well-practiced tasks were the last to be affected.

In most of the earlier studies, ambient temperature was the only variable considered. Therefore, it is not possible to assess the effects of humidity and/or air movement on those results. Most later investigations took these factors into account by employing some composite measure such as "Effective Temperature" (ET). ET is a function of both the Wet Bulb Temperature (WBT) and the Dry Bulb Temperature (DBT) and is defined as $ET = 0.4 (WBT + DBT) + 15$. WBT is normally obtained by placing the bulb of the thermometer in a water saturated

¹M. J. Duke, N. Findikyan, J. Anderson, and S. B. Sells. *Stress Reviews. II. Thermal Stress-Heat*, Technical Report No. 11, Institute of Behavioral Research, Texas Christian University, Fort Worth, May 1967.

wick. The bulb is cooled by evaporation of the water, so WBT is typically lower than DBT. Since evaporation rate is a function of both humidity and air movement, these factors determine the spread between DBT and WBT. An ET of 75°F is comfortable, an ET of 80°F results in some distress, an ET of 85°F brings great distress, and an ET of above 86°F can result in casualties due to heat prostration if personnel engage in any amount of heavy physical activity.² Since ETs of 86°F or higher can be expected at times during summer, even in Central Europe, heat stress is a problem to be reckoned with.

Heat stress may be even more of a problem to personnel in small enclosed spaces (e.g., bunkers or tanks) than for those in the open. Kennedy, et al.³ point out that WBT will approach DBT after a period of time in a small occupied but poorly ventilated area due to respiration and perspiration. The heat generated by personnel and the equipment they use will typically exceed any cooling from heat absorption by the confining walls. Therefore, both WBT and DBT will rise, and after a sufficient period of time, will approach body temperature. Even among completely sedentary personnel, ETs in this range will bring great distress and probable casualties. Ventilation can be employed to reduce the ET if the external temperature is at or below the comfortable range. However, personnel forced to close the ports of a bunker, or operate a buttoned-up tank, may be seriously affected in a hot climate. As an indication of the problem in tanks, Warnick and Kubala⁴ found that ET reached 86°F in a buttoned-up tank during the late summer afternoon when the tank was unoccupied and the engine was not running. With a full crew and a running engine the ET would have been much higher.

Heat stress can be expected to be an even greater problem for unacclimated personnel. Minard⁵ and his co-workers observed personnel in a field study involving several days of continuous exposure to high ambient temperatures. They reported significant physiological changes

²T. E. Kennedy, J. W. Ball, B. B. Hoot, and P. J. Rieck. *Expedient Field Fortifications for Use Against Nuclear Weapons*, Final Report, Technical Report N-74-7, US Army Engineer Waterways Experiment Station, Weapons Effects Laboratory, Vicksburg, Mississippi, September 1974.

³*Ibid.*

⁴W. L. Warnick and A. L. Kubala. *A Study of Selected Problems in Armor Operations*, ARI Technical Report, Human Resources Research Organization, Alexandria, Virginia, May 1978 (in process).

⁵D. Minard, G. J. Grayeb, R. C. Singer, and J. R. Kingston. *Heat Stress During Operations, Banyan Tree, I*, Report No. 5, Naval Medical Research Institute, Bethesda, Maryland, July 1961.

as well as performance impairment of combat efficiency. Minard's subjects were unacclimated paratroopers participating in combat exercises in Panama. Once acclimated, man's performance under high ambient temperature conditions improves and becomes more consistent. Acclimatization results in lower body temperatures, lower heart rate, and more stable blood pressure. Morgan, et al.⁶ state that: "Acclimatization takes from three to twelve days approximately and is more effective if men work in the hot climate than if they simply rest during the acclimatization period." Acclimatization lasts approximately two weeks after an individual leaves the hot climate, then declines and is lost in approximately two months. Duke, et al.⁷ report research results which corroborate the statement by Morgan, et al. The implications of the findings on acclimatization for the military are obvious. Great distress, and probably a number of heat prostration casualties, can be expected if men are quickly transported from a temperate climate into a tropical climate and immediately placed in combat.

In high ambient temperatures, regardless of the actual ET, dehydration can become a problem. While human beings can adapt to heat satisfactorily, there is no evidence for adaptation to dehydration. Adequate water intake is an important factor in heat tolerance, regardless of adaptation. Rohles, et al.⁸ found that even among sedentary personnel water consumption at an ET of 92°F exceeded two gallons per day per person. Active personnel would undoubtedly have consumed much more. Under such conditions, the individual soldier could not carry sufficient water for a day's combat. Even in tanks, there is inadequate storage for consumable liquids. Therefore, during intense combat, or during periods when troops are pinned down from heavy artillery barrages, water supplies in hot climates will likely be short. The resulting dehydration can be expected to increase heat stress.

In summary, given time to become acclimated and an adequate supply of water, a soldier can be expected to remain effective in relatively high ambient temperatures. Even temperatures approaching 100°F should not cause undue problems in climates with very low humidity. However, in the tropics, or even in temperate climates during the heat of the summer, heat prostration casualties can be expected if extended periods

⁶C. T. Morgan, J. S. Cook, A. Chapanis, and M. W. Lund. *Human Engineering Guide to Equipment Design*, New York: McGraw-Hill, 1963.

⁷Duke, Findikyan, Anderson, and Sells, *op. cit.*

⁸F. H. Rohles, R. G. Nevins, and P. E. McNall. *Human Physiological Responses to Shelter Environment*, Report No. 2, Institute for Environmental Research, Kansas State University, Manhattan, February 1967.

of great physical exertion are required. The problems of personnel in crowded confined spaces such as bunkers and tanks can be expected to exceed those of personnel out in the open. At ETs of 86°F-90°F, some degradation of performance a few casualties can be expected. At ETs above 90°F, degradation of performance on both physical and mental tasks can be expected, and numerous casualties due to heat prostration will occur among personnel engaged in heavy physical activity.

Cold. Findikyan, Duke, and Sells⁹ concluded that research on cold stress, like that on heat stress, has yielded relatively consistent findings. The human body is far less adapted for life in cold climates than in warm climates. The human thermal regulatory system is quite accurate, although it functions effectively only within a fairly limited temperature range. The lower limit of temperature at which the human can survive without protection is still open to question, but it is probably in the vicinity of 60°F. However, short exposures to much lower temperatures can be endured without ill effects. Of course, with proper clothing, personnel have been able to work fairly effectively at temperatures as low as -50°F.

The extremities of the body are those generally first affected by exposure to cold. Findikyan, et al. point out that exposure to cold produces numbness of the fingers, and degrades performances in tasks requiring fine finger dexterity. This occurs when the skin temperature of the fingers drops below approximately 60°F. Normally, gloves or mittens are worn to maintain higher finger temperatures. However, most gloves are not adequate to maintain a hand skin temperature of 60°F or above after long exposure at ambient temperatures below 30°F. Heavier, better insulated materials are required at lower temperatures. However, if heavy mittens or gloves are used, much of the use of the hands is lost. Tasks requiring manipulation of knobs, switches, pushbuttons, and keys become difficult if not impossible to perform.

Cold stress is likely to be a greater problem for personnel in the open than those in bunkers, tanks or other sheltered environments. Even if heaters are not used, body heat and heat generated by equipment will increase the ambient temperature. Nevertheless, even in sheltered environments, tasks requiring great hand strength as well as those requiring dexterity are likely to be affected by extreme cold. Two to three hours of exposure to cold have been shown to reduce hand strength by 20-30%. Beyond this, prolonged exposure of the extremities can result in "cold injury." Findikyan, et al. reported that McFarlane¹⁰

⁹N. Findikyan, M. J. Duke, and S. B. Sells. *Stress Reviews*. I. *Thermal Stress-Cold*, Technical Report No. 8, Institute of Behavioral Research, Texas Christian University, Fort Worth, July 1966.

¹⁰W. V. MacFarlane. "General Physiological Mechanisms of Acclimation," in S. W. Tromp (ed.), *Medical Biometeorology*, New York: Elsevier Publishing Company, 1963, 372-417.

listed three types of cold injury: chilblains, wet-cold syndromes, and frostbite. Chilblains is a relatively mild form of cold injury involving itching and swelling due to poor circulation. Wet-cold syndromes result from prolonged exposure (several days) to temperatures of 53°F or less. The so called "trenchfoot" so prevalent during WWI is a well-known example of this type of injury. In trenchfoot, the feet became red and swollen, blood vessels were damaged, and nerve injury was frequent. The fact that this type of injury can occur at relatively mild (53°F) temperatures is a good indication of the inability of the human body to adapt to cold. Frostbite, the most serious type of cold injury, results from prolonged exposure to temperatures below 32°F. In extreme cases, internal freezing takes place. When the injured tissue is warmed, it ruptures and swells and the individual suffers considerable pain. Damage to liver, kidneys, and adrenals has also been observed. Frostbite is likely to produce at least some disability of the affected parts.

Cold injuries should not be a major problem as long as soldiers are provided with adequate gear and food for low temperature operations. For the well-protected soldier cold is likely to be more of a psychological than a physiological hazard. Even so, the bulky clothing required will limit his ability to perform some activities and slow down others requiring gross body movements. Little research has been conducted on the effects of cold on mental performance. However, what has been done has indicated that mental performance is largely unaffected. Tasks requiring the use of the fingers are the most affected by cold due to the requirement to protect the hands and fingers. Even the all important task of pulling the trigger on an individual weapon will be affected by the requirement to protect the hands.

Humidity. Humidity (or the lack thereof) acts in conjunction with other aspects of the environment to add to stress. Personnel who move from very humid to extremely arid climates typically experience problems from the drying of the mucous membranes and the surface of the eyes. No permanent damage is likely to result, but the temporary discomfort experienced is simply one more irritation the soldier may face. The soldier faces different kinds of problems in conditions of high humidity. As humidity increases, WBT approaches DBT. Therefore, during hot weather, high humidity produces more heat stress. Still, a totally different kind of problem may be faced by occupants of tanks or personnel carriers. In a series of studies on closed-hatch operations, Hicks¹¹ found that condensation on the interior surfaces of test vehicles was a major problem. The condensation occurred mostly in the early morning hours. Crewmen inside the vehicles found that their clothing became wet

¹¹S. A. Hicks. *The Effects of Confinement on the Performance of Combat Relevant Skills, Summary Report*, Technical Memorandum 16-64, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, 1964.

if they tried to rest against the walls. Condensation forming on the ceiling dripped on clothing and other stowed gear. Vision blocks became fogged which would have made combat even more difficult and extremely hazardous. If condensation occurred on the outside of the vision blocks, hatches would have to be opened and personnel would have to expose themselves in order to clean the blocks.

While neither extremely high nor extremely low humidity is likely to result in fatalities, the annoyance and the personal discomfort simply adds to the burden already carried by the soldier. Humidity in the range between 40-60% is the most comfortable, and leads to few problems.

Noise. Noise is an occupational hazard for soldiers. During combat, the soldier is bombarded almost constantly by a wide variety of both impulse and steady-state noises. Depending upon the intensity and duration, the effect of noise may range from simple annoyance, to interference with verbal communications, to temporary lowering of auditory thresholds, or finally, to permanent hearing loss. Most of the criteria for exposure to noise have been set to prevent permanent hearing losses. Agreement on maximum acceptable noise levels is not perfect, but the range of disagreement is not great.¹² Criteria for the maximum level of a steady-state or continuous noise vary with the length of exposure to the noise. For example, much higher levels are acceptable if an individual is exposed for only 15 minutes per day than if he is exposed for 8 hours per day. Maximum acceptable levels also vary with the frequency of the noise. Garinther, et al. point out that noise limitation criteria set in 1972 by the Surgeon General place a limit of 85 decibels [dB(A)] for an 8-hour unprotected exposure. The Occupational Health and Safety Administration (OSHA)¹³ limit is 90 dB(A), while the Air Force set a limit of 84 dB(A). For exposures of two hours per day, the Surgeon General of the Army set a limit of 95 dB(A). For a large number of combatants steady-state noise levels are likely to exceed these maxima. For example, Garinther and Blazie¹⁴ measured sound levels in M60A1 tanks during a 4-day platoon-size maneuver. The average sound level of a tank

¹²G. R. Garinther, D. C. Hodge, G. Chaiken, and D. M. Rosenberg. *Design Standards for Noise: A Review of the Background and Bases of MIL-STD-1474 (MI)*, Technical Memorandum 12-75, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, March 1975.

¹³"Guidelines for Measuring OSHA Noise." B&K Instruments, Inc., Cleveland, Ohio, 1975.

¹⁴G. R. Garinther and D. B. Blazie. *Acoustical Evaluation of the M60A1 Tank During Typical Operations*, Technical Memorandum 6-73, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, March 1973.

during operations was 98.5 dB(A) in the turret and 104 dB(A) at the communications system earphone. Even if no permanent damage to hearing results, temporary hearing loss under these conditions is not uncommon. Garinther¹⁵ observed that exposure to noise in the interior of an M114 vehicle for one hour resulted in a temporary hearing loss. Normal hearing was not restored until 1.5 hours had elapsed.

Personnel in the open or in bunkers are less likely to be exposed to unacceptable levels of steady-state noise. However, all personnel in a battle area are likely to be exposed to unacceptably high levels of impulse noise. Impulse noise is defined as a noise in which there is a 20 dB drop in less than 500 milliseconds after the onset, and which is not followed by a new pressure wave in less than 500 milliseconds.¹⁶ The maximum acceptable intensity of impulse noise depends upon both positive pressure rise time and the duration of the positive pressure envelope. In their review of the development of noise limitation standards, Garinther, et al.¹⁷ point out that: (a) standards specified in HEL S-1-63, first published in October 1963, specifies 160 dB as the absolute limit under any conditions, (b) in 1972, the Surgeon General specified 140 dB as the maximum acceptable level, and (c) OSHA also lists 140 dB as the maximum allowable impulse noise level. However, Garinther, et al. further indicate that the maximum acceptable intensity is a function of the number of impacts per day. With 100 or fewer impacts per day, 140 dB is acceptable. However, OSHA states that 120 dB is the maximum acceptable level if 10,000 impacts per day is anticipated.¹⁸ The peak Sound Pressure Level (SPL) of virtually every weapon in the Army inventory exceeds the 140 dB standard at close range. Chmiel¹⁹ obtained a peak SPL of 147 dB two meters from the muzzle of an M16A1 rifle. He obtained a comparable measurement exceeding 160 dB for the M14 rifle. Impulse noises inside a vehicle can also exceed the 140 dB limit. For example, even with hatches closed, a measurement of 145

¹⁵G. R. Garinther. *Interior Noise Evaluation of the T114 Armored Command and Reconnaissance Vehicle*, Technical Report No. 3-62, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, 1962.

¹⁶[Conference on] Noise Evaluation and Control, Temple, Texas, 1975, presented by Texas A&M University, Occupational Health and Safety Institute.

¹⁷Garinther, Hodge, Chaiken, and Rosenberg, *op. cit.*

¹⁸*Guidelines for Measuring OSHA Noise, op. cit.*

¹⁹D. Chmiel. *Military Potential Test of Short Range Cartridges, 5.56-MM Ball and 7.62-MM Tracer*, Materiel Testing Directorate, Aberdeen Proving Ground, Maryland, October 1970.

dB was obtained at the commander's position when the caliber .50 machinegun on an M60A1E3 was fired. With hatches open, peak SPLs exceeded 140 dB at the driver's, gunner's, and tank commander's positions.²⁰ In brief, impulse noise from any weapon fired by an individual, or any weapon fired within a few meters of the individual will exceed 140 dB. Therefore, soldiers must wear protective devices in order to avoid permanent hearing loss. Protective devices which effectively reduce noise levels by 20-30 dB are readily available. However, protective devices are likely to interfere with communications, which poses another kind of hazard. Also, intermittent noise, especially impulse noise, interferes with sleep. This, of course, increases fatigue, which will be discussed in a later section. Even if the soldier suffers no permanent hearing loss, noise is virtually certain to be an annoyance. Communications are almost certain to suffer. If the soldier wears protective devices, normal levels of voice communication may be seriously attenuated. Without protective devices, the soldier is likely to suffer a temporary hearing loss, which will also interfere with communications, and possibly, his hearing will be permanently damaged.

Overpressure. It is the overpressure in noise which damages hearing. However, overpressure from larger explosions such as artillery rounds create additional hazards for the soldier. The overpressure resulting from a nuclear explosion may actually be more lethal than the ionizing radiation. Sprenger²¹ cites evidence indicating that 85% of the casualties from a nuclear explosion are expected to result from mechanical and thermal effects with only 15% from ionizing radiation. Overpressure from nearby explosions is most likely to cause lung hemorrhage, ear drum rupture, and air bubbles in the blood stream. Both the rise time and the peak pressure attained by a pressure wave are related to the probability of damage. With more rapid rise times, there is a greater likelihood of damage. With a very rapid rise time, an overpressure of as little as five pounds per square inch (PSI) is likely to cause ear drum rupture. Pressure waves with slower rise times (i.e., 10 milliseconds or longer) are unlikely to produce ear drum rupture unless the overpressure reaches 40-50 PSI. Regardless of rise time, casualties will occur when peak overpressures reach or exceed 75 PSI.²² The rise time of pressure waves from nuclear explosions is generally much longer than those from conventional explosives. Therefore, considerably greater overpressure is required for a nuclear explosion to inflict the same degree of injury as a smaller conventional explosion. Unfortunately, personnel on the battlefield have difficulty in protect-

²⁰ Personal communication from W. D. Diegel, STEAP-MT-6, Building 436, Aberdeen Proving Ground, Maryland.

²¹ T. R. Sprenger. *Survival on the Nuclear Battlefield*, Student Essay, US Army War College, Carlisle Army Barracks, Pennsylvania, September 1974.

²² Kennedy, Ball, Hoot, and Rieck, *op. cit.*

ing themselves from overpressures. The pressure wave resulting from a nearby explosion of an artillery round would reach the soldier in fractions of a second. Some warning is available in the event of a relatively distant nuclear explosion. However, the pressure wave from a 1 megaton blast occurring a mile distant would reach the soldier in approximately 4 seconds. Therefore, little time would be available to seek protection.

Personnel in shelters have some protection from overpressure. In general, the overpressure inside a shelter resulting from an outside explosion is a function of the ratio of the volume of the shelter to the square area of the openings. That is, the larger this ratio, the greater will be the attenuation of internal overpressure. However, personnel in foxholes may actually be subjected greater overpressure than those in the open. Davis²³ observed that internal pressure in a tunnel dug into the side of a foxhole was actually 2.6 times that of the external pressure. This type of amplification occurs at the end of a cavity if the square area of the entry is larger than the square area of the far side.

The likelihood that a soldier will be seriously injured by overpressure from nearby blasts in conventional warfare is comparatively small. Hearing is most likely to be damaged, but other relatively minor non-incapacitating injuries may occur. However, the threat of serious injury is always there, and the soldier is reminded of this each time he is subjected to an artillery barrage or an aerial bombing attack. At best, the buffeting from pressure waves is an annoyance and can interfere with work, especially communications efforts. At worst, it can result in deafness and serious internal injuries.

Toxic substances. Problems faced by the soldier in dealing with chemical or biological agents will be discussed in a later section. The toxic substances referred to in this section are those which accumulate during conventional warfare as a result of ammunition expenditure, fuel usage, and respiration. Again, personnel in confined and poorly ventilated areas are the most likely to be affected. A primary danger is either an insufficient supply of oxygen or an accumulation of carbon dioxide. Carbon monoxide could also reach dangerous levels from the burning of organic materials. Kennedy, et al.²⁴ provide the following information. The oxygen concentration of normal air is approximately 20%. Concentrations as low as 17% can be endured without apparent ill effect at low elevations. Unless ventilation is exceedingly poor, or

²³N. J. Davis. *Protection Afforded by Field Fortifications Against Nuclear Weapons* (U), Report 1557-TR, US Army Engineer Research and Development Laboratories, Corps of Engineers, Fort Belvoir, Virginia, December 1958.

²⁴Kennedy, Ball, Hoot, and Rieck, *op. cit.*

men must be confined for very lengthy periods, inadequate oxygen supply should not be a major problem on the battlefield. (At very high elevations, oxygen deficit may occur even with normal oxygen concentrations due to the lower partial pressure. However, healthy personnel typically adapt in a matter of a few days.)

Carbon dioxide accumulation is more likely to become a problem than oxygen deficit. A concentration of 0.4% is normal. Concentrations in the range of 4.0 or 5.0% can be tolerated without ill effect for several hours. However, concentrations over 0.5% can become dangerous if sustained over a period of several days. Adequate oxygen levels can be maintained for sedentary personnel with an air intake of as little as 24 cubic feet per hour per occupant. A much greater air intake (180 cubic feet/hour/occupant) is necessary to maintain carbon dioxide concentrations at less than 0.5% or less. Of course, personnel in bunkers or in buttoned-up tanks are unlikely to be "sedentary." Therefore, air exchange rates above 180 cubic feet/hour/occupant will be necessary if personnel are to be confined over a period of days. Data on the accumulation of carbon dioxide in a buttoned-up tank with a working crew could not be located. Therefore, the rate at which carbon dioxide accumulates within a buttoned-up tank is not known. Dangerous levels of carbon dioxide are more likely to be encountered in a crowded bunker sealed for protection against CBR agents.

Carbon monoxide is a by-product of inefficient burning of fossil fuels or other organic substances. Carbon monoxide is dangerous in very small concentrations, and adequate ventilation is a must in areas where fossil fuels are being burned. Carbon monoxide (CO) is odorless and colorless so cannot be detected by human beings. An individual exposed to high CO concentrations may lapse into unconsciousness without realizing he is being poisoned. Dangerous concentrations are most likely to occur in crew compartments of stationary vehicles on windless days. Personnel in other enclosed poorly ventilated areas are probably in little danger if reasonable precautions are taken. This implies that CO production in enclosed spaces must either be limited, or adequate ventilation must be provided. For example, heaters employing fossil fuels should not be used. Also, tobacco smoking should be prohibited. Cigar smoking can be especially dangerous, as cigars can produce as much as 20 times as much CO as cigarettes.

Fumes resulting from the expenditure of ammunition or other explosives are not generally a problem. Most of the resulting gases are expended into the atmosphere and quickly dissipate. In weapons systems where fumes are likely to accumulate, provision is made to expel the fumes from the crew compartment. For example, tanks have a ventilating fan designed to expel gases from the turret. So long as the ventilator fan operates properly, there is no real problem even during an extended fire fight. What may happen if the fan malfunctions is not known. No data could be located on the concentrations of various toxic substances in the crew compartment with an inoperable fan. If the crew must close

the hatches for protection against overhead artillery, a real hazard might exist. Certainly, data on this subject is needed in order to provide information to armored units.

From what could be ascertained from the literature, the hazards from exposure to toxic substances on the battlefield can be minimized with reasonable care. The chief danger lies in the fact that humans cannot detect inadequate oxygen supply or abnormally high concentrations of carbon dioxide or carbon monoxide. Even though concentrations may not reach lethal levels, some physiological damage might be done. The individual may become physically stressed, and not have any notion why. Unless the physiological damage is relatively severe, the individual is unlikely to become a medical statistic. Therefore, it is difficult to estimate the true extent of biological distress caused by toxic substances.

Fatigue. Many will argue that the fatigue experienced in combat is more frequently a result of stress than a stressor itself. These individuals can point to the research literature on extended operations in which decrements in performance of military tasks are seldom found, even after periods of up to 48 hours.^{25,26,27,28} There certainly is good evidence that fatigue has psychological as well as physiological origins. Hartman, et al.²⁹ reported stress-induced fatigue in aviators on 66-hour flying missions. Subjective fatigue was found to increase during the mission but diminished toward the end of the mission. Oral

²⁵L. L. Ainsworth and H. P. Bishop. *The Effects of a 48-Hour Period of Sustained Field Activity on Tank Crew Performance*, Technical Report 71-16, Human Resources Research Organization, Alexandria, Virginia, July 1971.

²⁶J. Banks, J. Sternberg, J. Farrell, C. Debow, and W. Dalhamer. *Effects of Continuous Military Operations on Selected Military Tasks*, Technical Report 1166, US Army Behavioral and Systems Research Laboratory (BESRL), Arlington, Virginia, December 1970.

²⁷D. Cannon, E. H. Drucker, and T. Kessler. *Summary of Literature Review on Extended Operations*, Consulting Report, Human Resources Research Organization, Alexandria, Virginia, December 1964.

²⁸R. E. Doll and E. K. E. Gunderson. "The Relative Importance of Selected Behavioral Characteristics of Group Members in an Extreme Environment," *Journal of Psychology*, 1970, 75, 231-237.

²⁹B. O. Hartman, H. B. Hale, D. A. Harris, and J. F. Sanford. "Psychobiologic Aspects of Double-Crew Long-Duration Missions in C-5 Aircraft," *Aerospace Medicine*, 1974, 45(10), 1149-1154.

temperature measurements taken during the flight correlated very highly with the subjective statements, demonstrating the validity of the self-reports. Hartman also found that longer periods of rest are normally required in stressful situations. He found that aviators on extended and stressful missions required more sleep *both* during and after the mission than while on regular duty. Hence, it appears that fatigue is at least in part a response to stress.

Concern with fatigue and its effects have led to a considerable amount of work in the past two decades. Chiles, Alluisi, and Adams³⁰ summarized eight years of work on the optimization of work-rest cycles for astronauts. Woodward and Nelson³¹ published a general review of the literature on the effects of sleep loss, work-rest schedules, and recovery on human performance in 1974. Morgan, et al.³² studied the effects of continuous work and sleep loss on the recovery of sustained performance. Hodge³³ edited a volume on military requirements for research on continuous operations in which a number of papers concerned with fatigue and work-rest cycles were presented. Some of the more relevant findings of these efforts will be described and discussed below.

Most civilians work on an 8/16 work/rest cycle five days a week. The same is true in a garrison situation for a large segment of military personnel. Military personnel in TOE units typically report work weeks longer than 40 hours. However, in non-combat assignments they are only required to work continuously for as much as 24 hours. In combat, the

³⁰W. D. Chiles, E. A. Alluisi, and O. S. Adams. "Work Schedules and Performance During Confinement," *Human Factors*, 1968, 10, 143-196.

³¹D. P. Woodward and P. D. Nelson. *A User Oriented Review of the Literature on the Effects of Sleep Loss, Work-Rest Schedules and Recovery on Performance*, Office of Naval Research, Biological and Medical Sciences Division, Arlington, Virginia, December 1974.

³²B. B. Morgan, Jr., G. D. Coates, B. R. Brown, and E. A. Alluisi. *Effects of Continuous Work and Sleep Loss on the Recovery of Sustained Performance*, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, July 1973.

³³D. C. Hodge. "Environmental Quality Considerations for Continuous Operations," in D. C. Hodge (ed.), *Military Requirements for Research on Continuous Operations, Proceedings of a Conference Held at Texas Tech University, Lubbock, Texas, 28-29 September 1971*, Technical Memorandum 12-72, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, April 1972, 133-187.

situation is likely to be quite different. As Alluisi, et al.³⁴ pointed out in 1964, military personnel in combat will often be called upon to perform under a variety of rigorous atypical work/rest cycles. Continuous operations for 24 or even 48 hours may be necessary. Alluisi and his co-workers indicated that performance was not greatly affected by variation in work/rest cycles, provided that the work/rest and sleep/wakefulness ratios were held constant and that the overall period did not exceed one week. The complete applicability of these findings to the soldier in combat is questionable. Soldiers in combat during previous major conflicts have been required to remain on a high alert status for periods considerably longer than a week. Also, it is highly doubtful that the sleep/wakefulness ratios can be held constant. Facilities for rest are seldom adequate. The noises of combat, alerts, and other interruptions all interfere with sleep. Virtually all soldiers in combat report an inability to obtain restful sleep (e.g., Glass³⁵). In addition, rations are likely to be inadequate, unappetizing, and consumed on a highly irregular basis. All of these factors combine to produce a state of fatigue the soldier has probably never encountered in garrison or in civilian life.

The results of research on continuous operations (i.e., 24 hours or more) have not been *entirely* consistent. As was pointed out earlier, many studies have shown no significant performance degradation during continuous operations of up to 48 hours. However, Morgan, et al.³⁶ obtained different results. They found that performance efficiency began to deteriorate after 14 to 18 hours of continuous work, and reached its lowest point after 22 to 24 hours. Performance then improves somewhat during the next 8 to 10 hours, but then decreases slightly thereafter. Four hours of rest following 36 hours of continuous work produced a significant, but not complete, recovery. Woodward and Nelson³⁷ attribute a considerable portion of the inconsistency in the research findings to a lack of a standard taxonomy for classifying jobs or tasks, and the lack of a standard system for quantifying human performance. Despite the inconsistencies, Woodward and Nelson felt that some valid generalizations concerning sleep loss and work/rest cycles could be made. They stated that sleep loss is most likely to affect performance on:

³⁴E. A. Alluisi, W. D. Chiles, and R. Smith. *Human Performance in Military Systems: Some Situational Factors Influencing Individual Performance*, Interim Technical Report 64-1, Performance Research Lab, Department of Psychology, University of Louisville, Louisville, Kentucky, August 1964.

³⁵A. J. Glass. "The Problem of Stress in the Combat Zone," *Symposium on Stress*, Walter Reed Army Medical Center, Washington, D.C., March 1953.

³⁶Morgan, Coates, Brown, and Alluisi, *op. cit.*

³⁷Woodward and Nelson, *op. cit.*

- a. uninteresting and monotonous tasks,
- b. tasks that require continuous attention on the part of the operator,
- c. tasks which must be performed on a time-shared basis with other tasks,
- d. tasks that are relatively unlearned prior to performance.

With relation to work/rest cycles literature indicates that regular cycles produce the most efficient performance. Cycles of 4 on and 2 off do not degrade performance over a period of days. However, investigators generally agree that this work/rest ratio uses reserves. For example, personnel required to perform continuously after a period of time on a 4/2 cycle performed more poorly than personnel who had longer rest periods, even though the work/rest ratios were the same. Although no differences in performance as a function of work/rest cycles were observed, Hartman and Cantrell³⁸ found that personnel on a 16/8 schedule recovered from a period of sleep loss more rapidly and completely than did personnel on 4/2 and 4/4 schedules. In summary, personnel not otherwise under great stress and performing tasks which do not require great physical exertion can function adequately on a wide variety of work/rest schedules over a considerable period of time. The combat soldier, however, is subjected to a wide variety of stresses, and at least at times, is required to put forth great physical effort. Therefore, rest periods of less than four hours will undoubtedly result in more rapid exhaustion. In fact, the best evidence available indicates that 8-hour rest periods will probably result in the best performance over the longest period of time. Of course, it is realized that combat cannot be completely scheduled. Nevertheless, whenever possible, regular rest should be scheduled involving a minimum of eight hours rest at a time. Even when the cycle must be broken, more rapid recovery can be expected than on other cycles.

Morgan and Alluisi³⁹ observed a rather interesting phenomenon in relation to shift work. There are many situations in both the civilian and military sectors in which personnel must be on duty 24 hours a day.

³⁸ B. O. Hartman and G. k. Cantrell. *MOL: Crew Performance on Demanding Work-Rest Schedules Compounded by Sleep Deprivation*, Technical Report 67-99, School of Aerospace Medicine, Brooks AFB, Texas, November 1967.

³⁹ B. B. Morgan and E. A. Alluisi. "Applicability of Research on Sustained Performance, Endurance, and Work-Rest Scheduling to the Development of Concepts and Doctrine of Continuous Operations," in D. C. Hodge (ed.), *Military Requirements for Research on Continuous Operations, Proceedings of a Conference Held at Texas Tech University, Lubbock, Texas, 28-29 September, 1971*, Technical Memorandum 12-72, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, April 1972.

Normally, such operations are manned by three 8-hour shifts. Personnel are typically moved from one shift to another on a regularly scheduled basis. A 4-week schedule is not uncommon. However, as Morgan and Alluisi point out, a 4-week schedule is probably the least optimum. Their data suggest that the biological adaptation to atypical work/rest schedules takes at least 20 days, and in some instances as long as 25 to 30 days on the average. Obviously, an individual on a 4-week schedule is shifted just as his adaptation to the previous schedule is being completed. Therefore, though longer schedules on a single shift may not be popular, they undoubtedly would result in better performance. Adaptation to new schedules can be enhanced, however. One means is to insure that the individuals involved stay awake for a sufficiently long period to assure that the normal diurnal rhythms are broken. This permits a new cycle to become established when sleep is permitted.

To summarize, after several days in heavy combat, fatigue is both universal and unavoidable. Other stresses increase fatigue and shorten the time before complete exhaustion, and fatigue adds at least psychological increments to the other stresses faced. Although fatigue is unavoidable, its effects can probably be minimized by maintaining highly regular work/rest schedules whenever possible, with rest periods of no less than eight hours each.

Stressors in the Psychological Environment

Confinement and isolation. At first, instances of confinement and/or isolation in combat might seem to be rare. However, upon further reflection, a number of situations which occur fairly frequently result in either confinement, or isolation, or both. The soldier in a foxhole subjected either to an artillery attack or other forms of suppressive fire is both confined and isolated. Men in field fortifications or more permanent types of bunkers may be confined for considerable periods of time while awaiting an attack or "sitting out" an aerial or artillery bombardment. Tank crews, especially when hatches are closed for protection against overhead artillery or sniper fire, are confined in a very small space. The crew members are not socially isolated from each other, but during periods of radio silence, they are isolated from human contact outside the group. Men in bunkers are similarly isolated during periods of radio silence or when communication lines are cut. In past conflicts, such periods of confinement have typically been relatively short, i.e., a matter of hours, and have apparently resulted in few psychological problems. In any major conflict in the future, longer periods of confinement for greater numbers of personnel can be expected. As an example, the Army has been concerned about the effects of confinement on tank crews during extended operations in the closed-hatch mode.⁴⁰

⁴⁰ Warnick and Kubala, *op. cit.*

Consideration has also been given to the problems of long-term occupancy of field fortifications.⁴¹ During periods of confinement of 24 hours or more, problems may surface which have not been encountered frequently in the past, but which must be considered in preparing for the future.

Most of the work on confinement and isolation was not undertaken with the combat soldier in mind. The US Navy has been quite active in the study of groups in relative confinement and isolation. Some of this work has been oriented toward the selection and training of submarine crewmen.⁴² Other work has been directed toward the study of groups of aquanauts or personnel isolated during the winter in arctic and antarctic climates.^{43,44,45} The National Aeronautics and Space Administration (NASA) has sponsored an extensive research program on confinement and isolation. NASA's interest, of course, is directed at the performance of astronauts in long-term space flights.^{46,47} Unfortunately, most of this research involved the confinement of carefully selected personnel. Therefore, it is of only marginal relevance to this present effort.

⁴¹ A. L. Kubala, J. L. Maxey, W. H. Ton, and W. L. Warnick. *A Study of the Psychological (and Associated Physiological) Factors to be Considered When Constructing Field Fortifications*, ARI Research Problem Review 76-12, Human Resources Research Organization, Alexandria, Virginia, 1977.

⁴² B. B. Weybrew. *Some General Comments Concerning Personnel Selections for Undersea Duty After Six Years of Research in Submarine Selection*, Memorandum Report No. 62-5, US Naval Medical Research Laboratory, Groton, Connecticut, October 1962.

⁴³ E. K. F. Gunderson and P. D. Nelson. "Criterion Measures for Extremely Isolated Groups," *Personnel Psychology*, 1966, 19, 67-80.

⁴⁴ Doll and Gunderson, *op. cit.*

⁴⁵ R. L. Helmreich. *Evaluation of Environments: Behavioral Observations in an Undersea Habitat*, Social Psychology Laboratory, Department of Psychology, University of Texas, Austin, August 1971.

⁴⁶ S. B. Sells (chairman). *APA Symposium on Factors Affecting Team Performance in Isolated Environments*, September 5, 1967, Institute of Behavioral Research, Texas Christian University, Fort Worth, July, 1958.

⁴⁷ S. B. Sells and R. E. Trego. *Normative Studies of Personality Measures Related to Adaptation Under Conditions of Long Duration, Isolation, and Confinement, Final Report, Part I. Personal Characteristics for Successful Adaptation*, IBR Technical Report 73-17, Institute of Behavioral Research, Texas Christian University, Fort Worth, July 1973.

Submarine crewmen are less highly selected than aquanauts or astronauts, but at present they are all volunteers for undersea service, and are still more carefully selected for their specific duty than the average soldier. Despite the questionable relevance of many aspects of this work, several of the findings do appear generalizable to the combat situation. These will be discussed briefly below.

One of the major findings reported in the literature on experiments on confinement and isolation is that confinement, without any physical stress, is a potent stressor. This has been demonstrated many times in laboratory-type studies by the finding that large numbers of volunteer subjects defect prior to the end of the confinement period.^{48,49,50,51,52} Defections were noted sooner in the more confining and isolating environments. When subjects were deprived of sensory input and requested to remain in recumbent positions, 13 of 30 subjects defected within 24 hours, and only 12 finished the entire week of the experiment.⁵³ Similar results were obtained by other investigators. Defections tended to come very early during the experiments, indicating that individuals with lesser tolerance of confinement will feel its effects earlier. The notion that confinement is a more potent stressor than social isolation was shown by Zubek, et al.⁵⁴ They compared three groups. One group was

⁴⁸ I. Altman and W. W. Haythorn. "The Effects of Social Isolation and Group Composition to Performance," *Human Relations*, 20(4), 313-339.

⁴⁹ J. A. Hammes and R. T. Osborne. *Shelter Occupancy Studies at the University of Georgia, 1962-1963*, Civil Defense Research Psychological Laboratories, University of Georgia, Athens, December 1963.

⁵⁰ T. L. Myers, D. B. Murphy, S. Smith, and S. J. Goffard. *Experimental Studies of Sensory Deprivation and Social Isolation*, Technical Report 66-8, Human Resources Research Organization, Alexandria, Virginia, June 1967.

⁵¹ J. P. Zubek, L. Bayer, and J. M. Shephard. "Relative Effects of Prolonged Social Isolation and Confinement: Behavioral and EEG Changes," *Journal of Abnormal Psychology*, 1970, 75(5), 625-631.

⁵² M. Zuckerman, H. Persky, K. E. Link, and G. K. Basu. "Experimental and Subject Factors Determining Responses to Sensory Deprivation, Social Isolation, and Confinement," *Journal of Abnormal Psychology*, 1968, 73(3), 183-194.

⁵³ Zubek, Bayer, and Shephard, *op. cit.*

⁵⁴ J. P. Zubek, L. Bayer, S. L. Milstein, and J. M. Shephard. "Behavioral and Physiological Changes During Prolonged Immobilization Plus Perceptual Deprivation," *Journal of Abnormal Psychology*, 1969, 74(2), 230-236.

socially isolated as well as confined, a second group was confined but not socially isolated, and the third group was an ambulatory control group. The two confined groups did not differ from each other in either behavior or EEG response, but both differed from the ambulatory control group. Zuckerman, et al.⁵⁵ attempted to determine the relative contributions of sensory restriction, social isolation, confinement, and set, to deviant behavior during sensory deprivation, isolation, and confinement. They concluded that: "The stress effects of confinement are rather massive and are found even when Ss are neither sensorially nor socially isolated." On the basis of the literature, it can be assumed that confinement for periods of 24 hours or more will place considerable additional stress on at least some individuals within the soldier population.

Sells and Rawls⁵⁶ conducted an extensive review of the literature on confinement and isolation in an attempt to determine the prevalence of antisocial or deviant behaviors. They noted three rather consistent behavioral tendencies. The first of these was "status-leveling." During close confinement, there is a virtually complete lack of personal privacy. All activities of all individuals are open to view by all other occupants. This makes it extremely difficult to maintain any social distance between superiors and subordinates, thus, all tend toward all the same status; that is, status-leveling occurs. Naturally, this tends to undermine authority. Since absolute authority during critical periods of combat is considered necessary by many Army authorities, this leveling could prove to be detrimental to mission accomplishment following confinement. A second tendency observed in isolated groups is that anger, scorn, and even ridicule, are directed toward competitors or superior authorities. The intensity is often out of proportion to the hardship suffered. This tendency to focus aggression outside the immediate group may be therapeutic, and certainly helps to maintain intergroup relations. However, it could result in problems with authority when the personnel emerge from confinement. Loss of faith in, or anger with higher command, is not conducive to effective battlefield operations. A third observation reported by Sells and Rawls was the tendency toward "territorial" behavior. It has been noted that communications break down, and individuals guard their personal possessions and establish territorial rights which are jealously guarded. Territory typically involved a particular location in a shelter, or an item of furniture such as a bed. Hammes and Osborn⁵⁷ observed terri-

⁵⁵Zuckerman, Persky, Link, and Basu, *op. cit.*

⁵⁶S. B. Sells and J. R. Rawls. *Effects of Isolation on Man's Performance*, USI 20, Bioengineering and Cabin Ecology, Science and Technology Series, American Astronautical Society, Tarzana, California, 1969.

⁵⁷Hammes and Osborne, *op. cit.*

torial behavior among personnel in fallout shelters. However, problems with territorial behavior were minimized under strong leadership. When the leaders allocated space and other resources, and stated explicit rules governing both behavior and the use of resources, far fewer interpersonal problems emerged. Also, with strong leadership, fewer defections from the experiments occurred. Although the subjects for Hammes and Osborn's work were of both sexes and a wide variety of ages, the results should be applicable to confined military personnel. Any time a long period of confinement is anticipated, leaders must take command quickly and state specific rules for conduct. However, so far as is known, instruction in handling men during confinement is not included in any Army leadership training.

This research on confinement has a number of implications for the military. It is anticipated that personnel in any major conflict of the future are likely to be confined at times for periods exceeding 24 hours. Confinement may prove intolerable to some. Status-leveling, territorial behavior, and aggression directed toward authority may also occur. The key to prevention of psychological problems appears to be strong leadership.

Close confinement can also result in physical stress. For example, Hicks⁵⁸ observed that circulation was reduced in the lower body of personnel confined in an armored personnel carrier. This hampered gross body movements during the immediate post-confinement period. If personnel were required to run to seek cover, for example, they would be at a disadvantage.

Crowding. Calhoun⁵⁹ opened a new area of research when he suggested that increasing population density resulted in greater social disorganization and a variety of maladaptive behaviors. In a more recent work on the subject, Stokols⁶⁰ pointed to a trend to consider "crowding" as a subjective variable, with "density" being the underlying physical variable. The two are closely correlated, but not identical. The feeling of crowding is viewed as a stress reaction to a total situation of which population density is only one element. For an individual to feel crowded, there must be some disruption in his normal social relationships with those in the immediate area. For example, an individual may not feel crowded on his way to work in a densely populated subway, while he does feel crowded at work as new office staff are moved into the same area.

⁵⁸ Hicks, *op. cit.*

⁵⁹ J. B. Calhoun. "Population Density and Social Pathology," *Scientific American*, 1962, 206, 139-148.

⁶⁰ D. Stokols. "The Relations Between Micro and Microcrowding Phenomena: Some Implications for Environmental Research and Design," *Man-Environment Systems*, 1973, 3(3), 139.

The notion of disruption in the individual's immediate surround is suggestive of the concept of Personal Space (PS). Evans⁶¹ reviewed over 130 publications dealing with PS. He found that a large number of hypotheses concerning social interaction (e.g., people who are friends will interact at closer distances than strangers) have generally been supported by the literature. A hypothesis of greater importance to the military is that hostile or stressful environments will likely increase Interpersonal Distances (IPD) between individuals, indicating a greater need for PS. This hypothesis has also been well supported most of the relevant literature. However, Stokols⁶² observed that the perception of crowding in a small area was greater among subjects playing a game competitively than when playing under a cooperative set. This finding suggests that the stresses experienced by men confined during combat may increase PS needs, but that common goals and basically interpersonal compatibility should decrease these needs. Therefore, PS requirements for the prevention of psychological problems are difficult to predict in the battlefield situation.

PS should not be confused with "territory." Evans⁶³ distinguishes the two on two bases: (a) territory is geographically bound, while PS surrounds the individual regardless of his geographical location, and (b) territory is typically defended by aggression, while PS is typically "defended" by withdrawal. The conditions under which withdrawal occurs vary considerably. Subjective statements indicate that personal compatibility, necessity, and personal hygiene habits are all important factors in determining requirements for PS. PS needs are also reduced if sufficient physical space per individual is available. Stokols⁶⁴ also suggests that exposure to high density situations and complete familiarity with the total environment will enable individuals to restructure their personal world, and thereby reduce crowding stress. He also suggests enhancing the attractiveness of activities as a means of coping with crowding.

Perhaps the main lesson to be learned from the literature in this field is that previous exposure to the situations which might be encountered should help individuals develop their own style of coping behavior. So far as is known, any training of this type occurs incidentally, rather than by design.

⁶¹G. W. Evans. "Personal Space: Research Review, and Bibliography," *Man-Environment Systems*, July 1974, 3(4), 203.

⁶²Stokols, *op. cit.*

⁶³Evans, *op. cit.*

⁶⁴Stokols, *op. cit.*

Combat stress. The extent of NP breakdowns during previous conflicts and the battlefield conditions which appear to precipitate combat exhaustion symptoms were discussed at some length in Chapter 2, and need not be repeated here. The primary stress imposed by the battle situation is, of course, the fear of disfigurement, mutilation, intense pain, and death. Carlock and Bucklin⁶⁵ conclude that combat fear is virtually universal. However, they also point out that feelings of fear are magnified in situations involving helplessness, hopelessness, or idleness in the face of threat of death. Fear in battle is accepted by the Army as a normal reaction. Fear becomes a problem only when it seriously degrades performance or leads to bizarre behavior. The stages in the development of combat exhaustion resulting from fear have been well described by Swank and Marchand⁶⁶ and by Kern⁶⁷ who based his model of the fear process on Swank and Marchand's work. As discussed earlier, every man has his breakingpoint. Given sufficient time in an intense combat situation, the symptoms of combat exhaustion are virtually certain to appear. At some point in the disintegration of behavior, men are referred for treatment. Glass⁶⁸ states that a breakdown of psychological defenses against fear is readily apparent in over 50% of the non-battle losses. He divides these into five categories. One group reports with minor organic disease or injury which should result in little, if any, incapacitation. Typical complaints include pes planus, scoliosis, scars from previous wounds, prostatitis, minor sprains, and contusions. Glass states that experience with these types of cases make it "abundantly clear that the medical condition only thinly disguises a psychological breakdown." Individuals in the second category are those with subjective complaints but negative physical findings. Glass lists symptoms such as headache, backache, anorexia, excess sweating, urinary frequency, diarrhea, weakness, muscular aches, joint pain, giddiness, night blindness, palpitation, and weight loss. Such symptoms represent an unconscious (or possibly even a conscious) attempt to withdraw from an intolerable situation. Men in the third category report with self-inflicted wounds or other non-battle injuries that may well have been avoidable. Again, the individuals are making a conscious or unconscious

⁶⁵J. Carlock and B. Bucklin. *Human Factors in Mine Warfare: An Overview of Visual Detection and Stress (Part II, Stress)*, prepared for presentation at the TTCT Panel 0-1 Work Group, Mine Warfare Study Group Seminar, October 1971.

⁶⁶R. L. Swank and W. E. Marchand. "Combat Neuroses. Development of Combat Exhaustion," *Archives of Neurology and Psychiatry*, 1946, 55, 236-247.

⁶⁷R. P. Kern. *A Conceptual Model of Behavior Under Stress, with Implications for Combat Training*, Technical Report 66-12, George Washington University, Human Resources Research Office (HumRRO), June 1966.

⁶⁸Glass, *op. cit.*, 1953.

attempt to flee the trauma of the battlefield. The fourth category of personnel report with broken or lost eyeglasses and dentures. These obviously serve to remove a man from combat only on a temporary basis. However, even a temporary break may appear attractive to men near the breakingpoint. Glass's fifth and final category contains men with complete psychiatric breakdowns who have lost all their abilities to cope with the situation. Glass mentions another group of combat failures. These individuals exhibit no overt psychiatric symptoms and have no physical complaints, nevertheless they manage to extricate themselves from combat. These are the men who commit disciplinary offenses connected with the battle situation, such as desertion, insubordination, or direct disobedience of an order. The reader interested in more detailed descriptions of symptoms of combat exhaustion is also referred to Garner⁶⁹ or Hanson.⁷⁰

A discussion of symptoms, such as that presented above, may not be seem wholly appropriate in a section intended to describe the various stresses impinging on the combat soldier. However, it was felt that some discussion was necessary to indicate the extremely wide variety of responses to combat stress. Physical stressors, such as heat, produce only a very limited range of symptoms. To be sure, tolerance to heat stress varies just as does tolerance to combat stress. But, once the symptoms appear, they vary very little from individual to individual. Furthermore, the conditions under which heat prostration is likely to occur can be scientifically measured. That is, medical authorities know that there is a high probability that heat prostration casualties will occur among personnel doing hard physical labor at effective temperatures above 86°F. There is no thermometer for measuring fear on the battlefield. Fear is highly subjective, and at least for the present, can be measured only by subjective reports. The extent of any individual's fear is dependent upon his appraisal of the danger in the situation. The individual who sees little danger in a situation will have little fear. Fears can be either rational or irrational. Fear of combat is certainly rational. Some fears which are quite common, such as fear of all spiders and all snakes, are not wholly rational. It is true that some snakes and some spiders can be quite dangerous, but the fear is not generally limited to the specific species which are dangerous. The fear "generalizes" to the entire genus. The most extreme form of irrational fear is the phobia. The individual with a phobic

⁶⁹H. H. Garner. "Psychiatric Casualties in Combat," *War Medicine*, 1945, 8, 343-357.

⁷⁰F. R. Hanson (ed.). "Combat Psychiatry. Experiences in the North African and Mediterranean Theaters of Operations, American Ground Forces, World War II," *Bulletin of the US Army Medical Department*, November 1949, vol IX, Suppl. Issue.

reaction develops a fear of something which is far out of proportion to the actual danger it represents. Therefore, any attempt to relate behavioral responses to fear must take into account each individual's appraisal of his personal hazard.

Psychological warfare. No discussion of stresses facing the combat soldier would be complete without some mention of psychological warfare. Unfortunately, like combat stress, the degree of stress that psychological warfare imposes on any individual can be measured only by subjective report. Psychological warfare certainly is not new. Throughout history it has been considered good military strategy to weaken enemy resistance by utilizing sounds or other stimuli which provoke fear. Even during the Korean War, the Chinese and North Koreans resorted to primitive methods of psychological warfare such as sounding strange oriental bugle calls, blowing whistles, and clashing cymbals.^{71,72} Adolph Hitler considered psychological warfare of such importance that one of his top aides was the Minister of Propaganda. Soldiers in the Pacific Theater during WWII all remember Tokyo Rose. Psychological warfare can take many forms, but it is all designed to weaken enemy resistance by increasing stress. As Leatherman⁷³ stated: "It creates fear, sows suspicions, causes doubts, spreads confusion, underscores hardships, emphasizes intolerable situations, or, in support of military operations, mentions overwhelming fire power. In short, *psychological warfare creates stress.*"

During the Korean and Vietnamese conflicts, US forces dropped millions of leaflets over enemy-held territory. They also used transport aircraft with high powered audioamplification systems. The propaganda leaflets dropped on troop concentrations frequently described means by which the soldier could "get lost" from his unit and surrender. The promise of adequate medical attention, which was sorely lacking by the enemy, was also promised as an incentive for surrender. Similar tactics were used on US troops. For example, copies of a letter, supposedly written by a captured US soldier and describing the wonderful treatment he had received, were air dropped on US position. The effectiveness of these efforts is difficult to ascertain, as the stress imposed by psychological warfare cannot be measured in isolation from the multiplicity of stressors faced by the soldier.

Psychological warfare will undoubtedly be employed against US troops in any future conflict. What forms it will take, of course, cannot be known. However, it is safe to assume that propaganda efforts

⁷¹Glass, *op. cit.*, 1951.

⁷²Glass, *op. cit.*, 1953.

⁷³C. D. Leatherman. "The Implications of Stress on Psychological Warfare," *Symposium on Stress (16-18 March 1953)*, Army Medical Service Graduate School, Walter Reed Army Medical Center, Washington, D. C., 1953.

will be directed at any weaknesses known or believed to exist in US soldiers.

Stresses in a Chemical, Biological, and Radiological Environment

Chemical warfare was first used during WWI. Since that time, chemical warfare has not been employed against US forces. Biological and radiological weapons are more recent additions to the arsenals of the major powers, but neither have been used against US forces. However, the potential for their use has been the impetus behind several research projects. Protective clothing for a variety of environmental conditions has been developed, and Army training stresses the notion that in the event of exposure the hazards can be largely overcome by following the proper procedures.

If an Army commander feels that a Chemical, Biological, or Radiological (CBR) attack is imminent, he adopts what is called a Mission-Oriented Protective Posture. These procedures are intended to insure the accomplishment of the unit mission with a minimum risk of casualties. Personnel wear individual protective clothing and equipment which is consistent with the threat, the environmental conditions, and the work rate imposed by their particular mission.

The use of protective clothing, including the face mask, can create problems for the wearer, especially in high ambient temperatures. No provision is made for the consumption of liquids while wearing the mask. Therefore, the mask must be removed, at least temporarily, for the wearer to satisfy his thirst. This could be an extremely critical problem at high temperatures. As was noted earlier, Rohles, et al.⁷⁴ pointed out that water consumption at an ET of 92°F can exceed two gallons per day per person, even among sedentary personnel. The protective clothing also prevents cooling by radiation into the atmosphere. Research personnel at CDCEC⁷⁵ found that infantry units were able to operate effectively for only 20 minutes at high energy expenditure rates in temperatures of 75°F to 90°F. However, time of effective functioning exceeded 20 hours while occupying a defensive position. Another problem will appear if personnel are required to wear the protective mask over long periods. If personnel are unable to shave, the growth of facial hair will eventually break the seal on the face mask. Also, no provision was made for defecation or urination while wearing protective clothing. While this will not likely prove fatal, it can result in great personal distress.

⁷⁵ *Road Battalion Operations in a Toxic Environment: Volume I of III. Operational Capability Experiment.* CDCEC 63-4, Department of the Army, Combat Developments Command Experimentation Center, Fort Ord, California, December 1963.

Without sufficient warning, even personnel with protective clothing available face a potential hazard. Dickinson, et al.⁷⁶ found that, even with practice, 16 minutes were required for an M60A1 tank driver to don protective gear. Additional time was required to put on the hood. It was found that only two crew members could dress at the same time--one in the loader's station and the other in the commander's station. It was also found that the hood could not be worn over the helmet because it was too small. Shorter times would probably result if the tankers were able to dismount and don the protective clothing outside the tank.

In case of a radiological attack, only those personnel able to find shelter underground will have adequate protection. Kennedy, et al.⁷⁷ stipulate three feet of earth as the minimum for protection against ionizing radiation. Tanks and other armored vehicles offer some protection, but the protection is not adequate for long exposure. Even those in well-built underground shelters will face problems with ventilation to disperse accumulations of heat and toxic substances. Shortages of provisions are also likely.

The extent to which the threat of a CBR attack will stress the combat soldier is not known. Against a sophisticated enemy, the threat will always be there. The degree of stress will undoubtedly be a function of each soldier's appraisal of the potential and the known availability of protection. Since chemical warfare has not been employed for six decades, and biological and radiological warfare have never been employed against the combat soldier, no data on actual behavior or performance are available. The reader interested in further details should consult Vineberg,⁷⁸ Warnick and Kubala,⁷⁹ Bordes, et al.,⁸⁰ DESERT ROCK IV,⁸¹ or White.⁸²

⁷⁶N. F. Dickinson, A. J. Eckles, and W. C. Mullen. *Human Factors Assessment of Equipment Interface Problems Associated with Tank Crewmen Protective Equipment*, Technical Memorandum 20-71, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, October 1971.

⁷⁷Kennedy, Ball, Hoot, and Rieck, *op. cit.*

⁷⁸R. Vineberg. *Human Factors in Tactical Nuclear Combat*, Technical Report 65-2, Human Resources Research Organization, Alexandria, Virginia, April 1965.

⁷⁹Warnick and Kubala, *op. cit.*

⁸⁰P. A. Bordes, J. L. Finan, J. R. Hochstim, H. H. McFann, and S. G. Schwartz. *DESERT ROCK I: A Psychological Study of Troop Reactions to an Atomic Explosion*, Technical Report No. 1, Human Resources Research Office (HumRRO), Alexandria, Virginia, February 1953.

81
DESERT ROCK IV: *Reactions of an Armored Infantry Battalion to an Atomic Bomb Maneuver*, Technical Report No. 2, Human Resources Research Office (HumRRO), Alexandria, Virginia, August 1953.

82
B. W. White. *DESERT ROCK V: Reactions of Troop Participants and Forward Volunteer Officer Groups to Atomic Exercises*, Information Report, Human Resources Research Office (HumRRO), Alexandria, Virginia, August 1953.

Chapter 4

PERFORMANCE UNDER STRESS

Introduction

Despite the voluminous literature on stress, there is a real paucity of data concerning the effects of stress on job performance. Furthermore, the findings of those studies which do deal with performance under stress are far from being consistent. Lazarus, et al.¹ Harris, et al.,² and more recently, West and Parker,³ have all concluded that performance under stress is virtually impossible to predict on the basis of the literature in the field. Each of these aforementioned reports cite several reasons why the literature on performance under stress is so meager, and, why there is such apparent inconsistency in the findings. A synthesis of the major reasons cited is provided below.

(a) Data on actual performance in operational settings is sparse for two reasons. First, experimental control of many pertinent variables is difficult (if not impossible) to achieve, making it virtually impossible to evaluate stress effects or to compare results obtained with those of other studies. Second, performance measurement in operational settings is also extremely difficult. For example, there is no known way to measure a rifleman's firing accuracy during combat for comparison with a pre- or posttest score.

(b) Most performance measurements in field settings are obtained after rather than during stress. Actually, the same is true for a large proportion of laboratory studies. The common research paradigm is to compare post-stress performance measures with pre-stress performance measures. Unfortunately, such data provide no indication of performance levels during stress which is of greater concern. Post-stress testing, especially if performance is sampled over a period of time, does provide data on recovery time following stress. However, the relationship between performance during stress and performance following stress must be established before it will be possible to predict performance under stress.

¹ R. S. Lazarus, J. E. Deese, and S. F. Osler. "The Effects of Psychological Stress Upon Performance," *Psychological Bulletin*, July 1952, 49(4), Part I.

² W. Harris, R. R. Mackie, and J. L. Wilson. *Performance Under Stress: A Review and Critique of Recent Studies*, Technical Report VI, Human Factors Research, Inc., Los Angeles, California, July 1956.

³ V. West and J. F. Parker, Jr. *A Review of Recent Literature: Measurement and Prediction of Operational Fatigue*, Final Report, Bio-Technology, Inc., Falls Church, Virginia, February 1975.

(c) Most experimental stressors are artificial, i.e., they are not the same as those found in operational settings. Lazarus, et al.⁴ classified all experimental stressors as either "fear of failure," or "distraction." Harris, et al.⁵ proposed a different system for classifying stressors. They felt that stressors could be categorized as either short-term or long-term. Under short-term stresses, they listed failure stress, distraction stress, fear stress, physical discomfort stress, and pacing or speed stress. Under long-term stresses, they listed combat stress, hazardous duty stress, confinement and isolation, biological stress, and fatigue. Long-term stressors are the types typically found in operational settings. Unfortunately, when these long-term stressors are studied, there is often a lack of good measures of duty performance. The short-term stresses typically used in the laboratory are quite unlike stresses found in operational settings. For example, anticipation of electric shock is frequently employed as a fear stress. Fear of electric shock is faced in the field by only a handful of military personnel, namely, those concerned with the maintenance of electrical and electronic equipment. Pacing or speed stress is a factor in a number of military jobs. However, the tasks typically involved in experimentation are quite unlike those found in field settings. Speeded arithmetic tests, cancelling tests, or digit symbol substitution tests are the most frequently reported types. And, speed, like fear of failure, stresses an individual only if he is ego-involved in the outcome.

(d) In most laboratory experiments, both the stress applied and the measurement of performance are short-term. That is, the participation required of any subject is, at most, a matter of a very few hours. Subjects may well be able to perform at high levels during these short periods but at considerable psychological or physiological cost. Performance under these conditions might suffer greatly after a period of several hours.

(e) The importance of motivation is usually ignored because it is unknown. It seems safe to assume that persons whose careers or even lives are at stake in operational settings will be highly motivated. However, the same is not necessarily true of individuals in experiments. Subjects in many studies have participated because it was a requirement for a psychology course. In the military, subjects may volunteer for experiments out of boredom, or because they think participation will be more interesting than their present duties. In either case, there is reason to suspect that they may not perform to capacity. The most likely result is that some subjects strive to perform well while others will not--producing great variability in the results.

⁴Lazarus, Deese, and Osler, *op. cit.*

⁵Harris, Mackie, and Wilson, *op. cit.*

(f) The status of training on the tasks which constitute the performance measures is rarely taken into account. Although the data are meager, it is generally believed that well-practiced tasks will be the least affected by stress. This has been the case in areas where the findings have been consistent, such as studies of performance under heat stress. In most studies of stress, performance was measured on unfamiliar tasks. In fact, several studies report improvement in the performance of both experimental and control subjects, probably reflecting a practice effect. If practice had been permitted prior to the study, and the subjects had reached a plateau, the results obtained might have been quite different.

(g) Investigators have used various mixtures of performance measures and types of stressors. Therefore, it is very difficult to compare results across studies because there is no reason to presume that a particular stressor will affect performance on all types of tasks equally. Harris, et al.⁶ classified the types of performance measures employed in experimental studies into five categories. These are intellectual, perceptual, psychomotor, physiological, and personality. A host of different measures of each of these five types can be found in the literature. There are no a priori grounds for assuming that a stressor such as the threat of electric shock would necessarily have equal effects on such diverse tasks as digit symbol substitution and pursuit rotor performance.

The kinds of experimental stressors employed have been no less varied. For example, noise has frequently been employed as a distraction. However, the type of noise, its duration, and frequency have differed greatly. Some studies employed a steady-state noise, while others used an intermittent noise. The noise itself might be produced by a bell, a buzzer, or a speaker system. Again, the degree of stress generated by a particular distractor in relation to others is not known, making it exceedingly difficult to compare the findings of different studies. Currently, subjective measures are the only means of scaling the stress produced by various stressor, but these have not been employed with any consistency.

Despite all the problems listed above, there are a number of findings of sufficient generality to be useful to military planners. These will be covered in a later section of this chapter.

Recently, a considerable effort has been made to determine the biochemical and physiological correlates of stress. In fact, these have been used as outcome measures in a number of studies. However, they will not be covered in this review. Such measures may be very useful in predicting when an individual is approaching his breakingpoint. For

⁶*Ibid.*

selected highly critical occupations, relieving individuals before they reach the breakingpoint may be an effective strategy in maintaining a high level of performance on the job, even in wartime. During peacetime, it might be possible to monitor large numbers of men performing highly hazardous duties for the same purpose. However, all combat jobs are hazardous, and continuous biochemical and physiological monitoring of all individuals would be impossible. Furthermore, the relationship between these biochemical indicators and actual job performance has not been established. Therefore, it does not seem appropriate to discuss these works in this report. The discussions which follow will also be limited to the effects of stress on performance rather than behavior in general. Finally, there will be no coverage of studies which compare successful and unsuccessful combat soldiers. Data obtained from these studies may be very useful in selecting men for especially hazardous duty, but they shed little light on how stress affects the performance of the representative soldier.

The remainder of this chapter will be organized into three sections. The first section will be devoted to a listing of the consistent or most significant findings concerning performance under stress. The second section will describe some of the concomitants of stress other than purely neuropsychiatric symptoms or performance effects. The third section will provide a brief discussion of means men have employed in the past to cope with severe stress.

Performance Under Various Stressors

Research findings concerning performance under each of the various stressors discussed in Chapter 3 will be summarized in this section. Following each summary statement, the source of the information will be cited. Some of these will be secondary sources, and may represent a conclusion reported by the original source or drawn by the authors of the secondary source on the basis of a review of the literature. For full bibliographic information the interested reader can refer to the reference section at the end of this report. The full bibliographic information is not provided here in the interest of economy of space. However, complete bibliographic information will be presented for documents not previously cited in this report.

Heat

(a) Effective temperatures of 85°F to 93°F result in casualties due to heat prostration in personnel engaged in strenuous physical activities. Performance will become degraded on virtually all tasks before casualties occur. (Duke, Findikyan, Anderson, and Sells)

(b) Performance on mental tasks, especially those involving mathematics, will be impaired at temperatures of 100°F (DBT) or higher. (Fox, Goldsmith, Hampton, and Wilkinson⁷)

(c) Monitoring tasks and reaction time are essentially unaffected by heat at temperatures up to 100°F (DBT). (Duke, Findikyan, Anderson, and Sells)

(d) Acclimatization to heat requires 3 to 12 days. Without acclimatization, the incidence of casualties due to heat prostration is increased. (Morgan, Cook, Chapanis, and Lund)

Cold

(a) Hand skin temperatures below 60°F result in reduced finger dexterity and a consequent degradation of performance in tasks which require fine finger control. (Findikyan, Duke, and Sells)

(b) Extended exposure of extremities to temperatures of 53°F or below will eventually result in tissue damage and a consequent degradation of performances which require the use of the damaged parts. (Findikyan, Duke, and Sells)

(c) Available data, while sparse, indicate that exposure to cold has little apparent effect on mental or perceptual tasks. (Findikyan, Duke, and Sells)

Humidity

No data were located on the specific effects of humidity on performance. However, humidity has been shown to act in conjunction with other environmental variables to inhibit performance. For example, humidity tends to intensify the stressful effects of heat and cold stress. Extended exposure to either extremely high or extremely low humidity results in discomfort which *may* affect performance. The chief effect of high humidity on performance stems from its effects on equipment. For example, humidity can cause optical devices to fog and equipment to rust, both of which interfere with human performance. (Hicks)

⁶R. Fox, R. Goldsmith, I. Hampton, and R. Wilkinson. "The Effects of a Raised Body Temperature on the Performance of Mental Tasks," *Journal of Physiology*, June 1963, 167(1), 22P-23P (abstract).

Noise

Noise is typically considered to be a distraction stress unless it is of sufficient intensity to damage hearing or cause pain. Noise has been shown to affect performance on a variety of both physical and mental tasks. (Harris, Mackie, and Wilson; West and Parker) However, the obtained results were inconsistent and the present authors feel that no listing of specific effects is warranted. These inconsistencies are probably due to variations in the type, duration, and intensity of noises between studies as well as the variety of performance measures employed.

In general, intermittent noise appear to be more distracting than continuous noise. Noise of sufficient intensity will interfere with verbal communications. If the noise exceeds the standards set forth in MIL-STD-1474 (MI)⁸ permanent damage to hearing can occur, and a temporary threshold shift is almost certain. In either case, interference with spoken communications can be expected.

Overpressure

No data were located on the specific performance effects of overpressure resulting from blasts. If overpressure is sufficient, physiological damage will result. Eardrum rupture is the most likely effect, followed by lung hemorrhage and kidney damage. (Sprenger; Kennedy, Hoot, Ball, and Rieck) Obviously, the extent of the injury will determine the extent to which performance becomes degraded.

Toxic substances

(a) Intermittent exposure to 3% carbon dioxide for six days did not affect vigilance performance, coordination, or problem-solving ability. However, there was some indication that emotional changes did occur.⁹

(b) Exposure to 3% carbon dioxide and 21% oxygen for a period of 144 hours resulted in an increase in the number of errors made on a hand-steadiness test and a letter-cancelling test. Subjects reported initial feelings of improved verbal and motor capability, but reported that later they had feelings of depression. (Harris, Mackie, and Wilson)

⁸ US Department of Defense. "Noise Limits for Army Materiel," MIL-STD-1474 (MI), Washington, D.C., March 1973.

⁹ B. B. Weybrew. *An Exploratory Study of the Psychological Effects of Intermittent Exposure to Elevated Carbon Dioxide Levels*, NSMRL Report No. 647, Naval Submarine Medical Center, Groton, Connecticut, December 1970.

It is possible that concentrations of carbon monoxide, carbon dioxide, and fumes from engines and burning propellants may reach levels where protective face masks are necessary to supply purified air to personnel in armored vehicles. Current standards for concentrations of toxic substances are found in MIL-STD 1472A.¹⁰ However, these standards may not be applicable to the continuous exposure that may be necessary in some military situations.¹¹ More data on this subject are needed. If face masks must be worn, some degradation in performance can be expected. For example:

(a) Wearing a face mask (with short breaks every two hours) produced less than 10% degradation in vigilance while driving, radio communications, target detection, weapon firing, running, and verbal communications. (Montague, Baldwin, and McClure¹²)

(b) Disturbances in breathing, vision, sense of balance, and voice communications have been reported. (*Road Battalion Operations in a Toxic Environment: Vol. I of III. Operational Capability Experiment*)

(c) Poor mating of the mask to the various optical instruments in tanks has caused difficulties in using the gunsight and the mil scale in binoculars. Tank gunnery tasks, however, were not affected. (Dickinson, Eckles, and Mullen)

Fatigue

(a) Continuous operations (up to 48 hours) involving military tasks (with no other obvious or intended stresses) resulted in few reports of performance decrements. (Ainsworth and Bishop; Banks, Sternberg, Farrel, DeBow, and Dalhamer; Cannon, Drucker, and Kessler; Doll and Gunderson)

¹⁰ US Department of Defense. "Human Engineering Design Criteria for Military Systems, Equipment and Facilities," MIL-STD 1472A, Washington, D.C., May 1970.

¹¹ D. C. Hodge (ed.). *Military Requirements for Research On Continuous Operations, Proceedings of a Conference Held at Texas Tech University, Lubbock, Texas, 28-29 September 1971*, Technical Memorandum 12-72, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, April 1972, 133-187.

¹² W. Montague, R. D. Baldwin, and A. McClure. *The Effects of Wearing the CBR Protective Mask Upon the Performance of Selected Individual Combat Skills*, Technical Report 57, Human Resources Research Office (HumRRO), Alexandria, Virginia, June 1959.

(b) Sleep loss will likely affect performance on uninteresting and monotonous tasks, tasks that require continuous attention on the part of the operator, performance where several tasks must be performed on a time-shared basis, and tasks that are relatively unlearned prior to performance. (Woodward and Nelson)

(c) Performance decrements were observed in subjects after 14 to 18 hours of continuous work without rest breaks. Performance was measured on three active tasks: target identification, problem solving, and arithmetic computations. Performance was also measured on three passive tasks: warning lights monitoring, blinking lights monitoring, and probability monitoring. The probability monitoring task required subjects to determine whether the average position of a needle varied from a given point. The largest performance decrements occurred between 0200 and 0600 hours. The investigators suggest that performance at these times was affected by diurnal rhythms. (Morgan, Coates, Brown, and Alluisi)

It is generally concluded that fatigue will result in some performance decrement. The point at which this decrement will occur, however, is still open to debate. In their recent review of the literature on fatigue and stress, West and Parker report considerable inconsistency in the research findings. Some studies reported improvement in the performance of certain tasks by subjects who were sleep-deprived. West and Parker conclude their paper thusly:

In summary, the issue of fatigue assessment and performance prediction remains a complicated one which is still largely unresolved. Several approaches offer promise. No one approach, however, appears to be valid for all individuals in all situations. At the present time, the goal of a reliable index of fatigue and/or predictor of performance is not close at hand in the field.

Confinement and Isolation

Most of the research on the effects of confinement and isolation on performance has been conducted by NASA or the US Navy. Periods of confinement were typically quite long; i.e., 48 hours to as much as 30 days. It is unlikely that Army personnel will be confined for much more than 48 hours at any one time. A possible exception is confinement in a bunker following a nuclear explosion. However, very little in the way of job performance would be expected under such circumstances. Duties would be routine, and consist mainly of maintenance of personal hygiene and housekeeping. Only two relevant studies were located:

(a) Close confinement with little opportunity to move resulted in reduced circulation in the lower body. As a consequence, activities such as running were adversely affected immediately following confinement. (Hicks)

(b) Confinement in a civil defense shelter for 52 hours resulted in no loss of ability to fire the service pistol. The temperature in the shelter was warm (81°F), and eight square feet of space were allocated per occupant. However, subjects apparently performed no duties while in the shelter, so confinement was the only obvious stressor. (Lidberg and Seeman¹³)

Although the effects of confinement in tanks, armored personnel carriers, or bunkers has apparently not been well studied, the literature on longer term confinement indicates that decrements in performance should be minimal. Cannon, Drucker, and Kessler reviewed a series of Navy and NASA studies on confinements lasting from 2 to 17 days. Few decrements in performance were observed in psychomotor tasks, perceptual tasks, or intellectual tasks. Some decline in performance was observed in complex monitoring tasks such as radar monitoring or aerial reconnaissance. Nevertheless, it would appear that confinement alone should not affect performance greatly for periods of 48 hours or less.

Many of the studies of confinement were characterized by numerous defections which tended to occur early during the confinement. In most of these studies with high defection rates the subjects were not as carefully selected as those in the NASA and Navy studies. It is also not known whether these defectors were representative of Army personnel, but some of the studies were conducted with military personnel. It seems reasonable to assume that volunteers defecting from an experiment because of stress would show more severe performance decrements if forced to remain in confinement. However, no data to substantiate this hypothesis were located.

In brief, the data indicate that confinement per se has few or only temporary effects on performance. However, individuals with a low tolerance for confinement stress may either defect or show decrements in performance.

Crowding

No studies were located which were related to performance during or following periods of crowding.

¹³L. Lidberg and K. Seeman. *Psychomotor Performance Before and After Confinement in a Shelter*, Laboratory for Clinical Stress Research, Departments of Medicine and Psychiatry, Karolinska Institute, Stockholm, Sweden, November 1969.

Combat Stress

Only one study was located which attempted to measure the effects of combat stress on performance. The results of this effort were first reported by Davis¹⁴ and later were described more completely by Davis and Taylor.¹⁵ Since this was the only known study of this type, it will be described here in some detail.

Three groups of combat soldiers in Korea were studied. These were:

(a) A group of 24 men who were to take part in an attack were tested 12 hours before the attack. The fighting was fierce and the engagement lasted 18 hours. The company suffered 61% casualties, so only five of the original men were uninjured and available for retesting. Fifteen other men from the same company were added to the group, and the 20 examined 12 hours following the engagement, again after five days, and again after 22 days.

(b) A group of 13 men from a company which took over the captured positions were also tested. These men were in combat for five days, but the combat was less intense, and the unit suffered only 17% casualties. The original 13 men all survived and were examined 12 hours following combat and again eight days later.

(c) A group of 24 men from a company occupying positions about 200 yards behind the main line of battle served as a control group. These men were under a constant threat; however, their situation was far less dangerous than that of the men in either of the other two groups. On the basis of physiological measures (largely biochemical analyses of blood and urine), they did not differ significantly from normal non-combatant males in the US. These men were tested twice, the second series of tests being administered approximately 11 days after the first. Fourteen psychological tests were employed. These tests were designed to measure judgment, speed and sensitivity of perception, memory span, insight ability, rationalization, ability to learn, ability to think, and visual and auditory efficiency. Flicker fusion frequency was the only test which differentiated the combat stress groups from the control group. The threshold for both stress groups was lowered during the first post-stress test period. These results indicate that "higher mental functions" were not affected by combat stress of the intensity and duration which characterized this study.

¹⁴S. W. Davis. "Stress in Combat," *Scientific American*, March 1956, 194(3).

¹⁵S. W. Davis and J. G. Taylor. *Stress in Infantry Combat*, Technical Memo:ORO-T-295, Operations Research Office of the Johns Hopkins University, Chevy Chase, Maryland, September 1954.

A number of physiological measures were also obtained. Both stress groups differed significantly from the control group on a number of measures in the immediate post-combat tests. The times the authors estimate were required for complete physiological recovery are of interest. The group involved in the 18-hour intensive combat situation is estimated to have recovered in an average of approximately six days. The group involved in the 5-day less intensive combat situation required an average of approximately 13 days to recover completely. No psychomotor performance tests (e.g., running, shooting) were administered. However, Davis states that the combat stress had had profound effects. In describing the men he states: "They were impassive, lethargic, uncommunicative, almost antisocial, where before being sent into combat they had been exuberant - telling stories, laughing and backslapping."

In summary, it can be surmised that the men were physically and emotionally drained, but that their mental performance did not suffer. It is unfortunate that no tests involving combat tasks such as firing accuracy and communications were included.

Although it is exceedingly difficult to obtain data on the effects of combat stress itself, it is less difficult to obtain data on the effects of other "fear" stressors. A number of studies have attempted to investigate the effects of fear on performance. In order to generalize the results of these studies to combat, it must be assumed that all fear stressors affect performance in much the same way. This assumption is clearly tenuous at best. However, data from these studies are the best data available from which to generalize. Therefore, the results of some of the fear stress studies will be summarized. Again, the results have not been completely consistent (Harris, Mackie, and Wilson; Katchmar;¹⁶ West and Parker)

Harris, Mackie, and Wilson, in their review of the literature, describe the following studies:

(a) Paratroop trainees were administered a tachistoscopic closure test and a test of digit span at intervals during the six weeks training period. In the tachistoscopic closure test, incomplete circles with small breaks were presented to the subject. The subject's task was to tell if and where the circle was open. A control group did significantly better than the trainees even at the outset. Both groups improved during the course of study, but the trainees did not "catch up" with the controls. The relationship between these measures and the performance of any military jobs is, however, unknown. These measures, especially digit span, are purported to be sensitive to anxiety and have been employed frequently in stress research.

¹⁶L. F. Katchmar. *A Review and Analysis of the Concept of Stress and Related Variables*, Technical Report No. 16, Project No. DA-49-007-MD-222, February 1954.

(b) Seventeen performance measures were selected which were reported in the literature to be sensitive to stress. The subjects were 46 paratroop trainees attempting their first jump from the 34-foot tower. The performance of each trainee was measured on each test. Four tests were selected for further study on the basis of the results. The tests were critical flicker fusion, cancelling Cs, word fluency, and trembleometer performance. In the followup study, only performance on the trembleometer showed a decrement. Performance on the other three tests improved under the stress.

West and Parker describe the following studies in their review of the literature.

(a) A group of soldiers was deprived of sleep for 78 hours and then subjected to the stress of an electric shock while monitoring radar. The sleep deprivation resulted in significant impairments in performance, but performance *improved* under stress.

(b) Two groups of subjects received 15 training trials on a conventional pursuit rotor. One group had expressed a high fear of electric shock, while the other group had expressed a low fear. Following training, each group was divided into three subgroups. One subgroup from each group was informed that they would receive an electric shock if their performance fell below training levels. A second subgroup of each group was informed that shock would be administered randomly. The remaining subjects served as controls. No shocks were actually administered. However, the high fear group exhibited impaired performance under the condition where the threat of shock was tied to their performance.

A number of other investigators have looked at various aspects of behavior and performance under hazardous duty or fear stress conditions. This literature is briefly summarized below:

(a) Britton¹⁷ employed a previously validated Landing Performance Score (LPS) as a measure of aviator performance effectiveness. Data were also obtained on pilot experience, mood, and biochemical variables. Experienced pilots were able to sustain performance during a cumulative workload period with no apparent increase in stress as indicated by the biochemical and mood measures. Inexperienced pilots were able to sustain performance, but apparently at a continuing high personal cost as indicated by the mood and biochemical measures. It should be noted that, although the inexperienced pilots showed greater signs of stress, they were able to sustain and actually improve their landing performance.

¹⁷C. A. Britton. *Longitudinal Study of Environmental Variables and Aviation Performance Effectiveness*, Final Report, Dunlap and Associates, Inc., La Jolla, California, January 1975.

(b) Capretta, et al.¹⁸ employed a bridge-crossing exercise as a stressor. The bridge was a 3-rope expedient toggle bridge 200 feet long and 50 feet above a canyon. Subjects crossed individually wearing headsets with an earphone and microphone. Subjects were stopped midway on the bridge for a test of backward digit memory span. Another administration of an equivalent form was given either just before or just after finishing the crossing. Some of the subjects had had previous experience in bridge crossing, others had not. A control group was tested similarly but on a bridge that was only one foot high. Experimental subjects showed a greater degradation on the digit span test administered at the middle of the bridge than did the controls. Experienced subjects in both groups, performed better than naive subjects. Following the bridge experience, all subjects were tested on digit recall, a digit symbol substitution test, number checking, and speed of rifle disassembly and assembly. There were no differences between the groups on these tests.

(c) Hammock and Prince¹⁹ studied the effects of stress on M1 rifle marksmanship. The stressor employed a series of nearby explosions. Scores obtained in the stress situation were lower than those obtained previously in a non-stress situation.

(d) Meeland, et al.²⁰ placed basic trainees in seven experimental stress situations involving fire, darkness, height, distraction by explosives, fatigue, and electric shock. A variety of performance measures were also obtained, including flicker fusion, maze performance, mirror drawing, time estimation, reaction time, tapping, two-hand coordination, tremor and weight estimation. Correlations were obtained between changes in the performance measures and ratings and other measures of stress obtained in the stress situations. Although a number of correlations were significant, they tended to be low (below .35). Thus, the relationship between the various measures, while reliable, are of questionable practical importance.

¹⁸P. J. Capretta, J. L. Berry, R. H. Kerle, and H. L. LaMonaca. *Validity and Reliability of Certain Indicators of Psychological Stress*, Research Memorandum, George Washington University, Human Resources Research Office (HumRRO), Washington, D.C., June 1960.

¹⁹J. C. Hammock and A. I. Prince. *A Study of the Effects of Manifest Anxiety and Situational Stress on M-1 Rifle Firing*, Staff Memorandum, George Washington University, Human Resources Research Office (HumRRO), Washington, D.C., October 1954.

²⁰T. Meeland, R. L. Egbert, and I. Miller. *Field Stress: A Preliminary Study of Its Structure, Measurements, and Relationship to Combat*, Staff Memorandum, George Washington University, Human Resources Research Office (HumRRO), Washington, D.C., May 1957.

(e) Perhaps the most realistic study of performance under fear stress conducted to date was reported by Berkun.²¹ Berkun used a series of situations in which the subjects were led to believe that they had been accidentally or inadvertently placed in a very dangerous situation. One situation was called the "ditching" situation. Subjects were told that they were to participate in a study of the effects of altitude on performance. However, once in the air, they were informed that an "emergency" existed, and that a crashlanding in the ocean would have to be made. Subjects were then requested to complete an Emergency Data Form which was to be placed in a waterproof bag and jettisoned prior to the crashlanding. Since no real emergency existed, the aircraft actually landed safely. The Emergency Data Form was scored according to the accuracy with which the subjects followed instructions. The subjects were also given an Emergency Instructions test after landing to evaluate their recall of the instructions. The experimental group performed worse on both measures than either a flying control group or a grounded control group.

Three other simulated emergency situations were also employed. The first involved accidental nuclear radiation in the area, the second involved an approaching forest fire, and the third, a series of misdirected incoming artillery shells. In each case, the subject found that his radio transmitter had supposedly malfunctioned, and he could not report his position in order to be rescued. However, emergency instructions were available for the repair of the radio. Each subject was scored on the speed with which he began to work on the radio, the speed with which he read a wiring diagram and connected the indicated wires, the speed with which he removed a panel from the radio, the speed with which he read instructions and completed a cross wiring task, and reaction time in extinguishing a light. These performance measures were consolidated into a single performance score. The scores of the experimental subjects were then compared with those of a control group. Only the subjects exposed to the simulated artillery fire scored lower than the controls. However, this was due largely to the fact that eight subjects did not attempt to complete the radio repair, but ran out of the area instead. Therefore, they received a "zero" score on some of the measures. When the data for the subjects who attempted to evacuate themselves were deleted, no differences were found between the remaining subjects and the control group. Utilizing a self-report measure of stress, subjects in the stress situation reported experiencing a higher degree of subjective stress than the controls. However, there was no relationship between reported stress and ability to perform the required tasks.

²¹ M. M. Berkun. *Human Psychophysiological Response to Stress: Successful Experimental Simulation of Real-Life Stresses*, Research Memorandum, George Washington University, Human Resources Research Organization, Washington, D.C., December 1959.

In another study reported by Berkun, subjects were isolated and requested to complete some wiring for a training exercise involving demolitions. While the subject worked at the task, an explosion occurred and the subject was informed over an intercom that a serious injury had occurred. It was intimated that it might have been the subject's fault. He was requested to telephone for help, but the telephone supposedly malfunctioned. He was then instructed to repair the telephone according to instructions on the phone. Performance measures were based on the ability of each subject to effect the repair. Under these conditions, the performance of the experimental subjects was significantly poorer than that of the control group.

Chemical, Biological, and Radiological Warfare

Chemical warfare has not been employed since WWI and biological and radiological agents have never been employed against U.S. forces. Furthermore, so far as could be determined, there are no experimental studies in the open literature which deal with performance during actual exposure to biological or radiological agents. During the 1950s, HUMRRG conducted a series of studies aimed at determining psychological reactions and spread of information among troops participating in atomic exercises. Unfortunately, individual performance data on military tasks were not obtained. Therefore, the ability of personnel to perform during exposure or the threat of exposure to radiation hazards cannot be determined. The only data available on performance were obtained during simulations of nuclear warfare. In these studies, the effects of wearing protective gear on performance were studied. Some of these results have already been discussed under the heading of "toxic substances." A few more pertinent observations made during a CDCEC study²² will be reported here:

(a) Personnel wearing protective masks reported difficulty in breathing, maintaining a sense of balance, and visual difficulties. Visual problems were presumably due in part to the reduced field of view afforded by the mask. There was no initial degradation in performances requiring gross motor coordination. However, as the experiment progressed, there was a slowing of pace, and casualties due to heat began to occur.

(b) Tank commanders wearing the protective gear reported that it was almost impossible to clear stoppages in and load the caliber .50 machinegun. Gunners experienced difficulty in using the primary and secondary firing sights. To use the sights, the gunner had to apply a

²²Road Battalion Operations in a Toxic Environment. Volume I of III. Operational Capability Experiment, CDCEC 63-4, HQ, Department of the Army, Combat Developments Command Experimentation Center, Fort Ord, California, December 1963.

great deal of pressure against the mask, causing a depression in the face piece. Loaders wearing the masks reported problems in removing rounds from the floor ready racks and loading them in the main gun. Loaders had difficulties in checking the recoil replenisher tape, and also reported problems in loading and clearing the coaxial machinegun.

(c) Infantry units performing in temperatures of 75°F to 90°F were able to operate effectively at high energy expenditure rates for only 20 minutes. However, effective functioning could be maintained in a defensive position for more than 20 hours.

(d) Tasks involving tactical performance, information processing, accuracy of discrimination reactions, learning a complex problem-solving task, and communications could all be satisfactorily accomplished. However, performance of these tasks was generally slowed while wearing the protective gear.

(e) During the course of the study, it was observed that personnel became less alert and appeared to lose motivation. Complaints of thirst and facial irritation from wearing the mask were common.

Other Concomitants of Stress

It has been noted that increased stress results in maladaptive behaviors other than degradations in performance or the clinical symptoms exhibited during combat exhaustion. For example, Beebe and DeBakey²³ observed that instances of cold injury increased with intensification of battle. Rubin, et al.,²⁴ dealing with Naval personnel, observed that many types of illnesses increased with periods on line. That is, illness rates were higher when the ship was in potentially hostile waters than when enroute or in port. Not all personnel were equally affected. Forty-three percent of the more than 700 individuals studied reported no illnesses, while 29% had 75% of illnesses reported. It was further noted that personnel with the most physically taxing and most hazardous duties were sick the most. Deckhands and boiler room personnel reported the most illnesses, while medical, dental, and electronics personnel reported the fewest. Doll, et al.,²⁵ in studying the

²³G. W. Beebe and M. E. DeBakey. *Battle Casualties-Incidence, Mortality, and Logistic Considerations*, Springfield, Illinois: John C. Thomas, 1952.

²⁴R. T. Rubin, E. K. E. Gunderson, and E. E. Doll. "Environmental Variables and Illness Onset in an Attack Carrier's Crews," *Life Stress and Illness Patterns in the U.S. Navy*, Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1969.

²⁵R. E. Doll, R. T. Rubin, and E. K. E. Gunderson. "Demographic Variables and Illness Onset in an Attack Carrier's Crew," *Life Stress and Illness Patterns in the U.S. Navy*, Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1969.

same data, noted that older personnel reported the fewest illnesses, and that higher rank personnel (E5 to E9) were also less illness-prone.

Marren²⁶ compared the incidence of criminal offenses committed by US military personnel in Korea during the first half and second half of 1953. Since the Korean cease fire occurred on 27 July 1953, the two periods essentially represent a combat and a post-combat period. Rates for aggravated assault, voluntary manslaughter, robbery, rape, and suicide did not vary significantly between the periods. However, 35 murders were committed during the first half compared to only 9 during the second half. There were 84 narcotics offenses during the first half compared to 41 during the second half. The presumed greater use of narcotics during the first half of 1953 probably reflected attempts to reduce the tensions produced by being in the combat zone. Murder, which is presumably more often than not an impulsive act, could also be expected to increase during periods of high stress.

Other data such as those cited above could undoubtedly be found. However, the effects of stress on illness rates or criminal activity are not completely consistent. For example, Rubin, et al.²⁷ noted that illness rates on the USS Ranger fell to an almost pre-combat level during what should have been the most stressful period of their study. This occurred when the USS Pueblo was seized by North Korea, and the Ranger was ordered to sea off the North Korean coast. This required a shift from a tropical to an extremely cold climate. Constant combat readiness was maintained, as the ship was frequently overflowed by Russian aircraft. This example further illustrates the difficulties in attempting to ascertain the relationship between stress and behavior.

Coping With Stress

The means by which different individuals have attempted to cope with the stress of combat are quite varied. Some of these are based on the individual's personal beliefs and values. For example, religious beliefs were cited as being important by both Sobel²⁸ and Grinker and Spiegel.²⁹ Some individuals felt that providence would protect them, or

²⁶J. J. Marren. "Psychiatric Problems in Troops in Korea During and Following Combat," *US Armed Forces Medical Journal*, 1956, 7(1), 715-726.

²⁷Rubin, Gunderson, and Doll, *op. cit.*

²⁸R. Sobel. "Anxiety-Depressive Reactions After Prolonged Combat Experience-The Old Sergeant Syndrome," *Bulletin of the US Army Medical Department*, November 1949, Vol IX, Suppl. Issue, 137-146.

²⁹R. R. Grinker and J. P. Spiegel. *Men Under Stress*, Philadelphia: Blakiston, 1945.

if not, that their death was God's will and that they would be saved. Pride was cited by Sobel and also by Garner.³⁰ Pride in one's work, not wanting to "let down" friends and family, and not wanting to be considered a coward provided many men with the motivation to continue in battle. The Army probably has little influence over factors such as these. The individual either comes into the combat situation with these characteristics, or he does not.

Other factors which have helped men cope with stress in the past can be influenced by the military. The importance of group identification during both WWII and the Korean Conflict was cited by Glass,³¹ Bourne,³² Garner,³³ and Sobel.³⁴ There are a number of means available to the military to promote identification with and pride in a unit. The use of distinctive uniforms, inter-unit athletics and other competitions, and unit citations for outstanding performance have all been successfully employed. Leadership is a factor in the development of group identification. If the combat soldier sees his leaders as guilty of favoritism, neglect, or unnecessarily harsh discipline, he is likely to develop strong resentment. As Grinker and Spiegel³⁵ stated: "...if the leadership is incompetent or unfair, the group no longer is worthy of their love, and their interest centers once more upon themselves. That is why good leadership is so intimately connected with good morale." Glass³⁶ feels that differences in leadership style partially explain the differences in NP casualty rates between units. He states: "Because the company-grade officer lives in intimate contact with his men he plays a vital role in their motivation and group spirit, and is figuratively and literally a father figure." The Army can train leaders to have a personal concern but not to be over-indulgent, to be fair without

³⁰H. H. Garner. "Psychiatric Casualties in Combat," *War Medicine*, 1945, 8, 343-357.

³¹A. J. Glass. "The Problem of Stress in the Combat Zone," *Symposium on Stress*, Walter Reed Army Medical Center, Washington, D.C., March 1953.

³²P. G. Bourne. "Military Psychiatry and the Vietnam War in Perspective," in P. G. Bourne (ed.), *Psychology and Physiology of Stress*, New York: Academic Press, 1969.

³³Garner, *op. cit.*

³⁴Sobel, *op. cit.*

³⁵Grinker and Spiegel, *op. cit.*

³⁶A. J. Glass. "Combat Exhaustion," *US Armed Forces Medical Journal*, 1951, 2(10), 1471-1478.

being judgmental, and to set a standard by exemplary behavior. Failure to properly train leaders will result in reduced unit effectiveness and higher NP casualty rates.

Marren³⁷ and Sobel³⁸ both mention hatred of the enemy as a factor which enhances performance in the combat soldier. In the past, stories of atrocities committed by the enemy have been employed to induce hatred among both military personnel and the civilian populations supporting the war effort. While this tactic may improve combat effectiveness, it is likely to have undesirable repercussions following the hostilities. Hatred, once developed, does not disappear immediately. The victorious side is likely to be vindictive, generating considerable resentment on the part of the vanquished, making it difficult for either side to return to normal.

The status of training has frequently been mentioned as a major factor in overcoming the effects of stress (Glass;³⁹ Harris, et al.;⁴⁰ Kern;⁴¹ Klier;⁴² Miller;⁴³ Shaffer;⁴⁴ Stouffer⁴⁵). Harris, et al. point

³⁷Marren, *op. cit.*

³⁸Sobel, *op. cit.*

³⁹A. J. Glass. "The Psychological Aspects of Emergency Situations," in H. S. Abram (ed.), *Psychological Aspects of Stress*, Springfield, Illinois: Charles C. Thomas, 1970, 62-69.

⁴⁰Harris, Mackie, and Wilson, *op. cit.*

⁴¹R. P. Kern. *A Conceptual Model of Behavior Under Stress, with Implications for Combat Training*, Technical Report 66-12, George Washington University, Human Resources Research Office (HumRRO), Washington, D.C., June 1966.

⁴²S. Klier. *Effects of Induced Stress on Learning and Performance*, Technical Report NAVTRADEVCEEN 565-2, New York University College of Engineering Research Division, March 1962.

⁴³N. E. Miller. *Fear and Courage in Training and Combat*, Prepared for the Working Group on Human Behavior Under Conditions of Military Service, Department of Defense Research and Development Board, Washington, D.C., June 1951.

⁴⁴L. S. Shaffer. *Fear in Combat and Its Control*, Prepared for the Working Group on Human Behavior Under Conditions of Military Service, Department of Defense Research and Development Board, Washington, D.C., June 1951.

⁴⁵S. A. Stouffer, et al. *The American Soldier: Combat and Its Aftermath*, Princeton, New Jersey: Princeton University Press, 1949.

out that the USAF currently trains men in realistic stress situations. Examples are the survival training program and the program designed to help men cope with the interrogation methods employed by the Communists. The effectiveness of these types of training programs has not been adequately studied. However, most authorities agree that such training should be beneficial. Miller states that: "Knowing exactly what to expect reduces fear." He recommends that:

Training should be made as realistic as possible. Men should be familiarized with the meanings of all the sights and sounds that they are likely to encounter in combat: They should be exposed to all factors including confusion and isolation. Men should be introduced into fear-provoking situations gradually with the proper coaching to make sure that they make the correct responses when frightened.

Similarly, Shaffer states that:

Most men who have been through combat believe that they would have been able to control their fears more effectively if they had received the benefit of certain training procedures. The recommended techniques are: (1) a maximum of realistically simulated combat exercises; (2) so thorough a learning of combat skills that they can be performed automatically even under very disturbing conditions; and (3) a thorough knowledge of the characteristics of enemy weapons and how to protect oneself from them.

Kern⁴⁶ lists the training conditions he believes to be necessary for the strengthening of situational confidence. These are: (a) a relatively high degree of stimulus fidelity for the cues critical to job performance, (b) a relatively high degree of response fidelity in the execution of the performance, (c) a relatively high degree of fidelity for performance feedback, and (d) repeated execution of the job performance responses under realistic conditions.

There is a small amount of experimental evidence which indicates that training under stress improves performance under stress. Klier⁴⁷

⁴⁶Kern, *op. cit.*

⁴⁷Klier, *op. cit.*

Chapter 5

REVIEW AND COMMENT

The literature on stress has been referred to as a "mammoth collection."¹ Yet, no generally acceptable definition is available, and the results of studies concerned with the effects of stress on performance are comparatively few. Furthermore, even within a single study, the results have not been completely consistent. Harris, et al.² attribute this in part to wide individual differences in stress tolerance. However, they point out that both the stresses studied and the performance measures employed are also extremely varied, making valid comparisons across studies extremely difficult. Furthermore, the performance measures typically employed have been quite unlike any military tasks. In brief, there are simply insufficient data available to predict how stress will affect the performance of the combat soldier.

The implications of this review of the literature, it seems, are clear. If the Army is genuinely interested in determining how stress will affect the performance of military duties, a considerably expanded research program is required. The performances that must be measured are those that are required of the soldier on the battlefield. The stressors involved must be more than a mild "fear of failure" or a "distraction." Unfortunately, it is not a simple task to place men under more severe stress without violating ethical principles. It is no longer possible to deceive personnel into believing that they are in real danger. However, the military finds itself in somewhat of a unique position in this regard. At least at present, all persons in the military are volunteers for their jobs, and by their very nature, some aspects of most military jobs are hazardous. It is not considered unethical to ask personnel to perform duties which are essential to the conduct of their jobs, even though some genuine hazard is involved. The problem then is to find highly stressful duties which can be employed for experimental purposes. Three situations employed in the literature cited apparently were sufficiently stressful to result in either biochemical changes, performance degradation, or both. These were the jump from the tower in paratroop training, the crossing of a suspension bridge over a canyon, and the extinction of a large oil fire. Other situations might also prove useful. For example, rappelling training might prove to be quite stressful, especially if the trainees were first shown movies of experts rappelling very rapidly down high sheer cliffs.

¹J. Weitz. *Stress*, Research Paper P-251, Institute for Defense Analysis, April 1966.

²W. Harris, R. R. Mackie, and C. L. Wilson. *Performance Under Stress: A Review and Critique of Recent Studies*, Technical Report VI, Human Factors Research, Inc., Los Angeles, California, July 1956.

The trainees would not actually be required to rappel from the same height, but the anticipation could prove stressful. In fact, the greatest time of stress is likely to be just prior to the actual event, and is when performance on other tasks should be measured. In any event, the first task in any further research on stress would be to develop stressful situations which can be ethically employed in research. The second task would be to select a representative and critical set of performances to be measured. The third task would be to ascertain the effects of stress on these performances.

It is realized that no artificial situation will produce the severity of the stress of combat. However, since so little is known about the effects of stress on the performance of military tasks, the information derived from studies such as those suggested above should still be quite useful. Measures of the degree of stress imposed by different situations could be determined by both subjective reports and physiological measures. It might then be possible to extrapolate the results obtained in the different situations to more stressful situations.

The authors feel a comment is in order concerning what many may see as a serious omission in this report. Two of the most prolific writers in the field of stress; i.e., Hans Selye and Irving Janis, were not cited at all. Some of the works of each were reviewed, but no appropriate point to cite either was found. Selye's present conceptions, it seems to the present writers, are more suited to discussions of the stresses of everyday living. Also, they are not readily amenable to experimental verification. Janis' primary concern appeared to be with the social and attitudinal aspects of stress, rather than with its effects on human performance. The omissions should by no means be considered as an attempt by the authors to reflect unfavorably on the work of these writers. Rather, as stated before, their works simply seemed less appropriate to this effort than the works of others.

REFERENCES

- Ainsworth, L. L. and Bishop, H. P. *The Effects of a 48-Hour Period of Sustained Field Activity on Tank Crew Performance*, HumRRO Technical Report 71-16, Human Resources Research Organization, Alexandria, Virginia, July 1971.
- Alluisi, E. A., Chiles, W. D., and Smith, R. *Human Performance in Military Systems: Some Situational Factors Influencing Individual Performance*, Interim Technical Report 64-1, Performance Research Lab, Department of Psychology, University of Louisville, Louisville, Kentucky, August 1964.
- Altman, I. and Haythorn, W. W. The Effects of Social Isolation and Group Composition on Performance, *Human Relations*, 20(4), 313-339.
- Appel, J. W. and Beebe, G. W. Preventive Psychiatry: An Epidemiologic Approach, *Journal of The American Medical Association*, 131, 1946.
- Appel, J. W., Beebe, G. W., and Hilger, D. W. Comparative Incidence of Neuropsychiatric Casualties in World War I and World War II, *American Journal of Psychiatry*, 1946-1947, 103, 196-199.
- AR 70-25. *Use of Volunteers as Subjects of Research*, Department of the Army, Washington, D.C., 31 July 1974.
- Banks, J., Sternberg, J., Farrell, J., Debow, C., and Dalhamer, W. *Effects of Continuous Military Operations on Selected Military Tasks*, Technical Report 1166, US Army Behavioral and Systems Research Laboratory (BESRL), Arlington, Virginia, December 1970.
- Beebe, G. W. and Appel, J. W. *Variation in Psychological Tolerance to Ground Combat in World War II*, National Academy of Sciences, April 1958.
- Beebe, G. W. and DeBakey, M. E. *Battle Casualties-Incidence Mortality, and Logistic Considerations*, Charles C. Thomas, Springfield, Illinois, 1952.
- Berkun, M. M. *Human Psychophysiological Response to Stress: Successful Experimental Simulation of Real-Life Stresses*, HumRRO Research Memorandum, George Washington University, Human Resources Research Office, December 1959.

Bordes, P. A., Finan, J. L., Hochstim, J. R., McFann, H. H., and Schwartz, S. G. *DESERT ROCK I: A Psychological Study of Troop Reactions to an Atomic Explosion*, Human Resources Research Office, Technical Report No. 1, February 1953.

Bourne, P. G. *Military Psychiatry and The Vietnam War in Perspective*, in Bourne, P. G. (ed.), *Psychology and Physiology of Stress*, New York, Academic Press, 1969.

Bourne, P. G. *Psychological Aspects of Combat*, in H. Abram (ed.), *Psychological Aspects of Stress*, Springfield, Illinois: John C. Thomas, 1970, 70-85.

Bricton, C. A. *Longitudinal Study of Environmental Variables and Aviation Performance Effectiveness*, Final Report, Dunlap & Associates, Inc., La Jolla, California, January 1975.

Calhoun, J. B. *Population Density and Social Pathology*, *Scientific American*, 1962, 206, 139-148.

Cannon, D., Drucker E. H., and Kessler, T. *Summary of Literature Review on Extended Operations*, HumRRO Consulting Report, Human Resources Research Organization, Alexandria, Virginia, December 1964.

Capretta, P. J., Berry, J. L., Kerle, R. H., and LaMonaca, H. L. *Validity and Reliability of Certain Indicators of Psychological Stress*, Research Memorandum, George Washington University, Human Resources Research Office, Washington, D.C., June 1960.

Carlock, J. and Bucklin, B. *Human Factors in Mine Warfare: An Overview of Visual Detection and Stress (Part II, Stress)*, prepared for presentation at the TTCT Panel 0-1 Work Group, Mine Warfare Study Group Seminar, October 1971.

Chiles, W. D. *Psychological Stress as a Theoretical Concept*, WADC TR 57-457, Wright Air Development Center, Wright-Patterson AFB, Ohio, July 1957.

Chiles, W. D., Alluisi, E. A., and Adams, O. S. *Work Schedules and Performance During Confinement*, *Human Factors*, 1968, 10, 143-196.

Chmeil, D. *Military Potential Test of Short Range Cartridges, 5.56-MM Ball, 7.62-MM Ball and 7.62-MM Tracer*, Materiel Testing Directorate, Aberdeen Proving Ground, Maryland, October 1970.

[Conference on] Noise Evaluation and Control, Temple Texas, 1975, presented by Texas A&M University, Occupational Health and Safety Institute.

Curran, P. M. and Wherry, R. J. Measure of Susceptibility to Psychological Stress, *Aerospace Medicine*, October 1975, 36, 929-933.

Davis, N. J. *Protection Afforded by Field Fortifications Against Nuclear Weapons* (U), Report 1557-TR, US Army Engineer Research and Development Laboratories, Corps of Engineers, Fort Belvoir, Virginia, December 1958.

Davis, S. W. Stress in Combat, *Scientific American*, Vol. 194, No. 3, March 1956.

Davis, S. W. and Taylor, J. G. Stress in Infantry Combat, Technical Memo: ORO-T-295, The Operations Research Office of The Johns Hopkins University, Chevy Chase, Maryland, September 1954.

Department of Defense. *Human Engineering Design Criteria for Military Systems, Equipment and Facilities*, MIL-STD 1472A, Washington D.C., May 1970.

Department of Defense. *Noise Limits for Army Materiel*, MIL-STD-1474 (MI), Washington, D.C., March 1973.

DESERT ROCK IV: *Reactions of an Armored Infantry Battalion to an Atomic Bomb Maneuver*, Human Resources Research Office, Technical Report No. 2, August 1953.

Dickinson, N. F., Eckles, A. J., and Mullen, W. C. *Human Factors Assessment of Equipment Interface Problems Associated with Tank Crewmen Protective Equipment*, Technical Memorandum 20-71, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, October 1971.

Doll, R. E. and Gunderson, E. K. E. The Relative Importance of Selected Behavioral Characteristics of Group Members in an Extreme Environment, *Journal of Psychology*, 1970, 75, 231-237.

Doll, R. E., Rubin, R. T., and Gunderson, E. K. E. Demographic Variables and Illness Onset In An Attack Carrier's Crew, *Life Stress and Illness Patterns in the U. S. Navy*, Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1969.

Duke, M. J., Findikyan, N., Anderson, J., and Sells, S. B. *Stress Reviews. II. Thermal Stress-Heat*, Technical Report No. 11, Institute of Behavioral Research, Texas Christian University, Fort Worth, May 1967.

Ethical Principles in the Conduct of Research with Human Participants, American Psychological Association, 1973.

Ethical Standards of Psychologists, *American Psychologist*, January 1963.

Evans, G. W. Personnel Space: Research, Review, and Bibliography, *Man-Environment Systems*, July 1974, 3(4), 203.

Findikyan, N., Duke, M. J., and Sells, S. B. *Stress Reviews. I. Thermal Stress-Cold*, Technical Report No. 8, Institute of Behavioral Research, Texas Christian University, Fort Worth, July 1966.

Fox, R., Goldsmith, R., Hampton, I., and Wilkinson, R. The Effects of a Raised Body Temperature on the Performance of Mental Tasks, *Journal of Physiology*, June 1963, 167(1), 22P-23P (abstract).

Garinther, G. R. *Interior Noise Evaluation of the T114 Armored Command and Reconnaissance Vehicle*, Technical Report No. 3-62, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, 1962.

Garinther, G. R., and Blazie, D. B. *Acoustical Evaluation of the M60A1 Tank During Typical Operations*, Technical Memorandum 6-73, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, March 1973.

Garinther, G. R., Hodge, D. C., Chaiken, G., and Rosenberg, D. M. *Design Standards for Noise: A Review of the Background and Bases of MIL-STD-1474 (MI)*, TM 12-75, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, March 1975.

Garner, H. H. Psychiatric Casualties in Combat, *War Medicine*, Vol. 8, 1945, 343-357.

Glass, A. J. Introduction, in Bourne, P. G. (ed.), *Psychology and Physiology of Stress*, New York, Academic Press, 1969.

Glass, A. J. Combat Exhaustion, *US Armed Forces Medical Journal*, 1951, 2(10), 1471-1478.

Glass, A. J. The Problem of Stress in the Combat Zone, *Symposium on Stress*, Walter Reed Army Medical Center, Washington, D.C., March 1953.

Glass, A. J. The Psychological Aspects of Emergency Situations, in H. S. Abram (ed.), *Psychological Aspects of Stress*, Springfield, Illinois: Charles C. Thomas, 1970, 62-69.

Grinker, R. R. and Spiegel, J. P. *Men Under Stress*, Philadelphia, Pennsylvania: Blakiston, 1945.

Guidelines for Measuring OSHA Noise, B&K Instruments, Inc., Cleveland, Ohio, 1975.

Gunderson, E. K. E. and Nelson, P. D. Criterion Measures for Extremely Isolated Groups, *Personnel Psychology*, 1966, 19, 67-80.

Hammes, J. A. and Osborne, R. T. *Shelter Occupancy Studies at the University of Georgia, 1962-1963*, Civil Defense Research Psychological Laboratories, University of Georgia, Athens, December 1963.

Hammock J. C. and Prince, A. I. *A Study of the Effects of Manifest Anxiety and Situational Stress on M-1 Rifle Firing*, Staff Memorandum, George Washington University, Human Resources Research Office, Washington, D.C., October 1954.

Hanson, F. R. (ed.). *Combat Psychiatry. Experiences in the North African and Mediterranean Theaters of Operations, American Ground Forces, World War II*, *Bulletin of the US Army Medical Department*, November 1949, Vol. IX, Suppl. Issue.

Harris, W., Mackie, R. R., and Wilson, C. L. *Performance Under Stress: A Review and Critique of Recent Studies*, Technical Report VI, Human Factors Research, Inc., Los Angeles, California, July 1956.

Hartman, B. O. and Cantrell, G. K. *MOL: Crew Performance on Demanding Work-Rest Schedules Compounded by Sleep Deprivation*, Technical Report 67-99, School of Aerospace Medicine, Brooks AFB, Texas, November 1967.

Hartman, B. O., Hale, H. B., Harris, D. A., and Sanford, J. F. Psychobiologic Aspects of Double-Crew Long-Duration Missions in C-5 Aircraft, *Aerospace Medicine*, 1974, 45(10), 1149-1154.

Helmreich, R. L. *Evaluation of Environments: Behavioral Observations in an Undersea Habitat*, Social Psychology Laboratory, Department of Psychology, University of Texas, Austin, August 1971.

Helmreich, R. L. *Human Reactions to Psychological Stress, Stress, Self-Esteem and Attitudes*, Technical Report No. 12, University of Texas, Austin, November 1970.

Hicks, S. A. *The Effects of Confinement on the Performance of Combat Relevant Skill-Summary Report*, Technical Memorandum 16-64, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, 1964.

Environmental Quality Considerations for Continuous Operations, in Hodge, D. C. (ed.). *Military Requirements for Research on Continuous Operations, Proceedings of a Conference Held at Texas Tech University, Lubbock, Texas, 28-29 September 1971*, Technical Memorandum 12-72, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, April 1972, 133-187.

HumRRO Policy Statement Concerning the Protection of Human Subjects. Office of the President, Human Resources Research Organization, (HumRRO), Alexandria, Virginia, April 15, 1974.

Implementing Guidelines for a General Institutional Assurance on Research Involving Human Subjects. Office of the President, Human Resources Research Organization (HumRRO), Alexandria, Virginia, November 13, 1974.

Katchmar, L. F. *A Review and Analysis of the Concept of Stress and Related Variables*, TR No. 16, Project No. DA-49-007-MD-222, February 1954.

Kennedy, T. E., Ball, J. W., Hoot, B. B., and Rieck, P. J. *Expedient Field Fortifications for Use Against Nuclear Weapons*, Final Report, Technical Report N-74-7, US Army Engineer Waterways Experiment Station, Weapons Effects Laboratory, Vicksburg, Mississippi, September 1974.

Kern, R. P. *A Conceptual Model of Behavior Under Stress, with Implications for Combat Training*, HumRRO Technical Report 66-12, George Washington University, Human Resources Research Office, June 1966.

Klier, S. *Effects of Induced Stress on Learning and Performance*, TR NAVTRADEVCEEN 565-2, New York University College of Engineering Research Division, March 1962.

Kubala, A. L., Maxey, J. L., Ton, W. H., and Warnick, W. L. *A Study of the Psychological (and Associated Physiological) Factors to be Considered When Constructing Field Fortifications*, ARI Research Problem Review 76-12.

Lazarus, R. S., Deese, J. E., and Osler, S. F. *The Effects of Psychological Stress Upon Performance*, *Psychological Bulletin*, July 1952, 49(4), Part I.

Leatherman, C. D. *The Implications of Stress in Psychological Warfare, Symposium on Stress (16-18 March 1953)*, Army Medical Service Graduate School, Walter Reed Army Medical Center, Washington, D.C., 1953.

Lidberg, L. and Seeman, K. *Psychomotor Performance Before and After Confinement in a Shelter*, Laboratory for Clinical Stress Research, Departments of Medicine and Psychiatry, Karolinska Institute, Stockholm, Sweden, November 1969.

MacFarlane, W. V. General Physiological Mechanisms of Acclimatization, in S. W. Tromp (ed.), *Medical Biometeorology*, New York: Elsevier Publishing Company, 1963, 372-417.

Marren, J. J. Psychiatric Problems in Troops in Korea During and Following Combat, *US Armed Forces Medical Journal*, 1956, 7(1), 715-726.

Marshall, S. L. A. *Commentary on Infantry Operations and Weapons Usage in Korea, Winter of 1950-51*, ORO-R-13, Operations Research Office, The Johns Hopkins University, October 1952.

Meeland, T., Egbert, R. L., and Miller, I. *Field Stress: A Preliminary Study of Its Structure, Measurement, and Relationship to Combat*, HUMRRO Staff Memorandum, George Washington University, Human Resources Research Office, May 1957.

Menninger, W. C. Psychiatric Experience in The War, 1941-1946, *American Journal of Psychiatry*, Vol. 103, No. 5, March 1947.

Mericle, E. W. The Psychiatric and the Tactical Situations in an Armored Division, *The Bulletin of the US Army Medical Department*, Vol. VI, No. 6, December 1946.

Miller, N. E. *Fear and Courage in Training and Combat*, Prepared for the Working Group on Human Behavior Under Conditions of Military Service, Department of Defense Research and Development Board, Washington, D.C., June 1951.

Minard, D., Grayeb, G. J., Singer, R. C., and Kingston, J. R. *Heat Stress During Operation Banyan Tree I*, Report No. 5, Naval Medical Research Institute, Bethesda, Maryland, July 1961.

Montague, W., Baldwin, R. D., and McClure A. *The Effects of Weaving the CBR Protective Mask Upon the Performance of Selected Individual Combat Skills*, Technical Report 57, Human Resources Research Office, June 1959.

Morgan, B. B. and Alluisi, E. A. Applicability of Research on Sustained Performance, Endurance, and Work-Rest Scheduling to the Development of Concepts and Doctrine of Continuous Operations, in D. Hodge (ed.), *Military Requirements for Research on Continuous Operations, Proceedings of a Conference Held at Texas Tech University, Lubbock Texas, 28-29 September 1971*, Technical Memorandum 12-72, US Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, April 1972.

Morgan, B. B. Jr., Coates, G. D., Brown, B. R., and Alluisi, E. A. *Effects of Continuous Work and Sleep Loss on the Recovery of Sustained Performance*, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, July 1973.

Morgan, C. T., Cook, J. S., Chapanis, A., and Lund, M. W. *Human Engineering Guide to Equipment Design*, New York: McGraw-Hill, 1963.

Myers, T. I., Murphy, D. B., Smith, S., and Goffard, S. J. *Experimental Studies of Sensory Deprivation and Social Isolation*, HumRRO Technical Report 66-8, Human Resources Research Organization, Alexandria, Virginia, June 1967.

Naylor, J. C. A Proposed Method for Determining the Psychological Effects of Weapons, *Proceedings of the First Symposium on the Psychological Effects of Non-Nuclear Weapons*, Vol. I, Eglin AFB, April 1964.

Page, M. M., Prior Art in the Psychological Effects of Weapons Systems, *Proceedings of the First Symposium on the Psychological Effects of Non-Nuclear Weapons*, Vol. I, Eglin AFB, April 1964.

Protection of Human Subjects, *Federal Register*, May 30, 1974, 39(105), Part II, 18914-18920, US Department of Health, Education and Welfare.

Road Battalion Operations in a Toxic Environment: Volume 1 of 11. Operational Capability Experiment, CDCEC 63-4, HQ, Department of the Army, Combat Developments Command Experimentation Center, Fort Ord, California, December 1963.

Rohles, F. H., Nevins, R. G., and McNall, P. E. *Human Physiological Responses to Shelter Environment*, Report No. 2, Institute for Environmental Research, Kansas State University, Manhattan, February 1967.

Rubin, R. T., Gunderson, E. K. E., and Doll, R. E. Environmental Variables and Illness Onset in an Attack Carrier's Crew, *Life Stress and Illness Patterns in the U.S. Navy*, Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1969.

Scott, J. P. Relative Importance of Social and Hereditary Factors in Life Adjustment During Periods of Stress in Laboratory Animals, *Life Stress and Bodily Disease*, Association for Research in Nervous Mental Disease, 1949.

Sells, S. B. (chairman). *APA Symposium on Factors Affecting Team Performance in Isolated Environments*, September 5, 1967, Institute of Behavioral Research, Texas Christian University, Fort Worth, July 1958.

Sells, S. B. and Rawls, J. R. *Effects of Isolation on Man's Performance*, USI 20, Bioengineering and Cabin Ecology, Science and Technology Series, American Astronautical Society, Tarzana, California, 1969.

Sells, S. B. and Trego, R. E. *Normative Studies of Personality Measures Related to Adaptation Under Conditions of Long Duration, Isolation, and Confinement, Final Report, Part I. Personal Characteristics for Successful Adaptation*, IBR Technical Report 73-17, Institute of Behavioral Research, Texas Christian University, Fort Worth, July 1973.

Shaffer, L. S. *Fear in Combat and Its Control*, Prepared for the Working Group on Human Behavior Under Conditions of Military Service, Department of Defense Research and Development Board, Washington, D.C., June 1951.

Sobel, R. Anxiety-Depressive Reactions After Prolonged Combat Experience-The Old Sergeant Syndrome, *Bulletin of the US Army Medical Department*, November 1949, Vol. IX, Suppl. Issue, 137-146.

Sprenger, T. R. *Survival on the Nuclear Battlefield*, Student Essay, US Army War College, Carlisle Army Barracks, Pennsylvania, September 1974.

Stokols, D. The Relation Between Micro and Microcrowding Phenomena: Some Implications for Environmental Research and Design, *Man-Environment Systems*, 1973, 3(3), 139.

Stouffer, S. A., et al. *The American Soldier: Combat and Its Aftermath*, Princeton, New Jersey: Princeton University Press, 1949.

Swank, R. L. Combat Exhaustion, *Journal of Nervous and Mental Disease*, 1949, 109(6), Serial No. 810, 475-508.

Swank, R. L. and Marchand, W. E. Combat Neuroses. Development of Combat Exhaustion, *Archives of Neurology and Psychiatry*, 1946, 55, 236-247.

The Institutional Guide to DHEW Policy on Protection of Human Subjects. US Department of Health, Education and Welfare, Washington, D.C., December 1, 1971.

Tischler, G. L. Patterns of Psychiatric Attrition and of Behavior in a Combat Zone, in Bourne, P. G. (ed.), *Psychology and Physiology of Stress*, New York, Academic Press, 1969.

Vineberg, R. *Human Factors in Tactical Nuclear Combat*, HUMRRO Technical Report 65-2, Human Resources Research Organization, Alexandria, Virginia, April 1965.

Walker, N. K., Schectman, F., and DeSocio, E. *Further Work on the Use of Tracking Tasks As Indicators of Stress*, Washington School of Psychiatry, Washington, D.C., January 1964.

Warnick, W. L. and Kubala, A. L. *A Study of Selected Problems in Armor Operations*, ARI Technical Report (in process).

Weitz, Joseph. *STRESS*, Institute for Defense Analysis, Research Paper P-251, April 1966.

West, V. and Parker, J. F. Jr. *A Review of Recent Literature: Measurement and Prediction of Operational Fatigue*, Final Report, BioTechnology, Inc., Falls Church, Virginia, February 1975.

Weybrew, B. B. *An Exploratory Study of the Psychological Effects of Intermittent Exposure to Elevated Carbon Dioxide Levels*, NSMRL Report No. 647, Naval Submarine Medical Center, Graton, Connecticut, December 1970.

Weybrew, B. B. *Some General Comments Concerning Personnel Selection for Hazardous Duty After Six Years of Research in Submarine Selection*, Memorandum Report No. 62-5, US Naval Medical Research Laboratory, Graton, Connecticut, October 1962.

Wherry, R. J. and Curran, P. M. *A Study of Some Determiners of Psychological Stress*, US Naval School of Aviation Medicine, Pensacola, Florida, July 1965.

White, B. W. *DESERT ROCK V: Reactions of Troop Participants and Forward Volunteer Officer Groups to Atomic Exercises*, Human Resources Research Office, Information Report, August 1953.

Woodward, D. P. and Nelson, P. D. *A User Oriented Review of the Literature on the Effects of Sleep Loss, Work-Rest Schedules and Recovery on Performance*, Office of Naval Research, Biological and Medical Sciences Division, Arlington, Virginia, December 1974.

Zubek, J. P., Bayer, L., Milstein, S. L., and Shephard, J. M. Behavioral and Physiological Changes During Prolonged Immobilization Plus Perceptual Deprivation, *Journal of Abnormal Psychology*, 1969, 74(2), 230-236.

Zubek, J. P., Bayer, L., and Shephard, J. M. Relative Effects of Prolonged Social Isolation and Confinement: Behavioral and EEG Changes, *Journal of Abnormal Psychology*, 1970, 75(5), 625-631.

Zuckerman, M., Persky, H., Link, K.E., and Basu, G. K. Experimental and Subject Factors Determining Responses to Sensory Deprivation, Social Isolation, and Confinement, *Journal of Abnormal Psychology*, 1968, 73(3), 183-194.