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Research Report 1545

# Soldier Performance as a Function of Stress and Load: A Review

AD-A221 530

**Louis W. Buckalew**
U.S. Army Research Institute



January 1990



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# 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**


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SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION<br>Unclassified | 1b. RESTRICTIVE MARKINGS<br>-- |
| 2a. SECURITY CLASSIFICATION AUTHORITY<br>--<br>2b. DECLASSIFICATION / DOWNGRADING SCHEDULE<br>-- | 3. DISTRIBUTION / AVAILABILITY OF REPORT<br>Approved for public release; distribution is unlimited. |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S)<br>ARI Research Report 1545 | 5. MONITORING ORGANIZATION REPORT NUMBER(S)<br>-- |
| 6a. NAME OF PERFORMING ORGANIZATION<br>ARI Field Unit--Fort Hood, HQ, TEXCOM<br>6b. OFFICE SYMBOL (If applicable)<br>PERI-SH | 7a. NAME OF MONITORING ORGANIZATION<br>-- |
| 6c. ADDRESS (City, State, and ZIP Code)<br>Fort Hood, TX 76544-5065 | 7b. ADDRESS (City, State, and ZIP Code)<br>-- |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION<br>U.S. Army Research Institute for the Behavioral and Social Sciences<br>8b. OFFICE SYMBOL (If applicable)<br>PERI-Z | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER<br>-- |
| 8c. ADDRESS (City, State, and ZIP Code)<br>5001 Eisenhower Avenue<br>Alexandria, VA 22333-5600 | 10. SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO. 63007A; PROJECT NO. 793; TASK NO. 1401; WORK UNIT ACCESSION NO. H1 |

11. TITLE (Include Security Classification)
Soldier Performance as a Function of Stress and Load: A Review

12. PERSONAL AUTHOR(S)
Buckalew, Louis W. (ARI)

| 13a. TYPE OF REPORT | 13b. TIME COVERED | 14. DATE OF REPORT (Year, Month, Day) | 15. PAGE COUNT |
|---|---|---|---|
| Final | FROM 88/09 TO 88/09 | 1990, January | |

16. SUPPLEMENTARY NOTATION
--

| 17. COSATI CODES | | | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) | |
|---|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | Stress | Fatigue |
| | | | Combat stress | Continuous operations |
| | | | Soldier load | Combat load |

19. ABSTRACT (Continue on reverse if necessary and identify by block number)


This report describes the results of a survey to identify and summarize literature related to soldier performance when under stress, with an emphasis on the relationship of stress to the combat load of the individual soldier.

Researchers used a number of different databases to conduct a computer search (DIALOG) of professional and military literature on stress. Results of the effort indicate that the majority of the empirical data on stress from within the scientific community is difficult to extrapolate to military combat situations. Conversely, the majority of stress-related data from combat situations is anecdotal. The most representative stress-related research appears in studies of sustained or continuous operations.


(Continued)

| | |
|---|---|
| 20. DISTRIBUTION / AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS | 21. ABSTRACT SECURITY CLASSIFICATION<br>Unclassified |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Louis W. Buckalew | 22b. TELEPHONE (Include Area Code)<br>AV738-9118 (817)288-9118<br>22c. OFFICE SYMBOL<br>PERI-SH |

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

ARI Research Report 1545

19. ABSTRACT (Continued)

The report concludes that stresses typical of those to which the soldier is exposed in combat result in a degradation of cognitive performance, motor skills, and load-bearing capability. In turn, excessive soldier loads may contribute to stress.

Stressors that were treated most thoroughly in the literature were fear, fatigue, uncertainty, sleep deprivation, work and rest cycles, and ambient temperature. The report includes recommendations for maximizing soldier performance in stressful situations.

Research Report 1545

# Soldier Performance as a Function of Stress and Load: A Review

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Department of the Army

**January 1990**

**Army Project Number**
**2Q263007A793**

**Human Factors in Training and Operational Effectiveness**

Approved for public release; distribution is unlimited.

## FOREWORD

U.S. Army policymakers, planners, and unit leaders are concerned about soldiers' responses to stresses encountered in combat situations. Particular interest has been devoted to soldier load bearing. This focus was prompted by needs to develop clear policies, procedures, and plans for implementing the light infantry division concept.

The U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Hood Field Unit, was requested by the Commanding General of the Training and Doctrine Command (TRADOC) Test and Experimentation Command (TEXCOM) to provide a review of available information on soldier stressors and stress effects associated with combat conditions. Emphasis was placed on the identification of documented and potential relationships of stress to individual soldier load-bearing capabilities in combat. Suggestions for enhancing load-bearing performance under stress were encouraged.

A wide range of literature was researched to identify stressors associated with combat, stress effects on combat-related performances, and impacts on soldier load bearing. Few directly relevant experimental studies were found, and most combat-related studies provided only anecdotal information. However, the relatively large body of literature reviewed on sustained or continuous operations offered insights into some stress effects and provided suggestions for minimizing the impact of these effects.

This research effort was conducted as an independent Advanced Development task within the scope of the Human Factors in Training and Operational Testing project area, and in accordance with a 7 May 1981 Memorandum of Understanding between ARI and the TRADOC Combined Arms Test Activity (later reorganized as the TRADOC Test and Experimentation Command (TEXCOM)). The results were presented to the Commanding General, TEXCOM, in September 1988, to be used in reexamining the combat load to be carried by individual soldiers, with an emphasis on soldiers of the light infantry division.

This report includes the information provided to TEXCOM in September 1988 and more recent information that was not available at the time of the 1988 research.

EDGAR M. JOHNSON
Technical Director

SOLDIER PERFORMANCE AS A FUNCTION OF STRESS AND LOAD: A REVIEW

## EXECUTIVE SUMMARY


Requirement:

To provide a review of research on stressors and stress effects that might be associated with performance in combat, with particular concern for load bearing, and to suggest ways in which stress-induced performance degradation could be minimized.

Procedure:

A computer search (DIALOG) of professional and military literature on stress utilizing psychological, sociological, medical, mental health, biology, health sciences, education, and defense databases was conducted. Appropriate stress-related research and review findings were identified and discussed. A number of recommendations for maximizing soldier performance in stressful situations were generated.

Findings:

Much of the empirical research data on stress sources and effects within the scientific community is difficult to extrapolate to military combat situations because of constraints required of experimental testing and the unrepresentativeness of a laboratory to a battlefield. Conversely, much of the stress-related research involving combat situations is anecdotal. The most representative stress research appears in studies of sustained or continuous operations. Application of reviewed research on stress effects indicates varying degrees of degraded cognitive performance should be expected. To a lesser degree, perceptual motor skills might be expected to evidence some degradation because of stress. Specific attention to load bearing has found degraded performance associated with a combat environment. However, statements attributing this degradation to stress may be artifacts, as reported initial soldier loads have been considerably greater than recommended or conditioned.

Combat-related stressors that were treated most thoroughly in the literature included fear, fatigue, sleep deprivation, work and rest cycles, uncertainty, and ambient temperatures. A number of factors mediate, and that could potentially attenuate, stress effects were identified. They included motivation, experience, coping style, training and conditioning (desensitization), personality, information and communication, and leadership. The role, importance, and manipulation of these factors are discussed, and suggestions for reducing stress effects and enhancing load-bearing performance are provided.

Utilization of Findings:

This review is intended to serve as a useful source document for stress-related studies that may impact on understanding, predicting, and modifying soldier performance, to include load bearing in stressful environments. The identification of potential stressors, deduction of possible stress effects, and discussion of variables and techniques that could modulate stress effects (performance degradation) should provide planners and policymakers with information useful in the design of programs to minimize soldier performance degradation on the battlefield.

SOLDIER PERFORMANCE AS A FUNCTION OF STRESS AND LOAD: A REVIEW

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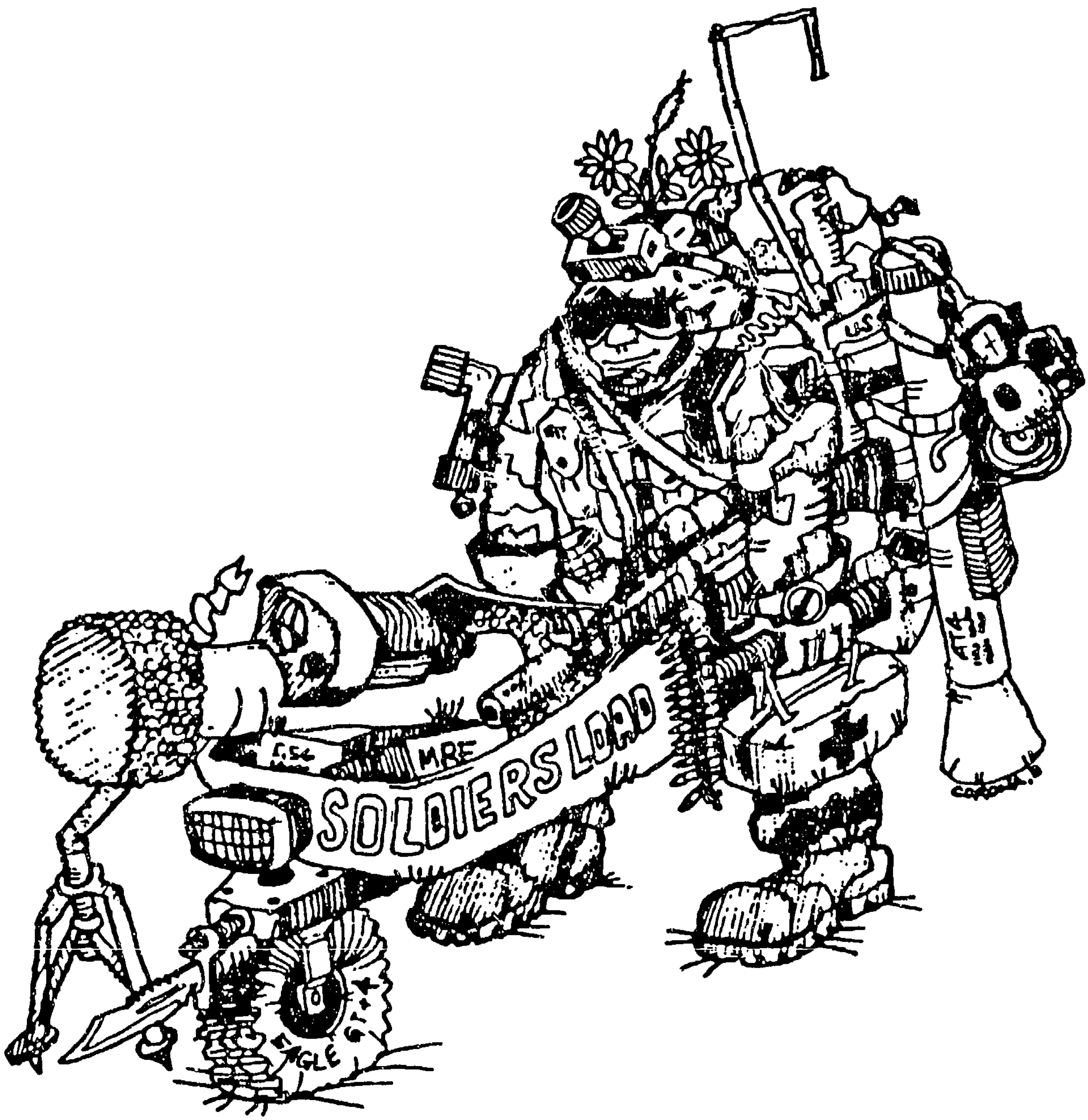
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## SOLDIER PERFORMANCE AS A FUNCTION OF STRESS AND LOAD: A REVIEW

### Introduction

Soldier performance, particularly in a combat situation, is a critical topic of concern, research, and experimentation within the modern Army. Traditionally, major concerns for soldier performance, both qualitative and quantitative, have rested with personnel selection and assignment, initial and sustainment training, and equipment and logistics. However, experiences in World War II, the Korean Conflict, the Vietnam Conflict, and Grenada have revealed that the performance of carefully slotted, well trained, and well equipped soldiers, while adequately predictable in a normal operational environment (peacetime), may suffer appreciable distortions in an actual combat environment. This distortion can be manifested either in a degradation of performance or an enhancement of performance, the former being of primary interest in this paper. One major variable contributing to diminished predictability of performance in a combat (life-threatening) environment is stress effects. Headley, Hartel, and Murphy (in preparation) reiterated continuing Army concerns that the issue of stress and performance is of special importance on the high tech battlefield because of the possibility that equipment may not be optimally operated by soldiers whose cognitive and sensory-motor skills are degraded by stress.

Operationally, stress is a complex variable, as it involves physiological and psychological components. Stressors (stimuli) and stress (response) may be either physical, mental, or both. For the purpose of this paper, it is posed that a combat situation inherently involves stressors of both a physical nature (e.g., terrain, fatigue, load, hostile fire, workload, explosions, barriers and fortifications) and a psychological nature (e.g., fear, grief, fatigue, self-doubt, anxiety). To these stressors, and intricate to their processing, must be added such moderators as motivation, religious beliefs, perceptions of leadership, feelings of vulnerability or indestructibility, emotional stability, experience, hormonal changes, optimism or pessimism, commitment, fatalism, courage, and risk-taking. Hence, considering the variety of stressors, each of which is variable, the variety of specific combat environments and missions which may exist, and the complex interactive effects of stress moderators, any attempt to accurately predict or prepare for stress effects on soldier performance is probably ill-fated. However, the key word is "accurately"--general effects of stress on some specific performances may have the potential for prediction.

This research was conducted in response to a request from HQ TRADOC Test and Experimentation Command, Fort Hood, TX. The Fort Hood Field Unit of the Army Research Institute (ARI) was requested to provide information relating to the effects of stress on soldier mission performance, with specific attention to load bearing. This concern was directly related to doctrine for the light infantry division, i.e., given current knowledge of stress effects on performance projected to a soldier, decisions could be better made on how to equip and employ the light infantry soldier and what could be expected in terms of combat performance? Particular interest was indicated in stress and fear effects on a soldier's load carrying capacity. The purposes of this paper were to: (a) review and summarize available current published research relating stress effects and performance; (b) identify physical performances or capacities likely to experience appreciable degradation in response to stress; and (c) review available research on soldier load and project the implications of stress research findings for load bearing.

## Method

A computer search of current (generally last 20 years) professional and military literature was conducted using DIALOG. Key term or descriptor combinations used in this search included: stress, fear, human performance, strength, endurance, and physiological impact. A broad-based search was instituted involving the scientific literature available in the disciplines of social science (SOCIAL SCISEARCH), psychology (PSYINFO, 1967-88; Mental Health Abstracts, 1969-88; PSYCALERT, 1988), medicine (MEDLINE, 1983-88; EMBASE, 1974-81; CANCERLIT, 1963-88; Clinical Abstracts, 1981-87), health sciences (Nursing and Allied Health, 1983-87), education (ERIC, 1966-88), biology (BIOSIS PREVIEWS, 1969-88), pharmacology (International Pharmaceutical Abs., 1970-88), sociology (SOCIOLOGICAL ABSTRACTS, 1963-88), and defense (DTIC). A number of related journal articles and government research reports were identified, and a review of abstract content isolated articles and reports of specific relevance. These are summarized in this paper and listed as references.

Personal contacts with professionals at various military laboratories and agencies provided an additional source of information and guidance. These included the following organizations: U.S. Army Research Institute; U.S. Army Institute of Environmental Medicine, Exercise Physiology Division, Natick Labs; U.S. Air Force Aerospace Medical Research Laboratory, Workload and Ergonomics Branch; Walter Reed Army Medical Center, Division of Neuropsychiatry; U.S. Air Force School of Aerospace Medicine, Crew Performance Branch; and U.S. Army Medical Field Service School, Behavioral Sciences Division, Psychiatric and Neuropsychiatric Branch.

## Findings and Discussion

There have been few reports in the last 20 years of empirical research on stress effects, i.e. the use of stress as a systematically manipulated or observed variable. One possible reason for this, according to Hobfoll (1989) is that current conceptualizations of stress may be too phenomenological and ambiguous, and consequently not given to direct empirical testing. What reports there are largely dealt with stress (stressor) in the form of heat (thermal), noise, sleep deprivation, or exercise. While all of these potential stressors may be operating in a combat environment and could impact soldier performance, exercise research appears the most relevant to load bearing concerns. Several studies did report on the influence of generalized stress associated with combat-related duties on soldier performance. In this regard, Headley, Hartel, and Murphy (in preparation) offer an interesting overview of military concern with the effects of stress on degradation of performance, anecdotal information which illustrates combat-related stress effects, and a discussion of the difficulties involved in attempting any straightforward interpretation and application of most available stress data to efficiency of behavior in real-life dangerous settings.

Part 1 of this review provides an overview of the general nature of and response to stress. Part 2 deals with specific stressors and their effects, regardless of nature. Part 3 explores continuous operations as both a stressor and as a performance measure of stress. Part 4 attempts to integrate findings of stress research and apply them to soldier load concerns.

## Part 1: Overview of Stress

All persons throughout their lifespan are exposed to numerous environmental stimuli which constitute potential stressors: these stressors can be as diverse as social pressures, personal pressures, or physical performance requirements and can produce physical damage and or psychological tension (Levitt, 1981). Hobfoll (1989) suggested that stress is a major factor affecting people's lives, is intimately tied with mental health, and is very possibly linked with many problems of physical health. While stress effects are typically thought to be negative, exposure to stress can be positive in that it can help an organism to adapt and reduce the impact of future stressors. The latter point may bear careful consideration relative to training or conditioning, particularly in light of the large body of psychological literature which deals with desensitization therapy (Wolpe, 1981) used in anxiety and fear reduction.

Excessive stimulation, either physical or emotional, is stressful and can readily reduce adaptability by breaking down behavior (Levitt, 1981; Schneider & Tarshis, 1986). One of the major problems in stress research has been identification of a stress tolerance "breaking point." There are significant interpersonal differences in response to stressful events and a number of possible reasons for these differences, to include special vulnerabilities or predispositions, genetics, and past learning experiences (Levitt, 1981). Nonetheless, it is established that when any individual's stress tolerance is stretched too far, a breakdown will ensue.

What happens to an individual subjected to sufficiently strong or lengthy stress? There appear to be two kinds of breakdowns: cognitive and visceral. These are not mutually exclusive and either ultimately leads to a behavioral breakdown. A cognitive breakdown is typified by emotional reactions to a situation becoming chaotic or detached (psychotic), and a visceral breakdown is typified by, ultimately, bodily damage (psychosomatic) (Schneider & Tarshis, 1986). In either case, but particularly the former, observable behavioral breakdowns occur.

There are a number of "classic" studies in the psychological literature which explored various stressors and stress reactions in animals. The majority can be united under the rubric of learned helplessness, and while animals were used, human analogs appear inescapable. Brady, Porter, Conrad, and Mason (1958) exposed two groups of monkeys to stress (electrical shock), with one group able to avoid the shock. Members of each group were paired (yoked) so that all animals received the same frequency and intensity of shocks. The group which, by timely response, could control whether they received a shock developed significantly more ulcers (visceral breakdown) than did the "helpless" group. The key appears to be that the "executive" monkeys had no cue to let them know they could relax. Weiss (1968) found that if an "executive" group of rats had feedback on their shock delay or avoidance behavior and hence could "relax," their physical condition was actually better than that of the "helpless" group. The lesson here is that an organism in a stressful environment which can control the stressor and gain feedback about behavioral effectiveness will suffer fewer emotional and physical consequences than one which has no control over the stressor. Seligman and Maier (1967) and Seligman (1975) noted that helpless (no control over shock) animals in some instances evidenced behavioral breakdowns curiously similar to human depression--animals apparently had been conditioned to accept the futility of their situation and simply gave up, i.e. learned helplessness. Other research with lower animals, reviewed by Schneider and Tarshis (1986), established that inability to control a stressor can result in weight loss, lowered resistance to illness, learning deficits, and submissive behavior.

Stressors, whether physical stimuli, such as fatigue or shell bursts, or emotions, such as fear or uncertainty, are processed cognitively (identification, evaluation, and assimilation) as well as physiologically to yield a reaction (behavioral and emotional). To appreciate response to stress, it is necessary to understand the essentially "automatic" reactions which the body will make, though these physiological responses can be manipulated or modified by training and experience. Emotional reactions are controlled by the autonomic nervous system which controls most of the glands and many of the muscles of the body. This system has two divisions: activity of the sympathetic division tends to excite or arouse, while activity of the parasympathetic tends to depress bodily functions (McConnell, 1986). These two divisions are antagonistic in that they have opposite effects. In a normal (minimal stress) environment, the divisions work together to produce an optimum balance of arousal, while in a situation of high stress such as fear, and assuming the absence of learned helplessness, the sympathetic division dominates. This division is connected to the adrenal glands which secrete hormones which institute all physical changes associated with strong emotions (fear, anger, and aggressiveness). The body's reaction to such stress has been found to almost always follow the same adaptive pattern according to Selye (1950; 1978) who labeled these reactions the general adaptation syndrome. In this model, the initial alarm reaction follows the emotional shock, and because vigorous behavior is required, all physiological responses involved in maximizing energy production are activated. If stress persists, the body enters a state of resistance during which any additional stress may prove deadly and prolongation of stress will cause the body to exhaust itself. It could be argued that the combat behavior described by Marshall (1950), given prolonged stress, may constitute a prime example of Selye's contentions. Alternatively, instead of stress-induced physiological exhaustion, some of the same behavior could be explained by Seligman's learned helplessness concept.

Stress, either short term or prolonged, can have dramatic cognitive and physiological effects on an organism. What has proven elusive is the ability to accurately predict the nature and severity of stress responses in humans. This problem is exacerbated by individual differences in personality, genetics, experiences, and coping styles, all of which moderate stress responses. The prime consideration may be coping style since it evolves from the other variables. McConnell (1986) summarized that coping methods typically involve one or more strategies: avoiding or denying certain inputs, changing how one processes problem-related inputs, and/or changing ways of responding to problems when they occur. Hence, coping may be either defensive (avoidance, escape, or denial) or direct (head-on encounter). An interesting study by Datel (cited in McConnell, 1986) involved Army recruits in basic training, a fairly stressful situation. Recognizing that coping responses by recruits are often of a defensive pattern (AWOL, illness, depression) and respecting these behaviors as costly to the Army, Datel experimented with positive reinforcement (privileges, praise, passes) rather than punishment (ridicule, demeaning, loss of privileges, pushups) in manipulating recruit behavior. This practice likely reduced stress and encouraged direct (head-on) coping. Following up on recruit and later, soldier, performance of this experimental group, Datel found these soldiers had lower AWOL rates, made better scores on marksmanship and map reading, had higher reenlistment rates, and performed better under enemy fire in Vietnam than did traditionally treated recruits. These results suggested that a positive reinforcement paradigm in training teaches soldiers to develop a direct coping strategy, as opposed to a defensive one, and soldier performance, to include that under combat stress, is enhanced.

To this point, focus has been on developing an appreciation of the general nature of stress, its processing, and its consequences, both psychological and physical, as well as patterns people use to cope. Attention is now shifted to more specific discussion of stresses/stressors and their consequences to human condition and behavior.

## Part 2: Specific Stresses and Effects

Soldier performance in a combat situation is critical, with little margin for error. This performance is dependent on several key elements: training, motivation, equipment, workload, leadership, and the soldier as an unique variable. The first five elements are fairly readily controllable. However, the individual soldier element entails a unique set of capabilities of unknown limits, a complex personality, and years of varied experiences and conditioning. All these variables interact in producing behavior. In a normal environment, soldier behavior is, to a fair degree, predictable. Where predictive accuracy seems to falter, often with dire consequences, is when stress is added to the environment. As has been noted, individuals differ in defining stress, tolerance levels for stress, internal consequences (visceral and emotional) of stress, coping strategies to stress, and in actually responding to the situation. To gain a better understanding of performance in a stressful environment, it would be beneficial to identify specific stressors likely associated with a combat environment and determine if any stereotypical behavioral response pattern may exist. For this discussion, stress was considered present in any exposure to a noxious (psychologically or physically) or unexpected stimulus. Significantly increased performance requirements would be subsumed under this definition.

As previously noted, most research with stressors has involved physical variables such as temperature, noise, electrical shock, and to a lessor degree, toxic substances, humidity, and fatigue. While research with psychological stressors is more limited, studies involving isolation, crowding, fear, increased task demands, and increased discriminatory skills are available. Several reports provide comprehensive reviews of the literature on stressors and their effects, and the reader is encouraged to peruse these reviews as each is thorough and offers a unique perspective. Cohen (1980) reviewed experimental and correlational studies of the aftereffects of stress on performance from a scientific standpoint and examined several theories as they relate to existing evidence. Kubala and Warnick (1979) concentrated on both physical and psychological stressors which might be assumed to exist and affect soldiers in combat. Weaver and Stewart (1988) investigated the Post-traumatic Stress Disorder and Combat Stress Reaction in terms of psychological factors during war, physical factors of war, demographic variables, and post-war adjustment factors. The present report is intended to complement these review efforts, with a concentration on fairly recent (1980s) research and findings. A summary of the content and findings of more recent studies is provided in Table 1.

Table 1

Recent Reports of Specific Stressors and Their Behavioral Effects

| Source | Stress Nature | Response Measure | Performance |
|---|---|---|---|
| Villoldo & Tarno (1984) | battlefield sounds, disorientation, fear, & heat (combination) | reaction time | degraded |
| | | short-term recall | degraded |
| | | selective attention & information processing | degraded |
| | | computational ability | none |
| | | blood pressure | increased |
| Petrofsky (1982) | cold | isometric strength | decreased |
| | | isometric endurance | increased |
| Petrofsky (1982) | heat | isometric endurance | decreased |
| Guastello (1985) | increasing load weight | obstacle course performance | decreased |
| Ikai & Steinhaus (1961) | shouting | forearm flex strength | increased |
| | gun shot | | increased |
| Rachman (1982) | noise (tone) | heart rate | same* |
| | | subjective reactivity | same* |
| Rachman (1982) | noise & shock | heart rate | same* |
| | | subjective reactivity | same* |
| Rachman (1982) | noise, shock, & discrimination task | heart rate | different* |
| | | subjective reactivity | same* |

(Table continued on next page)

Table 1 continued

| Source | Stress Nature | Response Measure | Performance |
|---|---|---|---|
| Rachman & McMillan (1986) | noise (tones) | heart rate | same** |
| | | anxiety feelings | same** |
| | | bodily sensations | same** |
| Rachman & McMillan (1986) | noise & shock | heart rate | same** |
| | | anxiety feelings | same** |
| | | bodily sensations | same** |
| Rachman & McMillan (1986) | discriminative avoidance task | heart rate | same** |
| | | anxiety feelings | same** |
| | | bodily sensations | same** |

* compared decorated and non-decorated bomb disposal operators
** compared decorated and non-decorated paratroopers

Rachman (1984) reviewed empirical and anecdotal evidence in an attempt to develop a clear concept of fear, courage, and individual characteristics which might be associated with fearlessness or courage. The samples studied included people who had endured repeated air raids (World War II), trainee parachutists, combat soldiers and air crews (World War II), and bomb disposal operators (service in Northern Ireland). Rachman summarized a dearth of individual physical or psychological (personality) variables which could account for fearlessness and courage in high-stress conditions. The most important factors contributing to courageous (fearless) behavior were found to be self-confidence, possession of skills required in the dangerous situation, high motivation to succeed, and a situational demand. The latter factor incorporates one's sense of responsibility to self and others, effects of group membership and group morale, and the need to avoid disapproval. Most of the available evidence suggested the overwhelming importance of training (and its perceived adequacy), group cohesion, and situational determinants in supporting courageousness in the face of high-stress situations.

Table 2 presents a summary of findings reported in the Cohen (1980) and Kubala and Warnick (1979) reviews. Caution must be exercised in interpreting findings of these reviews: Kubala and Warnick concentrated on studies which dealt with performance effects of stress as measured during the stress, and Cohen concentrated on stress effects on performance measured after cessation of the stress.

Table 2

Reviewed Reports of Specific Stressors and Their Behavioral Effects

| Review Source | Stress Nature | Response Measure | Performance |
|---|---|---|---|
| Cohen | noise | frustration tolerance | decreased |
| | | proofreading task | degraded |
| | | Color-Word task | decreased |
| Kubala & Warnick | heat | performance tasks | degraded |
| | | reaction time | unaffected |
| | | vigilance | inconsistent |
| | | combat efficiency | impaired |
| Kubala & Warnick | cold | finger dexterity | degraded |
| | | hand strength | reduced |
| | | mental performance | unaffected |
| Kubala & Warnick | sleep loss | monotonous tasks | degraded |
| | | continuous attention | degraded |
| | | time-shared tasks | degraded |
| | | new tasks | degraded |
| Cohen | harassment | proofreading | degraded |
| Kubala & Warnick | work/rest cycle | performance | unaffected |
| Kubala & Warnick | rest period | performance | affected |
| Kubala & Warnick | crowding/ spatial density | personal space need | unpredictable |
| Kubala & Warnick | confinement/ isolation | defection | increased |
| | | authority | undermined |
| | | territoriality | increased |
| | | complex monitoring | decline |
| | | aggression toward authority | increased |
| | | psychomotor tasks | unaffected |
| | | perceptual tasks | unaffected |
| | | intellectual tasks | unaffected |

(Table continued on next page)

Table 2 continued

| Review Source | Stress Nature | Response Measure | Performance |
|---|---|---|---|
| Cohen | | frustration tolerance | decreased |
| | | visual search task | unaffected |
| | | problem-solving | unaffected |
| | | helpfulness | degraded |
| | | cohesiveness | decreased |
| | | competitiveness | increased |
| | | sociability | decreased |
| Kubala & Warnick | combat | combat exhaustion | increased |
| | | physical complaints | increased |
| | | higher mental functions | unaffected |
| | | stress threshold | lowered |
| | | soocial behavior | degraded |
| | | murder and drug use | increased |
| | | other crimes | unaffected |
| Cohen | shock | proofreading | degraded |
| Kubala & Warnick | CBR threat | performance | unknown |
| Cohen | task load | reaction time | degraded |
| | | frustration tolerance | decreased |
| | | helpfulness | degraded |
| | | anagram task | degraded |
| Kubala & Warnick | toxic substances ($CO_2$) | vigilance | unaffected |
| | | coordination | unaffected |
| | | problem-solving | unaffected |
| | | hand-steadiness test | decreased |
| | | letter-cancelling test | decreased |
| | | breathing, vision, & balance | degraded |
| Cohen | anger | aggressiveness | increased |
| Kubala & Warnick | fear | trembleometer | decreased |
| | | critical flicker fusion | improved |
| | | word fluency | improved |
| | | pursuit rotor | impaired |
| | | aircraft landing | improved |
| | | digit span | degraded |
| | | accuracy in following instructions | decreased |
| | | recall of instructions | decreased |

As evident in Tables 1 and 2, a wide range of stressors, most if not all of which would be expected to exist to varying degrees in a combat situation, has been explored in controlled research. However, one problem in interpreting and applying these findings is that laboratory stress may operate very differently than real-life stress--the former typically has defined intensities, lengths of exposure, and known risks. Combat certainly offers none of these fixed parameters. Additionally, motivation is likely to be considerably higher in combat than in the laboratory, given what is at stake, and heightened motivation could negate many of the behavioral degradations associated with stress. These suppositions and limitations were noted by Kubala and Warnick (1979). However, some of the information in Table 1 and some reported by Kubala and Warnick was based on persons exposed to combat and was obtained, typically, immediately following combat. Additionally, Headley, Hartel, and Murphy (in preparation) provide some valuable insight on what aviators, in particular, found stressful in combat and what their reactions were. Overall, Cohen (1980) surmised that data were almost unanimous in supporting the role of control of a stressor in ameliorating stress aftereffects, i.e. decreasing deficits in poststimulation performance.

Weaver and Stewart (1988) provided a more clinically oriented perspective on stressors and stress effects through their review of over 90 articles dealing with post-traumatic stress disorder (PTSD) and combat stress reactions (CSR). Their review included studies of United States, British, and Israeli soldiers and concentrated on identifying possible causal factors of PTSD or CSR. A wide variety of factors, to include psychological, physical, demographic, and post-war adjustment, thought to contribute to the onset of stress reactions was explored, and the status and needs for research in the area of each factor was illuminated. Based on their extensive and detailed review of the literature (generally post-1970), Weaver and Stewart concluded a lack of any strong support for most variables. It was noted that the inability to provide conclusive findings was largely because of research which was methodologically unsound, conflicting findings, and a lack of sufficient empirical studies. However, by their consolidation and description of what information is available, Weaver and Stewart provided some intriguing ideas and suggestions for directions in future research towards achieving a better understanding of stress effects associated with a combat experience.

To illustrate the relevance of reviewed stressors to combat conditions, attention is drawn to FM 26-2, "Management of Stress in Army Operations," which outlines potential sources of stress based on characteristics (projected) of the Air-Land Battlefield. Particular interest is devoted to the following stressors, most of which are included in some form in Tables 1 and 2: continuous operations; threat of NBC warfare; poor visibility; inactivity and boredom; short and intense periods of excitement and danger; frustration and pressure; information and uncertainty; control of environment; leadership failure; confidence in decisions; fatigue (mental and physical); work/sleep cycles; isolation; and weather. In considering these stressors singularly and collectively, it is apparent that most might be present in any continuous operation, though to lesser intensity than actual combat. Hence, this stressor (continuous operation) composite may constitute the best scenario available, beyond actual combat, to allow a meaningful assessment of stress effects on the soldier and mission performance.

Part 3: Stress Effects on and of Continuous Operations

A sizable body of information is available on the conduct and outcome of continuous operations. Not only are continuous operations anticipated in the Air-Land Battle, but the Army periodically conducts such exercises for training and research. What follows is intended to review and summarize the information available from a number of these exercises from the perspective of the operation as both a stressor (to the soldier) and a performance measure which incorporates stress effects. This discussion has three components: continuous operations, physical fitness for continuous operations, and the soldier's load in continuous operations.

Continuous Operations. Continuous operations were defined by Knapik et al. (1987) as those combat missions carried out around the clock and requiring intense, persistent action. The study reported by Knapik et al. examined the physical and mental demands (stressors) on soldiers during continuous field artillery operations and explored potential methods for improving performance. Three batteries of soldiers, each representing a different pre-test training program, participated in an 8-day field scenario which portrayed a rapidly moving FLOT (forward line of troops), required many survivability moves, four to six fire missions per hour (target rich environment) for each battery, and 24-hour operations which precluded maintenance or rest periods in which an entire battery could shut down. Training programs, as variables in the study, included an augmented physical fitness program, stress reduction training, and a control (no special training) group. Data were collected before, during, and after the scenario on nutrition, psychological state, sleep, physical condition, operational efforts, and physical performance. In pre- and posttesting, essentially no differences among batteries were noted. All batteries showed a significant increase in run time and all measures of muscle strength were significantly increased. The various operational parameters indicated generally no decrements in performance during the scenario--in fact, there were improvements in lay times, fire mission times, and ammo resupply times. However, processing of fire missions, a cognitive task, did show a significant degradation over time. Pre-scenario training programs appeared to have no distinguishing effects on any test measure. In final analysis, while a number of stressors may be assumed to have been present (particularly sleep loss, work/rest cycle, and task load) during the continuous operations, evidence suggested that: a) performance of individuals and units does not appear to significantly suffer from this combination (8-day continuous operation) of stressors; b) a number of soldier performance tasks show positive training (learning) effects despite stress effects; and c) cognitive tasks and psychological state appear to be areas most sensitive (degraded) to stress effects associated with continuous operations.

Another study involving sustained operations of an artillery unit was reported by Headley, Brecht-Clark, and Whittenburg (1989), though their effort also included protective clothing (MOPP-4) as a stressor. Additionally, it was noted that added stressors of high temperatures, noise, and darkness existed. While the exercise was for a duration of only 24 hours, compared to the no-MOPP group, howitzer crews of MOPP 4 iterations suffered more medical casualties and their ability to perform fire missions (time-to-fire and interround interval) was rapidly degraded. The no-MOPP crew also showed some decrement in time-to-fire over time, likely the result of the continuous operation. At least for the stressor of protective clothing, it was argued that training in MOPP 4 would not only support habituation, but would improve performance proficiency and likely generalize to other tasks.

Siegel et al. (1979) provided a handbook which, based on extensive literature review, discusses degradation of human performances attendant to continuous operations, to include the factors acting to depress them. A companion volume by Kopstein et al. (1979) focuses on concepts and considerations in managing human resources within the context of continuous operations. As noted by Siegel et al. (1979), the overwhelming majority of constraints that prevent attainment of mission goals relate to the soldier himself. In continuous operations (or combat), the soldier's ability to perform tasks may be severely limited--performance depends on acquiring, processing, and responding to information in ways adversely affected by conditions associated with continuous operations. From a human factors standpoint, according to Siegel et al., soldiers who fight in the continuous operations situation will need to cope with the multitude of stressors associated with any battle compounded by the specific stresses of continuous operations. The major factors (stressors) which distinguish combat at night or under continuous operations from more typical combat and which affect a soldier's ability to perform appear to include, at minimum: light level (night), diurnal rhythms (work-rest cycle), fatigue, cognitive stress (constantly changing conditions and workloads with little time for evaluation and planning), and other visibility factors (corrective or enhancement devices generating new problems). Data from mechanized infantry, tank crew, fire support team, and artillery battery performance over a 5-day continuous operation revealed some relationships between stressors and critical abilities: a) fatigue/sleep loss depressed hearing, numerical facility, orientation, perceptual speed, reasoning, and vision; b) diurnal rhythms (work/rest cycles) depressed numerical ability and reasoning; c) light level/visibility depressed dynamic precision, hearing, orientation, and vision; and d) cognitive stress depressed communication, memory, perceptual speed, and reasoning. While Siegel et al. contributed a detailed analysis (taxonomy of combat relevant abilities and soldier position-specific critical tasks) and quantified (scaled) performance effects associated with stressors, the foregoing summary seems representative. The strong congruence between findings, by stressor, of Siegel et al. and those presented in Tables 1 and 2 is noteworthy.

The study of continuous operations as a stressor has not been limited to combat operations. Headley (1989) investigated performance and stamina of soldiers involved in extended fire line duty (Yellowstone) under such sources of stress as lengthy workdays, heavy smoke, steep terrain, high altitude, occasional periods of intense efforts (including load bearing), wide range of temperatures, and danger (flames, falling trees, equipment). A large majority of soldiers (87%) rated their duties as physically more taxing than in field training exercises (FTXs). It was noted that perceived importance of duties (actual fire-fighting vs fire fuel reduction work) may have negatively impacted on performance. A "sense of purpose" appeared to be necessary to maintain morale and combat boredom (repetitive tasks or "busy work"), and the median point of perceived decline in capability was five days. Also, unclear expectations concerning mission length were identified as probable influences on performance. Interestingly, these findings can be neatly integrated with the suggestions of FM 26-2 ("Management of Stress in Army Operations") on ways to reduce stress.

As noted, Kopstein et al. (1979) suggested guidelines for management of human resources in continuous operations which identified a number of stress effects. Particular attention was given deleterious effects of stress from any source on reasoning (decision-making), memory, perceptual speed, and motor speed, and reference was made to heat, cold, task load, and constantly changing battlefield conditions as examples of anticipated stressors. Most suggested strategies for dealing with these stressors (and others) strongly endorsed overlearning, exposure to the condition (desensitization), and anticipating the condition and preparing for it. Krueger et al. (1987) addressed the sustainment of soldier performance, with particular attention to sleep deprivation, fatigue, and work/rest cycles as stressors. This review of research on performance in continuous and sustained operations with limited or no opportunities for sleep confirmed that mental performance deteriorates more rapidly than physical performance. Initiative, integrating information, planning, and plan execution are the aspects of mental performance which degrade most rapidly. Krueger et al. offered human factors engineering suggestions, based on their studies and those from other services, intended to minimize effects of such stressors as fatigue, changes in work/rest cycles on soldier performance, and sleep deprivation.

A very comprehensive review of over 400 research articles and test reports on sustained or continuous operations was contributed by Dewulf (1987). Primary interest was devoted to sleep loss or deprivation as a major stressor, and a number of impacts on performance, based on reviewed studies, were derived, to include: (a) six to eight hours sleep per night maintains performance indefinitely; (b) four to five hours sleep per night maintains effective performance for five to six days; (c) 24 hours of sleep or rest are recommended to return to high cognitive workloads after 36 to 48 hours of sleep loss; (d) cognitive abilities degrade more rapidly than physical strength and endurance and performance degradation appears as early as 18 hours into sustained work; and (e) performance decline without sleep is about 25 percent for every 24 hours of operation. Dewulf also noted that the load a soldier must carry in extended combat is an important determinant of endurance, with soldier loads typically exceeding the Infantry Board's suggested load carrying standards. A further caution was added by Dewulf in the suggestion that simply meeting fitness standards (Army Physical Readiness Test) does not necessarily indicate that soldiers are fit to perform specific tasks during prolonged periods of time.

Physical Fitness. In combat, soldiers are expected to make numerous decisions, often rapidly and with incomplete or fragmented information, as a performance requirement. This type of performance is cognitive in nature and, hence, very prone to degradation by a wide variety of stressors. The other major type of performance is physical, ranging from very basic and uncomplicated behavior such as lifting an ammo box to much more complicated behavior such as laying out a gun azimuth. As evident in presentations in

Table 1 and 2 and preceding discussions, physical performance can be degraded by a number of stressors. However, evidence suggests that stress effects on basic physical performances can be minimized through training (overlearning and exposure to stressor) and maintaining a high level of fitness. While the study by Knapik et al. (1987) of artillery operations under stressful conditions failed to demonstrate that deliberate physical conditioning provided any particular benefit for soldier performance in continuous operations, it was noted that physical conditioning regimens were often not followed or fell below the frequencies prescribed. Other research on fitness and light infantry operations has revealed some physical capability degradations associated with effects from continuous operations.

A study by the Army Physical Fitness Research Institute of the Army War College (1984) contended that present fitness standards focus on current norms rather than requirements for mission accomplishment with specific reference to combat. Assuming the most physically demanding work in a continuous combat scenario would be performed by the light infantry, the study sought to determine the relationship among measures of physical fitness and individual and squad level performance, physical fitness levels necessary to sustain optimal effectiveness, and decrements in physical work capacity resulting from five days of continuous combat-simulated light infantry operations. In essence, what were the specific stress effects on physical performance and the minimal fitness requirements needed to sustain optimal performance under stress. Testing after the 5-day continuous operations scenario found: a) decline in upper body anaerobic capacity; b) decline in six of nine parameters of muscle strength; c) more decrements than improvements on the Army Physical Readiness Test except for push ups; d) low correlations between fitness parameters and performance scores, though several strength parameters were significantly related to performance; and e) the most common injuries were to the feet and lower back. Of particular interest, muscular endurance decreased over the course of the scenario, most clearly evident in the upper body muscle groups. A mismatch between upper body strength requirements placed on the infantry troop and the level of upper body training/conditioning received was concluded. A succinct statement of this research and findings was provided by Knapik et al. (1988).

Soldier Load. A major concern evolved from research on continuous operations, and particularly that involving physical fitness, is soldier load. It was clear in the Army Physical Fitness Research Institute (1984) report that soldiers experienced difficulty in bearing 42 pound (average) loads during a five day continuous operations scenario which involved light infantry soldiers and began with a 10-mile road march. The second most common medical incident experienced was of lower (lumbar) back pain and muscle spasms, and observations indicated that soldiers were not sufficiently conditioned for walking long distances while bearing a basic combat load. Krueger et al. (1987) stated that the foot soldier in an extended engagement may likely find the weight of what must be carried an important determinant of endurance. The U.S. Army Infantry Board suggested load carrying standards for a fighting load is 48 pounds, and for an approach marching-load, 72 pounds. However, Wagner and Kunz (In preparation) found estimated average individual loads in a light infantry division company operating under a low-intensity conflict to be 69 pounds for combat load and 104 pounds for marching-load; when a company was asked to prepare for a low-intensity 48-hour operation in which a soldier would carry 2 gallons of water, 4 grenades, and 6 meals, the average load was 145 pounds. Loads of this magnitude must be significant stressors (fatigue, endurance, discomfort, etc.) to a soldier and would be compounded by additional stressors associated with combat.

Two illustrations of soldier load bearing problems and compounding due to stress are cited. While these two accounts span some 40 years, both record similar problems. Marshall (1950) related stress and load bearing in salient fashion: a) the soldier's load is the greatest of all drags upon mobility in combat and the machine has failed to decrease by a single pound the weight an individual must carry in war; and b) sustained fear is as degenerative as prolonged fatigue and exhausts body energy no less. Marshall's insight, at least for load bearing, seems just as timely today as at the end of World War II, as the problem was noted in recent military operations in Grenada (Dubik & Fullerton, 1987). Marshall's (1950) central theme, based on his study of wars and specific combat scenarios, was one of an army's mobility, logistical system, and ability to sustain itself and the individual soldier as both a "beast of burden" and as a combatant. Marshall proposed that the logistical limits of a soldier should not be measured in terms of cargo which can be hauled without permanent injury to bone and muscle, but of what can be endured [stress] without critical impairment of "mental and moral powers." In essence, physiological studies of load bearing must incorporate psychological studies of stress effects. Marshall described World War II battlefields and beachheads cluttered with supplies cast off by soldiers in or facing combat to illustrate that even the most willing soldier will discard a weight he finds he cannot carry under the extraordinary stresses of battle--troops are victims of bad loading and faulty estimates of the relationship of loading to soundness in tactics. It was emphasized that battle shock [fear, anxiety] compounds the load bearing problem, as shock and fear take heavy tolls from physical strength and endurance. The lessons recounted by Marshall over 30 years ago were apparently not learned.

Dubik and Fullerton's (1987) account of the Grenada invasion (Operation Urgent Fury), based on interviews within seven infantry battalions, indicated that soldiers were overloaded and for the same reasons noted by Marshall (1950). Excessive loads led not only to poor fighting, but in some cases, no fighting at all, and overloading contributed to the high number of heat casualties. While unit leaders, for the most part, did not direct overloading, their lack of guidance and supervision left soldiers uncertain as to what to expect and how to prepare. This uncertainty is proposed by Dubik and Fullerton as the single basic cause of overloading, as plans tended to be made on the worst possible outcome of a dangerous and uncertain situation. Beyond the need to avoid or overcome uncertainty, the authors offered direction for managing the soldier's load: a) set and enforce specific weight standards; b) train to carry weight; c) know that fear reduces physical stamina; d) optimal fighting load is 80% of the training weight; and e) optimal training load is one-third of body weight. It was also found through the Grenada experience that lack of trust (in other units, in one's own unit, or in resupply) breeds overloading as it contributes to uncertainty. In essence, effects of overloading are well documented and easily deduced; the causes of overloading, largely related to uncertainty, can and must be managed through information control, strong leadership, and trust.

There is a developing body of literature involved with studying the soldier's load and tailoring it for conditions under which it is to be borne. The Army Development & Employment Agency (1987) initiative on the soldier's load concluded that the foot soldier is currently overloaded and suggested the need to tailor the load to anticipated mission, enemy, terrain, troops available, and time (METT-T). ADEA suggested that responsibility for the load should be echeloned, excess should be carried on transportation resources, and when load handling equipment is not available, part of the load should be stockpiled for later movement. Three major limitations are necessary concerns in determining soldier loads: physical, stress, and weight of munitions. An exercise was described in which a light infantry company was loaded out for a 48-hour low intensity operation. Example weights of equipment included: 137 pounds for a rifleman; 155 pounds for an assistant M60 gunner; 141 pounds for a DRAGON gunner; and 177 pounds for an RTO. While all this equipment was mission essential, these weights doubled the maximum recommended (USAIS) for approach marches. The ADEA (1987) report also noted the effect of battlefield stress (as recounted in Marshall's 1950 text) on ability to carry a load and reiterated Marshall's contention that individual loads should not exceed 40 pounds for soldiers in contact with the enemy. One reviewed study found the time required for a soldier to complete an obstacle course increased by 10 to 15% for every 10 pounds of equipment carried and the distance marched in 6 hours decreased by 1 mile for every 10 pounds carried over 40 pounds. ADEA has developed a soldier load model for varying conditions of METT-T and a light infantry company which incorporates partitioning the burden between the soldier and load handling equipment. Also, the ADEA report noted several training and leadership considerations dedicated to appropriate training with and tailoring of the soldier's load based on METT-T concepts endorsed by Krueger et al. (1987).

Wagner and Kunz (In Preparation) addressed the inability of individual dismounted soldiers to carry a combat load as a deficiency identified by the Close Combat (Light) Mission Area Analysis. Particular attention was placed on understanding the constraints that cause this deficiency. Variables that affect soldier load-carrying potential were grouped into categories of: those associated with the mission and conditions of a combat scenario, those determined by soldier characteristics, and those associated with the load carried. A listing of specific factors within each category indicated derivation of the ADEA soldier load model. A number of potential stressors such as recorded in Table 1 and 2 were included (strength, workload, work/rest cycle, fatigue) and influences on load bearing of experience, training, and conditioning were noted, though missing in this and the ADEA (1987) report are the psychological variables Marshall (1950) suggested as so significant. Motivation was excluded by design in the Wagner and Kunz (1986) report because it was "difficult to measure," and the variable (stressor) of fear was not even mentioned.

A majority of studies and reports (military) cited in Part 3 of this paper provide good insight into the soldier's load problem, particularly with reference to METT-T and physiological factors. The concept of stress and its effects was alluded in most reports but not specifically applied to either soldier performance in the broad sense or soldier load bearing in the narrow sense, though studies of continuous operations did attempt to identify and measure some stress effects. Conversely, most of the literature (scientific) reviewed in Part 2 of this paper quantified a large number of stress effects in terms of behavioral influence. The problem with these studies, for purposes of this paper, was that soldier performance in general and load bearing in particular were not behavioral concerns. The closest evidence available, beyond anecdotal accounts of Marshall (1950), which aligns stress, particularly in the form of fear, and soldier performance is that provided in Table 1. Again, soldier performance was not partitioned into components such as load bearing. What remains, given these constraints, is to attempt to consolidate all referenced material and derive implications for load bearing.

## Part 4: Integration of Stress Findings and the Soldier's Load

As reported, neither the extensive literature search nor communications with research agencies revealed any empirical research report which specifically studied or related fear, as a stressor, and soldier load bearing. However, as reviewed in Part 2 and 3, considerable information is available on a numerous physiological and psychological stressors and a variety of behavioral performance measures. Based on this information, several generic conclusions germane to military interests may be offered:

- Stress is a normal encounter of life--stimuli vary in their source, nature, and intensity (strength and length) and variation in response appear dependent upon factors of experience, training, motivation, conditioning, and personality.

- Stress produces both physiological and cognitive reactions, and with sufficient intensity will facilitate a breakdown in either or both areas.

- Coping methods are developed to deal with real or perceived stress. These methods may be either defensive or direct and, as largely products of learning, are amenable to change (desensitization, conditioning).

- Prediction of responses to stress in a combat situation is complicated because of multiple stressors and interactions thereof. However, prediction of major stressors associated with combat is straightforward: intense and prolonged sensory stimulation, heat or cold, uncertainty, fear, fatigue, work/rest cycle variability, sleep deprivation, toxic substances, and workload.

- Identified major stressors of combat, individually or in combination, are reported to degrade combat-related behaviors: reaction time, short-term recall, information processing, strength and endurance, frustration tolerance, continuous attention, sociability/cohesiveness, and perceptual motor coordination.

- Studies of continuous operations (stressor) have attended to sleep deprivation, fatigue, and altered work/rest cycles as they may impact soldier/unit performance. Results suggested minimal degradations except for upper body strength and endurance, both of which relate to load bearing.

- USAIS recommends 48 pound fighting loads and 72 pound approach marching loads for soldiers (based on proportion of body weight). Light infantry studies revealed average fighting loads of 69 pounds and marching loads of 104 pounds. One study found selected soldiers with marching loads up to 177 pounds and an average of 145 pounds. Data indicates a 10 to 15% decrement in performance for every 10 pounds of load over 40.

Beyond these findings, there remains a specific question of what influence stress, and fear in particular, might be expected to have on load bearing. To facilitate relating behavioral measures and effects recounted in this paper to load bearing, this behavior must be reduced to component parts. At minimum, load bearing involves several component physical variables: upper body strength and endurance, lower back strength and endurance, leg strength and endurance, balance, load configuration/distribution, maintenance of blood circulation, minimal restriction on respiration, and training and conditioning. These variables are determinants of what a soldier <u>can</u> carry--i.e., physiological capabilities and limitations. The evidence reviewed in this paper clearly indicates that stress in many forms can and does degrade particularly strength and endurance. Equally important are the psychological components of load bearing: motivation, leadership, sense of purpose, self concept, experience, and emotional state (including fear). These variables are determinants of what a soldier <u>will</u> carry--i.e., psychological capabilities and limitations.

The literature consistently and clearly points to motivation as a major influence on performance. Capacity represents relatively fixed physiological limits of behavior, while performance is a function of psychological factors (Ikai & Steinhaus, 1961). Performance, and particularly that involving strength and endurance, can appreciably improve with appropriate motivation even in the form of stress such as fear. Also, some forms of stress, such as fear, anxiety, or sudden appearance or unexpected appearance of a stimulus (startle response), typically induce circulation of an increased amount of adrenaline which can enhance performance requiring strength or endurance. However, Selye's (1950, 1978) general adaptation syndrome indicates that if this stress persists, any additional stress may prove deadly and prolongation of stress will cause the body to exhaust itself. Hence, stress produces both physiological and emotional changes in the body. Though initial response to these changes may be an enhancement of performance, at least for mechanistic or physiological behaviors such as strength and endurance, prolonged exposure (including anticipation of exposure) will degrade performance. For performances which require any appreciable cognitive processing (thinking, reasoning, problem-solving, decision-making), evidence rather clearly demonstrates degradation from both initial and prolonged encounters with stress.

Based this discussion, several points can be made, albeit as deductions and projections, about relationships between load bearing (strength, endurance, and will) and stress in the form of fear:

- Load bearing capability is generally limited by physiology but can be modified by training and conditioning;
- Load bearing capability is likely enhanced by initial exposure to fear;
- Load bearing capability will be degraded by prolonged exposure to fear;
- Load bearing performance is dependent upon capability mediated by psychological factors. These factors can enhance or degrade actual performance;
- Load bearing performance is likely enhanced by initial (short-term) exposure to fear;
- Load bearing performance is likely appreciably degraded by prolonged exposure to fear. Much of this degradation may be due to diminished cognitive processing and physiological changes in the body;
- Load bearing performance will also be appreciably degraded by fatigue and overloading;
- Load bearing standards tend to be grossly exceeded during normal exercises and continuous operations. Evidence indicates that this violation is exacerbated in pre-combat loading; and
- Load bearing performance can be improved through training and, particularly, conditioning. Effective conditioning must incorporate specific attention to psychological variables.

Respecting reviewed evidence and deductions applied to relating effect of fear on load bearing, and accepting that many of the deleterious effects of fear on performance can be ameliorated (Rachman, 1982, 1984), it seems feasible to design and institute efforts to maximize soldier performance in load bearing. Possible efforts might include:

- Institute procedures by which unit leadership are required to identify and justify the minimum essential equipment and supplies, within the context of METT-T, which should constitute the soldier's load;
- Ensure that the soldier fully understands the specific anticipated utility value of each component of their load;
- Train with the full minimum essential load (marches, field exercises, continuous operations); and

- Design and conduct specific conditioning experiences to introduce, acclimate, and desensitize a soldier to stressors anticipated in a combat mission--as examples, field exercises involving OPFOR in realistic scenarios, realistic simulations of combat to include use of pyrotechnics and battlefield sounds, and use of documentary war films as teaching and lessons-learned tools.

Ultimately, if a stressor is expected and the soldier has been repeatedly exposed to it under realistic combat conditions, and if the soldier's load has been thoughtfully designed and the soldier understands and appreciates the utility value of this load, and if uncertainties are minimized through good leadership and information communication, fear should be reduced, motivation should be increased, and load bearing should suffer but minimal degradation in actual combat. Based on this review, there appear to be several clearly stated "keys" to load bearing performance in combat:

* Training (extended operations with anticipated load)

* Conditioning (exposure to stressors under realistic conditions)

* Planning (careful consideration of METT-T in defining load)

* Leadership (supervision and enforcement of planned load)

* Information (utility value of load components; good intelligence)

* Communication (minimization of uncertainties)

In summary, the limited number of published empirical studies on stress constrains efforts to provide valid statements of stress effects on combat performance. This effort was further complicated by the requirement to narrow concern with performance primarily to load bearing. However, the poverty of empirical studies of stress may be ameliorated in the near future: Hobfoll (1989) has provided a new stress model which is based on a conservation of resources orientation. This model appears much more conducive to empirical testing than previous models which have been used to guide research.

## REFERENCES


Brady, J. V., Porter, R. W., Conrad, D. G., & Mason, J. W. (1958). Avoidance behavior and the development of gastroduodenal ulcers. Journal of the Experimental Analysis of Behavior, 1, 69-73.

Cohen, S. (1980). Aftereffects of stress on human performance and social behavior: A review of research and theory. Psychological Bulletin, 88(1), 82-108.

Dewulf, G. A. (1987). Continuous operations study (CONOPS). Final Report, U.S. Army Combined Arms Combat Development Activity, Fort Leavenworth, KS.

Dubik, J. M., & Fullerton, T. D. (1987). Soldier overloading in Grenada. Military Review, 67, 38-47.

Guastello, S. J. (1985). Euler buckling in a wheelbarrow obstacle course: A catastrophe with complex lag. Behavioral Science, 30, 204-212.

Headley, D. B. (1989). Fire fighting as extended operations: The Yellowstone experience. ARI Technical Report 844. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A126 672)

Headley, D. B., Brecht-Clark, J. M., & Whittenburg, J. A. (1989). Sustained operations of artillery crews in NBC and non-NBC environments. Military Medicine, in press.

Headley, D. B., Hartel, C. R., & Murphy, J. O. (in preparation). Investigation of the influence of air defense artillery on combat pilot suppression and attrition management practices. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. American Psychologist, 44(3), 513-524.

Ikai, M., & Steinhaus, A. H. (1961). Some factors modifying the expression of human strength. Journal of Applied Physiology, 15, 157-163.

Knapik, J., Daniels, W., Murphy, M. Fitzgerald, Drews, F., & Vogel, J. (in preparation). Physical fitness and light infantry operations. U.S. Army Research Institute of Environmental Medicine, Natick, MA, and U.S. Army War College Physical Fitness Research Institute, Carlisle, PA.

Knapik, J., Patton, J., Ginsberg, A., Redmond, D., Rose, M., Tharion, W., Vogel, J., Patton, J., & Drews, F. (1987). Soldier performance during continuous field artillery operations. Final Report No. T1-87, U.S. Army War College Physical Fitness Research Institute, Carlisle, PA, and U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Kopstein, F. F., Siegel, A. I., Wilson, L. B., & Ozkaptan, H. (1979). Human performance in continuous operations: Volume II. Management guide. ARI Research Product 80-4b. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A086 155)

Krueger, G. P., Headley, D. B., Balkin, T. J., Belenky, G. L., & Solick, R. E. (1987). Strategies for sustaining soldier and unit performance in continuous operations. Report WRAIR-NP-87-11, Walter Reed Army Institute of Research, Washington, DC, and U.S. Army Medical Research and Development Command, Fort Detrick, MD.

Kubala, A. L., & Warnick, W. L. (1979). A review of selected literature on stresses affecting soldiers in combat. Technical Report 79-A14. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A071 115)

Levitt, R. A. (1981). Physiological psychology. New York: Holt, Rinehart and Winston.

_________ (1986). Management of stress in Army operations. Field Manual No. 26-2, Department of the Army, Washington, D.C.

Marshall, S. L. A. (1950). The soldier's load and the mobility of a nation. Quantico, VA: The Marine Corps Association.

McConnell, J. V. (1986). Understanding human behavior (5th ed.). New York: Holt, Rinehart and Winston.

Petrofsky, J. S. (1982). Isometric exercise and its clinical implications. Springfield, IL: Charles C. Thomas.

_________ (1984). Physical fitness requirements for sustained combat operations of the light infantry. Final Report, U.S. Army War College Physical Fitness Research Institute, Carlisle, PA.

Rachman, S. J. (1982). Development of courage in military personnel in training and performance in combat situations. Research Report 1338. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A136 993)

Rachman, S. (1984). Fear and courage. Behavior therapy, 15, 109-120.

Rachman, S., & McMillan, T. (1986). Psychological analyses of courageous performance in military personnel. Research Note 86-95. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A176 275)

_________ (1987). Report on the ADEA soldier's load initiative. Army Development & Employment Agency, Fort Lewis, WA.

Schneider, A. M., & Tarshis, B. (1986). Physiological psychology (2nd ed.). New York: Random House.

Seligman, M. E. P. (1975). Helplessness: On depression, development, and death. San Francisco: Freeman.

Seligman, M. E. P., & Maier, S. F. (1967). Failure to escape traumatic shock. Journal of Experimental Psychology, 74, 1-9.

Selye, H. (1950). The physiology and pathology of exposure to stress. Montreal: Acta.

__________ (1978). The stress of life (rev. ed.). New York: McGraw-Hill.

Siegel, A. I., Pfeiffer, M. G., Kopstein, F. F., Wilson, L. G., & Ozkaptan, H. (1979). Human performance in continuous operations: Volume I. Human performance guidelines. Research Product 80-4a. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A086 131)

Villoldo, A., & Tarno, R. L. (1984). Measuring the performance of EOD equipment and operators under stress. NAVEODTECHCEN Technical Report TR-270. Naval Explosive Ordnance Disposal Technology Center, Indian Head, MD.

Wagner, M., & Kunz, E. (1986). Development of a soldier load assessment methodology. Research Note. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Weaver, S. F., & Stewart, N. K. (1988). Factors influencing combat stress reactions and post-traumatic stress disorder: A literature review. Technical Report 791. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A198 063)

Weiss, J. M. (1968). Effects of coping responses on stress. Journal of Comparative and Physiological Psychology, 65, 251-260.