Chapter I

Introduction

Stress is an integral part of natural fabric of life. The word stress is derived from Latin and was popularly used to devote force, pressure, strain or strong effort. A person experiences stress when there are pressures and worries arising due to individual's inability to cope with the demands of the environment. The term refers to both the circumstances that place physiological or psychological demands on an individual, and to emotional reactions experienced in these situations.

Initial work related with the phenomenon of stress was conducted by Dr. Hans Selye (1936). On the basis of his work, stress is considered as the non-specific response of the body to any demand made upon it. He suggested to use the term stress for the reaction pattern which the body produces while dealing with stressor. Selye observed that organisms respond in a stereotyped manner to a variety of widely different agents such as infections, intoxications, trauma, nervous strain, muscular fatigue, and so on. Specific effects of all these agents are different. Their only common feature is that they place the body in a state of stress. Hence, the stereotyped response represents a reaction to stress. Stressor is any stimulus which can give rise to a specific syndrome, named as 'general-adaptation
syndrome' (G.A.S.) by him. G.A.S. consists of a series of drastic physical changes in an attempt to adapt to stress. It includes three stages—the alarm stage, the resistance stage, and the exhaustion stage.

Alarm Stage:

This is an immediate reaction to the stressor. In this stage all the normal functions of the body like breathing, heart beat, blood pressure are mobilized and all the resources are concentrated on defence.

Resistance Stage:

In this stage, person attempts to return to equilibrium. Resources of the body are taken from normal functioning such as digestion, elimination and used for defense. This is the reason that for many people it is harder to digest, to concentrate and to avoid aggression during stress. In this stage various psycho-physiological disorders develop. If the stressor is applied continuously or the defense does not work, individual moves on to the third stage.

Exhaustion stage:

If, the stressor continues to act, all defence mechanisms sooner or later give out. In the extreme cases, the person can even die. Often, the exhaustion stage does not occur because the psychosomatic symptoms like infections,
pains in muscles and joints, aches etc. develop and the person escapes the stress setting.

Selye's notion of stress is a bio-chemical one. It does not explain stress from a psychological point of view. A number of psychologists have tried to explain the psychological aspect of stress, emphasizing the situations which give rise to it. For example, Haggard (1949) states that an individual experiences stress when his overall adjustment is threatened. Similarly, Lazarus (1976) indicated that stress occurs when there are demands on the person which tax or exceed his adaptive resources. McGarth (1970) defined it as the anticipation of inability to respond adequately to a perceived demand, accompanied by anticipation of negative consequences for inadequate response.

In all above definitions, i.e., psychological approach of stress, emphasis is on input or stimulus side. While Selye's theory describes the form of stress. Thus, both the approaches are complementary. To portray, what is significant in these approaches, Mikhail (1981) writes in his paper, "Stress is a state, which arises from actual or perceived demand capability imbalance in the organisms' initial adjustment actions and which is partially manifested by a non-specific response."
Response to stress:

The response to stress does not include a single organ but a number of bodily changes take place. These changes are psychological, physiological and behavioral in nature. Psychological changes have three main aspects: cognitive, affective and motivational. Cognitively, there is feeling of anxiety; affectively, feeling of distress and arousal; and motivationally, evidence of strong tendency to avoid the situation. With respect to physiological events, there are significant changes in various cortical measures, such as electroencephalographic activity, heart rate, blood pressure, electrodermal activity, catecholamine levels and so on. There is usually a little correlation between these various physiological measures (Lacey, 1967). With respect to overt behavior there is trembling, stuttering or physical avoidance of the stressor (Selye, 1956; Marks, 1969; Levi, 1975; Lang, 1977) and also decreased performance on the given tasks (Alper, 1946; Marquart, 1948; Zeller, 1950).

Due to the diversity of involvement of different mechanisms, the response to stress is a complex pattern of responding in different systems. A number of viewpoints of the multidimensional nature of the response to stress have been put forward and generally these point out to a complex interaction of psychological, physiological and behavioral systems (Lang, 1977; Lang, Rice, Sternbach, 1972).
Inducing Stress:

There are a variety of stimuli, which can act as a stressor. Torrance (1965) has attempted to enumerate the conditions likely to be stressful. According to Torrance, those situations will be stressful that might cause death e.g. water and food deprivation, extreme heat and cold, torture, prolonged activity without rest, sleep deprivation and the like. Psychological effects of such conditions include shock, mental confusion, inefficiency, recklessness, apathy, fatigue, exhaustion, hallucinations, fear of insanity etc. In general, those things are stressful which usually result in failure, fear, distraction, discomfort, rapid or inconsistent pacing, and speed. Any threat to fundamental needs is stressful.

In laboratory studies, various techniques have been used to induce stress. These techniques fall mainly into two categories:

1. Stress induced by failure.
2. Stress induced by the task itself.

Failure stress can be induced by presenting the subject with some unsolvable task, and interrupting at the task before he could possibly have finished it. Introduction of false norms which indicate failure even if performance has been adequate may also be used to induce the failure stress. This technique has an obvious limitation of control over subjects' motivation. In order to be stressful, it is necessary to motivate individual to succeed in
order to successfully induce stress by a failure situation. The problem is that all subjects are certainly not equally anxious. Some Ss may not be motivated at all. Some Ss are seriously disturbed by the failure while others may be scarcely threatened. The effect of stress, thus, depends upon what the individual expects or demands of himself.

Another method to induce stress in laboratory is related to the working conditions and the task itself. In this method pressure on the subject is induced by manipulating the situation in various ways so as to produce excessive demands upon him/her. Various forms of distraction may be used for this purpose, such as electric shock, noises or flashing lights and the like. Some tasks themselves are inherently stressful because they require the subject to attend to too many things at the same time. The increased length of task or working upon the tasks for a long time also helps in inducing stress. This length of work refers to workload.

Work Load:

As already mentioned, one way of inducing stress by the task itself can be to tell the subject to work continuously for such a long time, that it exerts an 'overload' and 'pressure' on him. In other words, workload may act as a stressor (Kakimoto, 1984).
Ogden et al. (1979) has defined workload as a discrepancy between the system input and the system's processing potential to deal with this input. Processing potential refers to the total ability of the processing system in execution of complex task demands. Different systems have different processing potential. For this reason, it is important, to know separately about mental and physical load.

The distinction between mental and physical load may be made on the basis of type of work that evoked them. Physical work load may be defined in terms of dynamic and/or static muscle work and mental load in terms of information processing.

Whether mental or physical, workload may be differentiated in terms of quantitative and qualitative. Quantitative refers to having too much to do while qualitative, 'a work, 'that is too difficult'. In the present study, 'quantitative workload' is being used as a stressor. Physiological workload or a prolonged muscular activity lead to physiological stress. Whenever, the muscular load involved is such, that the recovery of toxic material is slower than the consumption, there is an onset of fatigue. It eventually produces changes in the individual leading to subjective feeling of fatigue, reduction in output, and various physiological changes such as increase in blood pressure (BP), heart rate (HR) respiration, changes in electroencephalographic activity (EEG), catecholamine secretion and so forth.
In mental work load, information processing is the loading factor (Kalsbeek, 1967). The maximum load is reached when information processing is at a maximum for a particular individual, in the execution of a particular task under specific conditions. Luczak (1971, 1975) and Bainbridge (1974) felt that stress increases with the proportion of capacity used in information processing i.e. mental work load. This implies that performance will eventually deteriorate as a result of mental work load.

Measurement of Stress:

For the measurement of mental or physical workload, various methods are used. These methods can be categorised as physiological, subjective and behavioral measurements.

Physiological measures include blood pressure, urine contents, EEG, GSR, HR and so on. As described earlier, physiological systems react proportionally or integrally to stress and these reactions are not compensated for after a short period. Thus, a difference between before and after work load measurements can contain some information on the S's condition in the reaction. These measures have a major advantage that these can not easily be influenced voluntarily by subjects as these responses are governed by autonomic nervous system (ANS). During stress situations, sympathetic nervous
system, which is a sub-system of ANS is activated and it leads to increases in BP, respiration and the like.

Behavioral measurement entails performance of the subject on some task. It includes absolute performance or errors as a function of working hours. For this purpose, performance is studied in relation to level of stress on the same task which is used as a stressor (Kakimoto et al., 1984) or a before and after measurement on some other task is taken (Lantz, 1945; Alper, 1946). Though in some studies, there is an improvement or no effect of stress on performance (Hurlock, 1924; Lindsley, 1946; McKinnley, 1951; Lazarus and Eriksen, 1952), Usually, a decrement in performance is observed following a stress condition (Lantz, 1945; Alper, 1946; Marquart, 1948).

Subjective measurements include subject’s reactions on psycho-physiological scale. It has an obvious limitation that not all the components of stress/workload are not accessible to introspection.

A number of investigators have tried to explain the underlying principle of direction of change in performance due to stress. Farber (1955), emphasized the drive properties of anxiety that is produced by stress conditions. He argues that high anxiety increases the strength of all responses whether correct or incorrect in task performance. If the task is complex, a large number of incorrect responses are also facilitated and as a result, performance
is impaired. If task is easy and simple, a fewer incorrect responses are facilitated and as a result, performance improves.

Another explanation is provided by Korchin (1964) and Easterbrook (1959). According to them, impairment of performance results from narrowing or restriction of perception under stress. However, it is not clear why this restriction occurs.

Thus, none of the two explanations is sufficient enough to explain changes in performance in every situation.

A convenient way of studying workload can be the study of work performance and work errors as a result of number of previous working hours. Psychological and physiological tests before, during and after the work period including HR, BP, GSR, visual performance, mental performance, reaction time, CFF, and evaluation of subjective feeling of fatigue may be given.

Critical Flicker Fusion:

The test most frequently used is the measurement of critical flicker fusion (CFF) or flicker fusion threshold (FFT). The primary factor in CFF is that an intermittent illumination may appear as a steady (an illusion) light or
it may be seen to flicker. In this method, frequency of flashing lights is increased up to the moment when the subject declares the lights to fuse. This point is called critical flicker fusion (CFF); flicker fusion threshold (FFT), and flicker fusion frequency (FFF).

The study of flicker fusion began with observations on the persistence of vision. It is a common phenomenon that if in the dark, a flaming coal is turned rapidly, one sees a continuous luminous circle as if the coal left in the air a trace of its path. This observation gave rise to the idea that in some fashion the image of light persists after the source has moved on. This simple observation served as the starting point for the organization of many other varieties of subjective visual phenomena such as after images, coloured shadows, and colour mixtures made by whirling disks.

It remained for Segner (1740), to be the first to publish actual measurements of persistence of vision—that is of flicker-fusion. He found that the image of a whirling spark was related to the length of its circumference.

The first experimental study regarding CFF was done by Talbot (1934). He formulated a law, called 'Talbot's law', stating that the intensity of light and the time of bodies remaining at any given point of the circle are inversely proportional to the circumference of the circle that they describe.
The second major advancement was 'Ferry-Porter Law'. It related with the frequency of intermittence and intensity of light. This was stated by Ferry (1892) as "retinal persistence varies inversely as the logarithm of illuminosity."

In addition to Talbot's law and Ferry-Porter law, several other investigations were done related to the phenomenon and thus the findings were well formulated in terms of physical laws.

The conditions that cause the CFF to appear at different rates in terms of cycles/sec. constitute a fairly long list. CFF is changed by altering the intensity, color of light; ratio between length of flash of light and dark period in each cycle of intermittence and size, shape and position of patch as it falls on retina. The state of light or dark adaptation of eye also varies the CFF. Other factors such as binocular and monocular vision, temperature and chronological age of the observer also alter the CFF.

Between 1902 and 1935, only an occasional application of the flicker technique to clinical problems reached the literature. Since 1945, there has been an increasing interest in the application of flicker measures to clinical problems. Simonson, Enzer & Benton
(1943) investigated CFF in relation to fatigue. McFarland (1945), Krugman (1947), Krášno and Ivyc (1950) are illustrative of this interest who investigated the relationship of CFF to anoxia, anxiety, and cardiovascular pathology respectively. Halstead (1947) included it in the battery of tests, which he used to find organicity in patients.

In various studies, changes in CFF have been studied as a result of various drugs, chemicals, biological agents, and to certain conditions of pathology. A survey of literature indicates that the agents that tend to raise CFF are strychnine, thyroxin, benzodrine, adrenaline, small doses of glucose, dinitrophenal, pervitin, and testosterone. The following agents lower the CFF: Chloral, insuline, atropine, nicotine, pitocarpine, excess of CO₂, deficiencies of vitamin A and C, and almost any drug or chemical in barbiturate group. The agents which sometime lower the CFF depending on dosage and other conditions are alcohol, caffeine, scopolamine, oxygen, and nitroglycerin. Still others have been found to have no effect. Such drugs are saccharine, vitamin B, and neobetramine.

Clinical investigations have reported an altered CFF (usually a decreased CFF) in a wide variety of pathological states including many ophthalmological conditions, cardiovascular disorders, brain tumors, brain injury, nicotine neurosis, hyperthyroidism, castration,
oligiospermia, beri-beri, combat exhaustion neurousis, exogenous mental retardation, and exhaustive illness.

CFF phenomenon have been applied to the measurement of work stress in a variety of investigations. Usually there is a decrease in CFF threshold when the capacity for mental or physical performance is impaired (Hashimoto, 1968; Wotzka Grandjean, 1968; Urgelles Luis, 1982).

In various studies related with fatigue, CFF has been used along with many other measures such as EEG, HR, GSR, and there is a significant correlation between these measures (Hashimoto, 1968, 1969). It has also been related with performance on various tests such as grid tapping, ordinary tapping and self rating on 'refreshed-tired' scale. Significant correlations have been found among these tests. It indicates that all these measures are indices of the same mental state, that is stress.

However, there are various studies in which no change in CFF is observed (Davis, 1955; Nagatsuka, 1975). The relation of work and direction of change in CFF may be explained on the basis of excitation of central nervous system (CNS). CNS has two systems, one is activating system which arouses the organism and another is inhibitory system which leads to sleepiness, tiredness and other such feelings. An optimum level of excitation of cerebral
cortex makes CFF threshold remain constant, but during inactivity of performance of very monotonous tasks and very exhaustive work, inhibitory system is active and as a result there is a decrement in CFF (Grandjean, 1979) and various other measures.

Landis (1951) have reviewed various studies relating physiological stress factors to retinal reactivity and CNS excitability. He has suggested an overall perspective that any condition or agent which acts to decrease the available blood sugar and/or oxygen available to the retina and/or brain decreases CFF whereas conditions increasing the efficiency of vascular supply increase CFF.

Pullen & Stagner (1953) have discussed that personality is characterized by perceptual processes which are alert to changing stimuli. Perception always depends upon a balance of two complex systems i.e. system 'R' which is closely related to reality oriented responses and the other system 'W' the system of response tendencies which are oriented away from external stimuli. Applying this theoretical structure to FFT measurements, it would appear that in stress situations, 'W' system dominates and as a result, there is a decrement in CFF.

Simonson and Brozek (1952) commented that though decrement in CFF threshold have been reported in many studies, there are discrepancies with regard to extent, significance, and interpretation. This difference in part
may be due to different work and test conditions. FFF can be used as a useful index of CNS excitability, especially the visual centres.

Thus, CFF may be used as an index of the physiological functioning of the CNS. Fatigue, anoxia and effects of drugs, state of arousal and age of the observer are among the factors that influence CFF (Brown, 1965). Therefore, CFF measures cortical excitability rather than a retinal measure.

Either a measure of cortical excitability or a retinal measure, it seems from the above discussion that certainly there is a correlation in stress and CFF or performance. Whatever be the form or stress, or whatever be the kind of the natural or laboratory induced stress, it certainly affects the level of performance on a given task and the FFT.

To have a specified and vivid picture of this relationship, let us review some of the related studies and the pertinent literature in the next chapter of historical resume.