Mental Stress and its Implications on Reaction time

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Abstract— **Stress is a common in everyday life. Mental distress leads to increase in the reaction time and decrease in attention and concentration. It could results in poor performance. Reaction time implies on stress. When the mind gets exhausted, it usually faces some complications to do mental tasks at the satisfactory performance level which leads to many happenings and mishaps. Subsequently, monitoring of mental stress is essential to assess stress. This paper reviews about quantification of stress using reaction time.**

Keywords— **Distress, Eustress, Cognition, Latency, and Reaction Time.**

I. Introduction

Mental stress refers to changes in the psycho-physiological state that people experience during the course of prolonged periods of demanding cognitive activity that require sustained mental efficiency [1]. Nowadays, it is becoming increasingly common for people to stretch their limits to squeeze more time for work. That extra time is usually taken by decreasing the time period for which we sleep. Though it seems as an easy concession to make, but slowly and surely this lack of sleep catches up with us [2]. This is true not only for students preparing for exams or officials, but also for industrial workers, health care professionals, drivers [3], pilots and in military operations. In the latter situations, the people are working in high risk situations, and any mistake on their part, can even lead to loss of life for them or others. This is why the study of mental stress is very important to solve daily routine problems.

A. Stress

Historically, stress has been defined as a reaction from a calm state to an excited state for the purpose of preserving the integrity of the organism. For an organism as highly developed and independent of the natural environment as socialized man, most stressors are intellectual, emotional and perceptual [4]. Some researchers make a distinction between “eustress” and “distress,” where eustress is a good stress, such as joy , or a stress leading to an eventual state which is more beneficial to the organism[5], however in this paper we will refer to stress only as distress, stress with a negative bias, particularly distress caused by an increase in workload. There have been a number of studies that link highly aroused stress states with impaired decision making capabilities[6], decreased situational awareness[7] and degraded performance[8] which could impair ability.

B. Reaction Time

Reaction time is one of the most important factors in vigilance task. In literature, Reaction time has been a favourite subject of experimental researchers since the middle of the nineteenth century. Psychologists have named three basic kinds of reaction time experiments [9, 10]:

1. In simple reaction time experiments, there is only one stimulus and one response. 'X at a known location,' 'spot the dot,' and 'reaction to sound' all measure simple reaction time.
2. In recognition reaction time experiments, there are some stimuli that should be responded to (the 'memory set'), and others that should get no response (the 'distracter set'). There is still only one correct response. 'Symbol recognition' and 'tone recognition' are both recognition experiments.
3. In choice reaction time experiments, the user must give a response that corresponds to the stimulus, such as pressing a key corresponding to a letter if the letter appears on the screen. The Reaction Time program does not use this type of experiment because the response is always pressing the spacebar.

Many researchers have confirmed that reaction to sound is faster than reaction to light, with mean auditory reaction times being 140-160 ms and visual reaction times being 180-200 ms [10, 11]. Perhaps this is because an auditory stimulus only takes 8-10 ms to reach the brain [12] but a visual stimulus takes 20-40 ms [13]. Differences in reaction time between these types of stimuli persist whether the subject is asked to make a simple response or a complex response [14] For about 120 years, the accepted figures for mean simple reaction times for college-age individuals have been about 190 ms (0.19 sec) for light stimuli and about 160 ms for sound stimuli [10, 11].

II. Literature Survey

The pioneer reaction time study was that of Donders (1868) [20]. He showed that a simple reaction time is shorter than a choice reaction time, and that the recognition reaction time is longest of all. Laming (1968) [21] concluded that simple reaction times averaged 220 ms but recognition reaction times averaged 384 ms. This is in line with many studies concluding that a complex stimulus (e.g., several letters in symbol recognition vs. one letter) elicits a slower reaction time [22; 23; 24]. An example very much like our experiment was reported by Surwillo (1973) [25], in which reaction was faster when a single tone sounded than when either a high or a low tone sounded and the subject was supposed to react only when the high tone sounded.

Several investigators have looked at the effect of increasing the number of possible stimuli in recognition and choice experiments. Hick (1952) [26] found that in choice reaction time experiments, response was proportional to log (N), where N is the number of different possible stimuli. In other words, reaction time rises with N, but once N gets large, reaction time no longer increases so much as when N was small. Sternberg (1969) [27] said that in recognition experiments, as the number of items in the memory set increases, the reaction time rises proportionately (that is, proportional to N, not to log N). Reaction times ranged from 420 ms for 1 valid stimulus (such as one letter in symbol recognition) to 630 ms for 6 valid stimuli, increasing by about 40 ms every time another item was added to the memory set. Nickerson (1972) [28] reviewed several recognition studies and agreed with these results.

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Froeberg (1907) [30] found that visual stimuli that are longer in duration elicit faster reaction times, and Wells (1913) [31] got the same result for auditory stimuli. Luce (1986) [32] reported that the weaker the stimulus (such as a very faint light) is, the longer the reaction time is. However, after the stimulus gets to certain strength, reaction time becomes constant. In other words, the relationship is:

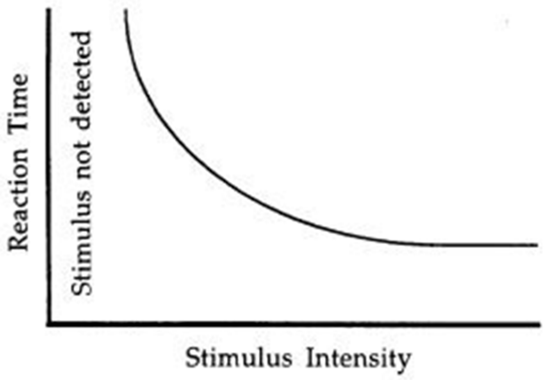

Fig 1. The proposed relation between stimulus intensity and reaction time.

III. Related Factors

There are many factors affecting reaction time. One factor is 'arousal' or state of attention, including muscular tension. Reaction time is fastest with an intermediate level of arousal, and deteriorates when the subject is either too relaxed or too tense [10; 15].

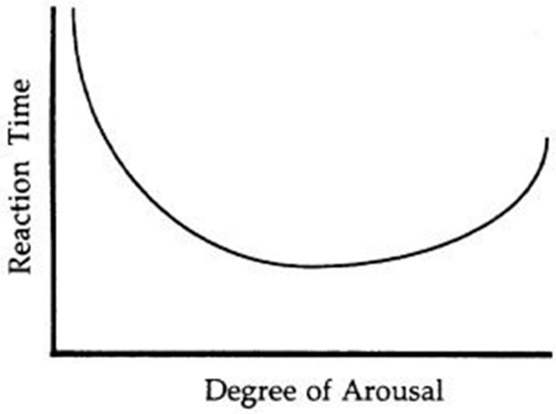

Fig 2. The proposed relation between stimulus intensity and reaction time.

Another factor contributing to reaction time is age. Reaction time shortens from infancy into the late 20s, then increases slowly until the 50s and 60s, and then lengthens faster as the person gets into his 70s and beyond [16, 17]. Previous studies also indicate that in almost every age group, males have faster reaction times than females, and female disadvantage is not reduced by practice [10; 18].

Welford [10, 11] found that, reaction time gets slower when the subject is stressed. Singleton (1953) [34] observed that, deterioration due to stress is more marked when the reaction time task is complicated than when it is simple. Mental stress, especially sleepiness, has the greatest effect. Kroll (1973) [35] found no effect of purely muscular stress on reaction time.

Unpleasant odours (such as from spoiled food) might have great relevance to survival and health. They found that reaction time to unpleasant food odours was faster and more accurate than reaction to pleasant odours and to non-food odours.

At the risk of being politically incorrect, in almost every age group, males have faster reaction times than females [10, 11, 12]. This study is remarkable because it included over 7400 subjects. Bellis (1933) [36] reported that mean time to press a key in response to a light was 220 ms for males and 260 ms for females; for sound the difference was 190 ms (males) to 200 ms (females). In comparison, Engel (1972) [37] reported a reaction time to sound of 227 ms (male) to 242 ms (female). However, things may be changing--Silverman (2006) [38] reported evidence that the male advantage in visual reaction time is getting smaller (especially outside the US), possibly because more women are participating in driving and fast-action sports. Spierer et al. (2010) [39] reported that when male soccer players were compared with female lacrosse players, males were able to respond faster to both visual and auditory stimuli. They said that the male advantage was greatest when using visual stimuli. Botwinick and Thompson (1966) [40] found that almost all of the male-female difference was accounted for by the lag between the presentation of the stimulus and the beginning of muscle contraction. Muscle contraction times were the same for males and females. In a surprising finding, Szinnai et al.(2005) [41]

found that gradual dehydration (loss of 2.6% of body weight over a 7-day period) caused females to have lengthened choice reaction time, but males to have shortened choice reaction times. Adam et al. (1999) [42] reported that males use more complex strategy than females. Barral and Debu (2004) [43] found that while men were faster than women at aiming at a target, the women were more accurate. Bayless et al.(2012) [44] found that when a choice reaction time task was made more challenging for rats by weak stimuli and distraction, male rats tended to "jump the gun" and make premature responses, but female rats were more likely to miss valid stimuli. Note that this study used rats, not humans. Jevas and Yan (2001) [45] reported that age-related deterioration in reaction time was the same in men and women.

Study on reaction times in performance in vigilance tasks found that individual periodograms indicated a rhythm in attentional capacity with periods ranging from 5 to 30 min [19]. These findings indicate that considerable individual variation can be accounted for by considering individual periodicity in performance.

IV. Methods for Assessing Stress

A. Self-report measures

Stress affects how we perform, how we feel (self-report), and many of our bodily functions (neuro-physiological). All three then should be able to serve in some capacity as measures of stress, independent of environmental or physical conditions that are said to be stressful [46]. Systematic and exacting experimental studies of stress and its effects on cognition require valid and reliable measures that can be taken both in the laboratory and in the real world. The best work available on the evaluation of subjective states of stress has been reported by Matthews and his collaborators [47].

It is difficult to create extreme or prolonged conditions of stress in the laboratory. Laboratory studies generally focus on relatively weak acute stress. An example involves adding workload or secondary task requirements to a primary or focal task. Subjects often find these additions to be stressful at least at the outset and they can adversely affect primary task performance. Given some experience or practice, however, individuals can often find ways to accommodate to the greater demands of doing two things at once.

Consider the work of Matthews, Sparkes, and Bygrave, (1996) [50], who tested the hypothesis that driver stress is associated with performance impairment mainly because stress-prone drivers are vulnerable to overload of attentional resources. In other words, those who are susceptible to the effects of stress suffer from limitations on attentional resources and are more distractible by irrelevant non driving events. Young subjects performed a simulated drive concurrently with a grammatical reasoning task, presented either visually or auditorily. In this experiment, the patterns of dual-task interference predicted by attentional resource theory were actually not found, although some interference was apparent with the auditory reasoning task. Measures of vulnerability to driver stress and intrusive cognitions were related to impaired lateral control of the vehicle mainly when task demands were relatively low, contrary to the overload hypothesis. These data indicate that performance in this task paradigm is characterized by adaptive mobilization of effort to meet changing task demands. Stressed drivers adapted to high levels of demand fairly efficiently. The levels of stress involved here obviously fall within the range that can be compensated for by strain or mobilization. But, in contrast, Metzger and Parasuraman, (2001) found that, at higher levels of overload, created by a secondary task during driving in high traffic density and assessed by HR and self-report measures, performance does gradually but significantly decline. Parallel results were reported by Zeier (1994) for air traffic controllers.

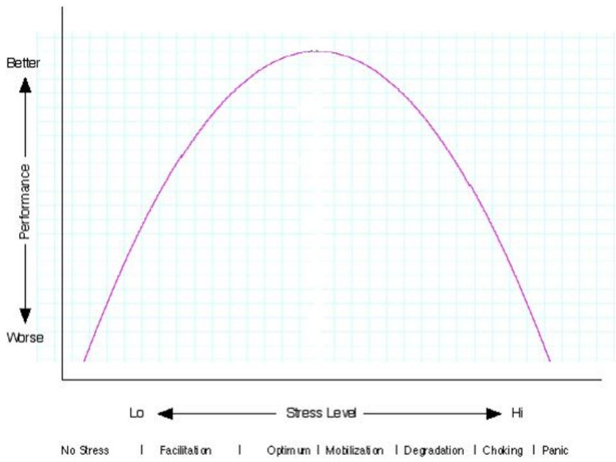

Fig 3. Variation of stress level and performance with respect to time

Task induced changes in stress are described within Matthews' system as patterned shifts in task engagement, distress, and worry. Patterns are sensitive to task and environmental demands. Matthews et al [46] illustrated this effect with studies of automobile driving. Operators' appraisal of task demands (workload) and choice of coping strategy mediate these stress effects. Thus, for Matthews, stress is an adaptive transaction between operator and task. Matthews et al. speculate that the consequences of task automation (e.g., cockpit automation) will vary widely depending on appraisal of the reliability and ease of control of the system, type and number of residual tasks left to the operator, and interpersonal factors such as personality and coping style. Thus there is likely to be no simple remedy for stress-related problems associated with automation, such as boredom or complacency [47]. Fine-grained assessment of the operator's feeling state and cognitions is required to determine vulnerability to performance degradation under stress.

B. Performance or Behavioural Measures

But the issue of which type of measure, self-report or neuro-physiological, is the better or more appropriate measure of stress effects is far from settled. Hancock and Vasmatzidis (1998) [48] contend that, rather than either self-report or physiological measures, task performance level should be the primary criterion for determining the effects of exposure to stress. They argue that change in behavioural performance efficiency is the most sensitive reflection of human response to stress, and that error-free performance is the principal criterion of work efficiency, especially in high-technology systems. Therefore, continuing exposure to stress after work performance efficiency begins to fail, but before current physiological limits are reached, is inappropriate for both the safety and the productivity of the individual worker, their colleagues, and the systems within which they operate. Behavioural performance assessment should therefore supersede physiological assessment or self-report as the primary exposure criterion, although these other measures still provide important supplementary information

There are, of course, others who disagree with this analysis, contending that how a person thinks and communicates about stress and/or how the body automatically reacts to stress are fundamental components of the stress syndrome that are not contained within measures of performance. Still, there have been several significant efforts, following the logic of Hancock and Vasmatzidis [48], which have been aimed at identifying and developing reliable performance measures to assess individual differences in reactivity to stress. Ackerman and Kanfer (1994) [49] developed a battery of cognitive ability tests for predicting performance under stress. As a test bed, they used a dynamic Target/Threat Identification Task performed under time-pressure. Their final battery consisted of a mixture of cognitive and perceptual speed ability and stress-reactivity measures. They showed that these measures accounted for the major amount of individual differences in performance on a variety of complex tasks. Two tests, called The Dial Reading and Directional Headings Tests, were found to be particularly promising predictors of performance in stressful information processing activities.

V. Conclusion and Discussion

Stress could be a major determining factor for inducing high performance if it's Eustress or worse performance if it's distress. The reaction time increases with the increase in distress, and this reaction time changes with age, sex and many dependent factors. Since reaction time tests are well performed with practice, only reaction time could not be used to assess stress. There are many physiological signals like Heart Rate Variability, Pulse Rate Variability and Electroencephalogram which vary with stress. By combining these parameters efficient stress assessment could be achieved which would be useful to prevent many stress related diseases.

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