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Stress and Human Performance

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ABSTRACT

The review endeavours to present a synoptic detail of the various aspects and issues concerned with stress and human performance in eyewitness testimony. It focuses on the features of multifaceted term 'Stress'. The phenomenon of stress is pervasive in almost every aspect of human life. It has cognitive, emotional and behavioural components which significantly determines and regulates several indices of human performance. The phenomenon of stress has been found to be useful in interpreting the accuracy of recall in eyewitness testimony. The findings of many studies in eyewitness research indicate that stress involved in an eyewitness situation significantly determines the performance of the eyewitnesses. The Yerkes-Dodson law does not directly applicable to interpret the performance, but its effects are moderated by a host of factors involved an eyewitness situation concerned with the personal qualities of an eyewitness, the nature and types of post event information and the content and ways of information sought.

INTRODUCTION

Stress is a descriptive term used in both the behavioral and biological sciences to cover conditions of a physical, biological, or psychological nature, that typically cannot be controlled by organisms, and that strain organisms often beyond their powers to adapt (Gaillard & Wientject, 1994). But there is no single universally agreed to definition of stress and consequently no single measure that will tell us when a person is stressed or operating under stressful conditions (Hancock & Desmond, 2001). Stressors are environmental, biological, and/or cognitive events that, among other things, challenge or threaten the well-being of an organism, increase its arousal or activation level, and deplete its resources (Hobfoll, 1991). They can be extraneous (non-work stress) or indigenous (stress created by the task) and they can arise from endogenous or exogenous sources. The resulting stress states can be acute and time limited, as in responses to a single transitory event, or they can be chronic, as when the condition of stress persists in time. Normally, human beings respond to stressors either through extraordinary mental or physical effort or by exhibiting degraded performance. Extreme effort over time in response to chronic stress can result in either mental or physical exhaustion or injury (Kolich & Wong-Reiger, 1999).

With respect to human performance, stress-related phenomena are often classified as emotional, cognitive, and physical (Van Gemmert & Van Galen, 1997). There are numerous examples of the effects of stressors in all three categories affecting human performance. For example, regarding emotional stress, Adam and Van Wieringen (1988) have shown that worry and emotionality, measured as personality traits, are negatively correlated with proficiency in a simple motor task. Cognitive stress, resulting from the need for coordinated multitasking in nearly all daily activity, is perhaps the most common stress condition. Heightened mental load resulting from multitasking typically slows responding, although it often has little effect on accuracy of performance (Castiello & Umilta, 1988).

Physical stress is particularly interesting in the light of the contemporary concern with the quality of the natural environment. Urban areas in particular present stressors in the form of noise, air pollution, and disturbance of natural light/dark rhythms. But research has presented an unclear picture of the effects of these stressors, sometimes reporting

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significant detrimental effects on performance and health and sometimes reporting no effect (Nivison & Endresen, 1993). Interestingly, Van Gemmert and Van Galen (1997) showed that performance in a complex sensory-motor task was more sensitive to cognitive stress, manipulated by concurrent memory load, than to physical stress, manipulated by sound pressure level. These often conflicting results argue for a more comprehensive study of stress effects on human performance and for an integrative theoretical framework in which to organize the empirical evidence.

Arousal and Performance

Arousal, alertness, and activation are terms used in the psychological literature more or less synonymously to describe a particular state of the organism. Like any state, arousal is capable of variation in time. As an organism becomes more aroused, it likewise becomes more alert and more highly active, at least up to a point. Human performance in nearly all situations tends to be correlated with arousal, improving up to a point as arousal level increases and falling off as arousal decreases diurnally. But there are, of course, many qualifications on this general rule. For example, arousal level can become too high for the task at hand. When a person is over-aroused, performance will deteriorate. Moreover, simple tasks like vigilance, time estimation, or the execution of a single well-practiced manual response are performed optimally under relatively high arousal levels, whereas complicated tasks such as those involving a sophisticated level of mental calculation are performed optimally under relatively low levels of arousal. Thus, it has been known for some time that modestly increasing a person's level of arousal, e.g., by introducing the threat of a painful stimulus, facilitates performance on a simple task like time estimation (Falk & Bindra, 1954), but can hinder performance on more complicated tasks like public speaking or mental arithmetic (Lovallo, 1997).

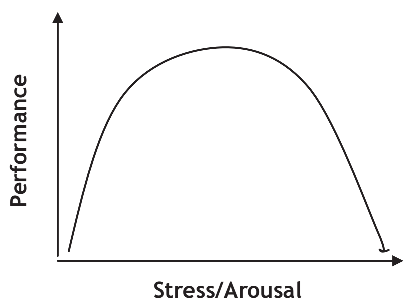

Figure 1: Relation between Stress/Arousal and Performance

The correlation between arousal and performance is so ubiquitous that it has come to be accepted as a law in psychology - the Yerkes-Dodson (Y-D) law, named for its putative discoverers (Yerkes & Dodson, 1908). The law takes the form of an inverted U -shaped relationship between performance and arousal. Performance on any task is best at some mid-level of arousal, falling off as arousal becomes too low or too high. The specific level of arousal that is optimal for performance differs among tasks, tending to decrease as task difficulty increases.

Motivation and Arousal

Arousal might affect performance simply by activating response systems. An aroused organism is an organism that is ready to respond. Whether the activated response systems are relevant or correct for the task or irrelevant or incorrect determines whether arousal facilitates or impedes task performance. An alternative theory (Lovallo, 1997) links arousal to motivation. The more aroused the organism is, the more it is motivated to perform well. Such a theory accounts easily for the initial upward leg of the Y - D law but requires interference or inhibitory processes to account for the possibility that an organism can be "too motivated" to perform well. Among the models that have been suggested are those that invoke activation of competing responses at higher levels of motivation (Lovallo, 1997). Even though there might be a strong link between arousal and motivation, there is plenty of evidence that these are separable concepts. For example, Dyregrov, Solomon, and Fredrik (2000) have shown that performers can counteract the potentially degrading effects of supra-optimal levels of arousal by extra effort. Making an extra effort is surely a matter of motivation, which means that, in this example, motivation competes with arousal for control of behavior. Countervailing influences imply unique and separable motivational and arousal processes.

Stress and Arousal

Stress effects on performance are, to some extent, mediated by arousal. Like arousal itself, stress can have either beneficial or degrading effects on performance, depending on the intensity of the stressor, the momentary level of arousal when the stressor occurs, the nature of the task to be performed under stress, the skill of the performer, and other variables. Light stress introduced while the participant is at some sub-optimal level of arousal has been shown to facilitate performance (Spielberger, 1972). But one unique and important feature of stress is that it can induce high levels of arousal that are rarely seen in normal circumstances. Thus, often, stressors induce levels of arousal beyond optimal for performance in any task, and as a consequence, performance is degraded. Modest levels of supra-optimal stress can be counteracted by the performer by increased effort, resource mobilization, or straining. Razmjou (1996) claims that resource mobilization involves deliberate processes, basically strategies for controlling effort, that allow the performer to adapt to the source of stress or arousal and to task demands. According to Hockey (1997), successful performance in any task requires the operation of a control mechanism, which allocates resources dynamically. Performance may be protected under stress by the recruitment of previously untapped resources, but only at the expense of increased subjective effort, and other behavioral and physiological costs. Of course, performance stability can be achieved by reducing goals, without further costs. At some high level, however, stress will degrade performance. Under the pressure of an emergency, close examination by others, time urgency, threat of bodily harm, or other strong stressors, people often falter.

Stress States: Qualitative Effects of Stress

Quantitatively, stress effects on performance follow the inverted U-shaped relationship (the Y-D law). Although there is considerable evidence in support of such a relationship, the Y - D law is not the whole story and has limited explanatory value for a variety of reasons (Hancock, 2002). For one thing, not all empirical evidence is consistent with a U-shaped function of performance across levels of arousal (Westman & Eden, 1996). Secondly, every stressor produces its own unique pattern of effects on cognition and performance, making it unlikely to find an adequate all encompassing principle or theory. Further different stressors can interact, often producing non-additive effects on performance (Hygge & Knez, 2001). Evans, Allen, Tafalla, and O'Meara (1996) examined the interactive effects of multiple, sequential stressors on cognitive performance and psycho-physiological indices. Subjects engaged in a relaxing or a highly stressful activity followed immediately by performance of a task under quiet or noisy conditions. Results indicated that the negative effects of noise on both concurrent and aftereffect performance and on BP were exacerbated by prior exposure to either a lab stressor (making a speech) or to a naturalistic stressor (college final examination). Thirdly, the Y -D law relates only to arousal or system activation and not to other processes such as interference and resource demands that might also be influenced by stress. Finally, and perhaps most importantly, Y-D law relates exclusively to simple quantitative measures of goodness of performance, e.g., speed or accuracy of response.

Attention and Perception

It is clear that stress, especially acute stress, has important effects on attention and perception. But the effects are quite irregular, and depend in serious ways on the qualitative features of the stressor. Different stressors have different effects on performance. One stressor might cause shifts in attention or a failure to inhibit irrelevant stimuli, while another stressor causes a lapse of attention or attentional narrowing in the same task.

Inhibition and Attention

Given that the effects of stress on attention can be unpredictable, still there are some results that are general, systematic, and reliable. One example is the latent inhibition (LI) effect. Pre-exposure to a stimulus reduces the utilization and the learning of that stimulus on some later occasion. This **LI** phenomenon is typically attributed to a reduction in attention to stimuli caused by their preexposure in another task. When stress is present in the learning or test phase, however, latent inhibition is reduced or eliminated.

Anxiety proneness associated with impaired inhibitory processing

Participants in a series of experiments reported by Wood, Mathews, and Dalgleish (2001) made speeded decisions which required inhibition of the meaning (threatening or neutral) of ambiguous words. Under normal conditions, they found that anxious and non-anxious participants perform equally well in this task. However, when a mental load was induced to reduce controlled processing, anxious subjects did not inhibit word meaning as well as non-anxious subjects. **In** a final experiment, attenuation of inhibition was demonstrated even without mental load in subjects who had recently experienced a traumatic event.

Mogg, Bradley, and Hallowell (1994) tested high and low trait anxious students for attentional bias to threat stimuli (words) under no stress, laboratory induced stress, and natural examination-induced stress. High anxious subject showed an attentional bias toward threat words, but only when those words were presented for long duration, without a mask, and under examination threat. Anxiety sensitized the subject to threat mainly when the induced anxiety is somewhat protracted.

Measured levels of stress hormones are consistent with the abovedemonstrated effects of stress on inhibitory processes. Skosnik, Chatterton, Swisher, and Park (2000) induced mild stress into the verbal priming paradigm using a video game. Stress reduced negative priming, a measure of inhibition processes, and also increased salivary cortisol and alpha-amylase (a correlate of norepinephrine).

So, both chronic anxiety, as in trait anxious subjects, or acute anxiety, as in trauma, is associated with a general deficit in inhibition of attention, and is best revealed when limitations are placed on controlled processing, forcing subjects to rely more heavily on automatic reactions. Behavioral and physiological measures are consistent with changes induced by stress on inhibitory processes. These results imply that, in a natural emergency, when stress is high, there is need to be concerned about an operator's ability to focus on the relevant information in the task at hand and to inhibit irrelevant sources of input.

Perception and Cue Utilization

Based on a review of the early literature on arousal and attention, Easterbrook (1959) concluded that stress, anxiety, or high arousal can narrow the range of environmental cues utilized, shrinking one' effective perceptual space. This idea has been expanded by Cowan (1999) in a theoretical analysis of working memory. Among other things, Cowan draws a sharp distinction between attentional processes, which in his view are basically capacity-limited, and working memory, (the activated portion of long-term memory in his theory), which is basically time-limited. Thus, consistent with Easterbrook, Cowan predicts that the effects of stress on attention are to limit its scope or content. People attend to and process less perceptually-available information when they are stressed. Since Easterbrook's publication, there have been numerous demonstrations of an attentional deficit under stress, in and outside of the laboratory. For example, Ozel (2001) found that time pressure and the stress created by the threat of fire affects how people process information provided to them about the right route to take to escape. Slight stress was beneficial to escape performance, but higher levels of stress narrowed the range of environmental cues attended to or processed and increased the use of negative coping styles by participants. Escape performance suffered as a consequence.

Vigilance

Performance in a vigilance task, which requires the detection of infrequent stimuli, degrades in time, a phenomenon known as the vigilance decrement. Galinsky, Rosa, Warm, and Dember (1993) observed that restlessness and subjective fatigue, both indices of stress, increased dramatically across a 50-min watch in a vigilance task in which sensory modality of signals (audition and vision) and the background event rate (5 and 40 events/min) were varied. Stress effects were most notable in the case of visual monitoring but were unrelated to variations in event rate. Thus, the stress of sustained attention seems to be identified more specifically with the sensory modality of signals than with the event rate context in which they appear. Temple, Warm, Dember, Jones, LaGrange, and Matthews (2000) observed that 30 mins or more of sustained vigilance produces not only a performance decrement, but also increases in felt workload and stress. Stimulant drugs, like amphetamine sulphate or caffeine, extraneous auditory stimuli, and other arousing agents should enhance vigilance and counteract the deterioration in vigilance performance that occurs with the passage of time. Temple et al. (2000) found evidence that ingestion of caffeine during the task improved vigilance and signal detection but did not reduce task-induced stress.

Memory

As we have noted earlier, cognitive psychology is currently concerned with a variety of forms of memory. One important distinction applies to the temporal character of information retrieved from memory. This distinction is based on a continuum from the remote past - retrospective long term memory - to the present or near present - short term memory and immediate or working memory - to the future - prospective memory. Long-term memory is theoretically a repository for facts and skills acquired in the past. Short term and immediate memory holds facts and skills that are currently at the focus of attention. Prospective memory contains reminders of actions to be executed at some future time and place. The important variables influencing memory might not the same in all three cases. One variable that seems likely to be influential is stress.

Stress effects have been studied in the context of various forms of memory, although the experimental data available are surprisingly few. There are no data comparing different forms of memory for their relative susceptibility to stress. The evidence that is available seems to suggest that stress, in general (including stress arising in emergency situations), causes the operator to focus on the here-and-now, with consequent potential degradation of retrospective and prospective memory performance. The results are consistent with a memory constriction or tunneling hypothesis to the effect that the time span from which knowledge can easily be retrieved and used in a given context shrinks as stress level increases. Neglect of facts or procedures in long term memory, and failure to execute required behaviors at appointed future time is a major reason for performance errors or failures in emergencies. Although memory tunneling has been observed in the retrieval of autobiographical events (Berntsen, 2002), empirical evidence to support this broad stress/memory hypothesis is weak. The hypothesis could, however, serve a framework for future research efforts.

Memory for emotion-arousing stimuli

There is conflicting evidence in the literature regarding memory for emotionally arousing stimuli. As we noted earlier, most studies have reported that memory is better for either pleasant or unpleasant material than it is for emotionally neutral material. But there are exceptions. Further, some investigations have, reported that traumatic stimuli, like autopsy photos, can inhibit memory for simultaneously presented neutral material (Kramer Buckhout, Fox, & Widman, 1991). In an eyewitness memory paradigm, Tiwari (2005) found that research participants were more prone to accept misleading post-event information about the unpleasant event in comparison to the pleasant one. Furthermore, in the absence of any type of post-event information, subjects retained lesser number of details of unpleasant event than that of pleasant event. Not only accuracy of recall of arousing events but metamemory judgements of such events and source-monitoring are found to be shaped in terms of arousal (Tiwari, 2009). Whether these differential observations should be attributed to differing methods of presenting materials and measuring memory or to the degree of emotion provoked by the stimulus material is not clear at the present time.

Lang, Davis, and Ohman (2000) attempted to explicate what is special about memory for emotional information, emphasizing the neural foundations that underlie the experience and expression of fear. They proposed that unpleasant emotions depend on the activation of an evolutionarily primitive subcortical circuit, including the amygdala and the neural structures to which it projects. This motivational system mediates specific autonomic (e.g., HR change) and somatic reflexes (e.g., startle response) that originally promoted survival in dangerous conditions. These authors show how variations in the neural circuit and its outputs may separately characterize cue-specific fear (as in specific phobia) and more generalized anxiety.

Context and State Dependency involving Stress

One of very few studies to take account of state and context dependency effects in memory was conducted by Thompson, Williams, L'Esperance, and Cornelius (2001). In the first of two experiments, experienced skydivers learned word lists prior to skydiving either in the air or on the ground and recalled them in the same context or in the other context. The second experiment was a replication of the first except that participants were shown a skydiving video in lieu of actual skydiving. Recall was poor in air-learning conditions with actual skydiving, whether learning took place in the air or on the ground. But when lists were learned on land, recall was higher in the matching context than in the mismatching context. In the skydiving video experiment, recall was higher in matching learn-recall contexts regardless of the situation in which learning occurred. It is proposed then that under extremely emotionally arousing circumstances, environmental and/or mood cues are unlikely to become encoded or linked to newly acquired information and thus cannot serve as cues to retrieval. Context and state dependency effects are real, but might be overridden when emotions are extreme. Results can be applied to understanding variations in context-dependent memory in occupations in which the worker experiences considerable emotional stress while learning or recalling new information. But the main point is that these dependency effects must to be taken into account in all future experiments purporting to study stress and memory.

False memories

Payne, Nadel, Allen, Thomas, and Jacobs (2002) demonstrated that stress can enhance a person's susceptibility to false memories. In a recall task, participants' ability to distinguish words that were presented for study from critical lure words that were semantically related, but not presented for study, was selectively disrupted. This finding indicates that stress potentiates false memories. An argument was made by the authors that this effect is mediated through the impact of stress on the hippocampus and prefrontal cortex, but this interpretation is an extreme extrapolation from the data, which contained no measurements of brain activity.

Trait Anxiety and Stress

Both general arousal level and felt anxiety increase in response to stressful stimulation. Probably the most detailed analysis of anxiety, in response to stress, has been provided by Spielberger (1972), who emphasized the need to distinguish sharply between state and trait anxiety. Trait anxiety is a relatively enduring personality characteristic which, according to Spielberger, has a strong somatic, non-deliberate, automatic component. State anxiety is a more transitory reaction to context and environmental stimulation, having a major cognitive appraisal component. Speilberger developed reliable paper and pencil measures of these two components of human anxiety. But, most of the subsequent empirical work using Spielberger's analysis relates to trait rather than state anxiety. Researchers have found it difficult, if not impossible, to separate state anxiety from other transitory consequences of a stressful event.

Low trait anxious individuals, as measured by the Speilberger tests, are less prone to the influence of momentary stressful stimuli than are high stress prone individuals. Similarly, the performance of low stress prone individuals on a variety of cognitive tasks is less affected by stress manipulations than is the performance of more stress prone individuals. Further, high trait anxious people show an exaggerated correlation between felt negative affect or anxiety and somatic and psychological stress (Wofford, 2001; Wofford & Goodwin, 2002).

Ashcraft (2002) have traced the influence of anxiety to working memory, at least in the context of quantitative problem solving. Ashcraft has repeatedly observed an inverse relationship between anxiety and working memory capacity. Ashcraft argues that high anxious subjects have a compromised working memory capacity, relative to low anxious subjects. The same effect is seen when working memory is stretched by the mental arithmetic task itself. That is, when working memory capacity is reduced by requiring subjects to perform a concurrent memory load task, reaction times and errors on mental addition problems are increased. Thus, high stress levels might exert a deleterious effect of performance in quantitative cognitive tasks through the reduction of available working memory resources. Dutke and Stroebber (2001) have demonstrated, however, that these adverse effects of high stress and anxiety can be compensated for, to some degree, both by enhanced motivation of performance and by external processing aids.

Ashcraft's working memory restriction theory of anxiety predicts that high anxious subjects will also have greater difficulty making quantitative analogies based on relations as compared to common concrete stimulus attributes. Abstract rules create more working memory difficulties than do perceptual attributes in general, and anxiety exacerbates the problem. Tohill and Holyoak (2000) induced anxiety in college students by requiring them to perform a difficult speeded arithmetic pre-task. Then, in a follow-on analogies task, anxious subjects produced more attribute than relational responses relative to non-anxious subjects. Consistent with Ashcraft's theory, Tohill and Holyoak conclude that anxiety reduces the scope of working memory, which is more extensively required by abstract relative to concrete analogies.

It is surprising that other forms of memory, e.g., retrospective or prospective memory, have not been examined in the context of individual differences in anxiety or anxiety producing manipulations. It is not clear at the present time whether the effects of anxiety are limited to working memory, as Ashcraft implies, or are more broadly consistent with a general memory constriction hypothesis. It might be, for example, that, as anxiety or stress in general increases, the time line for memory shrinks, resulting in the loss of prospective and retrospective memories even before limitations on working memory are observed. This possibility remains to be explored in future research.

In a variety of cognitive tasks, including decision making and similarity ratings, Pury and Mineka (2001) found that high trait anxious subjects (relative to low trait anxious subjects) are biased to encode (are more sensitive to) affect relevant information (in words, events, photographs with varying emotional content) than non-affect-relevant information. This effect occurs even if the affect-relevant information is weak or non-salient. Thus, trait anxiety not only narrows the perceptual (or aperceptive) field, as shown by Easterbrook (1959), but also specifically tunes attention to stimuli with emotional relevance, according to Prury and Mineka. Similar and confirmatory findings were reported by Russo, Fox, Bellinger, & Nguyen-Van-Tam (2001), who showed that anxious subjects are more likely to free recall mood-congruent stimuli than are low anxious subjects and by Calvo and Castillo (2001), who found that inferences are more often mood-based in anxious as opposed to non-anxious subjects.

High anxiety individuals are also more sensitive to a possible threat in an ambiguous situation than are low anxiety individuals. However, when the threat becomes stronger, more predictable, or higher in probability, high and low anxious subjects respond alike. Apparently, the difference between high and low anxious individuals resides in part in a threshold for perceived threat. High anxious individuals are more circumspect regarding possible threatening events than are low anxious individuals (Calvo & Castillo, 2001). Similarly, Russo, et al. (2001) demonstrated that, after incidental lexical processing of a list of words, high anxious subjects have better recall of threat-related words than low anxious. But the different disappeared if the pre-processing is semantic rather than lexical. These results suggest that anxiety acts primarily upon implicit as opposed to explicit learning/memory processes.

Conclusion

Researches in psychology have demonstrated and explained various types, expressions and psycho-biological correlates of stress. Recent studies have examined the effects of stress on various domains of human performance. The present review has made it clear that even though stress degrades performance in most of the cases, this relation is not so simple. There are so many factors that moderate the stress-performance relationship. Though this area is over researched, gaps in the knowledge still exist. One of such concerns is to create real life stress situations in laboratory settings. Therefore, new innovations in this area of research are deeply needed.

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