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REVIEWS

QUANTIFYING THREAT OR CHALLENGE RESPONSE OF UNDERGRADUATE PARAMEDICINE STUDENTS DURING HIGH-STRESS CLINICAL SCENARIOS: A NARRATIVE REVIEW

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ABSTRACT

Paramedicine practice can be inherently stressful. Encountering critically unwell patients, managing long shift hours and dealing with the unknown expose paramedics to mental, physical and emotional stress. In the learning environment, these types of stresses are difficult for educators to authentically replicate. Traditionally, students have been tested under pressure in scenario-based situations as a means of stress inoculation. However, the literature is unclear as to whether this exposure to stress enhances or hinders learning. A recent scoping review identified an acceptable level of stress during simulation can be beneficial, although a level of a balance is required. Too much stress can hinder learning and lead to underperformance. Ideally, high-acuity patient scenarios should be designed to invoke a challenging state of appraisal in the student to support both their learning and knowledge retention. To obtain a more holistic understanding of how students appraise these types of scenarios, quantitative physiological and psychometric data needs to be obtained and analysed. However, across the health care education literature, inconsistent methodologies and a variety of physiological and cognitive measures make it challenging to draw firm conclusions. This narrative review searched three prominent databases using common search terms to produce a subset of high-quality publications that we believe were most pertinent and insightful. Based on these findings, our paper presents guidance for appropriate physiological assessment and interpterion of challenge appraisal in students undertaking high-acuity, low-occurrence clinical scenarios.

INTRODUCTION

Paramedicine is a domain of practice that involves exposure to dynamic and stressful situations where lifesaving decisions are often made under immense pressure. Stress can be defined as a mental, physical, or emotional factors causing bodily or mental tension (Singh et al., 2018). The physical response to stress, or more accurately a group of adaptive physiological responses, was discussed in the early 1930's as 'general adaptation syndrome' (Selye, 1936), and is a mechanism by which the body attempts to restore internal homeostasis following exposure to adverse stimuli. This leads to the fight (confronting the situation) or flight (attempting to flee) response - an immediate and involuntary reflex exhibited when faced with the danger of a stressful situation. First discussed by Walter B. Cannon when studying epinephrine secretion in laboratory animals in 1929 (Cannon, 1994), this response signals the amygdala to activate the autonomic nervous system to release stress hormones (such as epinephrine and cortisol) into the blood to initiate a physiological response (Jansen et al., 1995).

Along with Cannon's study, much of the early stress and performance research was based on laboratory studies of animals such as mice, chickens and kittens (Cole, 1911; Dodson, 1915). However in 1955, seminal work published by Hebb (1955) introduced the concept of 'arousal' as drivers of "sensory excitations" (pg.248) within the human central nervous system. Researchers now know in any pressure situation, low levels of hormones such as cortisol and adrenaline are released (Domes et al., 2004; Hellhammer et al., 2009). These hormones help to arouse or stimulate us to a point of optimal performance when our creativity or productivity is maximised – known as the goldilocks point – and highly sought after by elite athletes (Jones et al., 2009). Too little pressure or stress can lead to a lack of alertness, disengagement, or under-performance and too much stress leads to anxiety and disorganisation where the ability to think and communicate clearly can be lost. This evolutionary response ultimately leads to a point where the participant perceives the situation to be so pressured they lose awareness of their surroundings and cease effective communication and movement all together. This behaviour is a protective response to excessive pressure, although if the pressure remains too high for long periods of time, chronic stress or burnout can manifest.

The aims of this paper are to identify and recommend appropriate modalities for assessment of physiological stress in paramedicine students which can further be generalisable to other healthcare educators. Our lens for this paper is from that of paramedic educators, but it is important to note that themes discussed here are relevant to all healthcare education settings where emergency or stressful scenarios are utilised as an andragogic tool. By providing individualised quantitative stress data to students in pre-employment simulated environments, it is hoped a better understanding of their own acute and chronic stress may be obtained. Acknowledging that the incidence of distress and burnout commonly seen in healthcare workforce is a major concern (Baier et al., 2018; Crowe et al., 2017; Shah et al., 2021), any pre-employment strategies to counter these must be thoroughly researched and implemented.

Search Strategy and Selection Criteria

We searched three prominent databases (Medline, PubMed and Scopus) for peer-reviewed, English language articles published between 2000 and 2023. Search terms (simulation OR scenario) AND (education OR undergraduate OR training) AND (health OR medical) AND (physiological OR psychophysiological OR stress) were used to garner publications suitable for our narrative paper. Titles and abstracts were reviewed to confirm these criteria. Where all search terms were present or remained uncertain from initial review, each publication was read fully. Articles that did not meet requirements or were of poor-quality (lacking significant contribution of new knowledge, poorly written, or from predatory journals) were excluded. Additional studies were obtained from reference lists of retrieved articles. This structured search and selection approach was adopted to minimise potential article selection bias based on author knowledge and perspectives, however as a narrative review we acknowledge this cannot be avoided fully. This review has included a subset of high-quality publications that we thought were most pertinent and insightful to address the aims of this article.

BACKGROUND

To understand the stress experienced by paramedicine students, the psychophysiological relationship between stress and performance must first be addressed. The seminal biopsychosocial model, conceptualised in 1977 by George Engel an American academic and psychiatrist (Engel, 1979), identified that a person's medical condition was not only influenced by biology alone; it also involved psychological and social factors. A collaboration between Jim Blascovich, a Professor of Psychological and Brain Sciences, and Joe Tomaka, a Professor of Public Health, in 1996 led to a published update linking Engel's model to Hebb's work of arousal regulation (Blascovich & Tomaka, 1996). These authors discussed cognitive, physiological, and social dimensions as arousal-regulators with proposed impacts on stress levels.

In 1997, Tomaka and Blascovich teamed with others to publish work on challenge and threat (CAT) appraisal, determining that cognitive appraisal precedes physiological responses (Tomaka et al., 1997). This theory suggests that during the pursuit of a goal/s, increased psychological processes (anxiety, excitement, arousal, etc.) lead to specific patterns of cardiovascular responses - sympathetic nervous system innovation (SNS) in effect. The SNS, one of two branches of the autonomic nervous system, is activated when the brain senses a stressful situation. This leads to increases in visual acuity, strength and reaction speed in times of physiological or cognitive distress.

Considering the biopsychosocial model and expanding on the above theories, if a student feels they lack cognitive or procedural resources to meet the demands of a stressful clinical scenario, then a state of 'threat' appraisal occurs. However, if resources are perceived to sufficiently meet the demands of the scenario, then a state of 'challenge' appraisal emerges. Threat is correlated with 'losses' or poor performance, whereas 'challenge' has linkages to promotion or perceived 'gains' (Sassenberg et al., 2015). Positive and negative emotions can occur in a challenge state, while a threat state is associated with negative emotions only (Jones et al., 2009). The appraisal of the situation as a threat or challenge may be linked to previous experience or the perceived stress of the upcoming situation, with researchers identifying patterns of cardiovascular responses correlated to the level of stress exhibited (Tomaka et al., 1993; Tomaka et al., 1997).

Research proposes that while threat and challenge both involve physiological and psychological movement toward goal achievement, threat state is likely to be the more variable, fragile, and stressful of the two (Blascovich, 2013). Some of the first researchers to explore this field identified individuals who appraised situations as a challenge were more likely to exhibit confidence and less likely to be emotionally overwhelmed than those in a threat appraisal state of mind (Lazarus & Folkman, 1984). Importantly, research from the field of psychology demonstrated that during stressful situations, a challenge mindset enhances performance, whilst the threat mindset has been shown to hinder performance (Blascovich et al., 2004; Seery et al., 2010). In these studies, the stressful situation varied from a high-stakes athletic competition (Blascovich et al., 2004) to a theory-based college exam (Seery et al., 2010). This demonstrates that the while the context of the stressor varies, a heightened stress response is often a significant indicator of poor performance. Importantly, no one agreed method for measuring stress response has been established, and much research on stress and threat appraisal is laboratory-based with the source of stress often unrelated (Kirschbaum et al., 1995) or lacking relevance to the task at hand (Domes et al., 2004).

The phrase 'Arc of Performance' was coined by Doctor Stephen Hearns, the lead consultant for Scotland's Emergency Medical Retrieval Service and author of Peak Performance under Pressure (Hearns, 2020). Hearns based his Arc on the Yerkes-Dodson curve, first discussed in the psychological literature in 1908, as shown in Figure 1. In the original paper, Yerkes and Dodson (1908) reported on learning discrimination in dancing mice. Three different experiments were undertaken using various levels of non-injuring electricity and light stimulus to assess rates of learning. Forty-two mice completed the experiment over three consecutive days, each given a choice of an interchangeable white or black box to enter. If the mouse entered the white box, a correct choice was determined. If the mouse entered a block box, a weak electrical shock graduating to a higher intensity was delivered and an incorrect choice recorded. The first experiment evaluated the speed at which the mice could discriminate white from black relative to the intensity of the shocks administered. The result produced the now well-known inverted U-shaped curve suggesting the point where optimal level of arousal for peak performance occurs. Despite acknowledging flaws in their research and lacking any statistical analysis, the empirical research by Yerkes and Dodson is now widely used in research focusing on stress and performance.

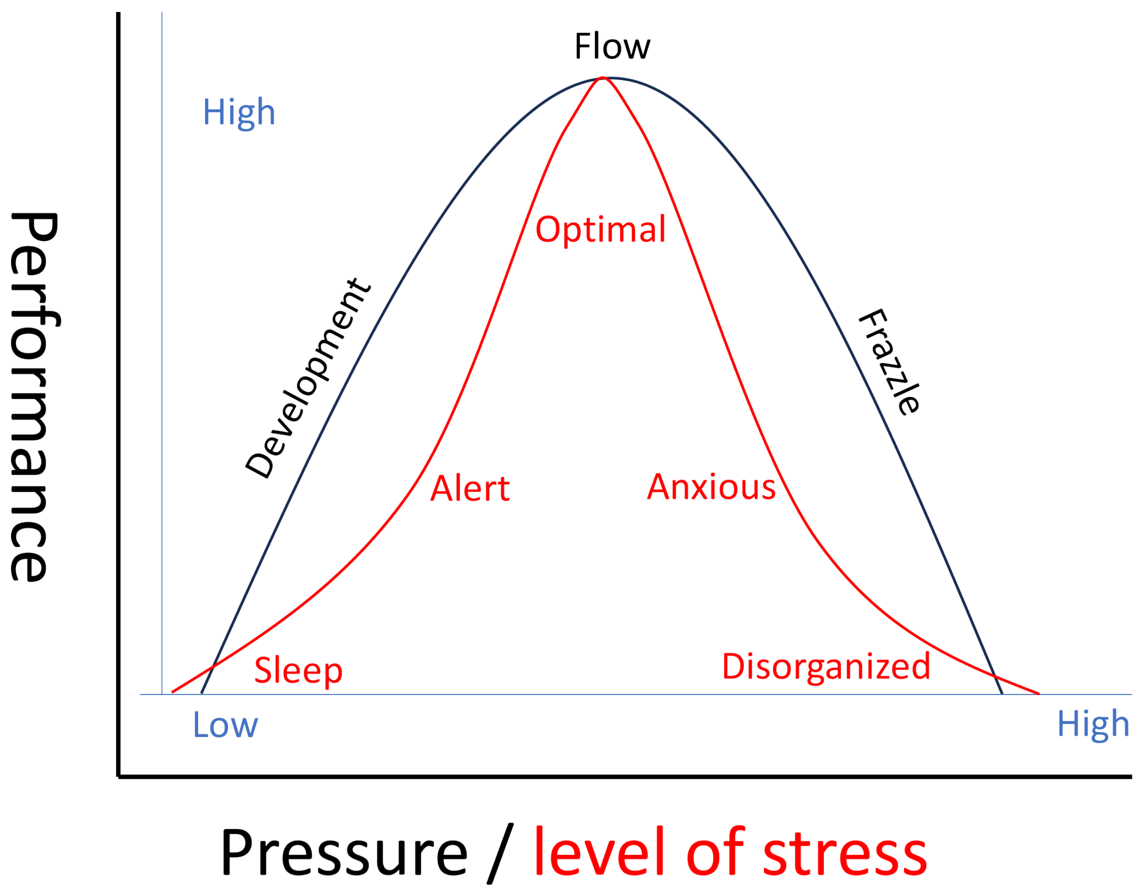

Figure 1: Hearns' Arc of Performance (in black) overlayed on Yerkes-Dobson (in Red).

The Yerkes-Dodson curve was first reported over a century ago and was conceived whilst studying mice, however, technological advancements now allow researchers to gain stress and performance data on human participants in real time. Considering Hearns' Arc of Performance in the context of CAT associated physiological changes to stress, researchers must gather objective data from several body systems, such as cardiovascular, respiratory, and neurological.

Measuring Cardiovascular Responses to Infer Physiological Stress

In response to a stressor, the heart and vascular system work together to ensure sufficient oxygenated blood is available to facilitate a flight response if required. Vital organs remain well perfused, while other body systems, such as digestion and reproduction, may be slowed or paused entirely (McCarty, 2016). In the context of CAT, appraising a situation as a challenge leverages high resources and low demands; conversely, threat appraisal results from a situation of low resources and high demands. Both states have been shown to increase heart rate (HR) and cardiac output (CO) when compared to rest (Seery, 2013). However, challenge leads to a decrease in total peripheral resistance (TPR) with a subsequent decrease in systolic blood pressure (SBP) and a decrease in blood volume of the microvascular bed of tissue. In the clinical setting, estimates of CO can be both invasive and expensive, leading to commonly used validated methods of obtaining estimated CO from HR and the mean systolic and diastolic blood pressure in non-clinical studies (Hill et al., 2011). Mean arterial pressure (MAP) is determined from a widely used algorithm (MAP (mmHg) = [1⁄3   SBP (mmHg)] + [2⁄3   DBP (mmHg)]). TRP is then calculated by dividing the CO by MAP, with that total multiplied by 80 (Sherwood et al., 1990).

Wearable devices, such as the Equivital monitoring system (ADInstruments, United Kingdom), the Biosignalsplux Hybrid (PLUX – Wireless Biosignals, Portugal) or the Hexoskin (Carre Technologies, Canada) are well established at measuring cardiovascular responses such as HR and SBP changes. This portable technology can also measure changes in skin sweat levels via a Galvanic Skin Response (GSR) sensor and an infrared Thermopile to detect peripheral skin temperature changes. A decrease in skin temperature accompanying an increase in sweat levels is indicative of a threat response from the vasoconstrictive sympathetic reflex. This can also be measured via a photoplethysmogram (PPG) sensor or a plethysmograph, which assesses Blood Volume Pulse (BVP) variability at common sites such as the fingers, forearms or calves. During the threat appraisal stage, most people will demonstrate a reduction in blood volume to the microvascular tissue beds at these sites.

To objectively measure CAT-induced cardiovascular responses, a triangulation of data should be gathered including HR, TPR and GSR, to obtain a full picture of the physiological changes. Ideally, one device or system should be capable of acquiring the cardiovascular data described. However, researchers must be aware that some systems require annual software licencing or cloud-based subscription that can significantly impact costs associated with the technology purchase.

Measuring Hormones for Stress Response

It has already been established in the review that stressful situations predominantly trigger a cardiovascular response. This, in turn, facilitates neurohumoral activation leading to secretion of the glucocorticoid cortisol from the adrenal cortex (Kim et al., 2009). Cortisol is considered the main biomarker in physiological stress research (Hellhammer et al., 2009). In experimental studies, mean cortisol responses to acute stressors have ranged from 29% to > 200% above baseline levels (Bohnen et al., 1990; Buchanan & Lovallo, 2001; de Quervain et al., 2000). Once released into the bloodstream, cortisol acts on almost every cell in the body to maintain allostasis. Furthermore, cortisol stimulates gluconeogenesis (Melmed et al., 2015) and glycogenolysis with rapid increases in circulating blood glucose levels (Pradhan & Goel, 2011). By mobilising energy to deal with actual or perceived environmental or physiological stressors, internal equilibrium can be maintained. Blood glucose levels can easily be measured by a single drop of blood from a finger and an inexpensive glucometer.

Cortisol also increases cardiovascular output, redistributes blood flow, increases immune response, and causes a marked spike in cerebral perfusion and glucose utilisation (McEwen & Seeman, 1999). To assess the impact of stress on the neuroendocrine axis, researchers can sample adrenal medullary catecholamines (epinephrine and norepinephrine) from either plasma, saliva or urine (Noushad et al., 2021). During periods of acute stress, sympathetic neurotransmitters epinephrine and norepinephrine levels increase and are subsequently regulated in the flight or fight response by the parasympathetic neurotransmitter acetylcholine (ACh) (Won & Kim, 2016). Due to the rapid action of catecholamines and the transient nature of recordable levels, researchers often focus on more stable hormones as indicators of CAT appraisal.

The adrenal hormone dehydroepiandrosterone (DHEA), released from the hypothalamus-pituitary-adrenal cortex (HPA) as a physiological response to stressful situations, is one of those that can be sampled (Sherwood, 2008). While the complete actions of DHEA and it's sulphated ester dehydroepiandrosterone-sulphate (DHEAS) are not fully understood, research has shown that it is released at higher levels in individuals experiencing stress-related situations (Oberbeck et al., 1998) and in people with symptoms of exhaustion (Sonnenschein et al., 2007). A study by Roth et al. (2002) on primates showed that diet control and caloric restriction resulted in DHEAS levels being maintained at youthful levels, leading the popular press and social media to label DHEAS as the 'fountain of youth' (Dhatariya & Nair, 2003). Despite a lack of human testing, this paper by Dhatariya and Nair (2003) supported earlier work by Nawata et al. (2002) to hypothesise that if DHEAS serum levels were artificially maintained as humans aged, better health maintenance, increased longevity and less burnout might result.

The non-invasive nature of salivary cortisol and DHEA testing and the ability of participants to administer the test themselves makes it an appropriate test for stress levels. Salivary cortisol samples have been found to be stable when stored at 5oC for up to three months and up to one year when stored at -20oC (Garde & Hansen, 2005). A consistently high correlation between the accuracy of saliva cortisol testing and plasma cortisol testing has also been found (Francis et al., 1987; Ryoji, 1981; Vining et al., 1983). Urine sampling research has also been undertaken to assess cortisol levels (Soo-Quee Koh & Choon-Huat Koh, 2007); however, as urine can remain in the bladder for extended periods and the half-life of cortisol is known to be approximately one hour (Gatti et al., 2009; Weitzman et al., 1971) the validity and practicality of urine sampling may be difficult in some settings.

Duplicate analyses of the salivary DHEA or cortisol levels are recommended using an enzyme-linked immunosorbent assay (ELISA) technique in a commercial laboratory (Gatti et al., 2009). Researchers need to be aware of the possible interactions of diet and DHEA / cortisol secretion. Proteins, specifically meat products, have been shown to stimulate cortisol secretion (Anderson et al., 1987; Benedict et al., 2005; Slag et al., 1981), and care must be taken not to allow diet to influence testing. Furthermore, consumption of alcohol, nicotine and caffeine (Kudielka et al., 2007) and certain medications (Brody et al., 2002; Fries et al., 2006) have been shown to impact the magnitude and duration of the stress response. Researchers assessing salivary DHEA or cortisol as an objective measure of stress must request that participants refrain from eating large portions of food or consuming any alcohol, nicotine or caffeine prior to testing. Also, participants should be excluded based on specific medications that might impact hormone, catecholamine or glucose levels. Based on this literature, it is our recommendation that salivary cortisol samples be obtained after a period of fasting for a minimum three hours. For studies that assess student response over multiple days, subsequent samples must be obtained at the same time of the day under the same conditions. The addition of DHEA sampling is expensive and would not be required for most studies of acute stress response where cortisol sampling is relatively simple to facilitate.

Cognitive Capacity and Cognitive Overload

The physiological stress responses discussed thus far are relatively easy to measure using simple wearable devices and collection aids. More challenging for researchers is the ability to gather objective measures of cognition and cognitive capacity in realistic situations away from the large-scale laboratory-based environment. Before exploring novel ways of doing this, a brief overview of cognition and memory processing follows.

Short-term memory, particularly the working memory, is the part of cognition where information is processed quickly, and decisions are made rapidly. Under pressure, the working memory can become overwhelmed, leading to cognitive overload. As part of the survival mechanism, the brain also utilises automatic processing (Hasher & Zacks, 1984), a subconscious rapid response reliant on previous exposure to a situation to where the brain matches the previous encounter and outcome achieved. This is pattern recognition and is seen as a 'cognitive shortcut' (Hearns, 2020). A novice may not have sufficient experience to facilitate automatic processing and is, therefore, more likely to rely on a thorough and considered process of analytically assessing each situation. This slows decision-making, uses more cognitive resources, and increases stress levels. As a way of attempting to reduce stress and reduce the cognitive overload, novices may practice repeatedly until their actions become more automatic in nature. This is known as procedural or muscle memory, and research shows that when under pressure, procedural memory is accessed preferentially (Knowlton & Greenberg, 2008; Siller-Perez et al., 2017; Wirz et al., 2018).

Another potential issue affecting novice clinicians is the Dunning-Kruger Effect, sometimes referred to as unconscious incompetence (Bradley et al., 2022), as shown in Figure 2. In this scenario, inexperienced clinicians will underestimate the severity of the problem they face, or more commonly, overestimate their abilities. A degree of stress should be associated with a high acuity patient presentation, so when the inexperienced clinician presents overtly calm in that situation it may indicate that they are unaware of the clinical severity of the presenting patient. Kruger and Dunning (1999) first reported their findings in response to a series of studies evaluating participants' level of knowledge, along with their social and logical reasoning. They found that individuals commonly overestimated their performance whilst simultaneously lacking the ability to recognise their incompetence. This led Nancy Diekelmann, a transformative figure in nurse education, to famously quip "you only know what you know, and you don't know what you don't know…don't you know?" (Diekelmann & Diekelmann, 2009) (pg. 85). For researchers in this field, the ability to objectively measure cognition or neural activity, alongside clinical ability, may provide valuable insight into the Dunning-Kruger Effect. Researchers would expect to see large increases in neural activity for particularly stressful or high acuity scenarios; however, if this was not evident, then we may determine that the student is either underestimating the severity of the problem they face or overestimating their abilities. Insight via quantifiable data, may provide the learner and researcher with strategies to mitigate the Dunning-Kruger Effect.

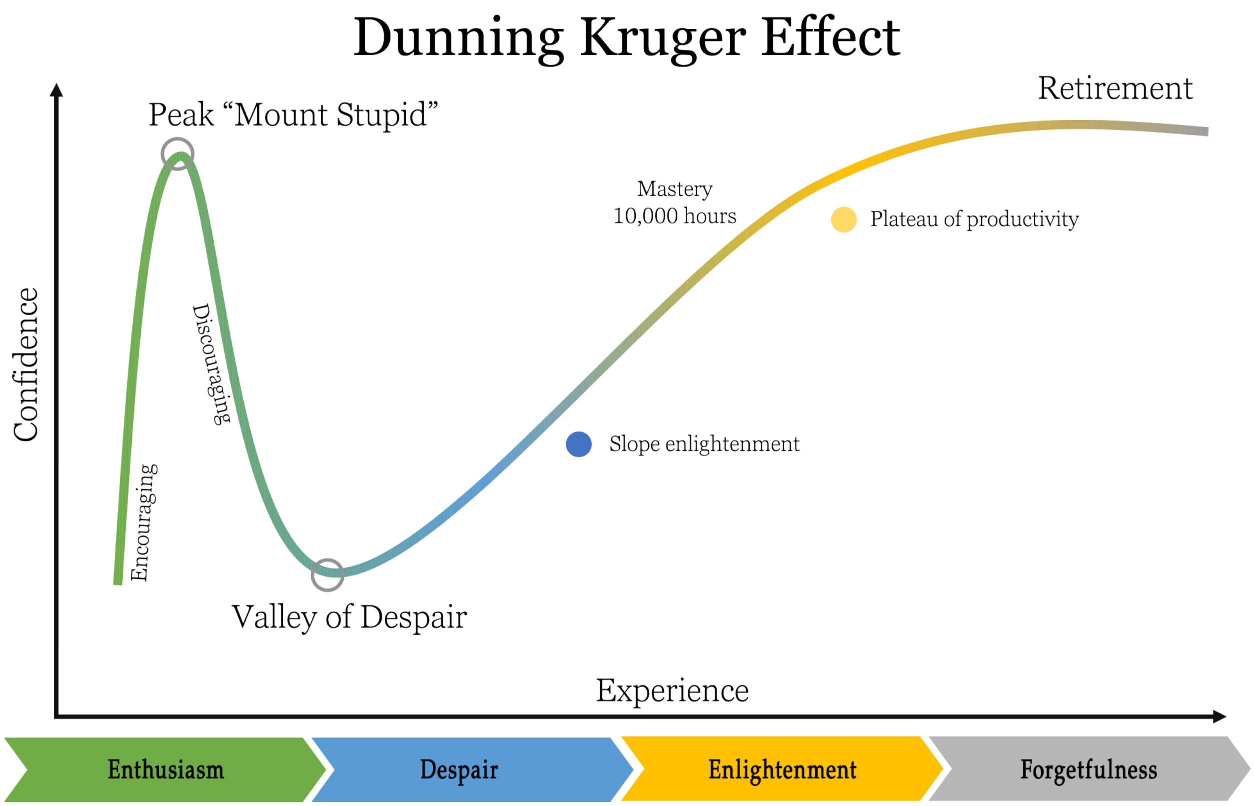

Figure 2: The Dunning Kruger Effect – adapted from work by Kruger and Dunning (1999)

Methodology of Wearable Devices for Cognitive Load Assessment

German Psychiatrist Hans Berger first used electroencephalogram (EEG) on human subjects in the 1920's as a tool in psychiatric diagnosis (Perron, 2015). Recently, EEG has expanded from clinical diagnostics to being used more widely in research aiming to assess cognitive load. The term cognitive load, like stress, is an umbrella term that encompasses different concepts in different disciplines. Cognitive load theory, first discussed in the 1950s, is based in instructional education (Miller, 1956). Miller's theory centres around the ability of the human memory to process a limited number of new elements of information at any particular time. Once this capacity has been exceeded, further learning is impaired (Bong et al., 2016). Whilst Miller's theory explained cognitive load in relation to learning, further work has linked increased cognitive load to decreased acquisition of motor skills (Paas & Sweller, 2011) and decreased performance in complex tasks (Van Gog et al., 2011).

The threat response leads to elevated physiological stress levels, increased cerebral perfusion, and increased beta band (13-25 Hz) activity at the anterior temporal sites (Seo et al., 2010). Antonenko and Niederhauser (2010) further identified increased oscillations in the alpha and theta bands correlated with increased cognitive load. Additionally, EEG recordings obtained from the parietal, central, and frontal lobes of the scalp have also been shown to demonstrate increased arousal and brain activity during periods of stress (Rahnuma et al., 2011). With the rapid expansion of wearable EEG technology, ranging from high-end amplifiers such EEGO (ANT Neuro Pty Ltd, The Netherlands) and SmartingPRO (mBrainTrain, Serbia), to 'off the shelf' real-time monitoring devices such as the Muse 2 Band (InteraXon Inc, Canada) or EMOTIV Insight 2.0 (EMOTIV, USA), it may be possible to obtain unobtrusive measures of the physiological response in brain activity (Gradl et al., 2019) to the threat appraisal. For any researcher, cost is a constant consideration. Cheaper products rely on pre-built software algorithms to define stress and cognitive load, which may need further study and validation. Another consideration for portable EEG monitoring is that participant movement can greatly affect the EEG signal and present as gross artifact which may be a limitation in data acquisition during mobile scenarios.

Technological advancement has seen rapid expansion in the use of functional near-infrared spectroscopy (fNIRS) to assess cognitive load. fNIRS uses wavelengths of near-infrared light as a method for studying neural activity outside the clinical laboratory (Pinti et al., 2020). In a similar way to functional magnetic resonance imaging (fMRI), fNIRS uses near-infrared light to estimate cortical hemodynamic activity and increased cerebral metabolic demands as proxies for increased neuronal activity (Meidenbauer et al., 2021). In simplistic terms, when brain activity increases, metabolic demand increases and so does the flow of oxygenated blood. The non-invasive nature of fNIRS allows neural activation to be measured in naturalistic settings and has been shown to be an excellent tool for tests of cognitive stress (Buxton, 2010). As discussed earlier, stress affects both neurological and cardiac function and leads to an increased HR. Typically, HR is assessed using an ECG or chest-worn HR monitor. Of note, HR can also be obtained from the fNIRS signal and has been shown to be better align with mental stress as opposed to chest-worn measurements of HR alone (Hakimi & Setarehdan, 2018). This can also reduce the need for multiple biosensors in the same experiment. These systems range in price from high-end research products such as the NIRSport2 (NIRx Medizintechnik GmbH, Germany), mid-range such as Octamon+ (Artinis Medical Systems, The Netherlands), to more consumer-orientated products such the Biosignalsplux Hybrid (PLUX – Wireless Biosignals, Portugal). The benefit of this emerging and evolving research technology is the ability to connect wirelessly to the recording computer allowing for full mobility studies with less artifact than EEG produces.

In summary, to objectively measure CAT-induced stress responses, researchers must gather a combination of cardiovascular and cognitive data while concurrently assessing hormonal changes to obtain a holistic appraisal of the participant's physiological stress state. Which individual device or combination of wearable technology that researchers chose will depend on funding and specific data acquisition requirements. The Biosignalsplux Hybrid system has a fNIRS component along with cardiovascular sensors, allowing researchers to utilise just one system and avoid the need for multiple software interfaces and charging stations. Ultimately, our recommendations are for researchers to test this technology and chose a system that delivers the objective data they require within available funding constraints.

Quantitative Psychometric Tools – Demand and Resources Questionnaires

To support objective data, researchers must utilise qualitative or subjective questionnaires to add detail and context to objective data recorded. The word psychometric literally means "measurement of the mind" (Hammond, 2006), and there are a great many psychometric tools available to researchers. One of the first attempts at measuring stress on a numerical scale was the Social Readjustment Rating Scale (SRRS) developed by Thomas Holmes and Richard Rahe in 1967 (Holmes & Rahe, 1967). The SRRS consisted of 43 items with Yes/No responses relating to life experience events over the preceding 12 months, so in effect, became a measure of chronic as opposed to acute stress. A variety of other scales were adapted from or attempted to improve the SRRS; such as The Hassles Scale (Kanner et al., 1981), Stressful Life Experience Screening (SLES) (Stamm, 1996) and the Life Stressor Checklist – Revised (Wolfe et al., 1997), amongst others. In realty, these tools are measures of 'stressors' and do not measure acute stress.

Numerous and diverse psychometric tools exist to assess acute psychological response to stress. Early questionnaires, such as the Taylor Manifest Anxiety Scale (TMAS) (Taylor, 1953), utilise a large number of true/false questions (50 in the case of TMAS) to produce a sole outcome measure (such as anxiety). Another commonly used questionnaire is The State-Trait Anxiety Inventory (STAI) (Spielberger, 1970). The STAI works from the TMAS to measure trait anxiety from half of the questions and also measures state anxiety (an acute situational-dependent psychological state) from the other 20 questions (Everly & Lating, 2002; Fein, 2017). The Subjective Stress Scale (SSS) (Berkun et al., 1962) is frequently reported in the literature and utilises 14 descriptors to measure situational (state) stress during a stressful situation. Both the STAI and SSS are validated (Johnston & Hackmann, 1977; Taylor et al., 1968) and can be administered rapidly, making them useful tools for assessing subjective stress in scenario-based education.

The scales discussed so far are all non-appraisal based, intended to determine a point-of-time score for acute stress. The Stressor Appraisal Scale (SAS), validated and described by Schneider (2008), is used to determine cognitive appraisal before a stressful event is attempted. Primary appraisal items include: (1) how threatening do you expect the upcoming task to be?, and (2) how demanding do you think the upcoming task will be?, amongst other similar questions. Secondary appraisal items included: (1) how well do you think you can manage the demands imposed on you by this task?, along with two other similar appraisal questions. Using a 7-point Likert scale to quantify results, if resources are deemed to be greater than or equal to demands, then the scenario can be deemed a challenge. If demands are scored as higher than resources, then the participant perceives the scenario as a threat. Recommendations by Hase et al. (2019) suggest the CAT score difference is calculated in place of a ratio, as ratio scores often produce highly nonlinear distribution (Vine et al., 2013).

Both the SAS and STAI are validated in the literature, providing excellent test-retest reliability, and are inexpensive and easy to administer. However, the SAS is targeted specifically for cognitive appraisal of CAT and is therefore recommended as a subjective adjunct to support objective data gathered in this field of research.

LIMITATIONS

As a narrative review, the intention is not to discuss all possible measures of psycho-physiological stress nor the ever-evolving technology to obtain these measures. This is acknowledged as a limitation, and researchers in the field should explore novel technologies and questionnaires most suited to their experimental protocols. Other limitations are acknowledged regarding the inherent nature of the search and selection of relevant published work for narrative reviews. The lack of structured methodologies and standard quality assessment criteria can lead to subjectivity in literature selection and interpretation, potential overrepresentation or underrepresentation of certain viewpoints, and challenges in replicability. Whilst a large body of literature examining physiological and psychological stress exists, very few publications quantify both in the same sample population. Even fewer specifically study healthcare students. This scarcity of published literature can be seen as a limitation but also a reason for producing a narrative review to give a broad perspective and encourage future research of this topic. Finally, the intention of this paper is to provide guidance and suggestions to researchers, unlike a systematic review which would present definitive generalized conclusions on a specific topic.

CONCLUSION

The biopsychosocial model emphasizes the interconnectedness of biological, psychological, and social factors in shaping an individual's response to stress. The appraisal of a situation as a threat or challenge is a subjective process influenced by these multiple factors. Research in business and sport shows that challenge appraisal leads to improved performance, and it is reasonable to assume similar correlations exist in health education. However, inconsistent methodologies that utilise a variety of physiological and cognitive measures make it challenging to draw firm conclusions. A combination of objective physiological data with behavioural observations and self-reported assessments may help researchers obtain a well-rounded view of whether an individual perceives a situation as a threat or challenge. Specifically, it is our recommendation that researchers undertaking experiments in this novel field gather objective data from multiple body systems that are supported by validated and convenient subjective stress appraisal scales. Additionally, the interpretation of data should consider individual differences, contextual factors, and the dynamic nature of stress responses. Only once this has been done can a succinct understanding of challenge or threat appraisal be determined.

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