INVESTIGATION OF STRESS SYMPTOMS AND INTERVENTIONS IN FIREFIGHTERS

Tamara Dawn Lorensen

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Abstract

Emergency responders' health and wellbeing is challenged by the cumulative stressors associated with the demands of their occupations. Firefighters in particular experience heavy operational demands and a range of stressors. These include for example, sleep disruption due to alarms and shift work; physical demands, such as the use of heavy personal protective clothing during fire management; and psychological demands such as human rescue and recovery. These stressors are features of the occupation and can be accumulative in their negative effects. A serious potential outcome is the development of posttraumatic stress disorder (PTSD).

There are a range of stress symptoms that can occur separately or as part of a potential trajectory to PTSD. Interventions often only occur at the stage of clinical diagnosis when functioning is impaired and there is significant psychological distress, and there is evidence that current interventions are inadequate due to the heterogeneous nature of the disorder. Further, there is little known about pre-PTSD or subclinical distress and the trajectory to PTSD. Consequently, there is increasing interest in exploring not only pre-PTSD conditions but also early interventions to build resilience and potentially prevent progression of symptoms from becoming clinically significant.

This research is underpinned by the use of concepts from stress theories, such as the resistance phase of the General Adaptation Syndrome, from Selye (1951), and more recently, the theory of allostasis with allostatic accommodation and allostatic load, by McEwen and Seeman (1999). Hence, this research considers two studies of aspects of PTSD among Queensland firefighters: first, pre-PTSD states (Study 1);

and second, the efficacy of an early intervention (Study 2), also pre-PTSD. Both studies are briefly reviewed below.

Study 1 takes a staging approach to identify homogeneous sub-groups that could potentially access early intervention to prevent progression to a more complex disorder. The staging model proposed by McFarlane, Lawrence-Wood, Van Hooff, Malhi, and Yehuda (2017) is explored to identify homogeneous sub-groups with early and subsyndromal symptoms of PTSD. The proposed model consists of five stages, representing increasing levels of symptom distress. One of the goals of staging is to identify those with early symptoms for preventative interventions and this research explores Stage 0 (asymptomatic) to Stage 2 (early PTSD). To conduct this research, Study 1 took the form of a survey of Queensland firefighters and latent class analysis was employed to identify unobserved latent groups. The survey consisted of multiple self-report measures that aligned with the Diagnostic and Statistical Manual of Mental Disorders 5. The latent profile analysis revealed a profile containing four classes which could be mapped to the staging model (N=88). Findings indicated that the prevalence within each class was representative of previous reporting of subclinical prevalence rates. Further, through staging and latent class analysis, heterogeneity of symptoms across the sample was reduced, which has implications for developing more targeted interventions. In addition, this finding has implications for researchers examining the efficacy of interventions by potentially staging symptoms. Another significant finding was that the staging of symptoms was able to be aligned with the theoretical underpinnings of stress disorders reviewed in this research. There was also evidence for the effects of accumulative stress in terms of the association between self-reported stress symptoms and number of years in service. Study 1 found that longer time in service was associated with higher distress scores.

Study 2 investigated the efficacy of an early intervention to shift potentially chronic stress responses to more stable and flexible responses. The study used neurofeedback as the intervention. Neurofeedback is a brain–computer interface that provides participants with real-time feedback of brain states. Through the process of operant conditioning embedded with learning theory, participants are able to train their brain circuitry to improve functioning.

Study 2 consisted of a 2 (1 * treatment, and control) x 3 (time 1, time 2, and time 3), controlled, factorial design with repeated measures (N=21). Both groups undertook self-report measures of symptom concerns at baseline and follow-up and, for the experimental group, long term follow-up. Analyses consisted of between-group ANOVAs and within-group repeated measures ANOVAs. Findings demonstrated statistically significant differences with positively altered symptom profiles in the experimental group, which were sustained over time. The control group, in contrast, showed no significant change from baseline to follow-up.

This research contributes to the growing need for evidence demonstrating efficacy of the early intervention treatments by applying a staging model of posttraumatic stress disorder symptom concern and designing a treatment option for the mid-stage of pre-posttraumatic stress. It evaluates and demonstrates the effectiveness of neurofeedback in building long-term resilience and managing symptoms of subclinical or emerging mental health disorders in emergency responders. This research is significant as there is a dearth of studies of evidence-based interventions for the treatment of pre-clinical conditions associated with stress and pre-PTSD in firefighters.

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List of Abbreviations

Abbreviation	Full term
BFB	Biofeedback
DSM-5	Diagnostic & Statistical Manual of Mental Disorders-5
EEG	Electroencephalogram
fMRI	Functional magnetic resonance imaging
GAS	General adaptation syndrome
Hz	Hertz
LPA	Latent profile analysis
mV	Microvolts
NFB	Neurofeedback
PCL-5	Post traumatic checklist – 5
PTSD	Post-traumatic stress disorder
QFES	Queensland Fire & Emergency Services

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Chapter 1: Introduction

> "On the afternoon of 10 January 2011, several of the Queensland Fire and Rescue Swift Water Rescue teams deployed to the vicinity of Murphy's Creek following major flooding that inundated the Lockyer Valley. They deployed as teams and conducted search and rescue operations, several members narrowly escaped being engulfed by floodwaters as they drove across a bridge which was hit by a wall of water and debris several metres high which crashed into it before they were able to reverse off the bridge. During separate incidents, other team members nearly drowned or were swept away. In horrendous conditions and in darkness, they searched damaged houses, properties, vehicles, waterways and creeks where they located and rescued men, women and children, some of whom had been stripped of their clothing by the forces of the water. Using swift water rescue techniques they conducted rescues on foot, wading through waist-high mud and water, and by inflatable rescue boat. The team also located deceased persons and advised the police. As they continued to sweep the area, they also released many animals and livestock who were trapped in flooded paddocks. The team performed numerous rescues in the Murphy's Creek, Grantham and Leichhardt areas until early on 12 January 2011" [two days later]
>
> (Group Citation — (Queensland Office of the Governor General, 2019, p. 29)

The moving citation above demonstrates the hazardous and emotionally demanding nature of the firefighter's profession. This program of research focuses on firefighters' health and wellbeing and specifically aims to explore and identify mental health symptom levels according to a proposed staging model that may reflect the trajectory to post-traumatic stress disorder (PTSD).

While a potential endpoint of exposure to trauma and accumulative stress may be post-traumatic stress injury or disorder, there is growing recognition that early

intervention may be preventative of this as an outcome (Hetrick et al., 2008; Scott et al., 2013). What is not usually addressed in the application of early intervention, however, is the identification, or even the exploration, of the 'staging' of the possible pathway or trajectory to PTSD. Staging may permit improvements to intervention designs that can address the level and severity of symptoms. PTSD is not an 'all or nothing' phenomenon (Schnurr, 2014), and this research assists in demonstrating that staging can effectively identify the levels of pre-diagnosis symptoms that would allow an intervention to be tailored to an individual. Using a staging approach to clinical assessment and subsequent intervention may lead to better outcomes and more consistent results and therefore contribute to resilience-building efforts.

In addition to exploring the staging of symptoms, this research also involves a program of neurofeedback (NFB) to test to what extent symptoms may be modifiable and positively alter a person's symptom profile. NFB is a brain-computer interface that provides biofeedback based on the electroencephalogram. This program focuses on early intervention as a way of potentially resetting and reducing stress responses that may linger and accumulate, worsening mental health.

Research Problem

The work of an emergency responder is associated with a high level of stress and traumatic stress consequences, including PTSD. There are multiple types of stressors for emergency responders related to operational experiences on the job — for instance, attending car accidents that have caused injuries or death, confronting violent people, and performing high-risk rescues (Harvey et al., 2016). In addition, there are stressors that are physiological in nature, such as the fatigue of extended duty hours; the use of heavy personal protective clothing and equipment (Aisbett, Wolkow, Sprajcer, & Ferguson, 2012); and regular deprivation of sleep due to shift

work (Barger et al., 2015). Further stressors include the challenges of working within a large organisation, and of coping and functioning as a member of the community and being part of a family after a challenging day. Operations occur in shifts 24 hours a day, seven days a week. These challenges can lower emotional and physical resilience, which can have a negative impact on the ability to cope with the emotional demands of exposure to traumatic events (McEwen, 1998). In addition, with increasing chronic or persistent stress, there is an increasing likelihood of failure of the ability to self-regulate mood and behaviour (Vohs & Baumeister, 2016).

In a submission to a Commonwealth senate inquiry into the mental health of emergency responders (Parliament of Australia, 2018), McFarlane (2018) stated that high rates of mental health disorders are a predictable phenomenon in first responders given their cumulative exposure to trauma. A dilemma is that while research has shown that a high level of resilience is associated with being less prone to appraising events negatively (Oginska-Bulik & Kobylarczyk, 2016), evidence also demonstrates that this is eroded with cumulative stress and trauma exposure related to the job, underscoring the importance of exploring early identification of symptoms and interventions (Harvey et al., 2015; McFarlane et al., 2017; Nijdam, Vermetten, & McFarlane, 2023; Skeffington, Rees, & Mazzucchelli, 2017). Limited research has been carried out to consider cumulative stress, the trajectory towards PTSD, the identification of subclinical PTSD, and the associated stress symptoms. Furthermore, until very recently, there have been very few rigorous studies on the early interventions that may alleviate stress symptoms. This is discussed further in Chapters 2 to 4.

In summary, there is agreement in existing research that cumulative stress leads to increased rates of mental health disorders (Friedman, 2014; Harvey et al., 2015).

There is also limited but growing evidence that demonstrates the benefits of early intervention treatments to assist in building resilience are protective or prevent the development or progression of mental disorders (Friedman, 2014; Harvey et al., 2016). There is, however, a need to identify the underlying stages of the progression to PTSD in order to develop targeted interventions. This is further explicated in Chapter 2 to 4.

Research Context

Serving as an emergency responder should not be at the expense of one's health and wellbeing and yet it appears to be so. Many emergency responders experience harm to their wellbeing through the very act of doing their jobs and through the stressors of organisational employment (Skeffington et al., 2017). The literature is consistent in its appraisal of heightened exposure to potentially traumatic events within the firefighting profession (Berninger, Webber, Cohen, et al., 2010; Halpern, Maunder, Schwartz, & Gurevich, 2011; Harvey et al., 2016; Murphy, Beaton, Pike, & Cain, 1994). Hazards are faced routinely and range from fighting fires, extricating accident victims from vehicles, recovery of the deceased and placing themselves at personal risk for the rescue and safety of others (Lee, Lee, Kim, Jeon, & Sim, 2017).

Papazoglou and Tuttle (2018) described some unique dual roles of police officers, such as law enforcer and social worker. A similar duality is found in the roles that firefighters take on during emergency operations—they fight fires and perform rescues, but also protect and serve the community. In violent or distressing encounters, for example, firefighters may deal with people resistant to rescue, they may be railed against, or even spat on, when an individual is angry or fearful. They may themselves become victims of violence; they may fear for their own lives or the

lives of their colleagues; they may enter premises not knowing what they will face; and they may take on the role of counsellor in de-escalating panicked community members (Martin, Marchand, & Boyer, 2009).

Another similar group of first responders is that of paramedics, who face trauma on a daily basis and are a particularly high-risk group (Petrie, Milligan-Saville, et al., 2018). They face stressors in providing emergency care, including failed rescue or resuscitation of persons, confrontation with victims, or dying victims (Jonsson, Segesten, & Mattsson, 2003; van der Ploeg & Kleber, 2003). These scenarios also apply to firefighters when they are often the first responders 'on scene'. It is noteworthy that, in the Australian context, all three emergency services will often attend a critical incident, essentially exposing all personnel to similar challenges and stressors.

Organisational stress is another contributing factor to the stress burden of emergency responders. Research by Allen, Bennett, and Heritage (2014) showed that organisational stress was a significant contributor to overall stress and negative mental health among 617 emergency workers in the UK, and that work factors were associated with more than thirty percent of reported negative emotions. Some examples of such factors include a lack of operational resources, which can heighten feelings of helplessness in a rescue response, and internal organisational conflicts, which can lead to a perceived lack of the psychosocial support of connectedness (Armstrong, Shakespeare-Finch, & Shochet, 2016). The impact of workplace stressors alone has been borne out in general in Australian health statistics (Medibank Private, 2008).

The statistics in Australia and across industrialised societies indicate that occupational stress results in social and economic costs for individuals,

organisations, and economies. In 2008, the overall health-related cost of occupational stress in Australia was estimated to be $14.81 billion annually, with direct costs to employers of $10.11 billion (Medibank Private, 2008). In a more recent survey by Medibank Private (2017), it was found that the incidence of stress has increased with the number of Australians affected in a five-year period 2012 to 2017 rising from 3.7 million to more than 4.9 million. It has been suggested that stress and mental health concerns are rising rapidly to become the primary problem within the workplace (Harvey, Henderson, Lelliott, & Hotopf, 2009; Joyce, 2019). Given these general population statistics, emergency responders represent an ever more significantly at-risk occupational category due to the additional, severe, destructive, and often fatal events that they deal with on a regular basis.

The impact of stress on the mental health of emergency services personnel was reviewed in a parliamentary inquiry into the rising rates of mental illness (Parliament of Australia, 2018). The submissions made to the inquiry highlighted that both operational duties and organisational stressors were the largest contributors to negative mental health outcomes. A final report, tabled in Feb 2019, made recommendations to improve organisational support, remove stigma around mental health, and provide earlier and more extensive access to support services. These findings were more recently reviewed in an extensive survey of over 14,000 Australian emergency workers and confirmed the risk of mental health conditions associated with these occupations (Kyron et al., 2022)

Stress is thus costly, for the individual, for the community, for the organisation, and for the national economy. Therefore, there is a need to consider the veracity of stress theories and the efficacy of interventions to assist in managing stress in workplaces. These factors are foremost in this research, which examines stress

theories from a current perspective and interventions that take a unique evidence-based approach using information about brain-behaviour influences on stress. According to Fink (2016), stress is a highly personal phenomenon that varies based on individual vulnerabilities and resilience between people, types of stressors and even between cultures.

Research Aims and Questions

This program of research consists of two studies. Study 1 focuses on measuring firefighters' health and wellbeing to explore a staging model of PTSD, as proposed by McFarlane et al. (2017), of increasing mental health problems spanning from asymptomatic to fully diagnosed. It is important to note here that PTSD is a potential endpoint of chronic stress and trauma exposure, and as mentioned, is not an 'all or nothing' phenomenon (McFarlane et al., 2017; Schnurr, 2014; Skeffington et al., 2017; Wagner et al., 2020). The research explores and identifies levels of stress, in homogeneous groups within the participants, that are potentially modifiable and that could inform and contribute to early interventions (i.e., before there is a mental health problem), to build and maintain resilience. Study 1 explores the proposed staging model to see whether symptom self-report can be aligned to a level of stress and a stage. This staging of symptoms aims to contribute to an improved understanding of ways to manage stress and build the resilience necessary for firefighters. The research activities for Study 1, exploratory in nature, assesses firefighters via a survey to determine early-stage homogeneous subgroups by self-report measures of stress symptoms. The study uses standard psychological measures that reflect, through the endorsement of symptoms, the level of distress or the frequency with which a symptom occurs. In this context, this is a type of positive symptom endorsement. It is expected that homogeneous subgroups can be identified,

with implications for the development of targeted and effective interventions and allowing an opportunity to correct heterogeneity. The exploratory research question for Study 1, which aims to measure levels of symptoms to map to the staging model is:

RQ1: How can self-reported levels of stress symptoms as measured by standard psychological tests be applied to a staging model to identify homogeneous subgroups of symptom severity?

It is additionally suggested that a longer length of service among firefighters likely contributes to accumulative stress exposure, so it is hypothesised that firefighters with longer service will show increased stress symptomatology. This is an important aspect of this research and is of consequence to a greater understanding of stress and its possible trajectory.

Study 2 investigates an innovative intervention—neurofeedback—as a means of supporting psychological health to build resilience and to investigate whether through neurofeedback an individual can reduce their stress symptoms. This could have implications for the costs associated with stress for both the individual and the organisation.

The same measures are largely used in the two studies to identify a baseline of symptom concerns. The aim of Study 2 is to improve the health, mental health and wellbeing of firefighters as well as to demonstrate the ability to restore stable functioning. The research objective is to investigate whether neurofeedback can substantially alter self-regulation (emotional, behavioural and physiological) capacity positively to improve stress symptoms and responses. Self-regulation capacity is discussed further below.

The following hypotheses were formed:

H1: Firefighters in the experimental group will show improved scores for stress symptoms as measured by self-report standard psychological measures from pre- to post-intervention.

H2: Firefighters in the experimental group will maintain positive changes in stress symptoms as measured by self-report standard psychological measures at long-term follow-up after the intervention.

H3: Firefighters in the control group that do not engage in the intervention will show no change in stress symptoms as measured by self-report standard psychological measures from baseline to follow-up.

Both studies aim to test whether accumulative stress and trauma exposure lead to more mental health problems. As well, to explore the possibility that the pathways or trajectories to PTSD are discontinuous, non-linear, and heterogeneous. It is important to identify early-stage symptoms that are modifiable and may prevent progression to clinical diagnoses but to also examine the efficacy of neurofeedback as an intervention. Both studies investigated the phenomena in the context of career members of the Queensland Fire & Emergency Services (QFES).

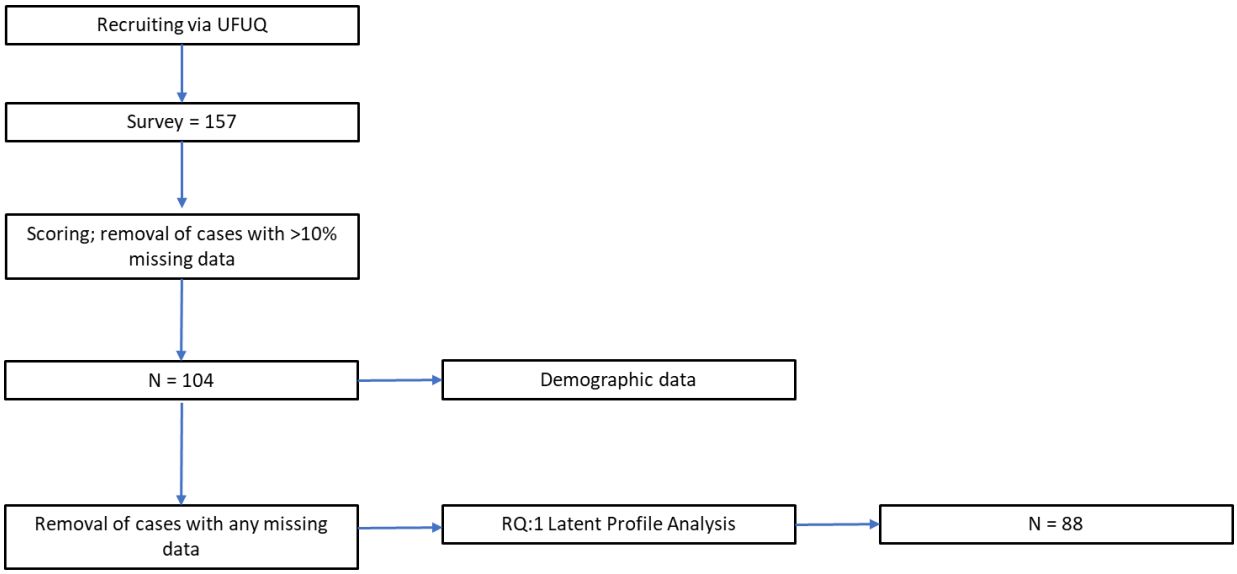
Research Design

Study 1 consisted of an anonymous online survey aimed at correlating the diagnostic criteria for PTSD. After scoring and data checking, subsequent analysis used MPLUS Latent Profiling (Muthén & Muthen, 2017) to identify homogeneous subgroups with like symptom concerns that were then theoretically linked to a proposed staging model. The flow diagram of participants through the study are

shown below, in Figure 1.1. Recruitment occurred through the United Firefighters Union of Queensland (UFUQ); this is discussed further in Chapter 3. Removal of ten percent of cases was determined *a priori* to lessen impacts of bias on initial analyses. Removal of all cases with missing data occurred prior to latent profile analysis and is discussed in Chapter 3.

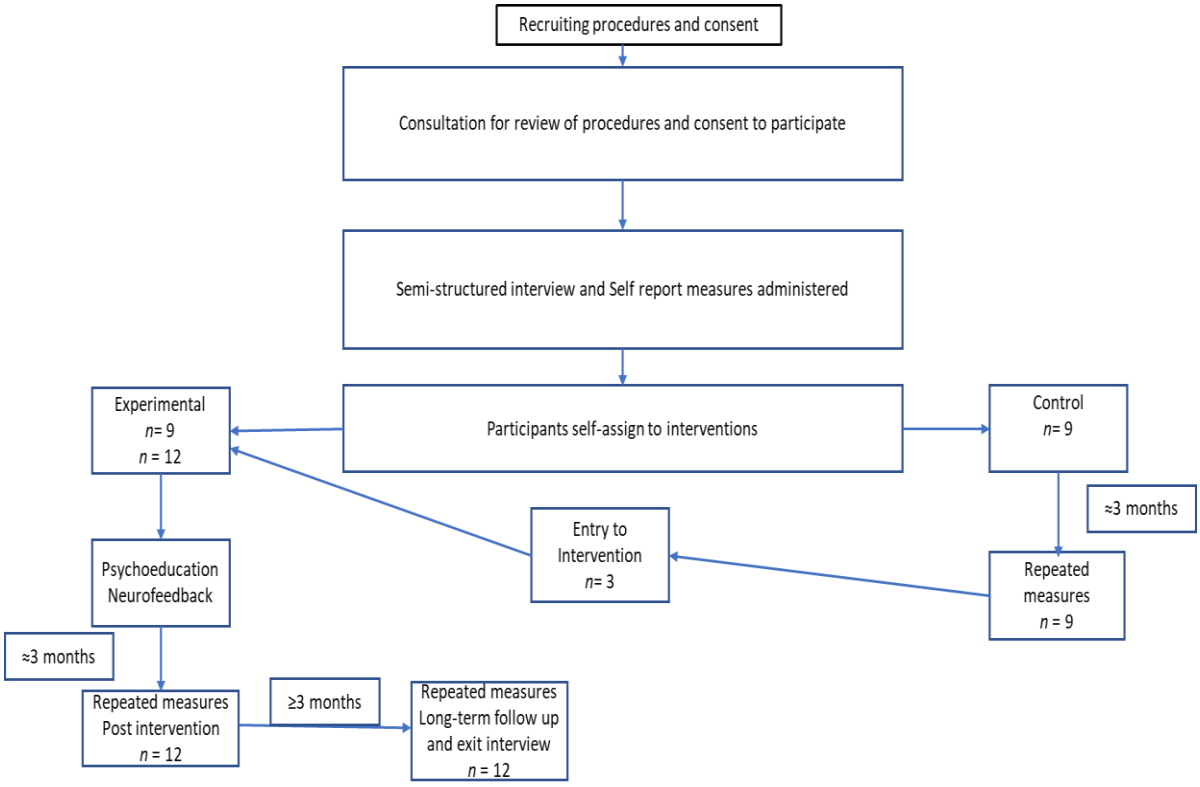
Figure 1.1.

Flow diagram of participants in Study 1



Study 2 consisted of a neurofeedback intervention with operational Queensland firefighters. Participants self-selected to the experimental or control condition based on personal preference and availability. This was intended to reduce any burden of participation in the research, since the neurofeedback intervention required several sessions of training and firefighters needed to fit travel into their shift schedules. The flow of participants is shown below, in Figure 1.2. Analysis consisted of a series of two-way mixed ANOVAs to examine the between-subjects main effects over two time periods and a series of one-way ANOVAs to examine the within-subject simple main effects for time over three time periods for the experimental group and two time periods for the control group.

Figure 1.2.
Flow of participants through Study 2 in accordance with the Consolidated Standards of Reporting Trials (CONSORT) statement and guideline for transparent reporting of RCTs.



Research Significance

There are several lines of evidence that underscore the significance of this research. First, in March 2018, the Commonwealth Government of Australia called for a Senate inquiry to investigate the high rates of mental health conditions experienced by first responders and emergency services workers (Parliament of Australia, 2018). This inquiry revealed an urgent need for improved interventions in mental health and wellbeing. This research demonstrates that current interventions are limited with respect to efficacy due to heterogeneity and fluctuation of symptoms, and the longitudinal nature of stress disorders—in this case, specifically in firefighters. The existing literature, as will be reviewed, states that current evidence-based interventions that target posttraumatic stress disorder have had limited success. Further, research that has targeted early intervention has not

accounted for the longitudinal nature of stress disorders and individual differences in resilience. Interventions such as resilience training programs provide positive but limited effectiveness, particularly over time (Hourani et al., 2016; Joyce et al., 2019; Venegas, Nkangu, Duffy, Fergusson, & Spilg, 2019). McFarlane and Bryant (2017) recognised these limitations and called for different types of interventions such as biological approaches (i.e., pharmacological) and novel interventions to be considered and tested. The current research project explored the proposed staging model by McFarlane et al. (2017), considering it a more sophisticated way of measuring symptoms that better informs prognosis and treatment programs than current programs and it also reflects the longitudinal course of stress symptoms. It can thus provide a useful underpinning for early intervention (McFarlane et al., 2017).

The significance of this research lies in directly addressing calls for alternative approaches to health and wellbeing and for early intervention. According to the recommendations in the expert guidelines by Harvey et al. (2015), PTSD may be preventable, although the evidence base for this is extremely limited and "there is an urgent need for good quality trials of early interventions with emergency services" (p. 53). A systematic review of the expert guidelines continues to expand knowledge arising from the research into the prevention and treatment for PTSD although preventative strategies still require research (Phelps et al., 2022). This research directly addresses this need.

Further, this research is comprehensive in its approach, with consideration given to breaking down the possible trajectory of stress symptoms as well as the testing of an intervention to ameliorate subclinical symptoms. This approach is supported by the theoretical and biological perspectives that rigorously tie the

research together. Multiple standard measures were used, and analysis was designed to specifically address the research questions. Importantly, Study 2 used an intervention, including a control group, to answer the research questions.

This research addresses the gap in knowledge relating to emergency responder health and wellbeing by exploring levels of symptoms and an intervention designed to avert the development of potentially significant health disorders. It determines the utility of staging symptoms and the efficacy of neurofeedback as a physiologically based stress intervention, which is supported by and aligned to the theories of allostasis and learning (which will be discussed later in this thesis). This research is not intended to intervene in diagnosed chronic or complex PTSD.

Thesis Outline

This chapter introduced the topic of stress, its possible consequences, and the population of interest, namely, firefighters. It outlined the context of the research, and its purpose, significance and scope. Chapter 2 provides an overview of the literature in relation to stress, the historical and theoretical aspects of stress and the evolution of the most recent iteration of stress theory, which is allostasis. The chapter includes a review of the biological underpinnings of stress and self-regulation and how excursions in these systems can fail with chronic stress. Stress is then considered in the specific context of firefighters and how PTSD impacts this population. Prevalence rates are also reviewed. Chapter 2 develops the argument for the need to explore subgroups for varying levels of stress symptoms and for the need for early intervention. It highlights the nonlinear nature of accumulative stress and its possible outcomes and concludes with the summary and implications of the research.

Chapter 3 presents Study 1 and explicates the need to identify early symptoms. It describes the staging model and argues for the importance of exploring this

paradigm, aligning it with the previously mentioned stress theories and explicating the stages of the model. It outlines the research design, which is a survey, and discusses the analysis and the results.

Chapter 4 presents Study 2, which is a controlled trial of neurofeedback. The introduction in Chapter 4 further expands on the theory of allostasis and its relationship to both self-regulation and neurofeedback. Existing interventions for PTSD are reviewed along with more current interventions that aim to build resilience and form early interventions to prevent PTSD. The chapter also provides a background on neurofeedback and the physiological underpinnings of the generation of electrical potentials that are the basis of neurofeedback. The study's constituent parts are reported along with a discussion of nuances of this particular research study. The chapter concludes with the findings of the neurofeedback study.

Chapter 5 provides a discussion of the main findings of the research from Study 1 and Study 2 and concludes with the overall contributions of the thesis. There is a review of the practical implications and a discussion of the limitations of the research. Considerations for future research are presented and some concluding comments are made.

Chapter 2: Literature Review

Chapter Overview

This chapter begins by describing the key theories related to stress and the stress response, as well as the influence of a reduced ability to self-regulate, as noted in self-regulation theory. The most recent theory to contribute to understanding stress and its consequences, allostasis, will be reviewed, and the discussion will show how this integrative framework ties the historical theories together. Importantly, a point arising from a review of allostasis is the biological underpinnings of stress and the potential for a breakdown in communication pathways in the neural circuitry as a result of chronic stress. This provides the context and understanding for the development of posttraumatic stress disorder, which is defined and discussed. The chapter then reviews stress in the context of firefighters and the prevalence rates for PTSD and mental health problems for firefighters, both globally and within Australia. This chapter provides the background for both Study 1 and Study 2.

Origins of the Study of Stress

The extensive literature on stress reflects that it is a major factor affecting people's lives and that it is closely aligned with negative mental and physical health (Devonport, 2013; Hobfoll, 1989; Lazarus, 1998). The ubiquitousness of stress suggests that it is a normal part of life; however, the experience of stress, particularly chronic stress, has promoted extensive research into theories of the process, causes, and consequences of it and how people cope with, manage, or recover from it (McEwen, 1998; McEwen & Seeman, 1999; Selye, 1951). While there is no definitive answer about why there is such growing interest in the subject of stress, Lazarus (1998) posits some viable explanations, which include rapid social change,

and the loss of a sense of identity in an industrial society that has removed the traditional anchors of 'village'. Marmot and Sapolsky (2014) attribute it to growing affluence, which removes concerns of survival and turns attention to life experiences in a socially connected world. Research into stress has followed a trajectory that is reflected in developments in scientific enquiry and in both physiological and psychological perspectives.

An early concept of human functioning was of an elastic but stable *milieu interieur,* developed by Bernard in the late nineteenth century. In the 1930s, this was expanded by Canon, who coined the term homeostasis (Hobfoll, 1989) to describe the tendency of physiological processes to maintain an equilibrium. Canon's concept investigated the body's varied and rapid responses to stress, such as increased blood pressure, heart rate and decreased digestion, and the restoration of these physiological excursions when the event or stressor ends. Canon essentially determined that homeostasis was the way in which the physiological systems of the body respond to stress and then re-establish baseline conditions. Canon is often considered to be the first researcher who showed that stress responses to physical challenges could lead to the eventual breakdown of the biological systems of an organism; however, ongoing research in this area was pioneered by Hans Selye (Hobfoll, 1989). This approach formed the basis of stimulus-based definitions of stress—essentially that it is the nature of the stimulus that is responsible for stress, rather than the response.

Theoretical Underpinnings of Stress

The major stimulus-based theoretical approach to the physiological understanding of stress was proposed by Selye (1951). He acknowledged that stress can be described in terms of a multitude of exogenous and endogenous factors, such

as physical trauma, emotional arousal, and mental or physical effort. Following that, Selye (1976) defined stress as "the nonspecific response of the body to any demand" (p. 15), and this definition was considered the most generic of the time.

Over time, broader definitions have emerged, as detailed by Fink (2016), including the perception of threat resulting in anxiety, discomfort and difficulty in adapting; and the situation in which environmental demands exceed one's perceived ability to cope, the latter of which is a perspective that takes a cognitive appraisal approach. Kim and Diamond (2002) provide the broadest cognitive definition of stress consisting of three components: (1) stress requires excitability or arousal; (2) the experience of stress must be perceived as aversive; (3) and there is a feeling of a lack of control over the aversive experience. In contrast, a purely biological perspective of a stressor is any stimulus that activates the stress response systems of the hypothalamic-pituitary axis (HPA) or the sympathetic-adrenomedullary (SAM) arm of the autonomic nervous system (Fink, 2016). This will be discussed in more detail later in the thesis.

More recent definitions of stress reflect the advancements in technology that can measure stress in a variety of ways. Hence, the 'nonspecific' nature of the Selye definition has been discounted, as researchers have shown that stress responses are indeed specific (McCraty & Shaffer, 2015).

While the early generic definition of stress has been superseded, Selye (1976) made significant contributions to the understanding of stress. He postulated that the stress response involves reactions occurring in three stages—alarm, resistance, and exhaustion—and involves the sub-systems of the autonomic nervous systems. This process was named the 'general adaptation syndrome' (GAS).

According to Selye (1976), in the initial phase of alarm, the shock reaction activates or up-regulates the sympathetic nervous system. This is characterised by responses such as increased heart rate, respiration and blood pressure, and tense muscles while other organs down-regulate, such as digestion or parasympathetic withdrawal. This is often referred to as the fight-or-flight response—a term which was coined by Canon. In the second phase, resistance, the body tries to counteract the physiological changes that have occurred during the alarm phase. This response can lead to a person struggling to concentrate, worrying, or becoming angry or anxious. If the stressor ceases, the body can return to normal with parasympathetic activation, or the rest–relax function. While resistance to the stressor is maintained, resistance to other forms of stressors decreases due to depleted energy and resources, which can lead to the third stage: exhaustion. Exhaustion occurs after an extended period of stress and is characterised by fatigue and the depletion of finite energy resources used in the resistance phase. In Selye's (1976) words "the human … becomes the victim of constant wear and tear" (p. 6).

While Selye's (1976) basic theory holds true there has been some criticism of the 'nonspecific' notion of the response, which has now been shown to be specific. For example, Pacák and Palkovits (2001) demonstrated heterogeneity of neuroendocrine responses to different stressors, such that they suggest there is a neurochemical stress 'signature' and specific pathways and circuits that may provide insight into the pathogenesis of stress-related disorders. This contention has been borne out by other researchers, such as McCraty and Shaffer (2015).

Chronic stress over time has significant negative effects on health and wellbeing. Selye suggested a conception of stress as part of ageing, arguing that childhood is a time of reactive and exaggerated responses to stress, adulthood is the

phase of resistance, adapting to most forms of stress agents, and old age or senility was the phase of exhaustion and losing the ability to withstand or resist stressors.

When it was later postulated that an absence of stress is also harmful, Selye revised general adaptation syndrome and introduced the term ‘eustress’. While distress results in damage or wear and tear from chronic demands that are unable to be resolved through adaptation, eustress occurs when the biology can manage the demands and leads to enhanced functioning and growth. However, what is distinctive about Selye’s (1976) theory is the strong emphasis on the physiological processes. The work did not fully account for other psychological processes, such as individual appraisals, perceptions of a stressor, or the characteristics of the individual (Devonport, 2013).

The constant in Selye’s theory of general adaptation was that stress is a physiological phenomenon and that it differs from emotional arousal or nervous tension. He found that physiological stress occurs even after total surgical deafferentation of the hypothalamus, which eliminates all incoming sensory input (Selye, 1976). He stated that the psychological aspects were beyond his competence (as he was an endocrinologist and biochemist). Selye (1976) acknowledged that “emotional arousal is one of the most frequent initiators of somatic stress” (p. 24) in humans and thus recognised that psychological factors play a role in the experience of stress. However, his focus remained on elucidating the physical processes of stress.

The major criticism of the stimulus-based model of Selye was the simplistic view that reactions to stressors occur passively through a sequence of an alerting response, a resistance response and exhaustion without any regard for prospectively identifying the source or cause of stress (Hobfoll, 1989). Other criticisms suggest

consideration should be given to the nature of the stimulus, and Elliot and Eisdorfer (1982) proposed four kinds of stressors: a) acute and time-limited; b) stressor sequences (such as bereavement); c) chronic but intermittent stressors; and d) chronic stressors (such as the occupational characteristics of emergency responders). These types of criticisms supported the evolution of alternative theoretical models that would take into account environmental demands and individuals' personal mediators that interact together (Devonport, 2013).

Prominent in this research to develop alternative psychologically-based cognitive theoretical models was the work of Lazarus (1984), who acknowledged the importance of such constructs as appraisal. The transactional model of stress proposes that the way an individual appraises the stressor determines the stress response in terms of ways of coping and emotional and behavioural responses (Lazarus, 1998). This theory posits that there is a relational and bi-directional interface between the person and their environment and that cognitive appraisals occur that determine the meaning of events in relation to well-being (Devonport, 2013). This appraisal process occurs in two parts. Initially, in primary appraisal, there is a consideration of the significance of a situation in relation to values, beliefs or situational intentions. The result is that the event is appraised as irrelevant (perceived as not threatening or harmful to well-being); benign or positive (perceived as maintaining or enhancing well-being); or stressful (perceived as harmful or a threat to well-being) (Devonport, 2013). Consequent coping is required if the initial appraisal is one of potential threat or harm to well-being.

The secondary appraisal occurs as a cognitive-evaluative process that aims to minimise and mitigate the threat. The individual evaluates coping options—for example, seeking social or familial support, or more broadly shoring up material

assets (Devonport, 2013). By engaging in various coping strategies, an individual improves their sense of control. Lazarus (1984) also considers that, on reappraisal of stress and coping, there is a danger that an individual can exceed the resources available for coping. The transactional model is thus centred on psychological states. While Lazarus (1998) provided the foundation, later theoretical developments had different emphases, such as that of Hobfoll (1989), who proposed that the loss of resources were central to stress. Hobfoll (1989) was critical of the theories of the time, stating that they were tautological and did not move the research forward. He proposed a new stress model called the model of conservation of resources (COR), believing that this model was more comprehensive, testable, and parsimonious.

The resources Hobfoll (1989) refers to are factors such as self-efficacy, self-esteem and personality factors (Devonport, 2013). Essentially, individuals attempt to build, retain and protect resources, and what is threatening to them is the potential or actual loss of these resources (Hobfoll, 1989). Hobfoll's work appears firmly aligned with human behaviour and psychology. He believes that individuals seek pleasure and success and aligns this notion with the work of Freud. He further elaborates his model as being in alignment with Maslow's hierarchy of needs: initially for physical resources, then social resources, and finally psychological resources. These needs (or goals) are met through acts that enhance positive reinforcement, where success is the creation and maintenance of personal characteristics, such as mastery or self-esteem; improvement in social circumstances includes tenure or successful relationships; and the building of valued resources includes improved socioeconomic or employment status (Hobfoll, 1989). There are four major categories of resources that are aligned to the goals, which are: object resources (linked to socioeconomic status); conditions (such as marriage or seniority); personal characteristics (such as personality and

personal orientation to the world); and energies (such as time, energy, and money). Threats to any of these types of resources produce stress and broadly encompass loss or changes in health or adjustments to life events. It is through personal experience that people can learn to recognise what it is necessary to acquire and retain to achieve success, either directly, indirectly, or symbolically (Hobfoll, Tirone, Holmgreen, & Gerhart, 2016).

In relation to this research, the COR framework posits that stress and trauma occur when resources are lost or threatened at an existential level. While traumatic experiences can vary, the common theme from COR is that all traumas are threatening to all categories of resources. The premise here is that the symptoms of PTSD heighten the awareness of threats that then generalises and persists into objectively safe settings (Hobfoll, 1989). An interesting digression here is the extensive work of Sapolsky (1982, 1990, 2005) who revealed that social hierarchy, social status, and social interactions are factors in primate society, much as they are in human society, as demonstrated in the Whitehall study (Marmot et al., 1991), a threat to or loss of these valued factors in primates results in stress among primates.

Hobfoll's work is not without criticism, particularly from Lazarus (Thompson & Cooper, 2001). Schwarzer (2001) notes that Hobfoll was critical of the cognitive-relational theory of Lazarus because of its emphasis on appraisal, which he saw as an obstacle to the advancement of stress theory but recognises that Lazarus's work laid an important foundation for Hobfoll's contributions. Schwarzer (2001) points out that there are many features that are similar in both theories, and that relational appraisal versus conservation of resources approaches are different more in degree of emphasis than in principle. Essentially, Lazarus's approach was that cognitive appraisal is a key feature embedded with objective precursors, coping resources, and

adaptive outcomes, and thus takes a process perspective. In contrast, Hobfoll focuses on objective resource status, ending with coping, and thus takes a resource-based perspective (Schwarzer, 2001). Hobfoll's contributions extend to the types of resource loss or threat and the categories stemming from this: resources threatened with loss; resources that are lost; and failure to gain resources. Schwarzer (2001) also makes contributions to stress theory by proposing four coping modes in proactive coping theory with the addition of a time dimension: reactive, anticipatory, preventative, and proactive types of coping.

Coping in this case is considered to incorporate a time element and subjective confidence about events. *Reactive coping* is an effort to deal with stress that has happened or is happening, whereas *anticipatory coping* is associated with inevitable threats that will occur in the future. *Preventative coping* is associated with uncertain threats in the future and *proactive coping* considers future challenges that may be self-promoting and forms goal management (Schwarzer, 2001). To prevent stress, Schwarzer proposed a future-oriented perspective of *preparedness* for potential stressors and a mindset of *positive challenge* aimed at achieving personal goals versus a view of a negative and ambiguous anticipated future. Constructs within proactive coping theory encompass skill development, long-term planning and a broad range of risk and goal management that moves away from responses towards the creation of opportunities.

All these theories contribute to an understanding of stress in relation to firefighters. The contribution from Selye (1976) highlights the physiological responses during stress in firefighters—for example, when they are engaged in fire control—and the physical and metabolic demands of heavy personal protective equipment. Further, the fright-or-flight response may be activated during a dangerous

rescue. These responses are contingent upon the appraisal of the threat as suggested by Lazarus (1984), such that competency developed through training may reduce the stress response and the experience may thus be appraised as non-threatening. Lazarus also shows us that coping can be in the form of seeking or engaging in social support, such as firefighters belonging to stable 'crews'. The conservation of resources, as proposed by Hobfoll (1989), is also relevant when considering firefighters, in that factors such as self-efficacy and self-esteem are elements of the firefighter occupation—training contributes to self-efficacy and there is a culture of altruism which may contribute to self-esteem. Further, the theory considers that traumas are threatening to all categories of resources. The contribution from Schwarzer (2001) shows that proactive coping encompasses skill development and supports a future-oriented perspective of preparedness through training.

In summary, there are broadly two distinct theoretical perspectives relating to stress and its origins: a stimulus-based response model where the stress is said to be determined by the nature of the stimulus (Selye, 1976), and a cognitive-transactional based model where stress is understood as being initiated or maintained based on cognitive appraisal of demand and the resistance resources available (Lazarus, 1998; Schwarzer, 2001).

While these theories, with the exception of Selye, focus on mental processes and subsequent behaviours, they lack critical integration with the biological approaches and represent the historical mind–body dualist approach in which the mind and body exist as separate entities rather than as an interaction. While there is some acknowledgment of mind–body processes in these earlier theories, recent advances in technology have permitted the evolution of new theories that properly integrate these perspectives.

One recent theoretical framework that considers the contributions of a multitude of factors, including both biological and psychological ones, is that of *allostasis*. This is an integrative model that highlights the brain as dynamically interfacing with the internal and external environment.

Introduction to Allostasis

The model of allostasis seeks to converge biomedical and psychosocial models of stress. It is an evolving theoretical framework of understanding stress that also seeks to recognise the cumulative effects of acute and chronic stress on the brain and body (Southwick, Bonanno, Masten, Panter-Brick, & Yehuda, 2014). Allostasis describes the process of achieving stability through adaptive change or adjustment of the internal milieu (Mirifar, Keil, & Ehrlenspiel, 2022). In essence, allostasis allows a person to adapt, respond, and flexibly cope with both internal states, such as hunger, and external demands, such as psychosocial stressors (Mirifar et al., 2022). This accommodation includes homeostatic imbalance and the process of restoration of balance, or the setting of a new equilibrium, which is called adaptive plasticity (Sapolsky, 2004). The physiological and mental health costs of chronic adaptation to stressors is referred to as *allostatic load* (McEwen & Gianaros, 2010). Over time, there may be a cumulative burden of chronic stress on both physiological systems and mental health that exceeds an individual's ability to cope and leads to a breakdown of health, or *allostatic overload* (Ganzel, Morris, & Wethington, 2010).

This model considers multiple factors that have an impact on the stress response. For example, genetics, environment and experiences interact in what is known as *epigenetics* to determine responses to stress. This has been substantiated by observing that individuals who have been exposed to similar (or the same) stress situations can react differently. Some individuals adapt successfully through what is

understood as resilience and others may go on to develop emotional problems or poor mental health (McGrady, 2007). According to Fink (2016), there is substantial literature on the role of stress in the causation and exacerbation of disease in most of the body's organ systems, and it plays a fundamental role in mental health. The model of allostasis seeks to converge biomedical and psychosocial models of stress, and *allostatic load* refers to the physiological cost of adaptation to stressors (Southwick et al., 2014).

Background to Allostasis

Early concepts of homeostasis—the equilibrium maintained in physiological states—were developed by Bernard (in the late nineteenth century) and then Canon in the 1930s (Hobfoll, 1989), which led to further theory development by Selye (1976). Although Selye (1976) acknowledged the presence of interceding factors such as environment, appraisal, cognition and emotional states to stress responses, the mediating pathways for how this occurred were never elucidated by him (Ganzel et al., 2010). Allostasis attempts to address this and accommodates for the brain, specifically the emotional centres, being the central and primary mediator of systemwide responses to stress, including how stress is appraised (Ganzel et al., 2010).

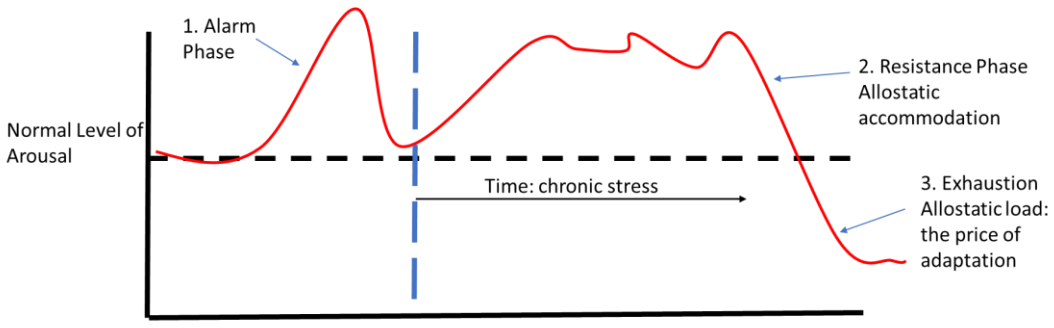
Allostasis also suggests that stress is not a static experience, but one that undergoes constant change, remissions and evolution representing brain plasticity (Sapolsky, 2003). According to Sapolsky (2003), neuronal plasticity occurs throughout the lifespan and changes in thinking, emotions, and psychophysiological responses to stress happen continuously through learning and experience. This perspective is a supplement to homeostasis, in that allostasis is an active process of maintaining homeostasis through the adaptive change of the internal milieu to meet

experienced, perceived, and anticipated demands. It is through this theory that integration with older theories is achieved.

McEwen (2016a) states that there are three components to allostasis, as shown in Figure 2.1. The first response to stress initiates and promotes adaptation, that is, allostasis. The second is that, when stress is chronic, there can be cumulative change, such as hypertension, changes in body fat distribution and metabolic syndrome, that is, allostatic load. This can lead to the third component of allostatic overload and disease, such as cardiovascular conditions and diabetes. According to McEwen (1998), "Allostatic load is the wear and tear on the body and brain resulting from chronic overactivity or inactivity of the physiological systems that are normally involved in adaptation to environmental [internal and external] challenge" (p. 37). The process of adaptation produces inevitable wear and tear (McEwen, 2016a). Concomitant to this is the development of poor mental health via multiple mechanisms tied to physiological alterations.

Figure 2.1

Example of allostasis and progression to allostatic load



1. Initial shock that can be very stressful that increases arousal
2. Becomes chronic but can be low grade stress/anxiety that accommodates.
3. Negative health and wellbeing: chronic illness

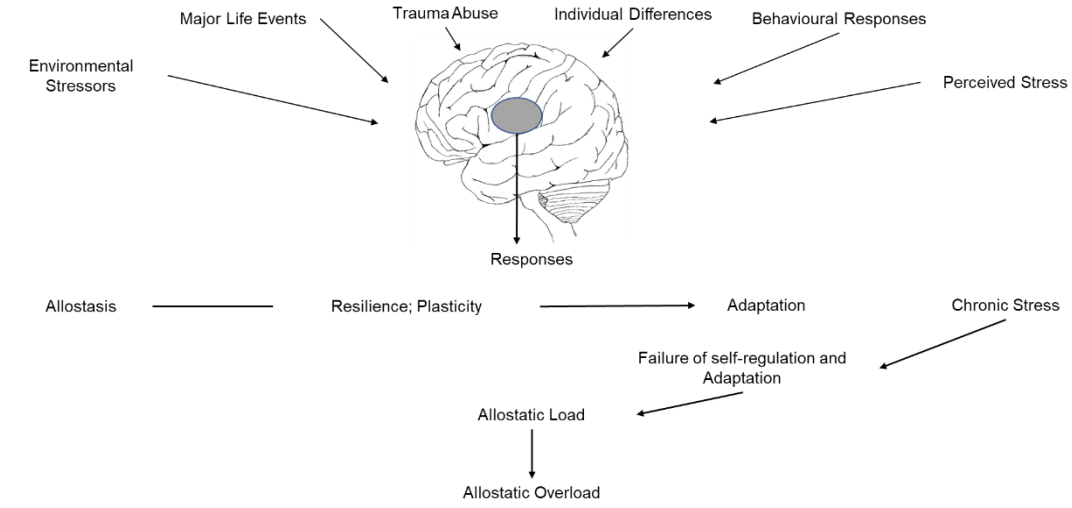
Key theoretical underpinning (McEwen, 1998)

The process of adaptation includes multiple interacting mediators that operate in a nonlinear way, as shown in Figure 2.2. This represents a reconceptualisation of homeostasis (which suggests a somewhat static state), into changing set points or stasis around set points. The concept of allostasis also helps us to understand how the ability to self-regulate can fails. This is relevant when considering the occupations of emergency responders, where routine stressors are experienced and can become a chronic feature of work over time.

An important and related concept to understanding allostasis is that of self-regulation. This is the concept that one can have the ability to monitor and manage energy states, thoughts, feelings, and behaviours, and therefore to control responses within the self (Bandura, 1989).

Figure 2.2

Contributions to Allostasis and Allostatic Load



Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist. https://creativecommons.org/licenses/by/2.5/

Self-Regulation

Early theory proposed that people have control over their lives through self-organisation and self-regulation, which mediate behaviour and emotional responses

learned through classical and operant conditioning ("Bandura's Social Cognitive Theory : An Introduction," 2016). Both social psychologists and personality theorists have postulated that emotional regulation is a form of 'effortful' self-regulation whereby cognitive processes control impulses and responses (Vohs & Baumeister, 2016). This perspective of the executive function of the reappraisal of emotions acknowledges the functional pathways between the executive pre-frontal cortex of the brain with the limbic and memory regions of the brain, as detailed later in this chapter. A very important extension of this psychological perspective of self-regulation is the biological understanding of self-regulation and the impact of chronic stress on this ability to self-regulate. This forms a critical foundation of this research, which is based on the integrated approach of allostatic theory.

Biological self-regulation

Alterations, either biochemical or structural, to the regions of the pre-frontal cortex or limbic system can impact a person's ability to regulate their own behavioural responses across a range of domains, such as the ability to maintain goals, have appropriate social interactions, or engage in the activities of daily living (Ganzel et al., 2010). Critically, the ability to remain in control of one's own behaviour relies on the healthy functional coupling of these brain regions, that is, the way in which these brain regions communicate.

When the capacity for self-control is reduced by chronic stress through brain remodelling (McEwen, 2016a, 2016b), disruptions can occur in the communication networks of these brain regions leading to a reduction in, or failure of, self-regulation. Remodelling (explicated below) is essentially the structural changes in neurons and associated communication pathways. An example of uncoupling has been demonstrated by Yoo, Gujar, Hu, Jolesz, and Walker (2007), in the form of

deleterious effects of sleep deprivation on emotion regulation, an exaggerated amygdala response (hyperreactive), and impaired functional connectivity with the pre-frontal cortex, demonstrated using functional magnetic resonance imaging (fMRI). This uncoupling is mediated by mutual feedback and feedforward loops between the amygdala and hippocampus and the frontal brain regions (de Kloet, 2016), representing a breakdown of communication between these brain areas due to chronic stress impacts. There can be resultant impairments in the functions associated with these areas, leading to problems such as anxiety, mood problems, memory issues, executive function problems and difficulties with decision making (McEwen, 2016b). In relation to this research on firefighters, it can be postulated that chronic stress and/or trauma exposure may contribute to a failure of self-regulation. This has implications for theoretical perspectives such as the appraisal of events or threats and how appraisal is potentially altered through brain remodelling.

It is these advancements in understanding biological underpinnings of behaviour that led to the theoretical framework of allostasis, which describes how a person maintains the regulation of physical systems when confronting events that may be stressful (or perceived to be so). Allostasis is thus an integrated theory that brings together stimulus-based and cognitive-transactional theories and spans the complexity of brain–body interactions and adaptation to change, significantly extending previous stress theories.

Biological Underpinnings of Stress

In order to understand the processes of interactions between the brain—both physiological and cognitive—and the body, as in allostasis, a review of the biological underpinnings is necessary.

The stress response is activated by the sensory systems of the brain, which perceives the stressor and evaluates it against previous stress memories and states (Fink, 2016). Stress is controlled by two major and interconnected neuroendocrine systems: the hypothalamic-pituitary axis (HPA) and the sympathetic-adrenomedullary (SAM) nervous system. Advances in molecular neurobiology, genomics and neuroimaging have provided a better understanding of the stress response and its impact on mental and somatic health and behaviour (Fink, 2016).

The hypothalamic–pituitary axis (HPA) and the sympathetic–adrenomedullary (SAM) arm of the autonomic nervous system (ANS) make up the neuroendocrine systems of the stress response. When a stressor is detected, the ANS activates the SAM pathway to rapidly release catecholamines (noradrenaline and adrenaline). These increase cardiac output and raise blood pressure to divert blood from the periphery and gut to the skeletal muscles for a rapid response, and energy in the form of glucose from the liver is shunted into the bloodstream. Simultaneously, the HPA releases glucocorticoids (cortisol in humans) to activate resistance and adaptation to the stressor, including effects on the immune system (Fink, 2016; Sapolsky, Krey, & McEwen, 2002). Glucocorticoids and adrenaline act synergistically to increase blood glucose to ensure energy for the stress response facilitating ‘fight or flight’. Brief acute responses to stress can enhance immune function and memory and increase synaptic plasticity; they are an adaptive response to improve survival (Sapolsky, 2004). However, chronically elevated glucocorticoids decrease axonal spine density and neurogenesis and negatively affect cognition and memory via impairments in synaptic plasticity (McEwen & Magarinos, 2001). Essentially, these are deleterious neuro-architectural changes affecting cognition, memory, and fear responses, and they increase hyper-excitability in the limbic system (Fink, 2016; Sapolsky et al.,

2002). Some studies indicate that this can be reversible (McEwen, 2016a); however, if stress-induced changes are accompanied by an increase in anxiety behaviours there is an increased likelihood that there will be a concomitant reorganisation and dysregulation of circuits in the amygdala that is maintained by the anxiety behaviour itself (McEwen, 2016b).

Glucocorticoid receptors, while extending throughout the body, are expressed in high levels in the limbic system, which is at the core of the stress response. Of particular importance is the amygdala, which anticipates and evaluates the emotional or novel event, retrieves information about previous experience, and engages response selection and emotional reactivity (de Kloet, 2016). The amygdala is also linked to the hippocampus in the formation of fearful memories (Fink, 2016). One type of receptor, the mineralocorticoid type, is implicated in the appraisal of stress and the modulation of the stress response, whereas glucocorticoid receptors activate and mobilise energy and behaviour changes in response to stress (de Kloet, 2016; Fink, 2016), which may include anxiety behaviours and facilitated learning and memory.

In summary, the stress response involves many brain areas and other chemical messengers, such as neurotransmitters and neuropeptides, and factors associated with initiation, termination and recovery (de Kloet, 2016). Stress is perceived by the sensory systems of the brain, which drives the hypothalamus and other pathways such as the hindbrain, thalamus and limbic forebrain to release (primarily) catecholamines and glucocorticoids. The amygdala receives sensory information through the thalamus and through the sensory cortex and plays a critical role in not only evaluating emotional events and modulating memory formation for these events but also in influencing attention and perception, thereby modulating information

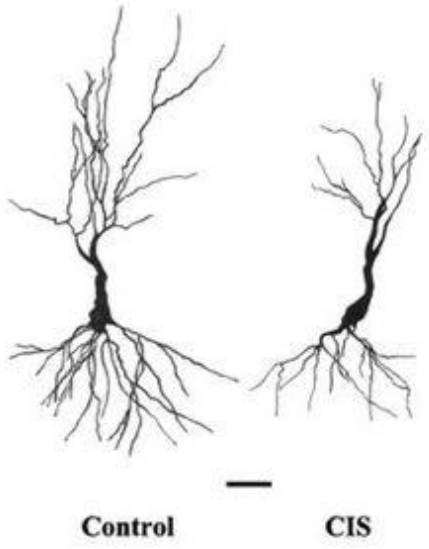
processing. This enables the preferential processing of salient information that is emotional or potentially threatening, ensuring that vital information for survival is noted and responded to (Fink, 2016; Sapolsky, 2003). Imbalance in the glucocorticoid pathways at a certain threshold may dysregulate the HPA and impair behavioural adaptation, resulting in reduced resilience to neurodegenerative processes and susceptibility to impaired mental health (de Kloet, 2016). Dębiec, Bush, and Ledoux (2011) have suggested that elevated noradrenergic activity is associated with the persistence and severity of PTSD.

Effects of Chronic Stress

Chronic stress or extreme stress can change the sensitivity of the HPA axis in terms of stress hormone imbalances. Chronic stress can cause cortisol to release more slowly, ensuring a steady flow of glucose to facilitate a sustained response to threat, as a continuous 'drip filtering' of cortisol (Nursey & Phelps, 2016). Eventually these biochemical changes can lead to both structural and functional changes within the brain and this can affect the resilience of the brain to withstand further insult (in this case, ongoing stress or exposure to trauma). Structural changes are changes to the circuits involved in cognitive functions, as correlated with PTSD symptoms, including attention, working memory, memory encoding and emotional and behavioural regulation (Nursey & Phelps, 2016). The amygdala, associated with fear and emotional regulation, can show increased dendritic connectivity and hyperfunctionality and conversely the hippocampus shows reduced volume, dendritic connectivity and hypofunctionality. Figure 2.3 illustrates the alterations of neurons in the hippocampus due to stress (Vyas, Mitra, Rao, & Chattarji, 2002). It can be seen in this image that there is reduced dendritic density and remodelling of the neuron.

Figure 2.3.

Chronic stress effects on hippocampal cells in rats from chronic immobilisation (CIS).



Source: https://www.jneurosci.org/content/22/15/6810/tab-figures-data

Posttraumatic Stress Disorder

PTSD is a severe form of stress that can develop following exposure to a traumatic event (Berger et al., 2012; Sartory et al., 2013), resulting in a diagnosable psychiatric illness. The *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) (American Psychiatric Association, 2013) provides an outline of diagnostic criteria for PTSD, which include a confrontation with death, or serious injury, threat of death or physical integrity of self or others. There are several significant diagnostic criteria that need to be met for a PTSD diagnosis. Criteria A must be met, Criteria B and C must have at least one symptom, and Criteria D and E must have at least two symptoms (American Psychiatric Association, 2013):

- Criteria A: exposure to death, injury or violence.
- Criteria B: intrusive symptoms, such as distressing memories, dreams or psychological distress.

- Criteria C: persistent avoidance of places/people/triggers or memories.
- Criteria D: negative alterations in mood or cognitions (such as memory) or negative emotional states, such as anger and hostility.
- Criteria E: marked alterations in arousal and reactivity, such as irritable behaviour, problems with concentration and sleep disturbance.

This disorder is discontinuous and variable between individuals (McFarlane, Ellis, Barton, Browne, & Hooff, 2008), but it is widely agreed that PTSD describes persistent and severe stress reactions after exposure to traumatic events (Foa, Steketee, & Rothbaum, 1989; Harvey et al., 2015; C. Hoge et al., 2016). There are a range of symptoms that reflect the excursions noted above in the neurophysiology, and from a psychological perspective, PTSD consists of clusters of symptoms, including intrusive memories associated with re-experiencing, and avoidance of thoughts, places, or situational reminders. The third cluster is negative cognitions and mood and the final cluster of symptoms involves arousal symptoms such as hypervigilance, irritability and hyper-reactive behaviours (Harvey et al., 2015).

As noted by several authors (Harvey et al., 2015; McFarlane, 2017; Nijdam et al., 2023; Steenkamp, 2016), there are a range of symptoms aligned with a number of functional areas of the brain and PTSD sufferers experience these symptoms in individual ways, but a consistent feature is that there are significant impacts on the brain and how the networks communicate. Recent use of fMRI has shown how the dysregulation of large-scale brain networks negatively influence perception, cognition and emotional processes (Reiter, Andersen, & Carlsson, 2016).

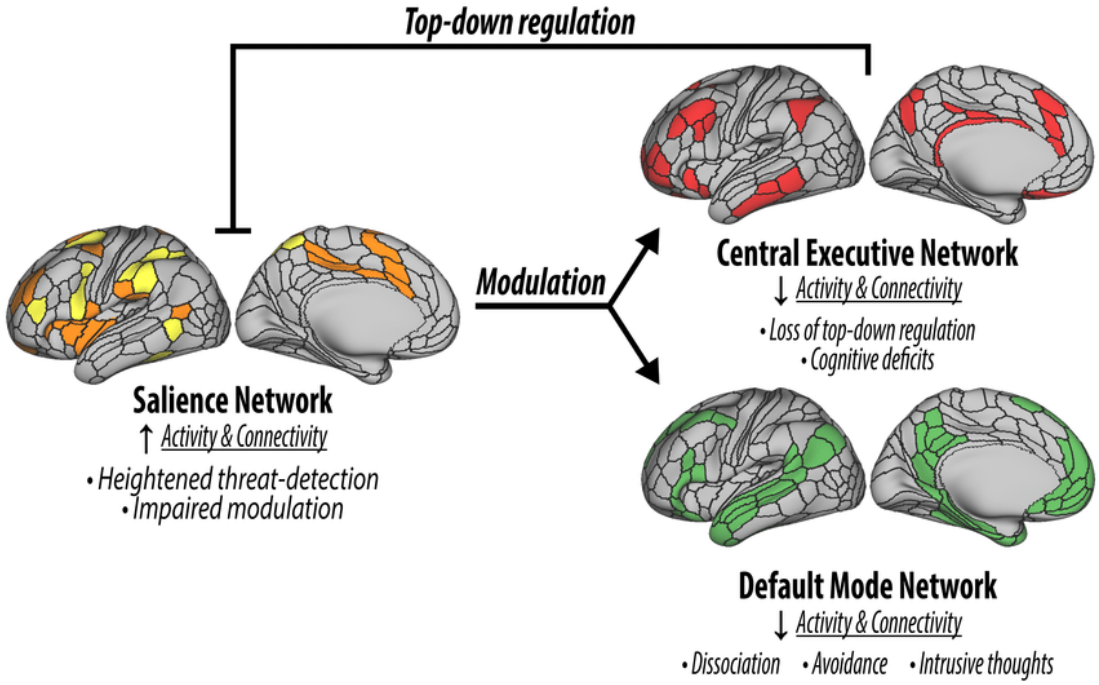
Three networks have been identified as vital to proper functioning (Menon, 2011). The first is the default mode network that involves the medial prefrontal cortex

controlling various aspects of self-referential and mental processes. The second is the salience network, which concerns the dorsal anterior cingulate and amygdala of the limbic system and integrates and regulates the somatic, autonomic, and emotional processing of information. The third is the central executive network associated with the dorsolateral prefrontal cortex and parietal cortex, which is related to working memory and attentional control.

These networks operate in tandem with feedback and feedforward loops, and dysregulation and variability can lead to heterogeneity of symptom expression across individuals (Patel et al., 2012) — especially with PTSD. Patel et al. (2012) used neuroimaging studies to show compromised neurocircuitry among PTSD sufferers, with an over-engagement of the salience network, a failure to properly recruit the central executive network, and altered connectivity with the default mode network. Essentially, there is a loss of top–down regulation, amygdala and hippocampal hyperactivation, a characteristic inability to regulate mood, emotion, and arousal, and the inability to extinguish the fear response (Patel et al., 2012). This has been described and discussed in this research as the ‘failure of self-regulation’. The networks that are associated with PTSD have also been elucidated by Abdallah et al. (2018), as shown in Figure 2.4. The figure depicts the cortical representations of the salience network (SN; orange and yellow), central executive network (CEN; red), and default mode network (DMN; green). PTSD has been associated with hyperactive SN leading to heightened threat-detection and impaired modulation of the CEN and DMN. In turn, CEN and DMN deficits are associated with disruption in top-control, as well as several PTSD related symptoms.

Figure 2.4.

A network-based model of posttraumatic stress disorder (PTSD).



Source: https://www.researchgate.net/figure/A-network-based-model-of-posttraumatic-stress-disorder-PTSD. (Abdallah et al., 2018). Copyright permission granted.

Variability in PTSD

While initial trauma exposure may spike a range of stress reactions in the following weeks, for many, symptoms are transient. The initial reactions are considered acute stress reactions and are part of post-trauma adjustment (Bryant, 2003), and include a very broad range of symptoms, such as a range of anxiety symptoms, depersonalisation, intrusive thoughts of the incident, and insomnia, to name a few—essentially, significant levels of distress. There are a range of studies that show recovery in approximately thirty percent of cases diagnosed with Acute Stress (Bryant, 2003) in the months following the incident. However, there is a dearth of convergence in research into symptom clusters that are predictive of PTSD from a purely psychological perspective (Bryant, 2003). This has led to increased interest in biological indicators and the breakdown of neural communication

networks which, through sensitisation and repetitive activation, lead to sufficient dysregulation that full-blown and persistent symptoms of PTSD occur. These neurobiological excursions can influence cognitions such as appraisal of the event, for example, in a manner that is bidirectional. This is particularly pertinent when considering the repeated exposure to traumatic events for firefighters and the additional chronic stressors of shift work and the physical demands of operations. Bryant (2003) considers that the optimal approach for predicting PTSD as an outcome is to recognise that there are multiple factors that are nonlinear, and it may possibly occur due to interactions between symptoms, biology and cognitive factors. Importantly, this supports the use of the theory of allostasis, which acknowledges these interactions in terms of understanding stress, chronic stress and the potential to develop PTSD.

Any review of the biological underpinnings of stress is complex. However, such a review serves to emphasise the importance of how allostasis integrates biological processes with an understanding of psychological theories, such as attention, anticipation, appraisal and ability to cope. It also serves to enhance the importance of investigating the staging model proposed by McFarlane et al. (2017) to identify homogeneous groups that experience similar symptoms pre-PTSD and the top–down or central interventions as used in this research as a primary intervention.

Firefighters and Stress

This section will now consider stress in the context of firefighters in light of a review of the literature on diagnosis and prevalence. Stress is a common experience for firefighters. It occurs at a physiological level, such as the body temperature and heart rate elevation associated with wearing heavy personal protective clothing while firefighting. It also occurs at the psychological level, in the form of exposure to

trauma, such as perilous rescues or the recovery of human remains. At the psychosocial level, there are organisational factors, such as job demands outpacing available resources, including limited mental health support. Stress can also occur as part of everyday life through negative experiences such as financial hardship or family dysfunction.

There are common themes in the experiences of stress among emergency services personnel. Police, firefighters, and paramedics all experience high intensity and high-risk work and all have frequent exposure to traumatic events. Historically, trauma exposure was considered a part of the job (Mitchell, 2016), with no support provided for mental health, although rising rates of mental health conditions are now being recognised (Parliament of Australia, 2018).

According to Harvey et al. (2015), there are over 80,000 full time emergency services workers in Australia, all performing a vital role in either protecting or providing assistance to citizens. Australia has three primary services—police, firefighters, and ambulance officers—although there are a range of support organisations, such as the coast guard, rural fire service, and workers in emergency call centres. Those who develop sub-clinical or PTSD symptoms as a result of their occupation have a range of symptoms, including negative thoughts and moods, poor interaction with loved ones, insomnia, irritability, burnout, anger, and substance abuse (Harvey et al., 2015). PTSD is not a given outcome of trauma exposure and workers may otherwise develop other conditions, such as depression, anxiety, or physical complaints, reflecting the heterogeneity of the condition.

Many emergency responders exposed to repeat traumas demonstrate sensitisation, with increasingly severe responses to each successive trauma exposure. Given the documented ‘tough’ culture (Education and Employment References

Committee, 2019; Papazoglou & Tuttle, 2018) of first response work, many workers attempt to minimise post-trauma symptoms and have fears of stigma, and consequently do not come forward for assistance. As a result of these complexities, there has been some debate regarding the prevalence of mental health concerns among these workers, particularly PTSD. However, Harvey et al. (2015) state that prevalence is higher than in the general population and this has been supported by a more recent large scale survey of 14,000 Australia emergency responders (Kyron et al., 2022). Meta-analyses of over 20,000 emergency responders world-wide showed PTSD prevalence was 10%, although the number may be higher (Berger et al., 2012). While the prevalence rates of the separate occupations within emergency services have been reported (Petrie, Milligan-Saville, et al., 2018; Syed et al., 2020; Wagner et al., 2020), several studies have examined overall rates in emergency services (Berger et al., 2012; Regehr & LeBlanc, 2017).

For firefighters, research has revealed varying rates of both mental health and well-being and PTSD across different countries. A possible reason is that firefighters experience differences in their training and roles. For example, in the US, firefighters may also hold the role of paramedic (Corneil, Beaton, Murphy, Johnson, & Pike, 1999), and in some parts of Australia, some firefighters work in 24-hour shifts, while in Queensland, firefighters work two day shifts and two night shifts, each of 12 hours. There may also be differences between urban and rural settings and among specialists within the services, such as urban search and rescue or swiftwater rescue, that face higher risks.

Heinrichs et al. (2005) reported prevalence rates in a prospective study in the USA. The 43 participants reported no PTSD at baseline recruit training; at two-year follow-up, 16.3% of participants had diagnosable PTSD and 18.6% met the criteria

for subsyndromal (subclinical) PTSD. This represents 35% of participants reporting negative symptoms from recruit training to two-year follow-up. Corneil et al. (1999) reported the rates of PTSD in firefighters to be 22% in a US cohort (N=203) compared with 17% of a Canadian sample (N=625). In contrast to these rates, Kehl, Knuth, Hulse, and Schmidt (2014) conducted a study across eight European countries and found clinical rates of PTSD to be 7.6% (N=1916). This latter study is somewhat at odds with other reported rates and the authors suggest that those with more severe symptoms most likely did not volunteer for the study.

In more recent studies Salleh, Ismail, and Yusoff (2020), conducted a systematic review of international prevalence rates reported between 2007 and 2017 and found the range broad from 6.4% to 57%. Another systematic review considered psychological variables that were associated with PTSD (Serrano-Ibáñez, Corrás, del Prado, Diz, & Varela, 2023). These authors conclude that there is high heterogeneity in the variables evaluated in the different studies and the implications for consideration of these factors in future research. Importantly their research covered investigations occurring between 2011 and 2020 and the total sample comprised of over 12,000 active firefighters. A reported critical finding included risk factors such as operational stress, job duration, rumination and burnout.

In terms of Australian studies, Bryant and Guthrie (2007) reported a 12% prevalence of PTSD in an Australian sample of firefighters (N=52) in a four-year follow up from trainee to firefighter. Cook and Mitchell (2013) showed that prevalence rates of PTSD in volunteer firefighters after the 1983 South Australian bushfires was 22%. Another Australian study, by Armstrong, Shakespeare-Finch, and Shochet (2014), reported rates of clinical PTSD to be 23% in a sample of 218 Queensland Fire and Rescue Service firefighters. In summary, research indicates that

in firefighters, 12–22% reach clinical levels of PTSD, with much higher subclinical rates suspected (Heinrichs et al., 2005; McCubbin et al., 2016). In the large scale and most recent survey by Kyron et al. (2022), prevalence rates are now more rigorously considered to be 9.1%.

Of particular significance for this research is those studies that demonstrated worsening symptoms of stress from initial recruitment to later years of firefighter employment (Armstrong, 2014; Bryant & Guthrie, 2007; Heinrichs et al., 2005).

Summary and Implications

Research has shown that emergency responders experience extreme demands and stressors that have the potential to cause negative health and wellbeing outcomes. The general adaptation theory proposed by Selye (1976) has long been the mainstay of understanding the physical stress response; however, it does not elucidate the mediating pathways involved, particularly mental processes. The cognitive-relational theories focus on processes, such as appraisal of threat and the consequent emotional and behavioural responses. Hobfoll (1989) considered additional factors, such as self-efficacy, and the extension by Schwarzer (2001) includes proactive coping with a time dimension of anticipatory coping. The more recent theory of allostasis is an integrative model that highlights the brain as the primary mediator between the environment and the stress response (Ganzel et al., 2010). The theory extends to include the contribution of self-regulation from both a psychological and physiological perspective. Further, allostatic theory seeks to understand the effects of chronic stress on health and wellbeing.

One of the most severe mental health conditions that can occur as a result of an emergency responder occupation is PTSD, which is also associated with substantial psychiatric and medical comorbidity. It appears, however, that subclinical PTSD

occurs in higher rates than PTSD itself. This suggests the importance of developing criteria for partial/subclinical PTSD or its associated symptoms through the proposed exploration of like symptoms that may permit connected interventions. Research has shown that individuals with partial PTSD or like symptoms experience functional impairment with implications of increased burden and decreased quality of life (McFarlane, Atchison, Rafalowicz, & Papay, 1994; McFarlane et al., 2008).

The staging model initially proposed by McGorry, Hickie, Yung, Pantelis, and Jackson (2006) and advanced by (McFarlane et al., 2017) reflects the ebb and flow of symptomatology, and importantly, acknowledges the significance of subclinical symptoms that have the potential to develop into full-scale mental health conditions. The staging model for PTSD, as proposed by McFarlane et al. (2017), is useful for identifying early clinical features and represents the opportunity for more targeted early intervention strategies. According to Scott et al. (2013, p. 266), we should not be waiting "for the mental health equivalent of a heart attack" before action is taken.

On the basis of the literature review, this research proposes to explore the proposed PTSD staging model for its ability to identify homogeneous subgroups and to investigate the effectiveness of neurofeedback as an intervention to reduce symptoms of stress and build resilience and wellbeing among Queensland firefighters.

Chapter 3: Study 1

Chapter Overview

This chapter presents Study 1 of Queensland firefighters who undertook a survey to explore whether stress symptoms could be aligned to the staging model using latent profile analysis (LPA). The research question explores whether self-reported levels of symptoms can be aligned to the staging model, permitting better classification and specificity of homogeneous subgroups. It was expected that homogeneous subgroups would be identified, particularly in light of the work by Heinrichs et al. (2005), which found an increase from recruits having no PTSD to subclinical rates of 18.6% and PTSD rates of 16.3% two years into the job. They state that this has important implications for developing targeted and effective interventions. It was also expected that Study 1 had the potential to demonstrate the opportunity to correct for heterogeneity. It was further expected that firefighters with a longer time in service would have higher reporting levels of negative symptoms.

This chapter first describes the current methods used to measure subclinical and clinical PTSD and considers the factors in the development of symptoms. Next, a review of the staging model is provided, as has been proposed by McFarlane et al. (2017), who suggest parsing out symptom severity concerns as part of assessing subclinical PTSD and the possible trajectory to PTSD. The chapter argues for the importance of testing this paradigm, and how it can critically align with the previously mentioned stress theories to demonstrate worsening symptoms over time. The chapter also explains the stages of the model and outlines the research design, which is a survey, giving the procedure, analyses, and results. A discussion of the findings of Study 1 concludes the chapter.

Introduction

Firefighters are exposed to potentially traumatic events as part of their operational duties. That a degree of psychological distress occurs is expected (Harvey et al., 2015; Kyron et al., 2022), and for a large part, personal coping, resilience and support allows an individual to return to normal levels of functioning. However, for some, negative symptoms may persist or worsen over time and may lead to a mental health diagnosis, distress, and reduced functional capacity. For others, there can be a delayed onset of initial symptoms attributed to a variety of explanations—including: an initial numbing response; overlooking early low-level symptoms; or post-trauma stressors that then trigger PTSD symptoms. For some there can be the impact of cumulative trauma exposure (Harvey et al., 2015; Kyron et al., 2022), resulting in the emergence of symptoms. The repeated nature of trauma exposure for firefighters can contribute to sensitisation—that is, with successive exposures causing more severe responses, as discussed in Chapter 2. There can be a gradual build-up of distressing symptoms over time or a sudden onset of PTSD symptoms, and this contributes to making a diagnosis difficult. Organisational culture is also influential, and firefighters can often attempt to minimise symptoms in an effort to reduce stigma or loss of standing among co-workers or in an effort not to compromise their career progression (Parliament of Australia, 2018).

Subclinical PTSD is complex, as symptoms are present but are not of sufficient severity to diagnose PTSD (Harvey et al., 2015; Harvey et al., 2016; McFarlane et al., 2017). These symptoms can become chronic and contribute to increasing mental health and physical problems, as shown in allostatic theory. Poor coping strategies, such as alcohol misuse, to mitigate stress can contribute further to reduced capacity for recovery (Harvey et al., 2015; Kyron et al., 2022; Parliament of

Australia, 2018). Among the array of symptoms between subclinical and clinical PTSD is a range of co-morbid conditions, such as depression and generalised anxiety disorder, creating diagnostic confusion (Harvey et al., 2015; Terhaag et al., 2019).

According to Harvey et al. (2015), "there is no agreed gold standard of clinical diagnostic assessments for PTSD" (p29), and diagnosis should be attained through convergent data including a thorough clinical interview and history combined with validated self-report measures along with consideration of comorbid conditions. The most recent iteration of the Australian Guidelines for PTSD has maintained this stance and has been endorsed by the National Health and Medical Research Council, the Royal Australian and New Zealand College of Psychiatrists, the Royal Australian College of General Practitioners, and the Australian Psychological Society (Lethbridge & Phoenix Australia, 2021). The International Society for Traumatic Stress along with the US National Centre for PTSD however, has stated that the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) is currently the gold standard. There is a range of self-report measures used both clinically and in research which can provide a provisional diagnosis, such as the Post-Traumatic Checklist (Blevins, Weathers, Davis, Witte, & Domino, 2015), the Life Events Checklist (Weathers, Marx, Friedman, & Schnurr, 2014), the Impacts of Events Scale (Gnanavel & Robert, 2013), and the Davidson Trauma Scale (J. Davidson et al., 1997). There are also structured interviews that diagnose PTSD, such as the Clinician Administered PTSD scale. There are various other measures, and what is common among them is they are developed to align with the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) diagnostic criteria for PTSD (American Psychiatric Association, 1994). Many studies (Griffith, Jin, Contractor, Slavish, & Vujanovic, 2022; Jongedijk, van Der Aa, Haagen, Boelen, & Kleber,

2019; Visser, Den Oudsten, Lodder, Gosens, & De Vries, 2022) also use a range of standardised psychological self-report measures to examine co-morbidities, such as depression or alcohol use. In most research, those with subclinical PTSD are found to have symptoms of PTSD but do not meet the clinical cut-off score for provisional diagnosis through the use of self-report measures (Armstrong et al., 2014; Berninger, Webber, Cohen, et al., 2010; Berninger, Webber, Niles, et al., 2010). However, greater insights into subclinical PTSD may be gained through investigating the proposed staging model of McFarlane et al. (2017) via independent measures that align with the DSM-5 criteria.

The Need to Identify Early Symptoms

One of the challenges in applying a diagnosis of PTSD or other anxiety or stress disorder, and options for treatment, is how to characterise those individuals who have symptoms but fall short of meeting current DSM-5 criteria (American Psychiatric Association, 2013).

The literature acknowledges partial, subthreshold, subsyndromal and subclinical PTSD and these terms are used variously and sometimes interchangeably. People who do not meet full criteria but have symptoms need mental health support and intervention as much as those who have been formally diagnosed. A key issue identified by Schnurr (2014, p. 1) is how to diagnose partial PTSD, particularly since the latest iteration of the DSM-5 does not specify any alternative specific diagnostic criteria apart from “Other Specified Trauma and Stressor-Related Disorder”. Schnurr (2014) also points out that the most common reason for not meeting criteria is that individuals do not have the required “C” criteria symptoms pertaining to avoidance. It is notable that avoidance is difficult for firefighters, who must continue their employment and engage in firefighting operations.

Schnurr (2014) also suggests that PTSD (either full or partial) is best characterised as a dimensional disorder rather than an 'all or nothing' phenomenon, and one that has variable clinical presentations. Therefore, the targeting of subclinical or emerging mental health disorders can be advocated. For example, Heinrichs et al. (2005), in their prospective study, demonstrated that at a two-year follow-up from recruit training, from having no PTSD symptoms, participants developed subclinical PTSD and PTSD. Findings from their research suggest the "potential benefits of early intervention" (Heinrichs et al., 2005, p. 2276). The lack of clinical levels of PTSD (Almedom & Glandon, 2007) or the absence of pathology (Akerboom and Maes (2006) do not suggest or reflect a measure of wellbeing or resilience.

From another perspective, McEwen and Lasley (2002) posit that, while much of the research into allostatic load from stress examines the negative effects on the system, much can be learned about resilience and building successful adaptation to extreme stress. It is important, in the context of the extreme stressors that firefighters routinely face, to equip them to deal with stress before it becomes a significant clinical issue or results in adverse health outcomes. This is supported by Berninger, Webber, Niles, et al. (2010), who studied 5,656 New York Fire Department rescue workers who attended the World Trade Center disaster. They found that 8.6% had PTSD symptoms after 9/11, and this figure increased to 11.1% 2.9 years after 9/11. Their research indicates that "early identification of those with sub-threshold PTSD … may present an opportunity to offer mental health services before symptoms become chronic" (Berninger, Webber, Niles, et al., 2010, p. 1184).

Thus, it is important to explore the ways in which subclinical PTSD can be measured (as in Study 1) and to explore the efficacy of neurofeedback as an intervention to improve symptoms of stress (as in Study 2).

Staging for PTSD

There are a range of recent studies aimed at determining how individuals with trauma symptoms can be grouped together, specifically using latent profile analysis, using symptoms rather than categorical diagnoses or dichotomised absence or presence of symptoms (Jongedijk et al., 2019) to identify homogeneous groups. Jongedijk et al. (2019) examined symptom severity in military veterans and they note that the majority of participants scored above the clinical cut-off for their PTSD measure, and consequently their profiles reflected clusters within the range of clinical PTSD. Terhaag et al. (2019) examined comorbidity profiles among military veterans who met the diagnostic criteria for PTSD, and clusters were identified in relation to the comorbidity.

In a veteran population, Armour et al. (2015) used latent profile analyses to explore patterns of PTSD and major depression. Their study also included a range of standardised psychological self-report measures; however, the PCL-M (military version) was included. These authors reported a three-class solution with increasing PTSD co-occurring with increasing major depression. A three-class solution was also found by Contractor, Roley-Roberts, Lagdon, and Armour (2017) in a university sample that also examined patterns of PTSD and depression.

In a later study by Contractor, Caldas, Weiss, and Armour (2018), PTSD and impulsivity was explored in two samples—university students and community members—using latent profile analysis. They used a range of standardised self-report measures which included the PCL-5 and Dimensions of Reaction Scale. A three-

class solution was found for severity of PTSD. While the focus of their study was on impulsivity factors, an additional finding was that anger regulation significantly predicts membership of the more severe class of PTSD. This includes difficulties in self-regulation of successful suppression, appropriate expression and inhibition of anger. Failure to manage anger can result in hostile appraisal and antagonistic behaviour for those with PTSD.

Griffith et al. (2022) recently explored PTSD and co-occurrence of sleep disturbances in a sample of firefighters. Like other studies reported above, these authors included the Posttraumatic Checklist-5 as a measure of PTSD symptoms as well as the Pittsburgh Sleep Quality Index and a measure of the Dimensions of Anger Reactions-5. Further, a three-class solution was deemed to be the optimal representation of their data. The classes were characterised into higher PTSD symptoms and greater sleep disturbance (10%); moderate PTSD and sleep disturbance (19%); and low PTSD and sleep disturbance (70%). As with the findings of Contractor et al. (2018), higher levels of PTSD were associated with difficulties in anger management, predicting membership to class. Griffith et al. (2022) cite the same underlying premise of difficulties in self-regulation of anger but also indicate that poor sleep is associated with difficulties in managing anger.

Most of these studies, however, have been on those already diagnosed with PTSD and the latent profiling used in analyses has investigated homogeneous classes within the clinical range. Importantly, a recent study by Visser et al. (2022) examined trajectories of PTSD after trauma exposure. Five distinct trajectories were found: (1) no PTSD symptoms; (2) mild symptoms; (3) moderate symptoms; (4) subclinical symptoms; and (5) severe symptoms. Notably, participants were patients who had experienced trauma and presented to emergency care in hospital, with all

participants having sustained significant injury, such as head or spinal injuries, multi-trauma, and/or burns, potentially confounding findings. Nonetheless, this research made a significant contribution to promoting the utility of latent class analysis in understanding pathways to PTSD and identifying stages or potential trajectories.

There are also several studies that have prospectively considered risk factors for the development of PTSD, although these are diverse and fail to consolidate their findings by utilising any type of staging model which connects symptom severity to expression of functional impact. For instance, Wild et al. (2016) followed participants, who were newly recruited paramedics, in their study every four months for two years and noted symptom changes and trauma exposures over time. Predictably, the results showed that those with pre-trauma cognitive predictors of episodes of PTSD were more likely to develop PTSD. These authors were attempting to identify possible risk factors, such as attitude or appraisal of events that may provide the basis for early intervention using cognitive therapies. They acknowledged that merely monitoring PTSD symptoms was of limited use in reducing symptomatology.

Like the studies reported above, this research used a suite of standard psychological measures that correlate to the DSM-5 symptom groupings for PTSD (American Psychiatric Association, 2013), of intrusion, avoidance, negative mood/cognition and arousal/reactivity. As stated previously operational emergency responders often do not meet the “C” criteria of avoidance.

The staging model for PTSD, as more recently proposed by McFarlane et al. (2017), provides a profoundly useful paradigm for the rationale to target subclinical thresholds for intervention to lessen further development of a disorder to clinically significant levels (McGorry et al., 2006). The staging model (Table 3.1) consists of

six stages and proposes to capture the progression of symptom expression from Stage 0 (no symptoms) to Stage 4 (increasing chronic illness).

McFarlane et al. (2017), in proposing the staging of PTSD, posit that no specific drug targets or other interventions have been successfully developed due to the heterogeneity of PTSD, and therefore the staging model is a necessary development to promote assessment of homogeneous sub-groups for targeted intervention. Essentially, these authors claim there is a lack of specificity in most interventions. PTSD is a moving target, a constantly changing dysregulation that can fluctuate according to, for example, environment, ongoing stressors, sleep patterns and individual coping strategies, as proposed in allostasis (McEwen, 1998, 2016b). The field of research and interventions in PTSD are often binary, in that there is either diagnosed PTSD or no PTSD; however, there is increasing interest in symptoms and interventions below cut-off scores (Joyce, 2019; Skeffington, Rees, Mazzucchelli, & Kane, 2016).

McFarlane et al. (2017) consider the staging model in terms of identifying biological markers, arguing that there is a significant body of research on the longitudinal course of PTSD and consequent alterations in neurobiology. These biological studies have shown that there are predictors that differentiate individuals, such as C-reactive protein levels, or the increased production of pro-inflammatory cytokines. However, the biological disease markers need to be explored to determine if there is a direct correlation reflecting the increasing severity of PTSD. Importantly, McFarlane et al. (2017) acknowledge the decreasing capacity of response inhibition in the frontal lobes and sensitisation of neural networks, as explicated in Chapter 2, and their model includes consideration of biomarkers, such as glucocorticoid sensitivity, pro-inflammatory cytokines and cortisol and norepinephrine levels.

In the context of this research, however, the focus is on examining the severity or stage of stress, based on symptom self-report aligned to the DSM-5 criteria for PTSD using measures that are independent of the usual measures for assessing PTSD but align to the constructs of, for example, avoidance or aggression, as well as a specific PTSD screening measure. This is similar to the above reported studies using latent profile analysis (Armour et al., 2015; Contractor et al., 2018; Griffith et al., 2022). In the context of the population of interest—firefighters—one can reasonably expect that Stage 0 is being trauma exposed without any symptoms. This exposure can potentially put a person at risk, as PTSD may emerge after a period of time. Alternatively, Stage 0 may reflect early career firefighters or those who work in areas that minimise exposure—although it should be noted that firefighters can be exposed to trauma vicariously (Berninger, Webber, Niles, et al., 2010; Lee et al., 2017). Another possibility is that an individual may have experienced trauma prior to recruitment and be asymptomatic until further exposure contributes to the development of PTSD.

Stage 1a is where a person is experiencing some undifferentiated symptoms of distress or anxiety at a milder level. This reflects a constellation of anxiety or stress features that do not meet any of the typical anxiety syndromes where a person may experience feeling restless, being irritable or having sleep problems. Stage 1a may also reflect stage of career or the area of operation that a firefighter works in. Individual differences can play a role in further symptom development, which reflects the concept of allostatic load and individual responses on a number of levels, such as cognitive appraisal, health, social support and coping styles (McEwen, 2016a). McFarlane et al. (2017) indicate that Stage 1a falls below the subclinical level while Stage 1b includes subclinical features.

Stage 1b is an increasing level of distress with more notable functional and behavioural decline, such as being unable to effectively manage the demands of day-to-day life or withdrawal from social interaction. While these may be associated with many different mental health concerns, the essential point is the difference between the person's previous behaviours and their current behaviours.

Stages 2, 3, and 4 represent diagnosable PTSD, indicating different possible trajectories dependent upon receiving intervention, including at best, remediation or reduction of symptoms, and at worst, persistent chronic illness, if left untreated. There are several factors that can influence the trajectory, such as receiving mental health support, taking medication, having family support, whether exposure is ongoing, and the individual differences discussed above as part of allostasis.

Table 3.1.

Proposed Staging Model for PTSD

Stage	Symptom progress profile
Stage 0	Trauma exposed although asymptomatic. At risk
Stage 1a	Undifferentiated symptoms of anxiety and distress
Stage 1b	Subclinical distress with functional and behavioural decline
Stage 2	The occurrence of full clinical symptoms. Different possible trajectories for different individuals
Stage 3	Persistent symptoms of disorder that fluctuates with ongoing impairment of mental and physical health
Stage 4	Increasing chronic illness

(McFarlane et al., 2017)

The utility of the proposed staging model is that it recognises that emergency responders will, by and large, be trauma exposed and that the evidence for the negative effects of *accumulated* exposure is sound. It is argued here that exploring this model and investigating the stages of symptom severity can assist in guiding

more targeted interventions with a greater likelihood of improved outcomes. It would also allow the opportunity to reduce the heterogeneity in the sample by applying an intervention to a targeted group with like symptoms.

This research will explore the staging model to demonstrate that it is potentially a more sensitive way than current methods of measuring symptoms that better informs prognosis and treatment programs (McFarlane et al., 2017). As noted, one of the challenges in applying a diagnosis of PTSD or other anxiety or stress disorder is how to characterise individuals who have stress symptoms, but do not meet any current DSM-5 (American Psychiatric Association, 2013) criteria. There is increasing recognition of the effects of repeated exposure to trauma and a subsequent interest in developing interventions that may improve resilience (Joyce et al., 2019; Metcalf et al., 2016; Varker & Devilly, 2012). For example, resilience training can be usefully applied in healthy or early career emergency responders, however, these interventions have shown positive but limited benefits. Research by Joyce et al. (2019) had variation in the number of years of service (ranging from one to over 20 years) as well as exposure to trauma incidents (ranging from three to 37). While any resilience program may confer some broad benefits, it would likely be more useful to apply some sort of staging to tailor the interventions.

The staging model has not been previously explored, tested or aligned with existing measures, and consequently there is no standardised measure or protocol for determining a level. What the staging model posits, however, is that PTSD is multidimensional, heterogeneous and nonlinear, and the review of the literature supports this view. This heterogeneity of symptoms can impact treatment options as well as outcomes (Jongedijk et al., 2019).

In summary, emergency responders do not usually become unwell after a single event; however, repeated exposure has been shown to result in a variable accumulation and gradual worsening of stress symptoms over time (Harvey et al., 2015; McFarlane et al., 2017). Consequently, there are several benefits in assessing emergency responders and staging symptom severity, which include: an opportunity to create better outcomes; improvements to cost effectiveness; and halting the possible trajectory towards PTSD. Not all trauma exposure leads to PTSD; however, many stages along the way have been shown, in the literature, to contribute to its development.

This project explores the staging model of classification of symptoms to contribute to potential early interventions. This rethinking of the nosology of mental health and interventions has been called for by scientists (Insel et al., 2010; McFarlane, 2017; Steenkamp, 2016) to stem the rising tide of mental illness. It is proposed that the PTSD staging model can be used to identify and classify firefighters at various pre-PTSD states, as explored in Study 1, and therefore the research question is:

RQ1: How can self-reported levels of symptoms be identified and applied to a staging model?

An additional question that is raised, given the argument for the effects of accumulative exposure, is whether a longer time in service for a firefighter increases the probability of experiencing increased distress. Unlike military personnel on time-limited deployment firefighters may experience repeated exposure to trauma of the time course of their careers (Kyron et al., 2022). This is an important area of this research and could be of consequence to a greater understanding of stress and its possible trajectory. Therefore, it is hypothesised that the data will show that longer

time in service is positively correlated with increased distress symptoms. This research is not intended to validate the model but to explore its utility in identifying clusters of stress symptoms that may be used as part of tailored intervention programmes.

Study 1 does not aim to identify contributors to or causation of PTSD, but rather, to explore stress symptoms and clusters of symptoms that are currently experienced by the population of interest. There is extensive literature on the increased risk of developing PTSD as a result of the firefighter occupation and equally, research showing that firefighters are resilient (Alex, Shannon, & Luke, 2017; Fraess-Phillips, Wagner, & Harris, 2017; Harvey et al., 2015; Harvey et al., 2016; Parliament of Australia, 2018; Skeffington et al., 2017; Varker et al., 2017). It is acknowledged that the contributing factors to PTSD are complex and heterogenous, as emphasised in the theoretical perspective of allostasis.

This research is specifically linked to the DSM-5 (American Psychiatric Association, 2013) criteria and uses individual self-report measures that correlate to, or may permit exploration of, the individual criteria. The research also includes other measures—such as organisational sense of belongingness, sleep patterns and level of burnout, for example—in an effort to further parse out symptoms and support the exploration of convergence of symptoms.

This research can assist in demonstrating that staging or grouping of like subclinical stress symptoms may:

- effectively identify the levels of symptom concerns (mild or moderate or severe), providing a more sophisticated classification that acknowledges heterogeneity and individual differences
- allow an intervention to be tailored or improved in design and advance treatment development, particularly early intervention

- provide a framework to better define treatment response, which may lead to better outcomes and more consistent results provided by the classification of more homogenous groups
- inform organisational policy and aid in its further development
- contribute to the scientific body of knowledge of stress disorders and challenge the current binary system of diagnosis
- permit identification of inflection points over the course of stress.

Method

Research Design

Study 1 uses a quantitative approach and an anonymous online survey between Oct 2020 and July 2021, in which the variables of interest were measured using self-report questionnaires. It was administered to a sample of operational career firefighters with the Queensland Fire and Rescue Services who self-selected to participate. This survey research was important in estimating the prevalence of stress symptoms in the sample of interest and identifying statistical relationships among the variables that may assist clinicians and policymakers who need to understand the common concerns at a subclinical level.

Traditional statistical analyses that examine prevalence rates or the efficacy of interventions have produced limited findings and outcomes due to complexities of PTSD, which include its multidimensional nature (Contractor et al., 2018; Contractor et al., 2017). As reviewed in Chapter 2, research has primarily focused on prevalence rates to determine PTSD in various populations, often reporting subclinical prevalence as well as investigating factors such as the mediating effects of social support or contributions of attributional style (Petrie, Milligan-Saville, et al., 2018; Regehr, Hill, & Glancy, 2000; Skeffington et al., 2017). Furthermore, traditional analytical approaches, such as general linear modelling, correlation and regression-

based techniques and factor and cluster analysis, are limited in characterising complex and non-linear symptoms. These approaches are variable-oriented and examine relationships between variables as opposed to the person-centred approach of latent profile analysis, which considers that there is homogeneity in the nature of individual differences (Hickendorff, Edelsbrunner, McMullen, Schneider, & Trezise, 2018). Given this, latent profile analysis will assist in identifying unobserved homogeneous subgroups that may be mapped to the staging model and identify individual differences.

Participants

Ethical approval was obtained from the Queensland University of Technology Human Research Ethics Committee (QUT Ethics Approval Number 2000000588). The participants for Study 1 were drawn from Queensland Fire and Emergency Services (QFES) and were operational career firefighters. Firefighter recruitment occurred via the United Firefighter Union Queensland (UFUQ). UFUQ was approached to request that the executive committee support the study by the dissemination of recruitment information to its members. An initial face-to-face meeting was held with key stakeholders who report to the executive to discuss the aims of the research and address any questions. The UFUQ committee was provided with the university ethics committee approved documents, which were then presented to the UFUQ executive for approval. In disseminating news of the project, the union noted it was in no way coercing people, or even recommending they engage in the survey, but was simply providing information that the project was being conducted. This organisation represents firefighters throughout the state of Queensland, meaning that members in rural, remote and urban locations were able to participate. An invitation to participate in the research was sent via email to the

database of members as part of the UFUQ newsletter with a link to the anonymous Qualtrics Survey (Qualtrics Provo Utah) (see Appendix A) as well as the participant information sheet describing the aims and objectives of the study (Appendix A).

Research suggests there is no current formula or calculation for determining sample size for LPA (Ferguson, G. Moore, & Hull, 2020; Hickendorff et al., 2018), and that sample size is dependent on several factors, including the number of profiles or distance between profiles, which is unknown in advance. Therefore, LPA is recommended to be applied in a theory-driven manner (Spurk, Hirschi, Wang, Valero, & Kauffeld, 2020). Sample sizes of previous research specifically on trauma symptoms include N=112 for latent profile analysis by Jongedijk et al. (2019), and N=119 for Au, Dickstein, Comer, Salters-Pedneault, and Litz (2013). Further, according to Nylund-Gibson and Choi (2018), in simple models with well-separated classes, sample sizes of 30 may be sufficient and decisions can be informed by known prevalence rates.

Overall, a sample of 157 participants was generated from the survey. Surveys missing ten percent or more of data were not included in any analyses. The final number of participant surveys used in demographic analyses was thus 104. Of the respondents, 100 were male (96.2%) and 4 (3.8%) were female. Currently, men make up 80% of the QFES workforce (QFES Annual Report, 2022). Ages ranged from 24 to 64, M=48.02, SD=9.99. Ninety-eight participants reported being married (94.2%) and 6 were not married (5.8%). Eighty-four participants had children (80.8%) and 18 had no children (17.3%). Years of service ranged from one to 46 years, M=19.96, SD=11.29.

Table 3.2.

Sociodemographic Characteristics of Survey Participants Study 1

	n	*M*	*SD*	%	Range
Age		48.02	9.99		24–64
20–30	5			4.8	
31–40	24			23.1	
41–50	24			23.1	
51–60	51			49.0	
Gender					
Male	100			96.2	
Female	4			3.8	
Service Years		19.96	11.29		
1–5	11			10.6	
6–10	13			12.5	
11–20	31			29.8	
>20	49			47.1	
Marital Status					
Married	98			94.2	
Not Married	6			5.8	
Children					
Have Children	84			80.8	
No Children	19			18.3	
Exposure					
Directly	22			21.2	
Witnessed	10			9.6	
Learned	1			1	
On Job	66			63.5	

Note: Exposure relates to the way trauma exposure has been experienced.

Procedure

Two meetings were held with the executive of the UFUQ to fully explain the aims of the research, background information and the importance of anonymity for members. The initial meeting was introductory, and the second meeting discussed and

explicated the research. It was requested that UFUQ disseminate the email information to their members. At no time was the researcher privy to the union database of members.

The Qualtrics survey platform was used, and the survey was developed through the QUT Business School link (Qualtrics Provo Utah). Qualtrics uses Transport Layer Security (TLS) encryption. The landing page of the survey provided the information sheet (Appendix A), which included information about the purpose of the study, examples of the questions asked, confidentiality, opt-out options and where to seek support. While there were no formal exclusion criteria associated with the survey, the information sheet included a statement that indicated that those personnel "with an existing mental health condition, stress from COVID, or those currently seeking support for mental health may not wish to participate". This was made on the recommendation by the Ethics committee with concerns raised for risk of triggers of adverse reactions to any question. In addition the survey was aiming to capture participants that would fall into the subclinical range without any diagnosed conditions. Further, there was provision for opting out of the survey after reading the information sheet. Opt-out could occur by closing the browser at any time, and through in-survey options for leaving the survey. There were also end-of-survey avenues of support, and an end-of-survey option for requesting assistance or follow up.

The information sheet included the statement that, "as the survey does not request any personal identifying information, once it has been submitted it will not be possible to withdraw" and "the submission or return of the completed survey is accepted as an indication of your consent in the research project".

Participants could withdraw from the survey in a number of ways:

a) At the conclusion of reading the information sheet, a question asks if the participant wishes to continue. If not, the participant is taken to the end of the survey and thanked for their time.
b) Halfway through the survey, the participant is asked via a pop-up question: "How able do you feel to complete this survey at this moment?" If not able, the participant is taken to the end of the survey to a message that includes repeated information on the sources of support (e.g., counselling through QUT, Lifeline, etc.).
c) The participant is informed in the participant information sheet that they can leave the survey at any time by closing the browser.

Measures

The staging model of interest in Study 1 has not been previously explored or aligned with existing measures and consequently there are no standardised measures or protocols for determining a level. The selection of standard psychological measures (Appendix B) were chosen to correlate to the DSM-5 symptom clusters for PTSD (American Psychiatric Association, 2013), of intrusion, avoidance, negative mood/cognition and arousal/reactivity and particularly to the Posttraumatic Checklist-5 (PCL-5). The PCL-5 specifically corresponds to the DSM-5 symptoms of PTSD (Blevins et al., 2015). The measure is not diagnostic; however, it is used to screen individuals for PTSD and assists with provisional diagnosis. Hence, exploration of the correlations between measures and specifically against the PCL-5 were conducted. No confirmatory factor analyses were conducted due to the small sample size.

Self-report measures were selected on the basis of their ability to reflect the symptoms in the diagnostic criteria of the DSM-5. Those symptoms associated with subclinical PTSD as well as an additional measure were considered relevant in this sample. This information is summarised in Table 3.3.

Table 3.3.

DSM-5 Criteria and Associated Measure in Study 1

DSM-5 Criteria	Measure
Criteria A: exposure to death, injury or violence	PCL-5
Criteria B: intrusive symptoms; memories/dreams	PCL-5, PSQI
Criteria C: persistent avoidance	PCL-5, BEAQ
Criteria D: negative alterations in cognitions, mood or negative emotional states: anger, hostility	PCL-5, BPAQ, DASS21, MBI,
Criteria E: alterations in arousal and reactivity. Irritable behaviour, poor concentration, sleep disturbance.	PCL-5, BPAQ, DASS21, MBI, PSQI, MSPQ

Note: PCL-5: Posttraumatic Checklist-5; PSQI: Pittsburgh Sleep Quality Inventory; BPAQ: Buss Perry Aggression Questionnaire; BEAQ: Brief Experiential Avoidance Questionnaire; DASS21: Depression, Anxiety, Stress Scale21; MBI: Maslach Burnout Inventory; MSPQ: Modified Somatic Perception Questionnaire

Posttraumatic Checklist-5

The PCL-5 is a 20-item self-report measure that corresponds to the 20 DSM-5 symptoms of PTSD (Blevins et al., 2015). The PCL-5 can be used to screen individuals for PTSD and assists with provisional diagnosis. When used as a measure of symptom change for an intervention, a five-point reduction is considered to reflect that an individual has responded to treatment. A ten-point reduction in symptom ratings is considered clinically significant. Provisional diagnosis is made by items rated 2 (*moderately*) or higher as endorsed symptoms correlating to the DSM-5

criteria. The Likert rating scale is 0–4 for each symptom, with descriptors from 0 (*not at all*) to 4 (*extremely*). The measure takes approximately 5–10 minutes to complete. Scoring can be either:

- a total symptom severity score (range 0–80) derived by summation of scores
- DSM-5 symptom cluster scores derived by summing the scores for the items within a given cluster: cluster B (items 1–5); cluster C (items 6–7); cluster D (items 8–14); and cluster E (items 15–20).

A total score of 33 is the cut-off recommended by Weathers et al. (2013), for provisional diagnosis of PTSD. Psychometric properties were ascertained primarily by comparison of the scale to the previous version of the Posttraumatic Check List (Blevins et al., 2015). PCL-5 scores exhibited strong internal consistency ($\alpha = .94$), and test-retest reliability ($r = .82$). Total score was used in this research.

Depression, Anxiety, Stress Scale

The Depression, Anxiety, Stress Scale-21 (DASS-21) is an extensively used self-report measure that aims to differentiate between the central symptoms of anxiety, stress and depression (Lovibond & Lovibond, 1995). Respondents rate the extent to which they have experienced each symptom over the previous week on a four-point Likert scale from 0 (*never*) to 3 (*almost always*). Scores for each sub-scale are determined by summing the scores for the corresponding item. In a normative sample, the internal consistencies were depression 0.91; anxiety 0.84 and stress 0.90 (Lovibond & Lovibond, 1995). While the DASS discriminates between the three sub-scales, the authors acknowledge the syndromes are moderately highly correlated. The depression scale is characterised by a loss of self-esteem and incentive relating

to achieving life goals. It assesses dysphoria, anhedonia and hopelessness (Lovibond, 2018). The anxiety scale emphasises the link between the enduring state of anxiety and an acute response, such as fear and fear-related symptoms. It assesses autonomic arousal and subjective sense of anxiety (Lovibond, 2018). The stress scale is related to states of persistent arousal and tension, and this scale shows the greatest overlap with the anxiety scale. It is considered to be sensitive to chronic non-specific arousal (Lovibond, 2018). This self-report measure is considered useful for tracking change over time (Lovibond, 2018) as well as for focusing on the arousal, cognitive and intrusive components of the DSM-5 diagnostic criteria for PTSD. It is considered a dimensional reflection of emotional state rather than providing any diagnostic category.

In a review of the psychometric properties of the DASS-21 in both a clinical group and community sample (Antony, Bieling, Cox, Enns, & Swinson, 1998), it was found that the measure distinguished well between features of depression, anxiety as psychological tension, and stress as physical arousal. Cronbach's alphas (Cronbach, 1951) for the DASS-21 subscales were depression 0.94; anxiety 0.87; and stress 0.91.

Maslach Burnout Inventory

The Maslach Burnout Inventory – Human Services Survey (MBI-HSS) was developed to assess people who work in the service of others—for example, in human services—who can experience chronic stress, which is emotionally draining and leads to burnout (Maslach, Jackson, & Leiter, 1997). As defined by Maslach et al. (1997), burnout is a psychological syndrome with three features: emotional exhaustion and depleted resources of being able to give of oneself to others emotionally; depersonalisation, or negative and cynical feelings and attitudes; and

reduced personal accomplishment. It is on this basis that the MBI is considered an appropriate measure for emergency responders.

The MBI consists of three subscales reflecting the three features described for which 22 items are answered on a seven-point scale ranging from 0 (*never*) to 6 (*every day*). Nine items make up the emotional exhaustion scale, which reflect feelings of being overextended and exhausted by work. Depersonalisation comprises five items and focuses on a lack of feelings or an impersonal response towards the recipients of services. Higher scores in these scales reflect a greater level of burnout. Personal accomplishment is an eight-item scale which assesses self-competence in working; lower scores reflect higher burnout.

Scores are interpreted by each sub-scale, not as a total, and can be broken down into low, moderate, or high burnout. The reliability coefficients for the subscales are: emotional exhaustion =.90; depersonalization =.79 and personal accomplishment =.71. Test–retest reliability coefficients were .82, .60, and .80 respectively.

Buss-Perry Aggression Questionnaire

This is a 29-item questionnaire rated on a five-point Likert scale ranging from 1 (*extremely uncharacteristic*) to 5 (*extremely characteristic*). Buss and Perry (1992) recommend users make up the measure by scrambling items so that factors are not clustered, and two items are reversed—in this case, items 9 and 16, which are worded in the opposite way to aggression. The score for each scale is the sum of the ratings (1–5) as well as a total score for aggression as the sum of the subscales. The BPAQ measures the four dimensions of anger, hostility, physical aggression and verbal aggression. Physical and verbal aggression represent the hurting or harming of others and are the instrumental or motor components of behaviour, while anger involves

physiological arousal and preparation for aggression as part of an affective component, and hostility is a feeling of ill will as part of a cognitive component.

Internal consistency was evaluated by the alpha coefficient, anger, .83; hostility .77; physical aggression, .85; and verbal aggression, .72 and overall, .89. Test–retest reliability correlations were anger, .72; hostility, .72; physical aggression, .80; and verbal aggression, .76 and overall, .80 (Buss & Perry, 1992).

Brief Experiential Avoidance Questionnaire

This is a 15-item self-report questionnaire that measures experiential avoidance. The items are rated on a six-point Likert scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The scores range from 15 to 90, with item 6 reversed. Higher scores indicate greater experiential avoidance. The measure has good reliability with a Cronbach's alpha of .80 to .89 across the samples measured. Experiential avoidance is defined as the maladaptive behavioural responses to distress as avoidance rather than the distressing content itself (Gámez et al., 2014).

Psychological Sense of Organisational Membership

The Psychological Sense of Organisation Membership (PSOM) scale measures the psychological sense of organisational membership and social support (Cockshaw & Shochet, 2010). The scale consists of 18 items rated by respondents for how true each statement is for them, from 1 (*not at all*) to 5 (*completely true*) (range = 1–90). Higher total scores indicate higher levels of perceived belonging. The PSOM has exhibited high internal consistency of .94. It is considered useful in this research, as the same scale was used in a previous QFES study that investigated the wellbeing and mental health in Queensland firefighters (Armstrong, 2014). It will examine the extent to which an individual feels included, accepted and respected within the organisation (Cockshaw & Shochet, 2010).

Pittsburgh Sleep Quality Index

Sleep quality is an important construct due to the fact that more than a third of the adult population complains of poor quality sleep, including difficulty falling asleep, and further that poor sleep quality can be an important indicator of medical disorders (Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989). The Pittsburgh Sleep Quality Index (PSQI) was developed to discriminate between good and poor sleepers as well as being a useful assessment of sleep disturbances. It measures seven areas: subjective sleep quality; sleep latency; sleep duration; habitual sleep efficiency; sleep disturbances; medication usage; and daytime function over the last month. These seven components are scored separately for each domain and then summed to provide an overall sleep quality rating. The questionnaire consists of 19 items. Questions 5–10 are on a four-point scale from 0 (*not during the past month*) to 3 (*three or more times a week*). Internal consistency is reported to be .70.

Modified Somatic Perception Questionnaire

The Modified Somatic Perception Questionnaire (MSPQ) scale aims to measure somatic and autonomic perception (Main, 1983) and consists of 13 items on a four-point scale from 0 (*not at all*) to 3 (*extremely; could not have been worse*). Internal consistency is reported to be in the order of .80. This scale is included to specifically measure a participant's heightened awareness of bodily functioning, which is a reflection of sympathetic activity (Main, 1983).

Results

Overview of Analyses

After scoring the measures and prior to analysis, all variables were examined via SPSS (IBM Corp, 2017) (v.28) functions to investigate accuracy of data entry and missing values. Measures were scored and the subscales for the DASS were separated, which resulted in scores for each of the dimensions of depression (DEP), anxiety (ANX) and stress. The Maslach Burnout Inventory also was scored separately for each of the three subscales of emotional exhaustion (EE), depersonalisation (DP) and personal accomplishment (PA). The Buss-Perry Aggression questionnaire has four subscales consisting of anger (ANG), hostility (HOS), verbal aggression (VA) and physical aggression (PhA). All other measures provided a single score.

Confirmatory and exploratory factor analyses were not conducted, for several reasons. The study aims to explore homogeneous subgroups, and any removal of cross loading factors would alter the person-centred approach this study takes. For example, removal of any item from the PCL would affect the standardised measure and therefore the cut-off scores, which are essential to analysis. The same is true for all other measures, and this would have the potential to negatively affect the overall findings of the latent class analysis. Further impacts arise from the small sample size. The measures employed are established scales that have been used extensively in both clinical and research settings. Results were compared with published psychometric properties. In addition, examination of the correlation matrix was considered to provide for convergent and divergent validity.

Firstly, descriptive statistics using SPSS ver.28 (IBM Corp, 2017) were used to identify demographic data and intercorrelations, means and standard deviations among

the measures. Univariate normality was checked using the EXPLORE command. Overall, violations of normality were detected in many of the variables; however, any transformation would have negative effects on the subsequent analysis and would remove the ability to detect homogeneous subgroups. There were outliers in a number of the variables, which were considered genuine values.

Secondly, the aim of the study was to explore the ability to identify homogeneous subgroups based on self-report measures. Traditional statistical analyses that are variable-focused rather than person-centred would limit the investigational aims (Ferguson et al., 2020; Nylund-Gibson & Choi, 2018). Given this, LPA was used in identifying underlying homogeneous subgroups that can be mapped to the staging model. MPLUS software (Muthén & Muthen, 2017) was used for the latent profile analyses.

LPA permits the identification of subgroups that may be aligned with the staging model. MPLUS (Muthén & Muthen, 2017) was used to identify unobserved sub-classes based on symptom severity of observed scores. LPA treats the profile membership as a categorical or continuous variable and indicates in which profile an individual may sit with a degree of probability (Spurk et al., 2020). Further, LPA assumes population heterogeneity that is unobserved *a priori* and that subgroups in key variables exist that represent latent profiles (Spurk et al., 2020). According to Spurk et al. (2020), LPA should be applied in a theory-driven manner and profile groupings should be theoretically related. The LPA posits three underpinning arguments: individual differences are present and critical in effect or within a phenomenon; these differences occur in a logical manner that can be understood through examining patterns; and a small number of patterns occur and these are meaningful (Ferguson et al., 2020). LPA analysis occurs in an iterative modelling

manner similar to structural equation modelling where the goal is to "uncover latent profiles (*k*) of individuals (*i*) who share a meaningful and interpretable pattern of response on the measures of interest (*j*)" (Ferguson et al., 2020, p. 6).

Responses from the Qualtrics survey were exported to SPSS for analysis of descriptive statistics and MPLUS for latent profile analyses. Data were stored and archived as per the QUT data management policies.

Descriptive Results

Initial analyses were performed using IBM SPSS Statistics for Windows Version 28.0, to determine both descriptive statistics and correlations between variables. All the demographic questions and the PCL were completed by 104 participants and these data were also used in examining the length of service and correlation to a higher level of distress symptoms.

Table 3.4 shows the means, standard deviations, and inter-correlations (*r*) among the variables. Overall, most correlations were moderate and significant and ranged from $r = -.09$ to $r = .81$. Alpha coefficients are reported in the measures section as well as the table.

As noted in the Measures sub-section of this chapter, the PCL-5 is the underpinning self-report measure that spans all the DSM5 criteria, hence in inspecting the correlation table it is important to consider the other measures that were used in relation to the strength and direction of their correlation to the PCL-5. In this case, all other measures show a significant positive correlation to the PCL except for *sense of organisational membership* and *personal accomplishment*, which show a negative correlation. The direction of these correlations is in line with expectations.

The depression (r = .77, p = .01), anxiety (r = .66, p = .01) and stress (r = .72, p = .01) subscales of the DASS21 are all strongly to very strongly correlated to the PCL-5. Given the breadth of similar symptoms the DASS covers, this is not surprising. The PCL-5 clusters of negative changes in thinking and mood and changes in physical and emotional reactions are aligned to depression, stress and anxiety respectively.

For the Maslach Burnout Inventory, emotional exhaustion shows a positive correlation to the PCL-5 (r = .52, p = .01) as well as depersonalisation (r = .53, p = .01). There is a negative correlation between low scores on personal accomplishment and higher scores on the PCL-5 (r = .25, p = .05), as would be expected.

The Buss Perry Aggression questionnaire subscales indicate that anger and hostility are more strongly positively correlated to the other negative symptom measures rather than sense of personal accomplishment and sense of organisational membership, which show mild negative correlations in the expected direction.

In addition, bivariate correlations were conducted on age and years of service with the variables. Age was positively associated with the clinical measures of PCL-5, r = .27, p < .001, depression, anxiety and stress, r = .23, .25, .22 p < .05 respectively, emotional exhaustion r = .25, p < .05, and avoidance r = .23, p < .05. As age increased, these negative symptoms increased. For the years of service, results revealed that for longer time in service several clinical symptoms also increased, PCL, r = .31, p < .001, depression, anxiety and stress, r = .24, .24, .24 p < .05 respectively, emotional exhaustion r = .31, p < .01, and verbal aggression r = .23, p < .05.

Further, the descriptive statistics output requested frequency for the PCL-5 score to anticipate the percentage of individuals that may be profiled in the LPA to be above the PCL-5 clinical cut-off for a provisional PTSD diagnosis. Clinical cut-

off is 33 from a range of 0–80 and the data revealed that 12.5% of the sample of participants scored above this level.

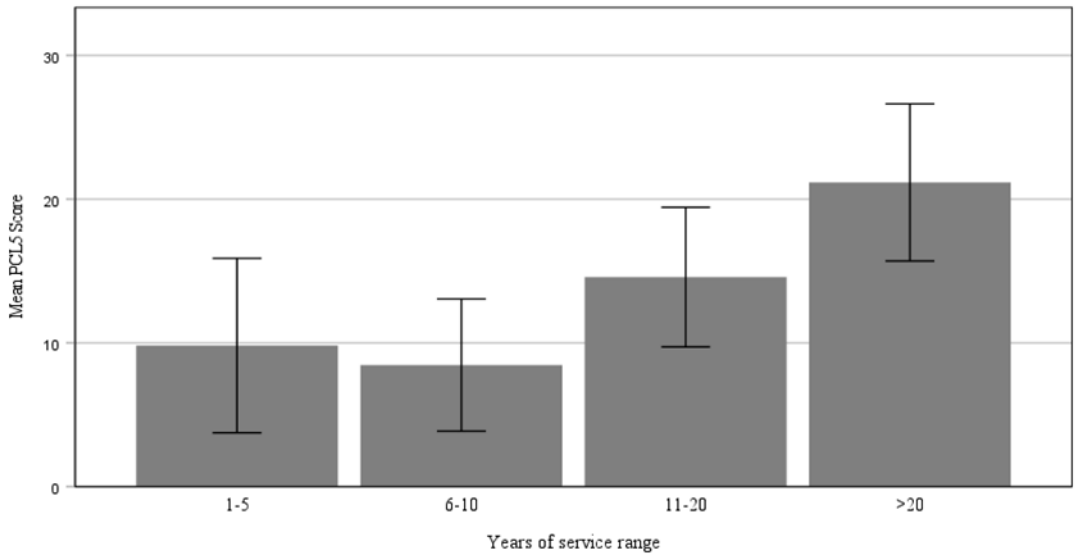
Accumulative exposure

Given that this research argues that accumulative exposure to stress is likely to lead to a worsening of symptoms over time, specifically in firefighters, an additional analysis was conducted to examine this.

Analysis used SPSS Somers' *d* to distinguish between the dependant variable of the PCL-5 and the independent variable of years of service (Laerd Statistics, 2013). It was run to determine the association between years of service and PCL-5 scores amongst all 104 participants, as this was a complete data set, as shown in Figure 3.1. There was a positive association which was statistically significant ($d = .008$, $p = <.01$) suggesting that longer time in service as a firefighter is associated with higher levels of positive endorsements on the PCL-5 and is concordant with the correlation finding. This aligns with the proposal that accumulative stress and/or exposure over time is likely to lead to further symptoms.

Figure 3.1.

Simple bar chart of mean PCL-5 scores and years of service



Note: Error Bars: 95% CI.

Table 3.4.

Means, standard deviations and correlations among the measures for Study 1

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 PCL-5	15.43	15.66	(.94)														
2 Depression	3.57	4.00	.77**	(.94)													
3 Anxiety	2.06	2.85	.66**	.65**	(.87)												
4 Stress	4.52	3.59	.72**	.81**	.73**	(.91)											
5 MBIEE	1.70	1.44	.52**	.58**	.49**	.55**	(.90)										
6 MBIDP	1.46	1.11	.25*	.30**	.12	.27**	.53**	(.79)									
7MBIPA	3.73	1.36	-.21*	-.24*	-.26*	-.17	-.09	-.12	(.71)								
8 BEAQ	44.70	12.82	.58**	.51**	.51**	.44**	.54**	.42**	-.43**	(.89)							
9 PSOM	51.55	9.09	-41*	-.46**	-.25*	-.35**	-.53**	-.63**	.41**	-52**	(.94)						
10 BPAQA	14.76	5.92	.42**	.39*	.36**	.43**	.28**	.12	-.35**	.34*	-.41**	(.83)					
11 BPAQH	19.67	6.76	.52**	.57**	.42**	.53**	.55**	.31**	-.39**	.60**	.73**	.63**	(.77)				
12 BPAQPA	17.20	5.97	.22*	.26*	.12	.18	.02	.26	-.33**	.26*	-.38**	.68**	.47**	(.85)			
13 BPAQVA	13.03	3.77	.23*	.25*	.22*	.29**	.26*	.16	-.22*	.17	-.36**	.67**	.51**	.47**	(.72)		
14 MSPQ	6.53	7.01	.51**	.47**	.66**	.57**	.50**	.24*	-.15	.54**	-.24*	.32**	.42**	.17	.19	(.80)	
15 PSQI	6.94	3.40	.70**	.64**	.61**	.64**	.51**	.23*	-.30**	.64**	-.40**	.41**	.55**	.26*	.26*	.64*	(.70)

Note. Cronbach's (1951) alpha reliability coefficient appears in diagonals. *p = .05, **p = .01 as assessed Pearson (r). Depression, Anxiety, Stress = DASS; MBI (Emotional Exhaustion, Depersonalisation, Personal Accomplishment); BEAQ (Avoidance); BPAQ (Anger, Hostility, Physical Aggression; Verbal Aggression; MSPQ (Somatic Perceptions); PSQI (Sleep).

Latent Profile Analysis

The demographic data were not used in the LPA analysis, as this was unrelated to the identification of unobserved subsets/classes that were based on symptom severity. The large majority of participants (87%), scored below the clinical cut-off scores, flagging the expectation that latent profiles should reflect this.

Data with any missing values in the measures were discarded for input, thereby providing a complete data set (N = 88). A complete data set was favoured to enhance the estimation process and reduce missing data rather than using an imputation process. The result is a smaller sample size; however, it was considered adequate to detect latent classes with high quality indicators (entropy) that can accommodate smaller sample sizes (Ferguson et al., 2020), with the goal of identifying the number and shape of profiles. A second consideration was whether the sample size within the latent classes has sufficient power to detect differences in the pre-determined metric (in this case, the staging model) to be meaningfully interpreted (Sinha, Calfee, & Delucchi, 2021) and aligned with the theoretical underpinning.

Latent Profile Model Retention Decisions

Scale scores for the measures were all used to define the profiles. A series of iterative models were each compared to the previous one to make a decision regarding the number of latent profiles in the data. The first model consists of a single class (k = 1) and each subsequent model has one more class than the prior. Fit statistics included Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Entropy, Sample Size-Adjusted Bayesian Information Criterion (SABIC), as well as the Lo-Mendell-Rubin Test (LRT) and the Bootstrap Likelihood Ratio Test (BLRT). According to Sinha et al. (2021), once models are fit, a decision

is made for best fit. Essentially, this means selecting the model with the lowest number of classes. The Bayesian information criteria measure is based on the likelihood of a model, the number of parameters and sample size, with lower values representing the preferred model (Spurk et al., 2020). BIC favours simpler models and is shown to outperform other indices with continuous indicators (Ferguson et al., 2020), and likewise for AIC; with both measures, a decreasing value indicates better fit (Sinha et al., 2021). SABIC adjusts for *n* and is considered to be accurate for information criteria with a smaller sample size, with decreasing values indicating better fit. Entropy is the measure for class separation and differentiation, and values range from 0–1 with higher values representing better fit (Ferguson et al., 2020), although the highest entropy does not immediately indicate the best fitting model (Sinha et al., 2021), with the reported cut-off for this value being 0.80 or higher (Spurk et al., 2020). Class size is another factor in the decision-making process; a model with a very small class in it may represent too many classes and can be driven by extreme values. In addition, existing prevalence rates in the literature can offer guidance for class size. According to Spurk et al. (2020), deciding on the final model should include consideration of statistical fit values, theoretical alignment and content. Importantly, the LPA approach was applied in a theory-driven way, ensuring that the final preferred model would have a strong conceptual basis in the final class selected.

Scoring the subscales separately, as per the administration and scoring recommendations, was considered to provide a more robust examination of the strength, direction, and contribution of each of the dimensions to the results, and further to ensure that the observed indicators were the principal determinant of

allocation to class. All other measures used a total score, as there were no subscales within the measures.

Latent Profile Results

LPA commenced with a model of one profile and iterated five profiles for interpretation. After entering USEVARIABLES command, the CLASSES command was entered to generate one profile. As LPA is a mixture model, TYPE was entered as MIXTURE. Output requested TECH11 for the Lo-Mendell-Ruben Likelihood Ratio test to compare the current model with the prior model from Class 2 onwards as well as TECH14 for the BLRT. For the ML estimators to reach convergence by extending the number of attempts, the STARTS command was included in the ANALYSIS. The initial stage Starts value was 500 for the maximisation step and 50 for the final stage optimisations.

Model fit statistics for profiles 1–5 is presented in Table 3.5. Model 4 was retained as the best model to fit the data, based on: second lowest AIC value; lowest BIC value; SABIC; an entropy value of .93; and the percentage of individuals in the class size that theoretically linked to the proposed staging model as well as reported prevalence rates. It is noted that in Profiles 2, 3, and 4, the smallest percentage of participants from the sample is 11%, which is similar to the prevalence that has been previously reported. The log likelihood values revealed large decreases until the difference between Models 4 and 5, and this was reflected in AIC, BIC and SABIC. BIC was marginally lower in Model 4 than in Model 5.

Models 1 and 2 were rejected, as they were estimated with only one profile and higher AIC and BIC values respectively. Model 5 was rejected, as the class sizes became very small samples (.02%) of participants and therefore reduced confidence

that the profile represented a distinct group that could be generalisable (Ferguson et al., 2020). Models 3 and 4 were considered plausible and subject to interpretation.

Consideration of Model 3 against Model 4 showed that Model 4 had the lowest AIC result as well as the lowest BIC result, suggesting this was the model with the best fit. The AIC is considered the superior fit criteria for small sample sizes (Spurk et al., 2020). Further, entropy was .935, reflecting that the model was able to return a well-separated profile greater than the .80 cut-off recommended by Clark and Muthén (2009).

In the nested model LRT and BLRT tests the non-significant ($p > .05$) adjusted LMR testing for a model with k + 1 indicates that the solution is not superior to a k-profile and that Model 3 could be retained. In this case, Model 4 is retained, given the AIC and BIC results as well as the theoretical alignment with the staging model. As noted by Sinha et al. (2021), separation of classes should be theoretically meaningful and the best fitting model is often at the discretion of the investigators, particularly from a clinical standpoint.

Table 3.5.

Model Fit Statistics Across Five Latent Profile Models in Study 1

	Model fit statistics							Class size				
Model	LL	AIC	BIC	SABIC	Entropy	LRT *p*-value	BLRT *p*-value	1	2	3	4	5
1	-4377.79	8815.59	8889.91	8795.24				1.00				
2	-4180.63	8453.27	8567.23	8422.07	1	.006	.00	.88	.11			
3	-4090.95	8305.90	8459.50	8263.85	.928	.15	.00	.34	.53	.11		
4	-4044.64	8245.28	8438.51	8192.38	.935	1.0	.00	.35	.34	.18	.11	
5	-4009.47	8206.94	8439.81	8143.18	.966	.33	.00	.34	.19	.34	.09	.02

Note. LL = Loglikelihood; AIC = Akaike information criteria; BIC = Bayesian information criteria; LRT = Vuong-Lo-Mendell-Rubin Likelihood Ratio Test; BLRT = Bootstrap Likelihood Ratio Test.

Table 3.6 shows the proposed staging model (McFarlane et al., 2017) with Model 4 containing four classes within the profile with the percentage of participants in each stage, as can be seen in Figure 3.2. Inspection of the percentage of participants over the clinical cut-offs, particularly the PLC, show that 12.5% were above clinical cut-off, which aligns best to the 11% of Model 4.

Table 3.6.

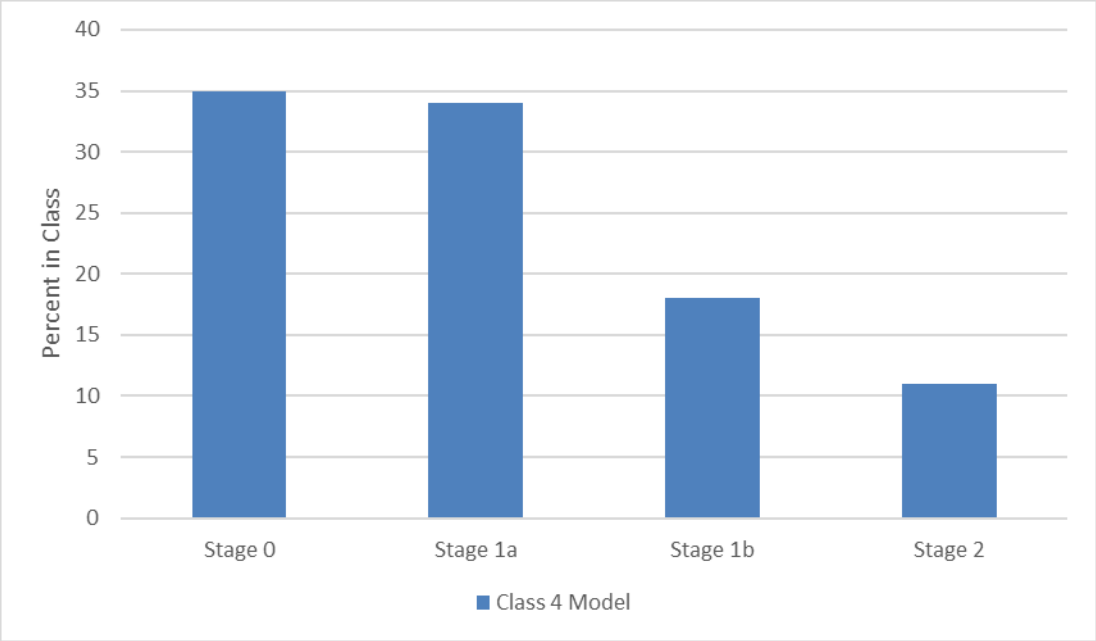
Proposed Staging Model and Percentage of Participants in each Stage

Stage	Symptom Progress Profile	% in class
Stage 0	Trauma exposed although asymptomatic. At risk	35
Stage 1a	Undifferentiated symptoms of anxiety and distress	34
Stage 1b	Subclinical distress with functional and behavioural decline	18
Stage 2	The occurrence of full clinical symptoms. Different possible trajectories for different individuals	11
Stage 3	Persistent symptoms of disorder that fluctuate with ongoing impairment of mental and physical health	
Stage 4	Increasing chronic illness	

Stage 0 acknowledges exposure to trauma but indicates no symptomatology and represents the greater percentage of participants. This percentage declines as symptom severity increases to above the clinical cut-off for PTSD. Importantly, this reflects the prevalence rates reported in the literature. It is also important to note that this spread of percentages has as an end point the reach to clinical cut-off at Stage 2 and does not parse out those who may fall into Stages 3 or 4. In addition, Stages 1a and 1b clearly show that a majority of firefighters have subclinical symptoms. This bolsters the case for early intervention.

Figure 3.2.

Retained Model 4 with 4 classes aligned to the staging model



The retained Model 4 was further examined for the means and standard error of the variables across the four classes within it, as shown in Table 3.7. Trends were plotted in the line graph shown in Figure 3.4. As expected, the Class 4, Stage 2 PTSD group (n=10) had the highest elevations on clinical measures (except verbal aggression), indicating the most distress, and the lowest values for personal accomplishment and sense of organisational membership. Conversely, those in Class 1, Stage 0 (trauma exposed but asymptomatic, n=31) had the lowest values on clinical measures, indicating the least distress and concomitant high values for personal accomplishment and sense of organisational membership. Of note are the trends for the differences between Class 2 (Stage 1a) and Class 3 (Stage 1b). The PLC, DASS, emotional exhaustion, depersonalisation, and somatic concerns are lower in Class 3 than in Class 2, suggesting that Class 2, Stage 1a (the lower stage) individuals are experiencing more negative symptoms than those in Stage 1b. However, avoidance remains the same, and anger, hostility, physical aggression, and verbal aggression increase from Class 2 to Class 3. Of note also between Class 2 and

3 is that personal accomplishment and sense of organisational membership reduce respectively.

Table 3.7

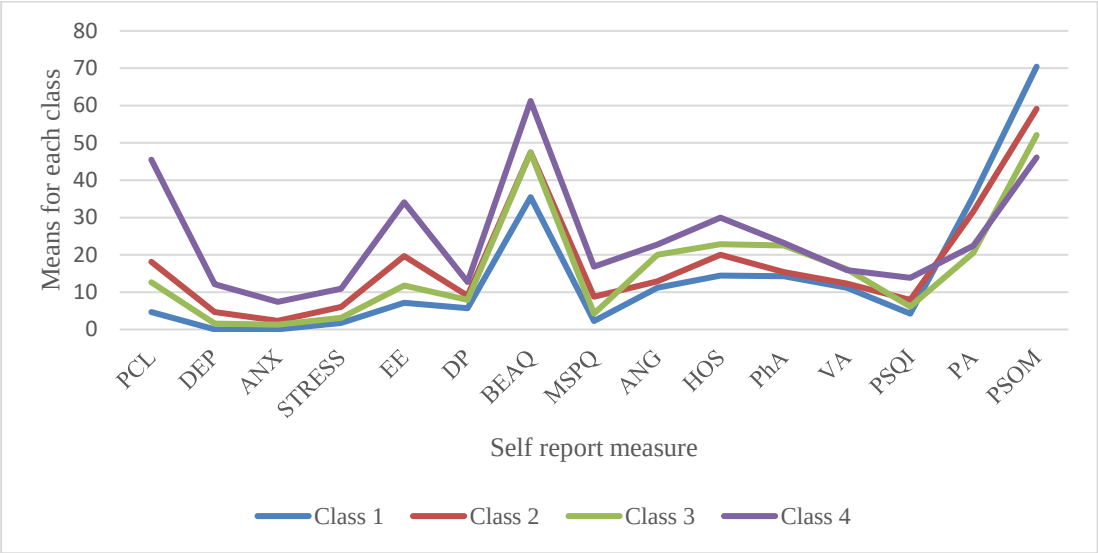
Four-class model results showing means and standard error against the staging model.

Variable	Class 1 Stage 0 Exposed, Asymptomatic (n=31)	Class 2 Stage 1a Undifferentiated Symptoms (n=30)	Class 3 Stage 1b Sub-Clinical Symptoms (n=16)	Class 4 Stage 2 PTSD (n=10)
PCL	4.63 (1.08)	18.16 (2.00)	12.67 (3.57)	**45.50 (4.18)**
Dep	0.03 (0.49)	4.65 (0.58)	1.60 (0.52)	**12.10 (0.95)**
Anx	0.50 (0.14)	2.32 (0.45)	1.29 (0.34)	**7.4 (1.17)**
Stress	1.75 (0.60)	6.05 (0.58)	3.11 (0.57)	**10.90 (0.93)**
EE	7.18 (1.09)	**19.70 (3.72)***	11.82 (4.33)	**34.10 (3.80)**
DP	5.72 (1.44)	**9.00 (1.71)***	**7.92 (2.95)***	**12.70 (0.79)**
BEAQ	35.42 (2.56)	47.43 (3.11)	47.33 (2.85)	**61.20 (2.38)**
MSPQ	2.32 (0.73)	8.74 (1.63)	4.23 (1.02)	**16.80 (2.34)**
ANG	11.20 (0.47)	12.93 (0.90)	**20.03 (1.01)***	**22.80 (2.10)**
HOS	14.40 (1.20)	19.99 (1.38)	**22.87 (1.25)***	**30.00 (1.48)**
PhA	14.26 (0.78)	15.40 (0.87)	22.52 (1.50)	**23.20 (2.30)**
VA	11.17 (0.65)	12.32 (0.76)	**16.17 (1.02)***	15.90 (0.95)
PSQI	4.24 (0.46)	**7.91 (0.59)***	**6.12 (0.65)***	**13.80 (1.14)**
PA	**35.70 (1.70)**	31.60 (2.27)	20.52 (2.74)	22.40 (1.84)
PSOM	**70.41 (2.29)**	59.87 (2.62)	52.10 (2.73)	46.10 (3.78)

Note: Values with highest positive response are given in boldface. (*) = above clinical cut off. PCL (post traumatic checklist), DASS (depression, anxiety, stress), EE (emotional exhaustion), DP (depersonalisation), BEAQ (avoidance), MSPQ (somatic concerns), ANG (anger), HOS (hostility), PhA (physical aggression), VA (verbal aggression), PSQI (sleep), PSOM (sense of organisational membership).

Figure 3.3.

Trends of variables based on mean for the four classes of the retained model.



Subsequent to the analysis, consideration was given to the amount of missing data (due to participants only partially completing the survey) potentially affecting the generalisability of the findings. Therefore, a series of one-way ANOVAs were conducted to determine if there were differences between the excluded participants (n=104) and the final sample in the LPA (n=88) on basic demographic variables.

For age, there were no statistically significant differences between the LPA group and the overall demographic group $F(1,102) = .004$, $p = .947$. For years of service, Levene's test was not statistically significant ($p = .834$) and there were no statistically significant differences between groups $F(1,102) = .725$, $p = .397$. PCL scores had a non-significant Levene's test ($p = .282$) and there were no significant differences between groups, $F(1,102) = 2.152$, $p = .145$. Based on these data, there are no differences between the partially completed data set of 104 participants and the fully completed data set of 88 participants.

Discussion

The primary aim of Study 1 was to explore the proposed staging model with respect to identifying homogeneous sub-classes on a possible trajectory to PTSD. The descriptive statistics revealed some relevant findings. Of note was the significant positive correlation the PCL-5 had to all clinical measures, which speaks to the validity of the measure regarding the range of symptoms that may contribute to PTSD and its use in provisional diagnosis.

Generally, correlations were moderate to strong and occurred in the expected directions. For example, personal accomplishment was negatively correlated with clinical measures of symptoms and positively correlated with sense of organisational membership.

As indicated by Maslach et al. (1997), in measuring burnout, emotional exhaustion refers to the depletion of self at the psychological level and should be correlated with depersonalisation, which is a callous, cynical or dehumanised attitude towards people the firefighters work with. Maslach also considers the third component of burnout to include a reduced sense of personal accomplishment, in that one tends to evaluate oneself negatively; in terms of how one does one's job, this would translate to perceived competency. This scale is independent of the other subscales. In considering the reported correlations in the context of Maslach's perspective, burnout in firefighters may be experienced at the psychological level (in terms of emotional exhaustion and depersonalisation) while a sense of personal accomplishment is retained (in terms of the way they do their job). Essentially, they retain a sense of competence and successful achievement in their work; the negative correlations across most measures support this contention.

As noted by Totawar and Nambudiri (2012), workers who experience depersonalisation may display a detached and callous attitude as a way of minimising intense emotional arousal that could otherwise potentially interfere with functioning during crisis situations. There is support for this contention in the way firefighters display such coping behaviours through the use of derogatory or abstract language (black humour), strict professional compartmentalisation, use of jargon, or extended conversations with co-workers (Rowe & Regehr, 2010). Importantly, Rowe and Regehr (2010), argue that the use of black humour is vital in venting feelings, distancing oneself from the situation and developing social support through the development of group cohesion and shared experience. This also lends itself to the consideration of positive correlations between the cognitive components of aggression, such as anger and hostility, versus the behavioural components of verbal and/or physical aggression, which require suppression as part of being a professional.

According to Buss and Perry (1992), hostility is a cognitive component and consists of feelings of ill will or injustice. Of note in the present study is a strong positive correlation between hostility and sense of organisational belonging (PSOM) in an unexpected direction. It was evident in the parliamentary inquiry into the mental health of emergency workers (Parliament of Australia, 2018) that there was some resentment towards organisational management and leadership and this was supported in the recent Australia guidelines (Lethbridge & Phoenix Australia, 2021). Firefighters reported feeling unheard or unsupported and lacked trust in their management to ‘have their backs’.

Latent Profile Analysis Discussion

For the LPA, this research demonstrates that the measures used—aligned with the DSM-5—were able to detect homogeneous classes of like-symptom severity

concerns. Further, these groups were able to be aligned and mapped to the staging model. This also supports the underpinning proposal made, that by improving specificity of symptom severity concerns, heterogeneity is reduced. This has the potential to improve the ability to develop targeted interventions. More powerfully, staging of future research participants undergoing intervention studies may improve outcomes and contribute to more consistent findings.

It is noted that 11 % of participants were aligned to Stage 2 (the occurrence of full clinical symptoms with different possible trajectories), and this is similar to other prevalence rates reported in the literature, such as by Berger et al. (2012) who found a rate of 10% in a meta-analysis of over 20,000 emergency responders. In an important study, Harvey et al. (2016) reported 8% prevalence of PTSD in current firefighters, although this percentage increased to 18% in retired firefighters, and they found a significant positive linear relationship between fatal incidents and PTSD. Most recent of prevalence studies was Kyron et al. (2022) who reported 9.1% prevalence in Australia firefighters. Studies that have examined latent classes within the PTSD diagnosis can better inform the trajectory of PTSD in the latter stages of the staging model.

Due to ethical reasons concerning the use of a survey, this research did not consider exploring Stage 3 (persistent symptoms with ongoing impairment) or Stage 4 (increasing chronic illness), although other researchers have examined these, and their findings also align well with the staging model proposed. For example, Cloitre, Garvert, Brewin, Bryant, and Maercker (2013) posit the distinction between PTSD and complex PTSD and determine three classes that reflect differences in the complexity of PTSD. It was found that there was a low-level symptom class (i.e., Stage 2), followed by high levels of symptoms with low-level symptoms of inability

to self-organise (i.e., Stage 3) and the most disturbed class had high levels of symptoms as well as affect dysregulation, negative self-concept and interpersonal problems (i.e., Stage 4). The more complex the PTSD experienced, the greater the functional impairment, and importantly, the authors point out that distinguishing severity can help organise more effective clinical services, intervention strategies and duration of treatment.

Similarly, Jongedijk et al. (2019) also found a three-class solution for those with a PTSD diagnosis, as did the Visser et al. (2022) study. They reported the same recommendations for the need to identify homogeneous subgroups and the implications for treatment. Notably, these authors suggest that at the highest level of chronic and severe symptoms, outcomes of treatment are generally poor. Furthermore, these studies have also demonstrated alignment with the staging model from Stage 2 (the occurrence of full clinical symptoms) to Stage 3 (persistent symptoms of greater complexity) and Stage 4 of complex PTSD with likely poor outcomes from intervention. Taking these studies in combination with the current research, the staging model appears to be fully aligned with the stages of PTSD; the latter stages are demonstrated by Jongedijk et al. (2019), while the current research demonstrates staging primarily for sub-clinical groups.

Discussion of Staging Model Stage 0 and LPA Class 1

This research has demonstrated a plausible number of classes that can be aligned to the staging model. Stage 0, which aligns with Class 1, shows the fewest distress symptoms, all of which were below the cut-offs for clinical symptoms (see Table 4.3). For example, the PCL-5 mean score was 4.63 from a range of 0–80, indicating an asymptomatic profile as suggested by the staging model. The depression, anxiety and stress subscales of the DASS were all within normal ranges,

along with all other measures. Additionally, this class had the highest scores for sense of organisational membership with a mean of 70.41 on a range of 18–90, with higher total scores indicating higher levels of belongingness. This reflects the extent to which an individual feels included and respected within the organisation. Likewise for higher scores on personal accomplishment as a sense of personal efficacy and self-esteem.

From a theoretical perspective, Stage 0 alludes to the adaptation phase of Selye (1976), where stressors are able to be resolved, and in the Lazarus's (1998) terms, where coping is robust in improving the sense of control. Lazarus also indicates that there is danger is exceeding the resources for coping, which is also reflected in the staging model. Additionally, the conservation of resources theory proposed by Hobfoll (1989) refers to factors such as self-efficacy, mastery and self-esteem, which are reflected in the scores for sense of organisational membership and personal accomplishment. Importantly, the addition of the focus on coping and the time perspective advocated by Schwarzer (2001) lends credence to the stage as well as the staging model. In terms of clinical measures, all scores were within normal ranges.

Another factor for consideration in applying a theoretical understanding of the stage is to integrate the self-reporting of symptoms that relate to mental constructs and those that relate to physical symptoms. This is reflected in the normal findings for those measures of physical symptoms and arousal in the subscale of stress in the DASS, PCL-5 items that measure arousal, anger in the BPAQ and the modified somatic perception questionnaire. From the perspective of self-regulation, this is demonstrated in Stage 0. Sleep is also a reflection of the ability to self-regulate and the sleep scores for this stage were also in the normal range.

Discussion of Staging Model Stages 1a & 1b as LPA Class 2 & 3

Classes 2 and 3 did not produce the expected means in the clinical measures that aligned with Stage 1a undifferentiated symptoms and Stage 1b sub-clinical symptoms according to the model of staging proposed by McFarlane et al. (2017). Both classes showed undifferentiated symptoms and subclinical symptoms although not in the expected direction, in that Class 3 (1b) should have higher means than Class 2 (1a). The PCL means were higher in Stage 1a than in Stage 1b, and this pattern of difference in means was found in the subscales of the DASS, emotional exhaustion, depersonalisation, and somatic concerns. Notably, the PCL scores are still below the clinical cut-off of 33 for both classes, supporting the subclinical focus of these stages. Also, for those in Stage 1a, only emotional exhaustion (EE), depersonalisation (DP) and sleep (PSQI) showed scores above the clinical cut-offs: EE was in the moderate range 19–26; DP was in the moderate range 6–9; and the PSQI ≥ 5. For those in Stage 1b, anger, hostility, verbal aggression and sleep scored above clinical cut-offs: ANG > 17; HOS > 21; VA > 15; PSQI = ≥ 5.

These data suggest that Stage 1a (Class 2) has marginally more distress than Stage 1b (Class 3), at least on clinical measures. In contrast, there is more anger, hostility and aggression, more sleep difficulties and reduced organisational membership and personal accomplishment in Stage 1b than in Stage 1a. There are a number of potential explanations for these findings. It is possible that Stage 1a reflects that stage of the general adaptation syndrome in which the initial phase is one of alarm, producing heightened awareness of distressing symptoms. Stage 1b having lower values is aligned with Selye's general adaptation syndrome in that maintaining resistance to the stressor (i.e., managing the distressing symptoms)

reduces resistance to other forms of stressors due to depleted energy or allostatic accommodation (leading to increased hostility and aggression).

There is also alignment with Lazarus's concept of secondary appraisal being an evaluative process that aims to minimise and mitigate the threat, while allostasis contributes to the understanding that there is a doubling down of attempts to cope. This is particularly reflective of the differences in Stage 1a, which shows mild symptoms and Stage 1b, which shows normal scores on clinical measures and higher scores on hostile feelings, reflecting this doubling down of efforts to minimise distress. The avoidance measure is the same for both classes.

Stress theories have postulated that there is a great deal of both metabolic and mental energy used in managing anger, aggression and avoidance and that this would likely contribute to ever-increasing dysregulation (Novaco, 2016; Romas & Sharma, 2017b). It may also be that there is improved coping (as mastery and competence) for some, along with increased metabolic energy, as part of the process of the energy required for suppressing negative feelings and increasing cynicism towards the organisation.

The differences between Stage 1a and Stage 1b may reflect the nature of stress as a constant moving target that operates in a non-linear way and does not necessarily mean that the trajectory will result in PTSD, as suggested by Bryant (2003). Bryant suggests that there are multiple factors that are nonlinear and there are interactions between symptoms, biology and cognitive factors aligned with allostasis. He further states that there is little research into symptom clusters that are predictive of PTSD from a psychological perspective. Likewise, as pointed out by Harvey, Devilly, et al. (2015), there are different ways in which PTSD can develop, such as delayed onset or the overlooking of early low-level symptoms, where symptoms are

minimised in an effort to reduce stigma or avoid loss of standing among co-workers and/or thwarting career progression.

Importantly, this study has some strong links to previous research that have explored patterns in PTSD of factors such as anger and sleep. This is particularly so with the work of Contractor et al. (2018) and Griffith et al. (2022), where anger and the appropriate management of anger were found to be significant predictors of PTSD, and Griffith et al. (2022), where higher PTSD symptoms and sleep disturbance were found in the most disturbed class of PTSD. Taken together, these studies may indicate an inflection point for the trajectory to PTSD, although the lower scores on clinical measures may not reflect this.

It is necessary in interpreting these findings to acknowledge that they are a snapshot in time of a population and do not reflect the time course of symptoms. As noted by McFarlane et al. (2017), there needs to be a move away from cross-sectional research to longitudinal research to fully explore the staging model. The challenge here is to define the inflection points or points of transition. These authors further argue that the greater portion of research into PTSD occurs at the tertiary or chronic/complex level, and that while symptoms at this level can be severe, they are often more stable. There is therefore a clear need for further research into the stages from a longitudinal perspective. Importantly, the staging model can demonstrate where to target interventions, such as resilience training in Stage 0, targeted reduction of symptoms in Stage 1a, and arousal reduction and improving organisational connectedness in Stage 1b. Stage 2 offers the opportunity for interventions targeted at reducing PTSD symptoms before they reach the more complex and difficult to treat latter stages, as shown in other research.

Summary

Findings from Study 1 demonstrate that, in the gestalt, there are differences in Stage 0, asymptomatic and Stage 2 PTSD symptoms. This is clearly reflected in the normal PCL-5 scores for Stage 0 and above clinical cut-off for Stage 2. Stages 1a and 1b represent a subclinical cohort with distressing symptoms on different measures. Future research may consider that further investigation of these stages might reveal nuances between the groups, particularly considering time in service, rank or seniority, which may show differences in patterns of coping.

Study 1 focused on the pre-conditions or symptoms of a possible trajectory to a diagnosis of PTSD and identifies classes for early intervention that may have more utility in assisting the arrest of symptom progression. These findings may also indicate that these early stages are not necessarily a trajectory to PTSD. It is not a given that PTSD is an end result. Instead, this research recognises and acknowledges that firefighters experience trauma exposure and that symptoms occur that are associated with varying levels of distress. To the best of knowledge, this staging model has not yet been explored, despite strong arguments for its necessity in developing improved methods of understanding stress and stress disorders such as PTSD (Nijdam et al., 2023). This study offers a unique opportunity to develop interventions that can be applied in a preventative and person-focused manner.

Therefore, for Study 2, based on behavioural learning theory, this research uses neurofeedback interventions to build resilience and manage symptoms of subclinical or emerging mental health disorders in firefighters. The study explores the possibility of the restoration of the capacity to self-regulate and tests whether symptoms can be successfully altered to reflect a lower level of symptom concern. Study 2 uses neurofeedback as a psychophysiological-based intervention to explore

whether symptom reduction can result in sustainable positive changes. It does not explore the intervention based specifically on the staging of participants, but rather the ability to flexibly alter or modify symptom expression, which is a proposed value of the staging model and aligns with the need for early intervention, stress reduction and resilience building.

Chapter 4: Study 2

Chapter Overview

This chapter presents a neurofeedback study as an intervention with operational Queensland firefighters. Neurofeedback is a brain–computer interface biofeedback intervention. It aims to alter mental states and behaviour by modifying neuronal activity in the central nervous system through the process of operant conditioning (van der Kolk et al., 2016).

The primary aim of this study is to investigate the efficacy of neurofeedback (NFB) as an intervention and whether it may be applied to all levels of intervention (primary, secondary and tertiary) to improve or relieve stress symptoms. The objective is to investigate whether NFB can substantially and positively alter self-regulation capacity to improve symptoms.

There are three hypotheses proposed:

H1: Firefighters in the experimental group will show improved scores for stress symptoms as measured by self-report standard psychological measures from pre- to post-intervention.

H2: Firefighters in the experimental group will maintain positive changes in stress symptoms as measured by self-report standard psychological measures at long-term follow-up after the intervention.

H3: Firefighters in the control group that do not engage in the intervention will show no change in stress symptoms as measured by self-report standard psychological measures from baseline to follow-up.

This chapter first reviews the theoretical underpinnings of how learning occurs and how it influences stress and ongoing chronic stress via persistent dysregulated

brain–behaviour responses. It reviews existing interventions used for PTSD and interventions used in general stress management. Prevention of PTSD is explored along with early intervention and resilience interventions. This is followed by a deeper explanation of the neurofeedback process and how it can be applied via learning theory to support its use as an intervention. Neurofeedback has as its foundation the use of the electroencephalogram (EEG) to monitor brain behaviour, and therefore the origins of the EEG are explained.

The research design is then reported, followed by presentation of the method, procedure, results, and a discussion.

Theoretical Underpinning

This research takes a psychobiological perspective and combines learning and allostatic theories as they apply to understanding both the intervention and its outcomes. Learning theories, such as those discussed in *A History of Modern Psychology* and put forward by Pavlov, Watson, and later Skinner (Schultz, 2014), and the theory of allostasis (in which the brain is seen as a central mediator of stress responses), have laid the foundations of our understanding of how functions of the central nervous system influence the development and maintenance of stress and PTSD.

As mentioned in the discussion of the biological underpinnings of stress (see Chapter 2), chronic stress decreases axonal spine density and neurogenesis, which has a negative impact on the functions of cognition and memory, and conversely increases axonal spine density in the emotional centres of the brain. These are deleterious neuro-architectural changes which, with repeated stimuli, increase the excitability of the emotional centres of the brain (Fink, 2016), sensitise their function, making them hyperreactive. These alterations in the limbic system affect

the connectivity pathways to the frontal lobe and executive function, which in turn alters the cognitions about the appraisal of events. When the stress-induced changes are accompanied by, for example, an increase in anxiety behaviour, there are continued feedback and feedforward alterations in the dysregulation of the circuitry of the brain which are maintained by the anxiety behaviour itself (McEwen, 2016a). This can be understood in the context of learning theory as a complex interplay of classical and operant conditioning—classical through the involuntary learning via the brain circuitry, and operant in how a person may engage with the world and the consequences of engaging in coping strategies to reduce anxiety or stress (Schultz, 2014).

Expanding on this, these changes can occur in concert with the theory of allostatic accommodation, such that when the physiology is challenged by a stressor it initially accommodates by adjusting parameters creating a new homeostasis to fit the circumstances (Ganzel et al., 2010). In conditions of chronic or repeated stress, there is a level of ongoing accommodation by the organism (i.e., the human), which results in 'wear and tear' and potentially allostatic overload (Ganzel et al., 2010, p. 8). Learning theory, including classical conditioning, explicates the development of PTSD in that the reflexive flight, fright, and fear responses become paired to the trauma or threat and consequently a neutral or meaningless stimulus evokes a similar response through the process of generalisation (Schultz, 2014) and consequent sensitisation.

Kolb integrated neuroscience into the understanding of PTSD development by showing that the emotional and memory centres of the brain mediate the hyperreactive responses to trauma (Friedman, 2014). Maintenance of PTSD is proposed to occur through the process of Skinnerian operant conditioning where

behaviours such as avoidance act as a negative reinforcer because of the effect of reducing anxiety (Friedman, 2014). This then circles back for the implications in how we understand self-regulation, as proposed by Bandura (1989). He posits that people have control over their lives through self-regulation that mediates behaviour and emotional responses learned through the interplay between classical and operant conditioning. In this case, however, the biological underpinnings play a role in how successfully an individual can self-regulate and have cognitive control when brain regions become dysregulated in its ability to communicate with other brain regions in an appropriate way.

There have been a range of interventions that use the concept of self-regulation to aid in stress management, mental health conditions and some physical disorders. This is discussed further later in the Chapter.

Existing Interventions for PTSD

It must be acknowledged that most research and subsequent treatments of PTSD have focused on intervention at the level of diagnosis. Subclinical PTSD is recognised as occurring but there has been no extensive research into interventions at this level. This section reviews the literature on current interventions for PTSD and argues for intervention at the stage of pre-diagnosis. This is followed by consideration of the prevention and early interventions that have been researched.

Research into treatments for PTSD has been weighted heavily towards cognitive approaches, particularly exposure therapy and its related prolonged exposure therapy, cognitive processing therapy, and eye movement desensitisation and reprocessing (EMDR) (Steenkamp, 2016). Current treatment goals, as stated by Harvey et al. (2015) and the updated Australian guidelines Phelps et al. (2022), include reduction in the severity of PTSD symptoms, prevention of co-morbid

conditions, improvement in social and occupational functioning, and protection against relapse. The recent Australian guidelines (Lethbridge & Phoenix Australia, 2021) have developed a stepped approach to prevention such as pre-incident preparedness training. While there has been sufficient research into these early options to conduct a systematic review findings have not supported the development of recommended use (Phelps et al., 2022). With trauma exposure within the first three months, psycho-education, emotional support and practical assistance is the suggested approach (Phelps et al., 2022).

The primary interventions consist of trauma-focused cognitive behavioural therapies (CBT), as recommended by Harvey et al. (2015) in the expert guidelines manual. These interventions have been maintained as the primary interventions in Phelps et al. (2022) Australian Guidelines. While the recommended interventions in the previous edition of the expert guidelines were collated into cognitive therapy the more recent edition has separated out the various types of cognitive based approaches. These include Trauma focused CBT which has components of imaginal exposure and in vivo exposure (Foa, Keane, & Friedman, 2000); Prolonged exposure therapy which is a manualised approach including components of education, breath retraining, in vivo exposure and processing; and cognitive therapy based on a cognitive model of PTSD (Phelps et al., 2022). These therapies aim to cognitively alter a person's maladaptive assumptions and misconceptions to aid in confronting the memory of the event in a gradual manner. This process is underpinned by the concept of habituation to the trauma memory. A similarly cognitive approach is Cognitive Processing Therapy developed by Resick, Monson, and Chard (2016) which includes protocols such as writing a trauma narrative. A meta-analytic review

revealed that there was a significant reduction in trauma symptoms compared to waitlist controls or usual treatment (Asmundson et al., 2019).

The second recommended intervention is eye movement desensitisation and reprocessing (EMDR), which is based on the belief that the trauma memory is unprocessed (Shapiro, 2001). The process of engaging dual attention, by following the movement of a therapist's finger while simultaneously focusing on the traumatic memory, allows the processing of the memory (P. Davidson & Parker, 2001).

The third commonly used intervention is medication, which is used particularly to assist with anxiety or depression symptoms that can co-occur with PTSD (Harvey, Devilly, et al., 2015). The updated guidelines report that there has been little additional research and therefore minimal change to treatment recommendations (Phelps et al., 2022), although expand considerations for use such as access to recommended interventions or that the individual may not be sufficiently stable to undertake the recommended interventions. Bernardy, Lund, Alexander, and Friedman (2012) reported 58.9% of PTSD sufferers were prescribed medication in their review of trends in prescribing for veterans. Mellman, Clark, and Peacock (2003) examined prescribing rates in community non-veteran populations and determined that PTSD was treated aggressively with medication. More recently Holder et al. (2021) examined trends in prescribing rates spanning 2009–2018 and found rates overall had declined in this period, suggesting this was due to concerns about effectiveness and adverse side effects.

These three major interventions are primarily reactive in nature, occurring once a person becomes unwell (Joyce, 2019). The approaches have largely been used in military populations and provide some promising results; however, their overall effectiveness has not been regarded as entirely favourable by McFarlane et al.

(2017). In general, exposure therapy is based on the idea that confrontation of traumatic memories or triggers develops habituation to the trauma and cognitive processing of the trauma experience (Najavits, 2015).

In an important review of randomised controlled trials of prolonged exposure and cognitive processing therapy, Steenkamp, Litz, Hoge, and Marmar (2015) showed that while these therapies were better than no treatment at all and participants attained meaningful clinical improvement in symptoms, at post-intervention follow-up, participants still remained at clinically significant levels of PTSD and two thirds (60%–72%) retained their PTSD diagnosis with cognitive processing therapy. With prolonged exposure therapy, the results reported by Steenkamp et al. (2015), show greater variability, ranging from no meaningful PTSD symptom reduction to clinically meaningful symptom reduction, to results that remained at or above clinical cut-offs for PTSD; only one trial showed a large effect. There are multiple studies that report either large dropout rates, small sample sizes, and/or high non-response rates (Chiba et al., 2019; McFarlane et al., 2017; Schnurr et al., 2007; Steenkamp et al., 2015). McFarlane et al. (2017) contend that current psychological interventions have shown limited effectiveness and that this is also true for pharmacological interventions. Given the background provided regarding sensitisation of the neural networks, it could be argued that these interventions using continued exposure may have the potential to contribute to the chronicity of PTSD.

The gold standard adopted in the psychological research of interventions is the same as that for the pharmacological industry: the randomised controlled trial. However, results of studies and interventions vary, due to factors including different methodologies, different measures of change, and importantly, the heterogeneity of participants. For example, Monson et al. (2006) conducted a randomised controlled

trial of cognitive processing therapy on military veterans with PTSD. These participants were mostly aged over fifty and primarily Vietnam veterans; 44% had current comorbid diagnoses, 59% had lifetime comorbid diagnoses, 48% were taking between one and three or more medications of varying types and 33% were engaged with other types of psychotherapy during the trial. The study reported positive outcomes and significant effects for the intervention, although the authors acknowledged that follow-up was undertaken after only one month, and that while there was a reduction in symptoms, 60% retained their PTSD diagnosis post-treatment, which is unsurprising given the complexity and confounding factors in the sample.

This researcher argues that heterogeneity is a major flaw in any investigation of cognitive psychological interventions—there is no ability to manage or account for individual differences, which is at the heart of psychology in practice and the focus of personalised medicine. This perspective is well supported by the model of allostasis, which demonstrates the great range of variability and individual differences in both the stress response and the ability to be resilient. It is acknowledged that PTSD is a dimensional disorder, and the literature review above gave a sound argument for understanding why this may be the case.

The Steenkamp et al. (2015) review of clinical trials suggests the need for critical thought in applying empirically based interventions that do not necessarily lead to good clinical outcomes. In addition, Metcalf et al. (2016) report that drop out and non-response rates to exposure therapies are as high as 54% and 44% respectively, highlighting the need for more research and funding to test other promising interventions. More recently Varker et al. (2021) conducted a review of the literature on dropout rates for guideline recommended psychological treatments

and found the rate to be 20.0% overall. Importantly the review highlighted confounds to dropout rates between different types of studies such as those with a focus on cognitive therapy alone (17%) or those studies that had an exposure component (33%). This concern is echoed by McFarlane , who has urged the development and testing of new, novel, or biologically based treatments. While symptoms may be persistent or severe enough that a mental health diagnosis can be made, there exist individual differences in symptoms. These differences, which are recognised by allostasis, include a large range of factors such as genetic heritage, early life attachment, cognitions, pre-morbid health, and psychosocial/organisational factors. These factors contribute to a heterogeneity of symptoms, further adding to the complexity of achieving successful treatment outcomes (McFarlane, 2017).

With respect to treatment, it has been argued that it is in the earlier stages of mental health disorders that intervention can confer the greatest benefit, and this contention has been supported by research (McFarlane et al., 2017; McGorry, 2015; McGorry et al., 2006).

The implications for this are that current treatments are lacking (McFarlane). The current cognitive and pharmacological approaches lack the ability to integrate physical, mental and medical therapy and do not support the recognition that somatic and sometimes non-specific complaints are often central to the presentation of PTSD-like symptoms.

Prevention of PTSD

Several studies have examined whether PTSD can be prevented, taking an early intervention approach. Qi, Gevonden, and Shalev (2016) acknowledge that individual reactions to trauma are varied and can follow divergent trajectories. With this in mind, they advocate for an individualised approach to early intervention with

the specific aims of mitigating the development of early symptoms to improve the chances of remission in individuals who develop or experience low level symptoms. Their individual approach appropriately takes into account pre-exposure factors, such as family history and living conditions, peri-traumatic factors, such as the type and intensity of the trauma, and post-traumatic factors, such as access to social support, or secondary stressors, such as the work environment (Qi et al., 2016).

The most common current methods for early intervention differ from the recommendations of Qi et al. (2016) and include critical incident stress debriefings, cognitive behaviour therapy, and, more recently, pharmacotherapy. Critical incident stress debriefings are based on the notion that trauma exposure presents a risk and therefore early processing of the trauma memories is thought to be preventative. The method involves psychoeducation about the trauma response and the sharing of experiences, conducted in either individual or group settings. Critical incident stress debriefing has been imbued with some controversy, however, with studies showing that it has little to no benefit and may possibly have a negative effect on recovery (Petrie, Joyce, et al., 2018; Qi et al., 2016).

Within Queensland Fire and Emergency Services (QFES), early intervention consists of psychological first aid (PFA) as recommended by the Fire and Emergency Services Support Network (FESSN). In this context, an incident controller will notify a Peer Support Officer who will conduct PFA. Generally, the Peer Support Officer is a firefighter with training in psychological first aid (Queensland Government, 2019). There are several grades of response but PFA chiefly includes: connecting with the members at the lowest level; providing individual or group support, education, and psychological care at the next level; and providing targeted psychological interventions by a regional counsellor. According to Wooding and Raphael (2012),

psychological first aid aims to provide a humane and supportive response to a fellow human being in the aftermath of a traumatic event. There continue to be criticisms levelled at PFA such that it is a form of critical incident stress debriefing with likely little or no benefit. According to Wang, Norman, Edleston, Oyo, and Leamy (2024), there is limited empirical evidence to mitigate the effects of trauma exposure and yet the intervention persists. These authors point out that there are numerous frameworks that have been developed with a lack of evidence regarding use, implementation, protocols, goals and expected outcomes impeding any consensus in the use of PFA. Wang et al. (2024), reports that there is no direct evidence that supports its use and therefore no ability to make any recommendation for use. Petrie, Joyce, et al. (2018) more recently identified several key strategies for supporting mentally healthy workplaces, including: designing workplaces to minimise harm; building resilience through management and personal resilience; promotion of help-seeking behaviour; and support for return to work.

Early Intervention and Resilience

More recently, there has been a flurry of research into early intervention as part of resilience building, which can play a role in preventative health measures across various industries (Joyce et al., 2019; Venegas et al., 2019). For emergency responders in Australia, this has possibly been prompted by the recommendations arising from the 2018 parliamentary inquiry into the mental health of emergency responders (Parliament of Australia, 2018) and the continued rise of mental health problems in workplaces in general (Harvey et al., 2009).

The underpinning of many early interventions is the concept of personal resilience building and psychoeducation, and while there is still limited evidence, it is nonetheless generally positive (Joyce, 2019).

Early research into resilience occurred in the 1970's when it was found that children who developed well in the context of adversity displayed a grit that allowed them to thrive (Masten, 2001). An outcome of this early research was that resilience was a common phenomenon that arises as part of human adaptation and according to Masten (2001), "resilience is that class of phenomena characterized by good outcomes in spite of serious threats to adaptation or development." (p.228)

In a much cited paper, Bonanno (2008), argues convincingly that resilience is common and refers to an ability who are exposed to disruptive events to maintain stable and healthy functioning. He makes a clear distinction between individuals that recover (displaying subthreshold stress symptoms) and those that are resilient with transient disruptions in normal functioning but generally a stability of healthy functioning (Bonanno, 2008). He insightfully considers that theorists and practitioners mistakenly assume that individuals exposed to traumatic events could benefit from professional interventions, that are sometimes ineffective, due to a failure to parse out recovery from resilience. In addition, that some critics of such interventions may pathologise normal reactions.

The concept of resilience was explored by Gayton and Lovell (2012) who considered in conjunction with resilience the idea of *hardiness*. Their research specifically considered Queensland ambulance personnel who had relatively low levels of stress leave. Hardiness was considered to be a stable trait that may be shored by experience, belief in the worthwhile nature of the work or by the process of natural selection in the characteristics of those who gravitate to the profession. Gayton and Lovell (2012) also stated that resilience is still a somewhat fuzzy concept that lacks clarity and methodological agreement. Resilience in their study was defined as the dynamic ability to display positive adaptation despite exposure to

adversity. The study showed increased resilience in workers that peaked at five years of service but then declined, indicating a possible saturation point. They report that while this finding may have been due to movement into management roles, resilience still declines. When considering their findings and conclusions, it might be argued that the 'fuzzy' concept of resilience is another word for *adaptation* in the allostatic model, and that resilience peaking at five years of service is reflective of allostatic load.

Many resilience programs draw on cognitive-based interventions that, for example, combine cognitive strategies with mindfulness, psychoeducation or mindfulness-based stress reduction. Further studies have also incorporated biofeedback techniques, such as breathing techniques for stress reduction (Dillon, Kelly, Robertson, & Robertson, 2016), or other biofeedback techniques, such as heart rate variability training (Kennedy & Parker, 2018). These intervention programs are designed to enhance a person's ability to cope with stressful events and gain greater insight into and understanding of the stress response to develop positive coping, and are delivered face-to-face, online, or increasingly, as mobile applications. Wu et al. (2013), state that most individuals do not develop illnesses after trauma and are considered resilient. They also consider that while resilience demonstrates successful adaptation it also relies on effective responses to manage deleterious effects of stress particularly on the neural circuits and pathways and that psychological interventions that can enhance resilience could be pursued (Wu et al., 2013).

In a pilot study of an online delivery mindfulness-based resilience training program (Joyce, Shand, Bryant, Lal, & Harvey, 2018), a group of 29 participants engaged in six sessions of training, of whom 16 completed just over half the program

and only 11 completed all six sessions. Findings, however, were positive overall, and this led to a broader randomised control trial that replicated the positive outcomes (Joyce et al., 2019) — although again, approximately half the intervention group was lost to follow-up at the six-month mark and only 22 of 60 participants completed 5–6 sessions. This issue was acknowledged by the researchers.

As stated earlier, there may well be a tipping point or ceiling that occurs with repeated exposure to trauma or adversity for some individuals. According to Joyce (2019), "psychological resilience is … the dynamic ability to adapt well in the face of adversity, trauma, tragedy, threats, or significant sources of stress" (p. 24). It is very plausible to consider that resilience may be part of the overall construct of allostasis, where adaptation to stressors occurs successfully and responses to stress are adaptive. Indeed, Joyce, Shand, Bryant, et al. (2018) described virtually the same factors influencing resilience as those described above in relation to allostasis.

Joyce, Shand, Tighe, et al. (2018) conducted a meta-analysis of resilience programs prior to their initial pilot study of an online resilience training programme. Of the 437 database articles and 174 WHO clinical trials, only 11 studies met their rigorous criteria for inclusion in the meta-analyses. They found that only five studies could be rated as good. There were mindfulness- and CBT-based training programs, with some taking a mixed format. Further, groups were generally quite heterogeneous and training packages ranged from two hours to 28 hours, primarily on a group basis. The authors also state that only four of the 11 studies indicated a significant effect of the interventions. While this study is extremely useful, it does not engender a high level of confidence in the current resilience training packages and does not account for the moving targets that are individual stress responses, adaptation to stress and allostasis over time.

In another example, Venegas et al. (2019) conducted a systematic review of interventions to improve resilience in physicians. These authors determined that the "interventions varied so greatly in approach, duration and follow-up", for example, "that no meta-analysis for resilience was able to be conducted due to high clinical and methodological heterogeneity" (p. 1). Importantly, Venegas et al. (2019) describe resilience as the "act of coping, adapting, or thriving from adverse or challenging events, where a complex and dynamic interplay exists between individual, environmental and socio-cultural factors" (p. 2), which again strongly aligns with the allostatic model. Finally, Liu et al. (2020) also conducted a meta-analysis to broadly substantiate the efficacy of resilience intervention programs, and while there was some limited evidence of positive outcomes, the overwhelming conclusions reflected great variability of outcomes and intervention approaches. A common theme among these meta-analyses is heterogeneity, small sample sizes, lack of program adherence and loss of follow-up data. An interesting note from these authors was the acknowledgement that one contributor to variability was ambiguity around the conceptual understanding and operationalisation of resilience. This speaks to the need to incorporate allostasis into current perspectives.

Levels of Interventions

Romas and Sharma (2017a) identify three levels of intervention in stress management: primary prevention, when stress is perceived by an individual; secondary prevention, which occurs when an individual has emotional or physiological arousal; and tertiary prevention, when clinical levels are diagnosable, and treatment is more complex. The primary level (Romas & Sharma, 2017a) focuses on preventative interventions, such as that seen in the work of Joyce et al. (2019), who conducted a trial of resilience building through an online mindfulness

based program, and in the work of Varker and Devilly (2012), which trialled a stress inoculation program that has elements similar to mindfulness programs. The common feature of these interventions is to build resilience through psychoeducation and the purposeful engagement of awareness and attention that is non-judgmental and in the present moment (E. Hoge et al., 2021). Such interventions are generally conducted as programs of approximately eight weeks.

The secondary level of intervention occurs when symptoms are being expressed and involves a broad range of psychological therapies, such as cognitive behaviour therapy, acceptance and commitment therapy, and others (Romas & Sharma, 2017a). These therapies have as their central tenet that problems are based on cognitions and that an individual can identify, dispute and change their beliefs, thoughts and emotions (Konstantinos, 2017). Mindfulness based interventions can be combined with cognitive therapies.

At the final level, the tertiary level, frank, diagnosable and complex problems occur (Romas & Sharma, 2017a). In this instance, for example, more intensive and targeted interventions can occur, such as cognitive based trauma focused therapy or eye-movement desensitisation and reprocessing (EMDR), as discussed above in terms of interventions for PTSD. While these two therapies are recommended for use in PTSD (Harvey et al., 2015), mindfulness-based stress reduction training may also be included to assist with arousal reduction, and to ensure focus is on reducing anticipatory threat by grounding the individual in the present moment. Mindfulness-based stress reduction therefore can be usefully applied across all levels of intervention, and interventions at secondary and tertiary levels take an additional cognitive approach.

Other approaches applied to all levels are psychophysiologically based, although these are less ubiquitous. They include biofeedback interventions, such as learning breathing techniques for relaxation, reducing galvanic skin conductance, and heart-rate variability training. These interventions require the participant to pay attention, in this case to biological signals conveyed via computer or mobile application interface to reduce physiological levels of overarousal (Kennedy & Parker, 2018). As the physical effects of stress unfold, an individual can monitor, track, and alter these physical signals. This is another example of how one can influence self-regulation. Biofeedback focuses on the peripheral measurement of physical signals that can be altered via cognitive control. For example, consciously altering breathing pace and using a measure for feedback such as a chest band that measures respiration or visual aids such as a mobile application that uses a breathing pacer, improvements can be made to enhance a state of relaxation. These changes are not permanent, although they can become easier to attain with repeated practice (Kennedy & Parker, 2018; McCraty & Shaffer, 2015). Another, seemingly more enduring, form of biofeedback is neurofeedback, which uses a similar methodology to biofeedback, although with brain waves as the feedback measure (using an EEG). It therefore directly influences the central nervous system through altering the amplitudes or oscillations of various EEG frequencies.

Operant conditioning principles are applied to neurofeedback interventions where reinforcement, reward and shaping can be used by the individual with the aid of a therapist to alter physiological information. Information about internal states provided to a participant can promote adaptive functioning and reduce the hyperreactivity occurring in the central nervous system (Roth, Sterman, & Clemente, 1967; Sterman, 1981; Wyrwicka & Sterman, 1968). This training can assist in

promoting disengagement from intrusive cognitions, negative emotional states and somatic hyperarousal (Vohs & Baumeister, 2016), and is discussed further below.

Neurofeedback

Behavioural conditioning in what is referred to as neurofeedback, uses features of the electroencephalogram (EEG) as a way of measuring and feeding back to a participant information about their brain states, with the goal of improving function (J. Evans & Abarbanel, 1999). The EEG is a recording of the electrical activity of the brain from the scalp.

The process involves computerised feedback through which a participant learns to alter their own physiological measure of interest in the EEG to consequently change central nervous system arousal. These 'correct' mental and physical states of arousal reflect an improved ability to self-regulate (Egner & Gruzelier, 2001; J. Evans & Abarbanel, 1999). Studies such as those by Egner and Gruzelier (2001), Ros et al. (2013) and Nicholson et al. (2017), have tracked positive and adaptive brain function changes following neurofeedback, as measured by functional magnetic resonance imaging (fMRI). These powerful studies were able to demonstrate positive changes in the brain and independent evidence for brain plasticity as fMRIs were conducted prior to and after neurofeedback and showed improved functional connectivity after participants engaged with neurofeedback. These changes were detected in the improved functional connectivity of the large-scale brain networks (see Chapter 2), particularly the salience network.

NFB approaches have been found to assist in building resilience and managing symptoms of stress (Chiba et al., 2019; Dupee et al., 2016; Panisch & Hai, 2018; van der Kolk et al.,2016). Much of the research into the efficacy of NFB has been focused on performance enhancement. Dupee et al. (2016) used the therapy to

enhance performance and reduce stress for 15 athletes training for the 2010 Olympics; this evidence lends itself well to firefighters in terms of building resilience and maintaining performance. The evidence is further enhanced by a recent systematic review by Rydzik et al. (2023), who examined NFB in sports training and determined that NFB had significant and positive impacts on physical fitness and sports performance. The study noted positive outcomes from NFB interventions including decreased stress levels, increased ability to self-control physiology, and enhanced behavioural efficiency. These factors align with the need for high levels of performance in stressful situations during operations for firefighters.

Other studies of NFB have investigated attention, learning and executive function (Arns et al., 2014). Most recently, a systematic review by Viviani and Vallesi (2021) considered executive function enhancement in healthy adults, in a study that acknowledged that there has been limited research in this area on healthy adults. Vallesi's (2021) findings indicated that results were positive; the executive functions were able to flexibly regulate and monitor goal-directed behaviours and thoughts, particularly in novel or complex circumstances. This again aligns with, and has implications for, improving firefighter wellbeing and cognitive function particularly when applied to, for example, complex rescues. Studies have examined the effects of NFB on depression (Fernández-Álvarez et al., 2022; Peeters, Oehlen, Ronner, van Os, & Lousberg, 2014), substance abuse (Saxby & Peniston, 1995) and PTSD (Gapen et al., 2016; Reiter et al., 2016; van der Kolk et al., 2016) and outcomes have been positive. Of particular note is the randomised trial from van der Kolk et al. (2016), who conducted neurofeedback with individuals with complex PTSD who had not responded to a least six months of trauma-focused therapy. In this

study, over 72% of the neurofeedback treatment group no longer met the criteria for PTSD.

NFB has not been without challenges in empirically demonstrating effectiveness. A recent review (Panisch & Hai, 2020), has shown that NFB for PTSD has yielded overall positive results. However, there are criticisms levelled at the limited number of randomised controlled trials, small sample sizes and heterogeneous methodological designs. This review identified 84 potential studies and a final 10 were analysed, of these only three were RCT's. Sample groups primarily consisted of less than 30 participants. Panisch and Hai (2020), reported that there was a variety of outcome measures used although it could reasonably argued that other types of interventional studies into PTSD also used a variety of measures. Importantly however the authors recommend that future research should aim to emulate the van der Kolk et al. (2016), particularly whether the findings would translate to different populations. This study attempts to do so.

NFB is used to down-regulate excessive sympathetic nervous system arousal and parasympathetic withdrawal associated with persistent anxiety, mental and somatic hyperarousal and dysfunctional stress responses. More recently, there has been significantly increased interest in NFB for a range of disorders with a concomitant increase in recent research publications (Micoulaud-Franchi, Jeunet, Pelissolo, & Ros, 2021; Nicholson et al., 2017; Nicholson, Ros, Jetly, & Lanius, 2020; Shaw et al., 2023). As there is an ever-growing positive research base for the intervention, it is important to understand both the background and physiological underpinnings for the generation of the EEG and how it can be understood to influence such a broad spectrum of human behaviour.

The signals or waveforms recorded when using NFB reflect the cortical electrical activity and are measured in microvolts (mV). There are several main frequencies of the human EEG (see Appendix C), which are discussed further below.

The process of reward and inhibition of various frequencies, which aims to create positive brain-wave states, is shaped through operant conditioning principles with a resultant alteration of arousal or state. Changes include the ability to self-regulate mood, emotion and behaviour and improve focus and attention (Hammond, 2011). For example, in chronic stress, where the symptom profile may include "*I find it hard to wind down*" or "*I find it difficult to relax*", neurofeedback can provide visual feedback of success at reducing these hyper-aroused symptoms in real time. With repeated practice, as with other learning, the state of being calm and relaxed becomes easier to access and experience with less conscious effort and this can then generalise to contexts beyond the training sessions.

The development of portable EEG recording devices has supported the growth of neurofeedback, which offers a psychophysiological-based intervention for mental health disorders that is well-grounded in learning and behaviour theories. Neurofeedback, via a computerised feedback of brain states, allows a person to see a shift in the measured frequencies of interest that results in a modification of behavioural output through the process of operant conditioning (Egner & Gruzelier, 2001).

The approach of NFB for use in early intervention directly addresses the second stage of Selye's (1976) general adaptation syndrome: resistance. It is in this stage that failure to return to normal levels of baseline arousal levels or failure to self-regulate can result in a chronic stress response that leads to exhaustion. This concept is extended by allostatic load, where there is chronic 'wear and tear'

(McEwen, 1998) on the mind and body and accommodation to chronic stress alters levels of arousal. There is a functional uncoupling of brain regions that leads to a breakdown of resilience. The conceptual embedding of the research into the staging model (as in Study 1) supports and directly reflects the increasing negative mental health effects of the failure to return to normal levels of functioning. The intervention addresses these physiological underpinnings of the stress response to aid in the re-establishment of normal levels of arousal and regulation.

Origins of Neurofeedback

Neurofeedback research originated from neurophysiology, particularly with the work of Golgi, who used cell staining methods to visualise neurons in brain tissue, and the decisive neuroanatomical studies by Cajal (Niedermeyer, Da Silva, Niedermeyer, & Lopes Da Silva, 2004), which led to the general acceptance of the neuron theory of brain organisation (Niedermeyer et al., 2004; Sterman, 1998). It was, however, the work of Hans Berger in the years between 1929 and 1938 that launched the field of human electroencephalography (abbreviated by him to EEG). Electroencephalogram recordings were originally made on a device called a galvanometer. British physician Richard Caton, in the late 1800s, observed weak currents of activity when electrodes were placed on the grey matter of rabbits and monkeys. Berger extended this work and wrote a series of papers that described and detailed many features of the EEG that hold true today. He identified two distinct bands of rhythmic activity (alpha and beta) that were of interest in terms of amplitude, noting that, with directed attention, the higher amplitude alpha waves were extinguished. He also observed that there were differences in EEGs between children and adults, and that, during sleep, there was a periodic suppression of rhythmic activity, now known as REM sleep (Gloor, 1969).

Advances in technology throughout the 20th century improved the quality and resolution of EEG recordings and led to important discoveries about the organisation of the central nervous system, such as the principles of neuronal function and the mechanisms underlying EEG patterns (Steriade, et al., 1990; Sterman,1998). Neurology, as an arm of medicine, flourished and EEG recordings became a tool for the diagnosis and evaluation of brain tumours, vascular accidents, seizure disorders and closed head injuries. The placement of electrodes was internationally standardised into the *International 10/20 System* of electrode placement.

In the late 1960s, several laboratories demonstrated that humans could voluntarily control physiological functions of which they were not normally aware by converting physiological signals into external visual and auditory events that could be monitored (Ancoli & Kamiya, 1978). Participants in these early EEG biofeedback studies appeared capable of learning to alter their own physiological signals and thereby gain control of central neural activity. Thus, the field of EEG biofeedback emerged, which is now more commonly known as neurofeedback (Ancoli & Kamiya, 1978; Beatty, 1972; Sterman, 1998). However, its popularity antagonised the traditional epistemologies, which linked the field of neurofeedback to altered states of consciousness and the drug culture of the time (Sterman, 1998). Further, the field lacked methodological rigour and standardisation in human research (Ancoli & Kamiya, 1978). Of the 45 studies reviewed by Ancoli and Kamiya (1978), several issues were raised: the frequency range, where rejection of adjacent frequencies was variable; electrode placement, where alpha at different scalp sites was not constant in amplitude; and recording conditions, such as training with eyes open or closed, a condition which is implicated in alpha amplitude and therefore meant that results of studies were not comparable.

Careful laboratory studies, in the same period, were conducted to explore and understand the physiology of the alpha rhythms. Researchers such as Beatty (1972) attempted to more carefully parse out confounding factors in a systematic manner, including mediating variables such as the influence of instruction on the effects of EEG training. The complexity of the field of EEG biofeedback was highlighted by C. Evans and Mulholland (1969), who reported on the concept of attention in neurophysiology. They indicated that there were problems not only concerning the multiplicity of definitions of attention, but importantly a general lack of comprehensive knowledge of the origin of the recorded EEG activity and the complexity of the physiological and biochemical processes. This indicates a true reflection of the technological challenges of the time. While research work in biofeedback remained challenging, the physiological origins of the EEG, the understanding of the network operations and neuronal properties in the corticothalamic systems, and the understanding of normal and abnormal brain rhythms during different states of vigilance and sleep, were being pioneered (Squire, 2011).

Physiological Basis for the Generation of the EEG

As described by Sterman (1998), the highly expanded surface of the cerebral cortex is made up of neurons arranged in functional columns in each of the two hemispheres. The cortical surface can be subdivided into different regions on the basis of cell type, layer organisation and the neuronal connections. This arrangement permits the functional classification of various brain regions mediating awareness of the sensory modalities, control of movement, storage and encoding of information and the capacity for higher executive and intellectual processing. A large portion of the cortex has the function of integrating these events.

There are also subcortical clusters of neurons divided anatomically into functionally distinct groups of nuclei with connecting structures known as axons. There are bundles of myelinated axons that form tracts which convey information between the subcortical structures and the cerebral cortex. These tracts are white in colour (and are called white matter) in contrast to the grey colour of the neurons in the cerebral cortex (called grey matter). These communication networks are critical to the sensory, motor, affective and cognitive functions of the mammalian brain.

The summated extracellular ionic currents arising from the populations of cerebral cortical neurons produce the bioelectric EEG signal. The currents create dipoles in the cortical tissue which produce local electrical field potentials. The EEG records this activity through the continuous measurement of the difference in potential between two sensors. The cellular currents are modulated by the membrane potential currents, known as action potentials, which result from excitatory and inhibitory inputs to the given population of cortical cells.

A substantial number of the inputs and outputs of the cerebral cortex occur through pyramidal cells (Niedermeyer et al., 2004). These large cells with a pyramid shaped cell body are found in layers III and V of the cortical mantle with two sets of dendrites. The cells are situated at right angles to the plane of the cortical surface. At the base of the cells which lie closest to the white matter is a complex of receptive processes called basilar dendrites. Extending upwards from the cell body are the apical dendrites, forming an umbrella shape. The currents of inhibitory and excitatory potentials flow through the extracellular space around the apical dendrites, creating complex dipoles at the cortical surface and are the primary source of the EEG. The pyramidal cells are topographically organised by functional system, and receive modulatory, intracortical and contralateral inputs from the upper portion of

the apical shaft and dendrites. The primary afferent input from the subcortical regions is through the basilar dendrites.

Sterman (1998) states that when information is being processed by the brain the pathways involved produce complex inhibitory and excitatory action potentials in adjacent cells which, together with modulatory and intracortical inputs, set up extracellular currents and field potentials that tend to cancel each other out. This results in a high frequency, low amplitude, irregular EEG pattern, described by Berger as beta waves (Niedermeyer et al., 2004). When the input is reduced, such as when the system is at rest, the resulting EEG becomes rhythmic and sequences of excitatory and inhibitory potentials are synchronous among many cells. This appears as high amplitude, low frequency EEG activity in electrical recordings.

It is of particular importance in understanding the genesis of rhythmic patterns found in the cortical EEG to acknowledge the organisation of the subcortical structure of the thalamus. The nuclei of the thalamus are the relay stations for the tracts that convey sensory, motor, and integrative information bidirectionally from related parts of the cortex (Niedermeyer et al., 2004; Steriade et al., 1990). Spatially organised cells in separate thalamic nuclei project to specific regions of the cerebral cortex where sensations are topographically organised for conscious awareness. These pathways carrying discrete sensory signals form the specific sensory systems to bring information into conscious awareness and are responsible for the extracellular currents that give rise to the EEG.

A second class of pathways also act on the thalamic nuclei and arise from the brain stem and forebrain to release specific neurotransmitters that influence the excitability of thalamic relay neurons. This neuromodulator function influences the specific sensory pathways in relation to perception, attention and emotion and is

referred to as the non-specific sensory system. The combined influence of the two sensory systems determines to a large extent what is attended to, what is sensed, and the response. The thalamus is considered to be the source of all but the slowest EEG rhythms (Niedermeyer et al., 2004; Steriade et al., 1990; Sterman, 1996). Intracortical dynamics contribute to initiation and influence the characteristics of thalamic oscillations and determines the magnitude and extent of the response to thalamic volleys.

Summary of the Theoretical Underpinning and Study 2 Hypotheses

This introduction has reviewed the impacts of stress, chronic stress, and the development of PTSD as a possible result of chronic stress or trauma exposure. This included a biological perspective as posited by allostasis and an explanation of how learning occurs in learning theory through both classical and operant conditioning. Interventions were also considered, and levels of intervention were discussed in terms of primary, secondary, and tertiary interventions, which are applied in degrees of complexity as mental health problems become more complex. Stress reduction techniques, such as mindfulness, can be applied to all levels of interventions. These interventions, however, take a cognitive approach to mental health problems. Interventions were also reviewed that take psychophysiological approaches, such as biofeedback for relaxation. The biofeedback approaches target the peripheral nervous system and require attention and cognitive functions and can result in present moment alterations in arousal and mood.

Neurofeedback, on the other hand, has been shown to result in lasting changes although evidence is limited, as shown in the introduction to this chapter. The efficacy of neurofeedback across a number of domains of functioning was reviewed through a number of studies, including one on peak performance in athletes

(Dupee et al., 2016) and a systematic review of its application in sports performance (Rydzik et al., 2023). Other domains included attention, learning and executive function (Viviani & Vallesi, 2021), and PTSD (Panisch & Hai, 2020; van der Kolk et al., 2016). The process of neurofeedback was reviewed along with the origins of the development of understanding of EEGs and the development of neurofeedback as an intervention. To contribute to the understanding of the EEG's relationship to 'state', as seen at the cortex, the physiological basis for the generation of the EEG was reviewed.

This research aims to investigate the application of a neurofeedback intervention to operational career firefighters of the Queensland Fire and Emergency Service (QFES). The study specifically aims to investigate the efficacy of neurofeedback as an intervention that may be applied to all levels of interventions (primary, secondary and tertiary) to improve or relieve stress symptoms.

The following describes the design adopted by this research to achieve the aims and objectives of Study 2. The research objectives were to assess firefighters on baseline self-report measures and to implement a neurofeedback intervention on an experimental group compared with a control group with no intervention. Repeated post-intervention measures were also administered to identify any changes in self-reported symptoms. This study is designed to demonstrate improvements in the health, mental health, and wellbeing of emergency responders after the intervention. Given the positive outcomes of the neurofeedback studies reported in the above literature, the following hypotheses were made:

H1: Firefighters in the experimental group will show improved scores for stress symptoms as measured by self-report standard psychological measures from pre- to post-intervention.

H2: Firefighters in the experimental group will maintain positive changes in stress symptoms as measured by self-report standard psychological measures at long-term follow-up after the intervention.

H3: Firefighters in the control group that do not engage in the intervention will show no change in stress symptoms as measured by self-report standard psychological measures from baseline to follow-up.

Method

Research Design

This study represents a 1*treatment x 3 (time 1, time 2, time 3) and 1*control condition x 2 (time 1, time 2) controlled, factorial design with repeated measures. A controlled trial is a rigorous method of demonstrating whether a cause-and-effect relationship exists between the intervention and outcome. Participants were followed prospectively to compare the intervention group with the control group. The control group received no treatment.

The main independent variables were the results of the treatment intervention over time, as measured by multiple repeated dependent variable self-report psychological questionnaires, as discussed in the measures section. Participants self-assigned to one of the two groups (experimental versus control) after completing baseline dependent measures of self-report psychological tests in order to ascertain the level of symptom concerns a participant had. The experimental group measures were completed at baseline (Time 1), at the conclusion of the intervention (Time 2), and at minimum 3-month follow-up (Time 3). Measures for the control group were completed at baseline (Time 1) and at minimum 3-month follow-up (Time 2).

Sample sizes were reviewed in the literature. For meta-analysis of neurofeedback studies in PTSD, there was a mean sample size of N=20 (Panisch & Hai, 2018). This study was exploratory in nature, and calculations for sample size included: two-tailed type I error rate: 0.05; type II error rate (power) .8; and an effect size of .5. The calculation revealed that 12 participants were required in each group, for a total sample of 24. Guidelines for acceptable levels of power indicate that alpha levels of at least .05 and power levels of 80 percent should be achieved (Kohn & Senyak, 2024).

As the study had a control group, for ethical considerations these participants were offered the intervention after the completion of the study if the outcomes proved favourable. Three participants in the control group requested the intervention at the time of their follow-up.

Participants

Ethical approval was obtained from the Queensland University of Technology Human Research Ethics Committee (QUT Ethics Approval Number 1900000154). The participants in Study 2 were drawn from QFES and were operational career firefighters. QFES recruitment initially occurred via the Queensland Firefighters Charity. This body provides support and assistance to firefighters and their families during times of hardship, injury, or illness (see Appendix D). Firefighters donate an amount from their salary to the fund and this network represented an opportunity for information about the study to be disseminated, creating a purposive sample. Further, via the firefighters' social media networks, a snowballing effect was created to flag recruitment to the study. The Firefighters Charity receives donations, primarily from the firefighter community and it has 3,500 Facebook followers. Later, additional recruitment occurred via the United Firefighters Union Queensland who had

disseminated information regarding Study 1 and included news of Study 2 in their email flyer (see Appendix A).

A participant information sheet describing the aims and objectives of the study (Appendix D) was disseminated by both the Firefighters Charity and Firefighters Union. Eligible participants contacted the researcher to make further enquiries or volunteer to participate with signed consent (Appendix D) in an initial information session that further described the aims, objectives and details of the protocols of the study. Those prospective participants that wished to be part of the study then signed consent to participate (Appendix D). Participants self-selected to either the experimental condition or control group. Self-selection was based on the participant's own desire to engage with the intervention, which required multiple on-site visits for training and travel to the clinic. The description of the neurofeedback training procedure given to participants is included in Appendix E.

Participants were drawn from Southeast Queensland, as they were required to travel to their appointments to engage with the neurofeedback intervention. No incentives to participate were offered; however, support in the form of a fuel gift card was provided to participants at the conclusion of their appointments. The gift card had a value of one hundred dollars.

Limitations to Representativeness

All firefighters are assessed and recruited into the service based on a standard of physical and mental wellbeing and all personnel receive the same basic training to commence duties in the field. The parliamentary inquiry of mental health in emergency workers (Parliament of Australia, 2018), identified that emergency responders are a relatively culturally homogeneous group in their respective organisations. It identified this as both positive (in terms of cohesiveness among

members) and a challenge (in terms of help-seeking behaviour and trust in the organisation). This may have implications for agreeableness in supporting research.

Limitations of this study include that firefighters in remote or rural areas are not represented. Further, firefighters with a prior interest in the charity may have had positive feelings towards help-seeking behaviours.

Exclusion criteria included: currently not working, diagnosed mental health condition, head injury, DSM-5 PTSD diagnosis, unstable medical condition, suicide risk or ideation, history of seizures, and current substance abuse. An unstable medical condition was considered to mean any medical condition that was in the early stages of investigation or management—for example, unresolved orthopaedic concerns and/or the use of pain medications, and the early stages of controlling blood sugar (pre-diabetic) where stability was still to be assessed or where a condition was not considered stable and well controlled (pre-hypertension). The rationale for this exclusion is that any alterations to mood, energy or fatigue could be attributable to the stabilisation of the medical condition rather than the influence of the intervention.

A total of 21 participants were recruited and self-selected into either treatment or control conditions, equating to 12 and 9 respectively. In the intervention two participants had 6 sessions; 2 had 7 sessions; 3 had 8 session; 3 had 9 session;, with 1 each having 10 and 15 respectively. Self-selection was on the basis of availability of participants and ability to attend and travel to sessions. All participants were male, except for one female in the treatment condition and one female in the control condition. Demographic characteristics can be found in Table 4.1. The age range for all participants was from 22 to 62, $M = 41.86$, $SD = 9.23$.

Nineteen participants reported being married (90.5%) and two were not married (9.5%). Fourteen participants had children (66.7%) and seven had no

children (33.3%). Years of service ranged from one to 31 years, *M* = 12.24, *SD* = 9.28.

Table 4.1.

Demographic Characteristics of the Participants Study 2

Characteristics	Values
Age, mean (SD), range	41.86, (9.23), 22-62
Gender	
Male n (%)	19 (90.5)
Female n (%)	2 (9.5)
Married n (%)	19 (90.5)
Not Married n (%)	2 (9.5)
Children n (%)	14 (66.7)
No Children n (%)	7 (33.3)
Years of Service n (%)	
1-5	5 (23.8)
6-10	8 (38.1)
11-20	4 (19)
> 20	4 (19)

Procedure

Neurofeedback Instrument

The important components of electrophysiological recordings include electrodes, amplifiers and a means of recording and displaying the electrical signals of the brain (see Appendix C). The NFB system utilised was EEGer neurofeedback software V4.04, manufactured by EEG Spectrum International Education and Research Inc (EEG Education & Research Inc, 2018). The software consists of a set of graphical interfaces designed to process signals and provide a visual of the electrical data produced by the brain. The application includes real-time filtering of the signal and fast Fourier transform for spectral analysis. Fast Fourier transform is

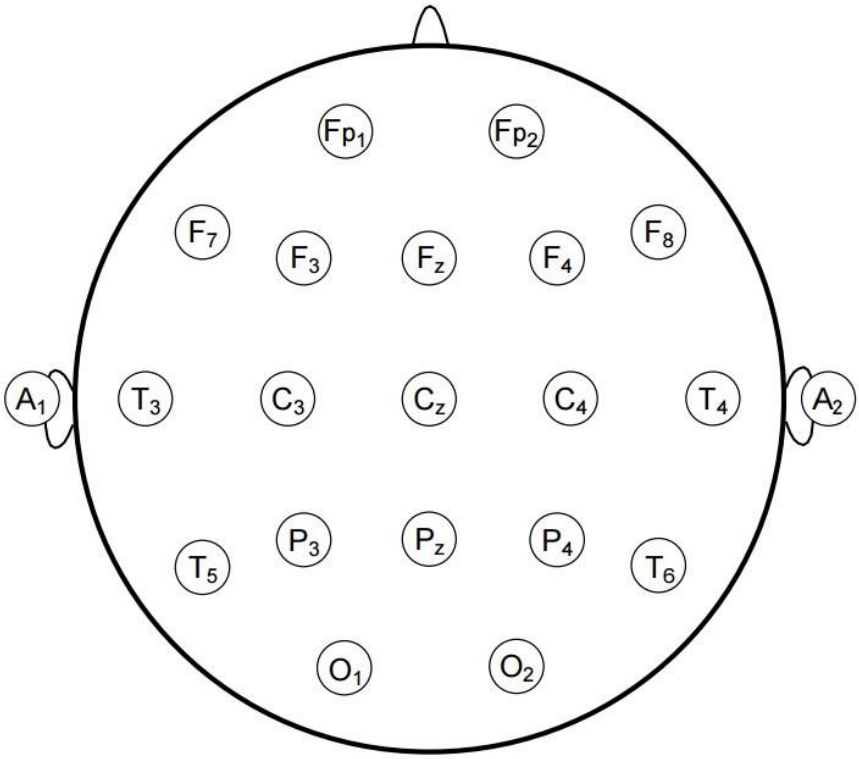
an algorithm that samples a signal over a period of time and divides it into its frequency components. The software allows for a therapist/researcher screen of the electroencephalographic (EEG) data for in-session adjustment of the frequency ranges of interest, and manual adjustment of inhibitory and reward thresholds (see Appendix C).

In general use there is also capacity for a client-oriented screen which has a graphical representation of the EEG screen in an engaging 'game' format providing visual and auditory feedback which was not used in this study. The hardware was the Spectrum-2 amplifier manufactured by JJ Engineering, USA. The Spectrum-2 hardware amplifies the bioelectric potentials generated by the neuronal firing within the brain and detects the voltage difference between two signals at each of the sites of the electrodes on the scalp. Lowpass filtering to reject noise at frequencies higher than an EEG is included in the EEGer software as well as a notch filter to reject 60Hz powerline noise. The rationale for selection of this NFB system is that this is the same system used in previous studies (Gapen et al., 2016; van der Kolk et al., 2016) of neurofeedback intervention in PTSD that demonstrated positive effects of training.

The training sites were fixed for all participants using the International 10-20 System for Electrode Placement (Harner & Sannit, 1974). The 10-20 system is a standardised procedure for the measured location of equally spaced electrode placements using recognisable anatomical landmarks as reference points (see Figure 4.1). This system was developed based on the relationship of an electrode site and the underlying cortical functional area and structures. The system of electrode placement is named according to the spacing of either 10% or 20% of the total distance between pairs of skull landmarks.

Figure 4.1.

International 10/20 System of Electrode Placement



In this research, there was a sequential placement of electrodes with C3 and C4 as the summed active sites with linked ears as reference and a ground electrode at the hairline of the forehead. The training occurred with a therapist screen to monitor EEG signals and allow for threshold adjustments while participants viewed a separate monitor for video feedback with the screen duplicated from the therapist's screen.

Location of electrodes

Previous studies, as reported by Ancoli and Kamiya (1978), raise some concerns given the inconsistencies in methodology, sample size and heterogeneity of the approach to neurofeedback and among the participants of trials. What is common across the studies is the reporting of positive outcomes. This design and the implementation of this intervention were made on the basis of the understanding of

brain connectivity networks and the pathways associated with various functions, with the view that correcting dysregulation can have broad effects, as elucidated below.

The previous discussion on the generation of the EEG provides the basis for understanding how the pathways communicate, particularly those involved in self-regulation of mood, cognition and behaviour. Sterman (1996) and others (Clemente, Sterman, & Wyrwicka, 1964; Niedermeyer et al., 2004; Steriade et al., 1990) set the early research foundation of understanding through anatomical and histological studies and the neuronal theory of brain organisation. More recent imaging methods have additionally contributed to understanding the large-scale brain communication networks. This provides support for the procedures used in this study, which are based on the understanding of these biological underpinnings of behaviour, and thus for initial training over the sensorimotor cortex for stress disorders. This author, however, would argue that the initial training occurring in any neurofeedback intervention for stress conditions should commence with the protocols used in this study. This is because of a number of important factors, including biological evidence of the pathways associated with the processing of information, the type of reinforcement used, and the application of aspects of operant conditioning to enhance learning, which are elucidated below.

The selection of electrode placement in this research was based on previous research (Roth et al., 1967; Sterman, 1981, 1996; Sterman & Mann, 1995; Wyrwicka & Sterman, 1968), which determined physiological down-regulation could be achieved through the entrainment of rhythms specifically found in the sensorimotor cortex from volleys of impulses relayed through the hypothalamic sensory inputs. The sensorimotor rhythm (SMR) is the presence of this particular EEG rhythm over the sensorimotor cortex that is non-rhythmic low voltage, with a spectral peak around

12–14 Hz. The SMR rhythm can be detected by the placement of electrodes at the C3 and C4 position over the sensorimotor cortex.

As noted by Sterman, Wyrwicka, and Roth (1969), the SMR was discovered in the context of sleep research for learned suppression of a previously rewarded cup-press for food reward in cats. It was found that a drop in muscle tone produced SMR bursts. In subsequent unrelated studies to examine dose–response functions of a highly epileptogenic fuel compound, some of the same cats that had been entrained to produce SMR were used in the study. The SMR-trained cats had a greater latency to the onset of seizures and less advancement to death. Essentially, there was a protective effect induced by training the SMR rhythm. Subsequently, studies were conducted on humans where it was demonstrated that SMR training could significantly lower seizure incidence.

To appreciate these results, it is necessary to understand the afferent somatosensory neurons, which are responsible for bringing sensory information from the outside world into the brain. The somatosensory system consists of three main divisions of external stimuli, internal stimuli, and the sense of where the body is in space. The neurogenesis of the SMR is well understood and emanates from the ventrobasal nuclei (nVB) of the thalamus, which is generally associated with conducting the information from afferent somatosensory neurons. When training SMR, the nVB firing patterns alter from fast tonic discharges to rhythmic bursts, which influences the suppression of somatosensory information relay as well as the reduction of muscle tone (Harper & Sterman, 1972; Howe and Sterman 1972, 1973).

The nVB cells hyperpolarise with the reduction of afferent somatosensory input, leading to a gradual depolarisation mediated by slow calcium influx causing the nVB to discharge burst spikes relayed to the sensorimotor cortex as well as the

thalamic reticular nucleus (nRT). The activation of the nRT leads to GABAergic inhibition of VB cells resetting the hyperpolarised state, and then a new cycle can start. This interplay results in the rhythmic thalamocortical volleys and EEG oscillations at the cortex. These processes can initiate SMR, although SMR is also influenced by other factors, such as the non-specific cholinergic and monoaminergic neuromodulation affecting excitability levels.

During behavioural quiescence, oscillations at the SMR frequency recorded at the somatosensory cortex can be observed. As stated by Egner and Sterman (2006, p. 22):

> [SMR] constitutes the dominant 'standby' frequency of the integrated thalamocortical somatosensory and somatomotor pathways [and] operant training of the SMR is assumed to result in improved control over excitation in this system. Increased thresholds for excitation in turn are thought to underlie the clinical benefits of SMR training.

Of note is that SMR training has been successfully applied to healthy volunteers to reduce impulsive tendencies (Egner & Gruzelier, 2001, 2004). Further, there are numerous studies that support the actions of training the SMR through fMRI (Beauregard & Lévesque, 2006), which shows increased metabolic activity in the striatum, and supporting anatomical research (Brodal & Bjaalie, 1992; Chevalier & Deniau, 1990), which has mapped the functional pathways of the striatum (in the basal ganglia). The reduction of activation of the striatal inhibitory mechanisms has a concomitant reduction of background motor tone and reflex excitability. These findings indicate the reorganisation of experience-based motor and thalamic status (Egner & Sterman, 2006), which may underlie the outcomes of SMR training. The afferent thalamocortical volleys travel to the pyramidal cells on the sensorimotor

cortex via arousal reduction and relay back from cognitively based distal excitation of the same neurons, magnifying depolarisation and subsequent long-term potentiation. These continuous changes in the sensorimotor circuits through SMR training are strengthened, resulting in a decrease in sensorimotor excitability that is progressive and sustained over time, and positively affecting functioning beyond the neurofeedback session.

There is solid evidence from these anatomical and histological studies that the relay of almost all incoming sensory information projected to the cortex occurs through the hypothalamus. Therefore, the sensorimotor cortex could be the starting point for any resetting of the ability to self-regulate conditions of overarousal and attention prior to the specificity of electrode placement at alternate scalp sites. This provides the rationale for the selection of the electrode placements in this study, particularly as the target of neurofeedback is neural regulation and stabilisation.

This rationale can be supported by further consideration of the functions and pathways of the default mode network (DMN), salience network (SN) and central executive network (CEN). Research using fMRI has demonstrated positive changes in the connectivity of these large-scale networks. This was demonstrated by Bauer et al. (2020) who investigated DMN and CEN changes using fMRI neurofeedback with sufferers of auditory hallucinations. They stated that altered connectivity reflects deficiencies in reality monitoring that create a failure to deactivate this network, which is hyperconnected during rest. Further, the CEN to DMN was anti-correlated and communication was significantly reduced.

Another study, by Russell-Chapin et al. (2013), demonstrated positive DMN changes and connectivity and concomitant improvements in measures after neurofeedback training of ADHD sufferers. These participants displayed symptoms

of inattention and impulsivity and failure to self-regulate and the study found that, after neurofeedback, the brain was normalised when compared with normal brain templates. Of note in this study, the researchers used sensorimotor (SMR) training at 12–15 Hz at the CZ location.

Most pertinent to the current study, a recent study by Krause et al. (2021) investigated the ability to self-regulate stress related large-scale brain networks using fMRI neurofeedback. The focus of their work was on the salience network and central executive network, which revealed alterations in the balance between the SN, which integrates cognitive processes associated with salient information, and the CEN, which regulates higher-order cognitive functions. When operating normally, a balance shift occurs due to stress. This can actively be reversed to return to homeostasis, which is reflective of successful self-regulation and resilience. With chronic or repeated stress, this balance between networks becomes compromised and unable to restore itself to normal function. The Krause et al. (2021) study demonstrated that participants were able to differentially control the balance between the SN and CEN. Furthermore, the skills learned were generalised beyond the fMRI neurofeedback sessions. Also of relevance is that the fMRI showed that all three major networks were recruited through the learning of self-regulation.

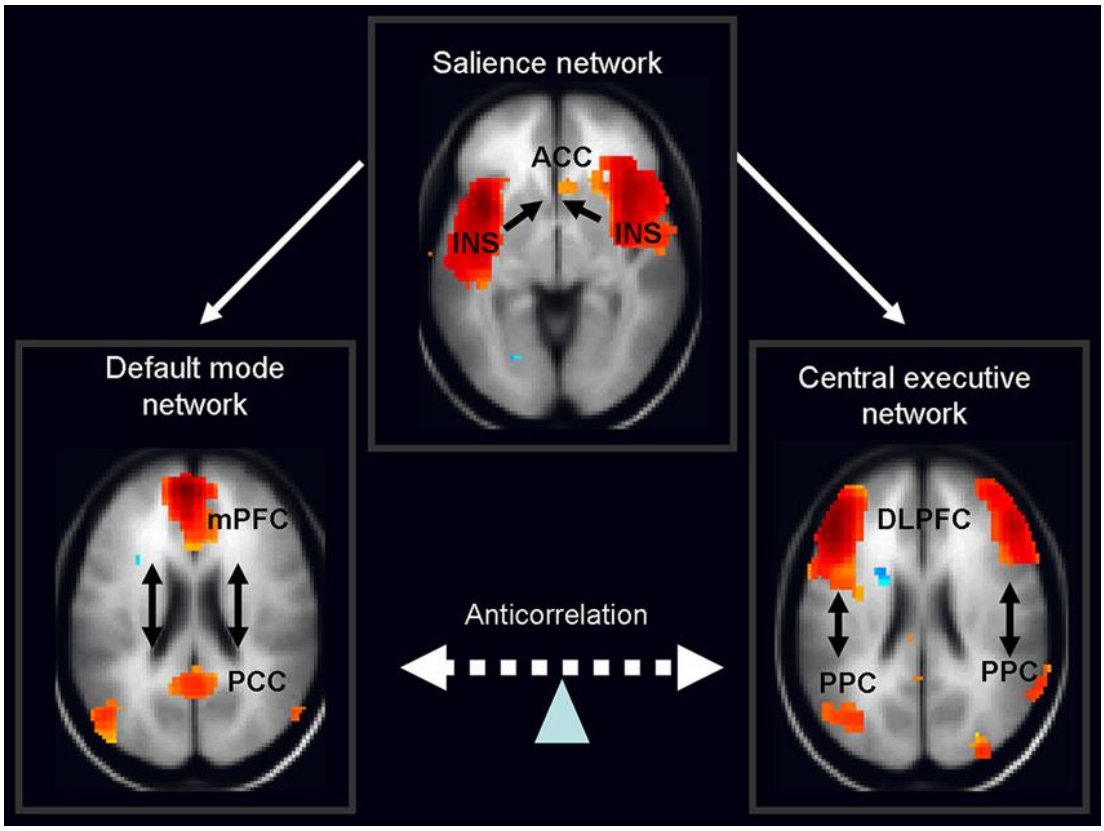
These study results have a significant bearing on this research and on the proposal that initial training should occur over the sensorimotor cortex at the C3/C4 sites for conditions associated with overarousal. Figure 4.3 identifies the node connections of the default mode network and salience network. The node connections represent the neural elements, including neurons, neuronal populations, and regions of neurons. As can be seen in these images, these large-scale networks, particularly the salience network, span the areas of C3 and C4, which sit over the

sensorimotor cortex. This location for training is supported both by the anatomical research and the imaging research for influencing the populations of neurons within this area. This is posited as evidence that training in this region can achieve the alteration of rebalancing the communication networks broadly and hence lead to improvements in a wide-ranging set of symptoms associated with stress, chronic stress, and PTSD.

While training in any location is likely to induce positive changes this research is specific in its intent to train to the sensorimotor cortex to improve dysregulation. The intent is to improve the DMN, which controls self-referential processing (i.e., introspection and self-preoccupation) and to improve the salience network with respect to the stimuli, cognitions and emotions that are attended to, and the CEN involved in memory, decision making and attentional control. The coordination of these networks can usefully recruit all components and restore the ability to self-regulate. It was expected that operant training of the SMR will result in improved control over excitation in these systems.

Figure 4.2.

The salience network mediates switching between the DMN and CEN.



Source: Wikimedia Commons. Nekovarova, Fajnerova, Horacek, Spaniel — Bridging disparate symptoms of schizophrenia: a triple network dysfunction theory, CC BY 3.0

Neurofeedback Procedure

Participants contacted the researcher on a dedicated mobile phone and were provided with an information sheet which gave an outline of the study and initial information of what a participant would be asked to do. This included disclosing what participation involved, risks, benefits, other support avenues, and privacy, confidentiality, and consent statements as well as information about where to submit concerns or complaints.

Consent occurred in two processes. First, the participants who contacted the researcher were provided with an information handout. Those participants who were interested in volunteering for the study contacted the researcher again to make an appointment for an initial face-to-face information session. The first consent

procedure related to this first face-to-face contact. It aimed to provide the opportunity for full disclosure of the study and allowed the researcher to provide a face-to-face explanation, using lay language, of the intervention and procedures to be undertaken to ensure the participant was fully informed. Participants were able to see the equipment that was to be used and given an opportunity for asking questions directly about matters that required clarification. The prospective participant was in no way obligated to continue in the study. The participant was offered the opportunity to leave and consider further participation; if they were happy to continue, they proceeded to the second consent process of actual participation in the study.

Conflict of interest was declared in the initial information sheet. This disclosed that the researcher was also a practising psychologist with concomitant limits on confidentiality. Consent depends on the clear understanding of the limits of confidentiality with respect to harm to self or others or disclosure as required by law in accordance with the ethical conduct required of a health professional, an acknowledgement of understanding of the intervention and procedures and assurance that withdrawal from the study could occur at any time. All consent procedures included the option to withdraw or not participate in the study. After participants signed the consent form to engage in the study, an appointment for assessment and baseline data collection was arranged or, if the participant elected and time permitted, they commenced engagement in data collection on the day. The entire study took place at a private psychology practice centrally located in Brisbane, Queensland, with free parking facilities for participants.

On arrival, the participant had a consultation and was given the opportunity to ask any questions in relation to consent or the procedures of the study. The participant was provided with detailed information regarding the procedure of the

treatments, and commitment for attendance and training. They were also advised that all information collected would be de-identified and they could withdraw from the study at any time. The participant was informed that following the assessment, their de-identified results would be reviewed and collated with that of other participants. Participants were assigned to treatment (intervention) or control conditions according to their entry into the study and ongoing availability.

Following final consent, a semi-structured interview at the outset provided data relating to demographics, symptoms of most concern, and the participant's experiences in relation to their sense of organisational support. These data provided qualitative information. The participant completed self-report psychological measures at this time, which included: PCL-5, DASS 21, MBI, BPAQ, STAI, MSPQ, PSOM, and PSQI. Those who self-selected to the control group were contacted for follow-up at approximately 2–3 months. As noted, those in the control group were at liberty to engage with the intervention at a later point. Three control participants on follow-up requested to join the intervention. The follow-up measures formed the baseline (Time 1) measures when entering the experimental group. During the intervention sessions there was the opportunity to collect further qualitative information via clinical review of progress.

Participants made a series of appointments to fit in with their work schedule. All participants underwent psychoeducation pertaining to the stress response from a psychobiological perspective (see Appendix E). This included understanding the underlying neural structures and their functions. This information was described in lay terms to assist with understanding and was designed to be congruent with the study interventions.

Neurofeedback Training Process

Most participants had between six and ten sessions (one participant had 15 sessions), each lasting up to 30 minutes (as reported in Participants). Sessions were concluded on the basis of the criteria of electrical stability, as measured by consistently low microvolt readings in the frequency of interest in the EEG and positive behavioural feedback. Sessions were a minimum of one week apart and maximum of two weeks apart. The scalp sites of interest were prepped according to industry standards using an alcohol swab and Nu-prep gel to ensure integrity of the signal. Electrodes (Grass or Nicolet: 10mm gold cup) were applied to the scalp with Ten20 paste and covered with a cotton ball. Impedance measured for each electrode placement was maintained below 10kOhms. At the initial three-minute eyes open resting baseline, thresholds were determined such that the overall rate of reward occurred 60% of the time. The breakdown of reward and inhibition included that 4–7Hz activity was inhibited; 20–30Hz was inhibited and 13–16Hz or 12–14Hz was rewarded for being over threshold.

Method of operant conditioning

The type of reinforcement used in this research was unique in that participants trained with the raw EEG signal rather than a 'game' screen that is in common use and generally part of the software of neurofeedback programs (see Appendix C). This decision was supported by the work of previous researchers who have closely examined the factors associated with optimal learning in conditioning paradigms (Sherlin et al., 2011; Wyrwicka & Sterman, 1968). In order for learning to occur, a post-reinforcement synchronisation (PRS) of the EEG must occur (Clemente et al., 1964). In a seminal work, Clemente et al. (1964), noted an 'alpha-like' EEG synchronisation in the parieto-occipital cortex that was visible just after

reinforcement and correlated to a greater ability to learn. This research did not measure the PRS response specifically; however, it is assumed to have occurred due to the fact that reinforcement was given and learning occurred and was demonstrated in the study via self-reported mood and behaviour changes and long term follow up results. Through using the raw EEG signal as feedback, the learner can extract meaningful information and improve the response–reinforcer association. Gaming screens, in contrast, can overshadow this association and reduce salient information critical for maximising learning. Essentially, using the raw signal meant that the reinforcement of the visual cue of the amplitude readout and sound cues tied to reward could elicit specific brain behaviour responses that led to 'knowledge of results'.

Another aspect of the learning involved a shaping procedure that involved adjusting thresholds manually to promote learning rather than utilising automatic calculation of thresholds based on *a priori* percentages of reward or inhibition. The rationale for this is that if the participant is asked to reduce the amplitude of a specific frequency band and the threshold is continually being calculated on a percentage, they will always receive a percentage of feedback over time, even if the amplitude is rising. While the thresholds were pre-set for efficiency in this research, the adjustment of thresholds throughout sessions occurred 'on the fly'. The shaping method permitted the researcher to manually adjust thresholds from easier to harder over time. Easier thresholds were utilised for the purpose of initial learning and understanding the feedback screen, and as the participant achieved greater mastery, the thresholds became more difficult. Seeing this on the feedback screen is considered to have contributed to stronger motivation to succeed. The satisfaction of

achieving success is thought to subsequently contribute to secondary reinforcement tied to the learning, as used in behavioural conditioning.

Another contribution to this method of training was the ability to filter artifacts both through the software and in the use of the raw signal so that muscle activity, eye movements and electrocardiogram interference could be seen and understood by participants, reducing artifact-driven feedback and improving specificity.

The utility of neurofeedback cannot be overstated. While any research may be confronted with heterogeneous samples, neurofeedback can still be applied, as the intervention targets brain 'behaviours' common to all. For example, baseline measures can vary and there are individual differences in terms of coping or cognitive styles, and yet all can benefit from neurofeedback through an understanding of the neural substrates. It is thus an important strategy that aligns with the emerging concept of personalised medicine.

Participants received auditory and visual feedback indicating success for meeting the threshold and viewed an extended screen view of the raw EEG signal as seen by the therapist. Further adjustment of thresholds was made during training sessions to maintain the target threshold levels and this was recorded on the case report form. No adjustments were made to the protocol other than the reward frequency band based on self-report between sessions of over-arousal where the reward frequency band was lowered to 12–15Hz. Each trial consisted of three-minute blocks of training followed by a ten-second break. At the end of each three-minute trial, the software was set to hold and was only progressed on initiation by the therapist. This also allowed an opportunity to check in with the participant or discuss

any aspect of the training, in which case the hold was sustained until the conversation ceased. Overall, there were 7–8 training trials in each session.

Training aimed to teach participants to alter the EEG amplitudes of filtered frequencies—specifically to decrease or maintain amplitude in the 4–7Hz range and decrease amplitude in the 20–30Hz range while increasing or maintaining 13–16Hz or 12–15Hz activity based on the threshold of reward occurring 60% of the time. By convention, slow wave (Theta) activity is associated with drowsiness, inattention and pre-sleep states and the fast activity generally referred to as 'high beta' is associated with high levels of mental activation. Participants aimed to enhance mid-range frequencies, generally referred to as sensorimotor rhythm (SMR) when monitored across the sensorimotor cortex. Previous research (Roth et al., 1967; Sterman, 1996) has demonstrated the enhancement of motoric/somatic quiescence and a calm, relaxed state of focused attention when training occurs at these sites.

Each subsequent session commenced with verbal feedback about what the participant noticed after the session and during the intervening time between sessions which was recorded on the case report form. At the conclusion of the training protocol, all baseline measures were re-administered. The participants were thanked and asked if they had any feedback about their experience. The participants were also invited to return after a minimum three-months for a follow-up and administration of survey as well to attend further sessions if they reported a preference for additional training.

Measures

Self-report measures for Study 2 were the same as for Study 1 (see Chapter 3) and were selected on the basis of their ability to reflect the diagnostic criteria of the DSM-5 and symptoms that may be associated with sub-clinical PTSD. They included

the Posttraumatic Checklist-5; the Depression, Anxiety Stress Scale; Maslach Burnout Inventory; Psychological Sense of Organisational Membership; Modified Somatic Perception Questionnaire and the Pittsburgh Sleep Quality Index. The State–Trait Anxiety Inventory was also used. The measures used in Study 2 are summarised in Table 4.2 and a description of the extra measures is given below. Table 4.3 summarises the range and clinical cut-off scores for the major clinical measures.

Table 4.2.

Measures used for the DSM-5 Criteria

DSM-5 Criteria	Measure
Criteria A: exposure to death, injury or violence	PCL-5
Criteria B: intrusive symptoms; memories/dreams	PCL-5, PSQI
Criteria C: persistent avoidance	PCL-5
Criteria D: negative alterations in cognitions, mood or negative emotional states: anger, hostility	PCL-5, BPAQ, DASS21, STAI, MBI,
Criteria E: alterations in arousal and reactivity. Irritable behaviour, poor concentration, sleep disturbance.	PCL-5, BPAQ, DASS21, STAI, MBI, PSQI, MSPQ

Note: PCL-5: Posttraumatic Checklist-5; PSQI: Pittsburgh Sleep Quality Inventory; BPAQ: Buss-Perry Aggression Questionnaire; DASS21: Depression, Anxiety, Stress Scale21; STAI: State Trait Anxiety Inventory; MBI: Maslach Burnout Inventory; MSPQ: Modified Somatic Perception Questionnaire.

The State–Trait Anxiety Inventory

This widely used self-report assesses the presence and severity of current symptoms of anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1970). It examines how respondents feel at the time, including subjective feelings of tension, worry and autonomic system arousal; it also examines their propensity for anxiety

and their calmness and confidence. It thus differentiates ‘state’ versus ‘trait’ features (Julian, 2011). The State–Trait Anxiety Inventory (STAI) consists of 20 items allocated to state anxiety; response options range from 1 “*not at all*” to 4 “*very much so*”. There are 20 items allocated to trait anxiety, and response options range from 1 “*almost never*” to 4 “*almost always*”.

Items are summed to obtain a subtest of total scores. The range of scores for each sub-test is 20–80, with higher scores reflecting greater anxiety. Cut points have been suggested at 39–40 to indicate clinically significant symptoms.

Internal consistency coefficients for the scale have ranged from .86 to .95, and test–retest reliability range from .65 to .75 (American Psychological Association, 2018). Internal alpha coefficients are 0.95 for military recruits. This test is considered useful in tracking change over time, particularly the state scale.

Table 4.3.

Measures used, range and clinical cut-off for Study 2

Measure	Range	Cut off
PCL-5	0–80	33
Depression	0–21	0–4 Normal
		5–6 Mild
		7–10 Moderate
		11–13 Severe
		14+ X Severe
Anxiety	0–21	0–3 Normal
		4–5 Mild
		6–7 Moderate
		8–9 Severe
		10+ X Severe
Stress	0–21	0–7 Normal
		8–9 Mild
		10–12 Moderate
		13–16 Severe
		17+ X Severe
MSPQ	0–39	
BPAQ A	7–35	17
BPAQ H	8–40	21
BPAQ PA	9–45	24
BPAQ V	5–25	15
MBI EE	0–54	High ≥ 27
		Moderate 19-26
		Low 0-18
MBI DP	0–30	High ≥ 10
		Moderate 6-9
		Low 0-5
MBI PA	0–48	High 0-33
		Moderate 34-39
		Low ≥ 40
PSQI	0–21	≥ 5

Results

Overview of Analyses

This research provides an opportunity for some extensive analyses of multiple factors, relationships and outcomes. The primary aim of this study is to investigate the efficacy of neurofeedback as an intervention to improve or relieve stress symptoms.

There were three primary hypotheses:

H1: Firefighters in the experimental group will show improved scores for stress symptoms as measured by self-report standard psychological measures from pre- to post-intervention.

H2: Firefighters in the experimental group will maintain positive changes in stress symptoms as measured by self-report standard psychological measures at long-term follow-up after the intervention.

H3: Firefighters in the control group that do not engage in the intervention will show no change in stress symptoms as measured by self-report standard psychological measures from baseline to follow-up.

Descriptive statistics using SPSS (v.28) were used to identify demographic data and intercorrelations among the measures. A series of two-way mixed ANOVAs were used to examine the hypotheses, which was that firefighters in the experimental group would show improved scores on dependent measures from Time 1 to Time 2 compared with the control group. The between-subject factors were group (experimental or control), and the within-subject factor was time (baseline as Time 1 and Time 2). The two-way mixed ANOVA examined main effects for group*time interaction and simple main effects for group. A series of one-way ANOVAs

examined the within-subject simple main effects for time. The results section reports the findings for the experimental group for Time 1 (baseline), Time 2 (intervention end) and Time 3 long-term follow up and for the control group at Time 1 (baseline) and Time 2 (follow up).

Preliminary data analyses

Descriptive data (means and standard deviations) and inter-correlations among the measures are displayed in Table 4.4. Overall, correlations show a strong relationship among the measures in the expected direction.

Table 4.4. *Means, standard deviations, and inter-correlation among the variables Study 2*

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1PCL-5	15.05	9.26	(.94)															
2 DEP	3.76	2.55	.52*	(.94)														
3 ANX	2.48	2.20	.43	.42	(.87)													
4 STR	7.81	3.57	.66**	.58**	.68**	(.91)												
5 STAIS	34.81	9.44	.73**	.54*	.50*	.52*	(.95)											
6 STAIT	36.19	8.04	.70**	.58**	.69**	.68**	.75**	(.95)										
7 MSPQ	6.62	4.65	.34	.29	.68**	.50*	.47*	.52*	(.80)									
8 PSOM	63.67	7.30	.15	-.14	-.21	.02	-.03	-.21	-.33	(.94)								
9 ANG	16.62	5.85	.07	-.02	-.17	.13	-.27	-.06	-.13	-.32	(.83)							
10 HOS	19.14	6.03	.38	.51*	.47*	.41	.23	.69**	.36	-.40	.27	(.77)						
11 PA	16.95	4.92	.08	.03	-.12	.06	-.23	.00	-.27	-.03	.45*	.45*	(.85)					
12 VA	15.10	5.26	-.00	-.00	.01	.11	-.19	.08	-.17	-.36	.77**	.42	.64**	(.72)				
13 EE	15.90	10.14	.58**	.70**	.46*	.56**	.59**	.59**	.35	-.09	-.18	.27	-.05	-.11	(.90)			
14 DP	9.48	5.56	.65**	.31	.40	.67**	.49*	.56**	.40	.06	.16	.17	.04	.12	.53*	(.79)		
15 PA	32.95	6.64	-.17	-.29	-.35	-.23	-.25	-.53*	-.50*	.64**	-.19	-.55**	-.07	-.14	-.32	-.25	(.71)	
16 PSQI	7.67	5.09	.16	.12	.10	-.02	.25	.35	.22	-.25	-.09	.13	-.33	-.24	.08	.19	-.56**	(.70)

Note. Cronbach's (1951) alpha reliability coefficient appears in diagonals. * $p < .05$, ** $p < .01$ as assessed Pearson (r). PCL-5 (posttraumatic checklist); DASS21 (DEP,ANX, STR); STAIS/STAIT (state/trait anxiety); MSPQ (modified somatic perceptions); PSOM (sense of organisational membership); BPAQ (Ang, Hos, PA, VA); MBI (EE,DP, PA); PSQI (Pittsburgh Sleep Questionnaire).

Data Checking

Prior to further analysis, the data were examined via SPSS functions to investigate the accuracy of data entry and missing values and to see if the data met the necessary parametric assumptions needed for the ANOVAs. Using the EXPLORE function of SPSS, outliers were assessed by inspection of the box plots and studentised residuals. Normal distribution was assessed by the Shapiro-Wilk test ($p > .05$) and visual inspection of Normal Q-Q plots. Homogeneity of variances was assessed by Levene's test ($p > .05$) and homogeneity of covariances by Box's test ($p > .001$). For the experimental group, inspection of the box plots revealed there was one case of an outlier in the PCL-5 measure. An outlier occurred in only one case, in one measure, and was considered a genuine value. Also, given that the sample size was small, the decision was made to apply winsorisation to the outlier. Statistics such as mean and variance are susceptible to outliers, and another consideration was that the goal was to determine change in values over the time course of the intervention. Retention and modification of the outlier would still enable this to be determined. It was also considered that removal of the outlier would have a greater negative impact on accurately determining change. Further, as it was considered that the outlier was a genuine value, the purpose of modification was to improve statistical efficiency (Ruppert, 2014). Winsorisation permits the modification of outliers by changing the values to be closer to the values in the data set. However, the changes in values maintained the rank of the outlier as well as its value, being the highest (Wilcox, 2005). The outlier followed the same pattern of change of the group over the three time points. The outlier values were reduced to being just larger than the second largest value over each time point to maintain its rank (Laerd Statistics, 2013). For Time 1, 46 was reduced to 38, with the second largest value at 36. For Time 2, 32

was reduced to 15, with the second largest value at 11. For Time 3, 42 was reduced to 17, with the second largest value at 15.

For the control group, analyses examined significant differences in scores on measures over the course of two time periods—Time 1 and follow-up—with a time difference of a minimum of two months. There were three cases of an outlier in the control group for the PSQI measure only. Outlier values were retained for the analyses for this single measure. As there were only two levels of repeated measures there is only one set of difference scores and nothing to compare those differences against to indicate any violation of sphericity.

Comparison of treatment vs control group by measure and time

For the two-way mixed ANOVA for the following results, and unless otherwise stated, there were no outliers as assessed by inspection of the box plot, and the data were normally distributed, as assessed by the Shapiro-Wilk test ($p > .05$). There were no outliers as assessed by examination of the studentised residuals for values greater than ± 3. The scales were normally distributed, as assessed by visual inspection of Normal Q-Q plots. There was homogeneity of variances, as assessed by the Levene's test of homogeneity of variance ($p > .05$) based on means. There was homogeneity of covariances, as assessed by Box's test of equality of covariance matrices ($p > .001$). The main effect and simple main effect for group for each of the measures are reported first. Data are mean ± standard error, unless otherwise stated. A summary of the findings can be found in Table 4.5.

Post-traumatic Checklist

Main Effect: There was a statistically significant difference between the experimental group and control group on PCL-5 scores: $F(1,19) = 19.92$, $p < .001$, partial $\eta^2 = .512$.

Time effect for group: There was a statistically significant difference between the experimental group and control group on PCL-5 scores at Time 1: $F(1,19) = 4.87$, $p < .04$, partial $\eta^2 = .204$ as well as Time 2, $F(1,19) = 5.22$, $p < .03$, partial $\eta^2 = .216$. Pairwise comparisons of PLC-5 scores were statistically significantly higher in the experimental group than in the control group at Time 1: (8.250 ± 3.73), (95% CI .427 to 16.073), $p = .04$. The control group was higher than the experimental group for Time 2: (5.08 ± 2.22), (95% CI .430 to 9.736) $p = .034$.

Depression Anxiety Stress Scale: Depression

Main Effect: Homogeneity of variances was violated, as assessed by Levene's test ($p > .05$) Time 1 ($p = .435$) but not at Time 2 ($p = .001$). There was a statistically significant difference between the experimental group and control group on depression scores: $F(1,19) = 13.829$, $p = .<.001$, partial $\eta^2 = .421$.

Time effect for group: There was no statistically significant difference between the experimental group and control group on depression scores at Time 1; however, Time 2 showed there was a significant difference between the experimental group and control group on depression scores at Time 2: $F(1,19) = 7.67$, $p = .01$, partial $\eta^2 = .288$. Pairwise comparisons of depression scores at Time 2 were statistically significantly higher in the control group (4.22 ± 2.77) than the experimental group (1.75 ± 1.21), (95% CI .605 to 4.34), $p = .01$.

Depression Anxiety Stress Scale: Anxiety

Main effect: The anxiety scores were normally distributed, as assessed by a Shapiro-Wilk test ($p > .05$) at Time 1 but not Time 2 ($p <.001$). There was one outlier, which had a studentised residual value of 3.02 and was retained. There was homogeneity of variances, as assessed by Levene's test ($p > .05$) at Time 1 but not at Time 2 ($p =.01$). Homogeneity of covariances was violated, as assessed by Box's test ($p < .001$). This

violation was noted, and the mixed ANOVA was run regardless. There was a statistically significant difference between the experimental group and control group on anxiety scores: $F(1,19) = 5.99$, $p = .02$, partial $\eta^2 = .24$.

Time effect for group: There was no statistically significant difference between the experimental group and control group on anxiety scores at Time 1; however, there was for Time 2, $F(1,19) = 7.67$, $p = .01$, partial $\eta^2 = .288$. Pairwise comparisons at Time 2 were statistically significantly higher in the control group (2.33 ± 2.39) than the experimental group (.42 ± .67), (95% CI -3.43 to -.406), $p = .01$.

Depression Anxiety Stress Scale: Stress

Main Effect: There was one outlier from the experimental group at Time 2 in the data, as assessed by inspection of a boxplot, and this was unaltered. There was a statistically significant difference between the experimental group and control group on stress scores: $F(1,19) = 15.03$, $p < .001$, partial $\eta^2 = .442$.

Time effect for group: There was no significant difference in stress scores between the experimental and control group at Time 1; however, there was a significant difference at Time 2, $F(1,19) = 16.32$, $p < .001$, partial $\eta^2 = .462$. Pairwise comparisons were significant at Time 2, with the control group (8.56 ± 3.67) higher than the experimental group (3.25 ± 2.34), (95% CI, 2.55 to 8.05), $p < .001$.

STAIS and STAIT

Main effect: The box plot showed one outlier in the control group at Time 2 and was retained. Homogeneity of variances, as assessed by Levene's test, was violated: ($p >$ .05) at Time 1 (p =.966) and at Time 2 (p =.14). Homogeneity of covariances was violated, as assessed by Box's test ($p < .001$). These violations were noted, and the mixed ANOVA was run regardless. There was a statistically significant difference

between the experimental group and control group on STAIS scores: F(1,19) = 12.44, p = .02, partial η^2 = .24.

Time effect for group: There was no statistically significant difference between the experimental group and control group on STAIS scores at Time 1; however, there was significance at Time 2: *F*(1,19) = 5.77, *p* = .02, partial η^2 = .233. Pairwise comparisons at Time 2 were statistically significantly higher in the control group (34.00 ± 9.36) than the experimental group (26.17 ± 5.54), (95% CI -14.66-1.006), *p* = .012.

There was a statistically significant difference of STAIT scores: *F*(1,19) = 9.735, *p* = .006, partial η^2 = .339. However, there were no significant simple main effects for group.

Maslach Burnout Inventory: Emotional Exhaustion

Main Effect: There was no statistically significant difference between the experimental group and control group on EE scores: *F*(1,19) = 3.971, *p* = .061, partial η^2 = .173 although this was approaching significance. This was followed up by examining main effects for the between-and-within subject factors, where there were no statistically significant findings.

Maslach Burnout Inventory: Depersonalisation

Main Effect: Homogeneity of variances, as assessed by Levene's test, was violated (*p* > .05). Homogeneity of covariances, as assessed by Box's test (*p* = .09), was violated. There was no statistically significant difference between the experimental group and control group on depersonalisation scores. This was followed up by examining main effects for the between-and-within subject factors and there were no statistically significant findings.

Maslach Burnout Inventory- Personal Accomplishment

Main Effect: Homogeneity of variances, as assessed by Levene's test, was violated at Time 2 (p .> .05). There was a statistically significant difference between the experimental group and control group on personal accomplishment scores: $F(1,19)$ = 21.21, $p < .001$, partial $\eta^2 = .528$.

Time effect for group: There was no statistically significant difference between the experimental group or control group at Time 1; however, there was significance for Time 2: $F(1,19) = 7.14$, $p = .015$, partial $\eta^2 = .273$. Pairwise comparisons for scores at Time 2 were higher in the control group (31.89 ± 8.46) than the experimental group (39.17 ± 3.71), (95% CI 12.97 to 1.58), $p = .01$.

Buss-Perry Aggression Questionnaire

Main Effect: Levene's test was violated at Time 2 ($p = .03$). There was a statistically significant difference between the experimental group and control group on BPAQ scores: $F(1,19) = 15.669$, $p < .001$, partial $\eta^2 = .452$.

Time effect for group: There was no statistically significant differences for group at Time 1 or 2.

Modified Somatic Perceptions Questionnaire

Main effect: There was a statistically significant difference between the experimental group and control group on MSP scores: $F(1,19) = 16.969$, $p < .001$, partial $\eta^2 = .472$.

Time effect for group: There was no statistically significant difference between groups either at Time 1 or 2.

Psychological Sense of Organisational Membership

There was no interaction or statistically significant differences between groups at any time point.

Pittsburgh Sleep Quality Index

Main Effect: There were several outliers in the data, as assessed by inspection of a boxplot occurring at Time 1 in the experiment group and Time 2 in both groups. These were considered genuine values and were retained. Homogeneity of variances, as assessed by Levene's test, was violated ($p > .05$). Homogeneity of covariances, as assessed by Box's test $p > .001$ ($p = .21$), was violated. These violations were noted, and the mixed ANOVA was run regardless.

There was a statistically significant difference between the experimental group and control group on sleep scores: $F(1,19) = 7.58$, $p = .01$, partial $\eta^2 = .285$.

Time effect for group: Between-subject effects for Time 1 on sleep scores were approaching significance: $F(1,19) = 3.76$, $p = .067$, partial $\eta^2 = .165$. However, there were no differences between groups for sleep scores at Time 2.

Table 4.5.

Between-subject simple main effects for Group at Time 1

Measure	Experimental	Control							
	M (SD)	*M (SD)*	*F*	*df*	*p*	partial η^2	Mean Difference	Standard Error	95% CI LB-UB
PCL-5	18.58 (10.04)	10.33 (5.65)	4.87	1,19	**.04***	.204	8.25	3.73	.427-16.07
DEP	3.75 (2.41)	3.78 (2.86)	.001	1,19	.98	.000	-.02	1.15	-2.4-2.3
ANX	2.42(2.19)	2.56(2.35)	.019	1,19	.89	.001	-.14	.99	-2.22-1.94
STRESS	7.42(4.03)	8.33(3.0)	.327	1,19	.57	.017	-.91	1.60	-4.27-2.43
STAIS	36.83(9.90)	32.11(8.58)	1.30	1,19	.26	.064	4.72	4.13	-3.92-13.37
STAIT	37.92(8.20)	33.89(7.65)	1.31	1,19	.26	.065	4.02	3.52	-3.33-11.39
EE	16.33(10.51)	15.33(10.22)	.048	1,19	.83	.003	1.00	4.58	-8.58-10.58
DP	10.00(6.19)	8.78(4.87)	.239	1.19	.63	.012	1.22	2.50	-4.01-6.46
PA	31.25(3.39)	35.22(6.61)	1.93	1,19	.18	.092	-3.97	2.86	-9.96-2.01
BPAQ	68.83(13.03)	66.44(22.82)	.092	1,19	.76	.005	2.39	7.85	-14.06-18.83
MSPQ	7.33(4.71)	5.67(4.66)	.648	1,19	.43	.033	1.66	2.07	-2.66-5.99
PSOM	62.58(5.21)	65.11(9.57)	4.07	1,19	.05	.177	-8.94	4.43	-18.21-.327
PSQI	9.42(5.10)	5.33(4.27)	3.76	1,19	.06	.165	4.08	2.10	-.32-8.48

Note: *p < .05. DEP = Depression; ANX = Anxiety; Stress; EE = MBI Emotional Exhaustion; DP = MBI Depersonalisation; PA = MBI Personal Accomplishment.

Table 4.6.

Between-subject simple main effects for Group at Time 2

Measure	Experimental	Control							
		M (SD)	*F*	*df*	*P*	partial η^2	Mean Difference	Standard Error	95% CI LL-UL
PCL-5	6.58 (4.29)	11.67 (5.91)	5.22	1,19	**.03***		-5.08	2.22	-9.73, -.43
DEP	1.75 (1.21)	4.22 (2.77)	7.67	1,19	**.01***	.288	-2.47	.89	-4.34, -.605
ANX	.42(.669)	2.33(2.39)	7.05	1,19	**.01***	.271	-1.91	.722	-3.43, -.406
STRESS	3.25(2.34)	8.56(3.67)	16.32	1,19	**<.001***	.462	-5.306	1.31	-8.05, 2.55
STAIS	26.17(5.54)	34.00(9.36)	5.77	1,19	**.02***	.233	-7.833	3.26	-14.66, 1.00
STAIT	32.42(6.17)	36.11(9.80)	1.12	1,19	.30	.05	-3.70	3.48	-10.99, 3.60
EE	11.92(4.96)	16.44(9.26)	2.09	1,19	.16	.09	-4.53	3.13	-11.08, 2.02
DP	7.42(5.77)	9.00(5.62)	.232	1,19	.63	.01	-.233	.48	-1.25, .781
PA	39.17(3.71)	31.89(8.46)	7.14	1,19	**.01***	.27	7.28	2.72	1.58, 12.97
BPAQ	58.50(9.85)	68.33(21.01)	2.05	1,19	.17	.098	-9.83	6.86	-24.19, 4.52
MSPQ	3.50(2.78)	7.56(6.06)	4.23	1,19	.054	.18	-4.05	1.97	-8.18, .068
PSOM	67.92(7.84)	65.67(10.37)	.416	1,19	.52	.02	-2.28	3.53	-9.67, 5.11
PSQI	5.08(2.39)	5.22(3.73)	.011	1,19	.91	.001	-.139	1.33	-2.93, 2.65

Note: *p < .05. DEP = DASS depression; ANX = DASS anxiety; EE = MBI emotional exhaustion; DP = MBI depersonalisation; PA = MBI personal accomplishment.

Within-subject change over time in the experimental and control group

As a series of one-way ANOVAs was used to determine the simple main effects for time as the independent variable, normal distribution was assessed by a Shapiro-Wilk test ($p > .05$). Mauchly's test of sphericity was not violated unless otherwise stated. Data are mean ± standard deviation, unless otherwise stated.

Post-traumatic Checklist

For the experimental group, Mauchley's Test of Sphericity was violated, $\chi^2(2) = 10.61$, $p = .005$. Therefore, a Greenhouse-Geisser correction was used: $\chi^2(2) = 10.61$, $p = .605$. Scores were statistically significantly different at the different time points during the neurofeedback intervention: F (1.209,13.302) = 21.829, $p < .001$, partial $\eta^2 = .66$. There were statistically significant decreases in the PCL score from pre-intervention (18.58 ± 10.04) to both post-intervention (6.58 ± 4.29) and long-term follow-up (8.50 ± 5.42), (95% CI, 4.98 to 19.02), $p = .002$ and (95% CI, 4.24 to 15.93), $p = .001$ respectively. There was no significance noted from post-intervention to long-term follow-up. There were no statistically significant findings for the control group.

DASS — Depression

For the experimental group, depression scores were normally distributed for Time 1 and Time 2 but not for Time 3 ($p = .008$), as assessed by a Shapiro-Wilk test. Depression scores were statistically significant at the different time points for the experimental group: $F(2,22) = 6.351$, $p = .007$, partial $\eta^2 = .366$. The depression scores decreased from Time 1, baseline (3.75 ± 2.41) to Time 2, end of intervention (1.75 ± 1.21), (95% CI .527 to 3.47) and increased from Time 2 to Time 3; however, this was not statistically significant. There were no statistically significant findings for the control group.

DASS — Anxiety

Mauchley's test of sphericity was violated for the experimental group; therefore, a Greenhouse-Geisser correction was used: $\chi^2(2) = 10.61$, $p = .64$. There was a decrease in the anxiety scores for the experimental group from Time 1, (2.42 ± 2.19), to Time 2 (.42 ± .66), a statistically significant decrease of (95% CI, .335 to 3.66), $p = .01$ and an increase for long-term follow-up, which was not statistically significant. There were no statistically significant findings for the control group.

DASS — Stress

Stress scores were statistically significantly different at the different time points during the neurofeedback intervention: $F(2,22) = 14.959$, $p < .001$, partial $\eta^2 = .576$. There was a statistically significant decrease in stress scores from Time 1, 7.42 ± 4.03 to Time 2, 3.25 ± 2.34 (95% CI 1.668 to 6.666) as well as to Time 3, 3.83 ± 2.44 (95% CI .907 to 6.260), but no significance from Time 2 to Time 3. There were no statistically significant findings in the control group.

STAIS and STAIT

Mauchley's test of sphericity was violated, $\chi^2(2) = 13.75$, $p = .001$ in the experimental group; therefore, a Greenhouse-Geisser correction was used $\chi^2(2) = 13.75$, $p = .57$. STAIS scores were significantly different at the different time points during the neurofeedback intervention, $F(1.145, 12.591) = 11.540$, partial $\eta^2 = .512$. There was a statistically significant decrease in scores from Time 1, pre-intervention 36.83 ± 9.90 to Time 2, post intervention 26.17 ± 5.54 (95% CI, 2.36 to 18.91) and Time 3, long-term follow-up 29.08 ± 5.31 (95% CI, .737 to 14.76). There was also a statistically significant increase in scores from Time 2 post-intervention to Time 3, long-term follow-up, of (95% CI, .173 to 5.660). This suggests that STAIS scores decreased across the time periods; however, there was an increase in state anxiety

that was significant between post intervention and long-term follow-up, which was nonetheless still significantly below baseline (Time 1) levels.

Mauchley's test of sphericity was violated in the STAIT experimental group: $\chi^2(2) = 7.82$, $p = .02$. Therefore, a Greenhouse-Geisser correction was used $\chi^2(2) = 7.82$, $p = .64$. STAIT scores were significantly different at the different time points, $F(1.296,14.259) = 7.794$, partial $\eta^2 = .415$. There was a statistically significant decrease in scores from pre-intervention 37.92 ± 8.20 to post-intervention 32.42 ± 6.17 (95% CI, .196 to 10.804) and to long-term follow-up 32.83 ± 6.46 (95% CI, .181 to 9.86) with an increase in scores post-intervention to long-term follow-up which was not statistically significant. There were no statistically significant findings for the control group.

MB —- Emotional Exhaustion and Depersonalisation

Neither emotional exhaustion nor depersonalisation scores were significantly different across different time points for either group.

MBI — Personal Accomplishment

The Shapiro-Wilk test of normality was violated at Time 3, $p = .031$ in the experimental group. Personal accomplishment scores were significantly different across the different time points, $F(2,22) = 10.129$, $p < .001$, partial $\eta^2 = .479$. Scores were significantly different from pre-intervention 31.17 ± 6.39 (95% CI, -13.175 to -2.659) to post-intervention 39.17 ± 3.713 (95% CI, -9.678 to .678). There were no significant findings observed for Time 2 to Time 3. Essentially, the personal accomplishment score increased (improved) from pre-intervention to post-intervention and was in the expected direction.

For the control group, personal accomplishment was statistically significantly different between baseline (Time 1) and follow-up: $F(1, 8) = 6.452$, $p = .035$, partial

η^2 = .446. Baseline (Time 1), 35.22 ± 6.610 and follow-up (Time 2), 31.89 ± 8.462 (95% CI, .307 to 6.360).

Buss-Perry Aggression Questionnaire

Scores were statistically significantly different at the different time points during the neurofeedback intervention: F (2,22) = 13.22, p <.001, partial η^2 = .54. There were statistically significant decreases in the scores from pre-intervention (68.83 ± 13.03) to both post-intervention (58.50 ± 9.84) and long-term follow-up (58.33 ± 14.31), (95% CI, 3.88 to 16.78), and (95% CI, 2.82 to 18.18) respectively. There was no significance noted from post-intervention to long-term follow-up. There were no statistically significant findings for the control group.

Modified Somatic Perceptions Questionnaire

Somatic concern scores in the experimental group were statistically significantly different across the different time points, F (2, 22) = 11.562, p =< .001, partial η^2 = .512., and decreased from pre-intervention 7.33 ± 4.71 to post-intervention 3.50 ± 2.78 (95% CI, .693 to 6.973) and pre-intervention to long-term follow-up 3.25 ± 2.989 (95% CI, 1.232 to 6.934). Scores were not statistically significantly different between the post-intervention and long-term follow-up.

For the control group, the MSPQ showed significance across the time points F(2,22) = 11.56, p < .001, partial η^2 = .512, and was significantly different from baseline (Time 1), 5.67 ± 4.664 to follow-up (Time 2), 7.56 ± 6.064 (95% CI, -3.245 to -.533).

Psychological Sense of Organisational Membership

Organisation membership scores were not significantly different across different time points for either group.

Pittsburgh Sleep Quality Index

For the experimental group, Shapiro-Wilk was violated at Time 1, $p = .02$ and the box plot showed one outlier at Time 1 and one outlier at Time 3. Mauchley's test of sphericity was violated, $\chi^2(2) = 14.568$, $p = < .001$, and therefore a Greenhouse-Geisser correction was used $\chi^2(2) = 14.568$, $p = .56$. There was statistically significant difference across different time points: $F(1.132,12.450) = 11.072$, $p = .005$, partial $\eta^2 = .502$, from pre-intervention 9.42 ± 5.10 to post- intervention 5.08 ± 2.39 (95% CI, .962 to 7.705) and to long-term follow-up 5.00 ± 2.13 (95% CI, .575 to 8.258). Scores were not statistically significantly different from post-intervention to long-term follow-up.

There were no statistically significant findings for the control group.

Table 4.7.

Within-subject simple main effects for the experimental group Study 2

Measure	Time 1	Time 2	Time 3					
	M (SD)	*M (SD)*	*M (SD)*	*F*	*df*	partial η^2	ε	*p*
PCL-5	18.58 (10.04)	6.58 (4.29)	8.5 (5.41)	21.829	1.209,13.302	.665	.605	**<.001****
Dep	3.75 (2.41)	1.75 (1.21)	2.42 (2.53)	6.351	2,22	.366		**.007***
Anx	2.42 (2.19)	.42 (.669)	.92(.996)	8.084	1.280,14.083	.424	.64	**.009***
Stress	7.42 (4.03)	3.25 (2.34)	3.83 (2.44)	14.959	2,22	.576		**<.001****
STAIS	36.83 (9.9)	26.17 (5.54)	29.08 (5.31)	11.540	1.145,12.591	.512	.572	**.004***
STAIT	37.92 (8.20)	32.42 (6.17)	32.83 (6.46)	7.794	1.296,14.25	.415	.648	**.010***
MBIEE	16.33 (10.50)	11.33 (5.91)	16.83 (9.45)	1.739	2,22	.137		.199
MBIDP	10.00 (6.19)	7.42 (5.77)	8.08 (5.83)	1.955	2,22	.151		.165
MBIPA	31.17 (6.39)	39.17 (3.17)	35.75 (4.97)	10.129	2,22	.479		**<.001****
BPAQ	68.83 (13.03)	58.50 (9.84)	58.33 (14.31)	13.22	2,22	.546		**<.001****
MSPQ	7.33 (4.71)	3.50 (2.78)	3.25 (2.98)	11.562	2,22	.512		**<.001****
PSOM	62.58 (5.21)	67.92 (7.84)	64.75 (7.23)	2.567	2,22	.		.10
PSQI	9.42 (5.10)	5.08 (2.39)	5.00 (2.13)	11.072	1.132,12.450	.502	.566	**.005***

Note. **p* < .05, ** *p* < .001 Dep, Anx, Stress = DASS

Table 4.8.

Within-subject simple main effects for the control group Study 2

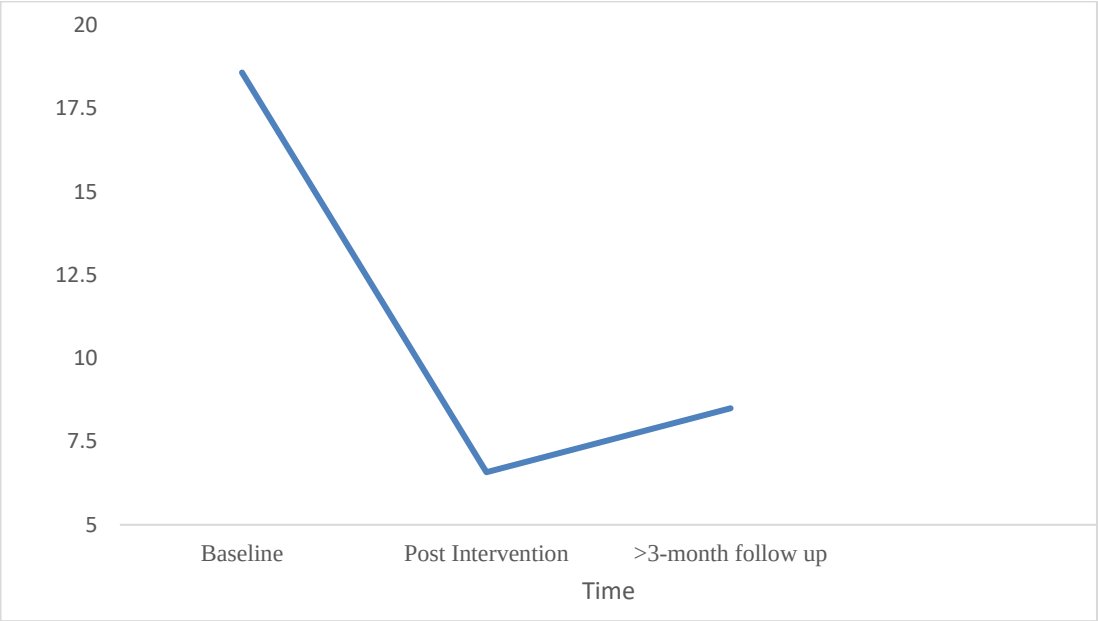
Measure	Time 1	Time 2				
	M (SD)	*M (SD)*	*F*	*df*	Partial η^2	*p*
PCL-5	10.33 (5.65)	11.67 (5.91)	2.370	1,8	.229	.162
Dep	3.78 (2.86)	4.22 (2.77)	2.286	1,8	.222	.169
Anx	2.56 (2.35)	2.33 (2.39)	.640	1,8	.074	.447
Stress	8.33 (3.0)	8.56 (3.67)	.165	1,8	.020	.695
STAIS	32.11 (8.5)	34.00 (9.36)	2.766	1,8	.257	.135
STAIT	33.89 (7.65)	36.11 (9.80)	2.703	1,8	.253	.139
MBIEE	15.33 (10.22)	16.44 (9.26)	1.818	1,8	.185	.214
MBIDP	8.78 (4.86)	9.00 (5.61)	.129	1,8	.016	.729
MBIPA	35.22 (6.61)	31.89 (8.46)	6.452	1,8	.446	**.035***
BPAQ	66.44 (22.82)	68.33 (21.08)	1.066	1,8	.118	.332
MSPQ	5.67 (4.66)	7.56 (6.06)	10.321	1,8	.563	**.012***
PSOM	65.11 (9.57)	65.67 (10.36)	.148	1,8	.018	.711
PSQI	5.33 (4.27)	5.22 (3.73)	.022	1,8	.003	.886

Note. **p* < .05 Dep, Anx, Stress = DASS

An example of trend over the repeated measures for the experimental group from Time 1, through Time 2, to long-term follow-up at Time 3 can be seen in Figure 4.2 in the means of the PCL-5 scores.

Figure 4.3.

PCL-5 means from baseline to long term follow up, experimental group.



Impact of self-assignment to control group vs experimental group

In order to reduce the possibility of confounds arising from the self-assignment of participants to the control or experimental groups, a series of one-way ANOVAs were conducted for Time 1 to determine if there were any significant differences between the groups.

For age, inspection of the box plots showed no outliers; however, the Shapiro-Wilk test was .004 and the data were not normally distributed. The ANOVA was run regardless, and the Levene test (p = .343) indicated there were no significant differences in the variances. There were no significant differences between the control group and experimental group for age: $F(1,19)$ = .396, p = .593.

Years of service revealed no outliers in the boxplots, although a Shapiro-Wilk test indicated the data were not normally distributed (p = .028). The Levene statistic, however, was p = .858. There were no significant differences between the groups for years of service, $F(1,19) = 1.590$, p = .223.

Marital status and having children were also examined and the Levene's tests were (p = .688, p = .143) respectively. Hence, there were no significant differences between groups on either marital status or having children, $F(1,19) = .042$, p = .840 and $F(1,19) = .826$, p = .375 respectively.

Exploration of possible stages of participants

Study 1 participants were not initially compared to the staging model, as the focus of the study was on exploring neurofeedback as an efficacious intervention. However, subsequent exploratory comparisons were made. The comparisons focused solely on the reported PCL-5 scores from the total sample (N=21) as the anchor measure representing all criteria of the DSM-5. Percentages were computed for the Study 2 sample that aligned to the class percentages found in Study 1 for the staging model. These are reported in Table 4.9. It can be seen in the table that only three of the 21 participants were allocated to Stage 2 and that 85.71% of the Study 2 participants were below Stage 2, compared with Study 1, where the percentage of participants below Stage 2 was 87%. Differences in means were not considered in this case due to the unexpected findings in Study 1 that showed varying symptom scores on scales for Stage 1a (class 2) and Stage 1b (class 3).

Table 4.9.

Study 2 PCL scores at Time 1 and percent in class from LPA in Study 1.

Participant	PCL-5 Score				Percent in Class
	Stage 0	Stage 1a	Stage 1b	Stage 2	
1	4				35%
2	4				
3	5				
4	7				
5	7				
6	9				
7	11				
8		12			34%
9		12			
10		12			
11		12			
12		12			
13		14			
14		18			
15			19		18%
16			21		
17			22		
18			23		
19				35	11%
20				36	
21				46	

Discussion

The primary aim of the study was to investigate the efficacy of neurofeedback to improve or relieve stress symptoms in firefighters, and the findings clearly demonstrate that symptoms can be positively altered across a range of severity of symptoms and are able to be maintained.

For the first and second hypothesis, and using the PCL as the anchor, results indicate that firefighters in the experimental group showed improved scores on repeated measures from Time 1 (pre-intervention) to Time 2 (post-intervention) ($p <$ .001). Scores from Time 2 to Time 3 (long-term follow-up) were not maintained, but did not return to baseline levels, and the increase in scores was not statistically significant. Therefore, Null Hypothesis 2 can be rejected.

Firefighters in the control group overall showed minor changes in scores from Time 1 (baseline) to Time 2 (follow-up), which supports the third hypothesis that no change would occur over time for the control group. Overall, most significant findings for the between-group two-way ANOVAs related to no differences at Time 1 and differences occurring at Time 2 with a statistically significant decrease in symptom levels for the experimental group. Thus, those exposed to the experimental treatment had an overall reduction in symptoms while those in the control group experienced a statistically significant decrease in personal accomplishment and an increase in somatic symptoms.

For all other measures, the control group did not experience any change in their symptom levels. This is also reflected in the series of one-way ANOVAs that tested the within-group repeated measures. The results are consistent in showing a reduction of symptoms across the PCL-5, depression, anxiety, stress, STAIS, STAIT, BPAQ, MSPQ, and PSQI, and increases in personal accomplishment for the experimental group. Of note, according to the National Center for PTSD (2022), a minimum five-point difference in the PCL-5 score indicates that an individual is considered to ‘have responded to treatment’ and a minimum ten-point score

difference is considered clinically meaningful (in this case, from Time 1 to Time 2 was a 12-point reduction and from Time 1 to Time 3 was a ten-point reduction).

The trend is similar across most measures, in that there is a reduction in symptomatology from pre- to post-intervention with a small uptick of symptoms at long-term follow-up. While this uptick is not a statistically significant finding, it does suggest either that training should be continued for a longer period to consolidate changes, or that the intervention should be part of an annual health update for maintenance. Given the ongoing nature of exposure to long hours, shift work, challenging operations and trauma, this presents a viable non-invasive option for managing stress responses.

This uptick finding may reflect the events occurring through the time course of the research, as QFES dealt with multiple disaster events, such as the Queensland bushfires, Covid-19 and then floods. The impact of these events potentially reflects that lack of change in emotional exhaustion scores over time, as these disasters occurred in a back-to-back fashion. Firefighters were consistently deployed on extended operations during this period. On the other hand, it may be attributable to the neurofeedback, in that the experimental group showed improvements in personal accomplishment scores. It could be argued that while these disaster events were emotionally exhausting, improvements were made in the areas of professional and personal agency and pride in positively achieving operational goals. The converse occurred among the participants in the control group, who experienced a decrease in personal accomplishment scores.

As the primary aim of the study was to investigate the efficacy of neurofeedback to improve or relieve stress symptoms, the most profound finding is the clear demonstration that symptoms can be positively altered across a range of

severity of symptoms and this improvement is able to be maintained. Findings also demonstrate that, rather than participants progressing to allostatic overload or exhaustion, the symptom reduction restored allostatic accommodation. This is evident in the reduction of physiological symptoms of overarousal, improved cognitive appraisals, such as sense of efficacy and personal accomplishment, and reduction in distressing symptoms. These represent the tenet of allostasis that posits the brain is the central mediating factor in stress and stress responses.

Self-assignment to group

It further appears that self-assignment to either condition did not introduce any confounds, as the results indicate there were not any significant differences between the groups. As reported, self-assignment was made on the basis of availability of the participant to attend the training sessions within a clinic environment, the necessity of travel to the clinic, and the ability to fit sessions around shift schedules.

Possible Staging

While this research took a different perspective from the other studies discussed in the literature review, it likewise had positive outcomes that were similar to those of other studies. For example, van der Kolk et al. (2016) examined the efficacy of neurofeedback on veterans with chronic, non-responsive PTSD treatment and who were reported to have multi-causal chronic PTSD and were undergoing multi-drug therapy. There was both an experimental group and a waitlist control. Participants received 24 sessions of neurofeedback. Results are reported to have positively and significantly produced improvements in symptoms, with effects sizes of (d = -2.33 within, d = -1.71 between groups) on measures of tension reduction and affect dysregulation in Time x Condition interactions. Given the population of interest in the van der Kolk et al. (2016) study of treatment resistant complex PTSD,

it would align to the stage of allostatic overload, or Stages 3 and 4 of the staging model.

The current research, in contrast (Study 2), included participants from Stage 0 (no symptoms), Stages 1a and 1b (mild symptoms) where participants may be considered to be either in allostatic accommodation or on the cusp of allostatic overload, and Stage 2 (PTSD at the lowest level). All other participants scored below cut-off scores. Seven of 21 were found to be at Stage 0 (no symptoms), seven of 21 were found to be at Stage 1a (undifferentiated symptoms) and four of 21 were found to be at sub-clinical Stage 1b. Overall, 19 of the 21 participants were in the sub-clinical stage.

Given the complexity of the findings in Study 1, which showed unexpected lower values for clinical measures in Stage 1b than for Stage 1a and higher values for aggression and sleep disturbance, tracking the change of stage for Study 2 was not considered. For example, the experimental group overall showed positive changes and a reduction of negative symptoms, including anger and aggression concomitant to a reduction of clinical symptoms, but this is unable to be represented as movement through the stages according to Study 1—although the significant reduction of distressing symptoms in Study 2 shows there is indeed movement in a positive direction. What is important in Study 2 is the efficacy of the intervention at several levels of the model, albeit not formally assessed against the stages.

This thesis has argued that neurofeedback has the potential to be applied at all levels of interventions, from primary (as a preventative), through secondary (as an early intervention), to tertiary (as treatment for fully expressed clinical conditions). The findings of this study, together with existing literature from van der Kolk et al.

(2016) and others (Gapen et al., 2016; Peniston & Kulkosky, 1991; Reiter et al., 2016) support this contention.

Study procedures and protocols

The study protocols used in the intervention reported by van der Kolk et al. (2016) were similar to those of Study 2 in this research, in terms of the equipment used and similar training thresholds of decreasing the power spectrum of slow (2–4 Hz) and fast (18–22 Hz) while increasing the power spectrum of either 12–15 Hz or 13–16 Hz (van der Kolk et al., 2016). While the training protocol used a similar power spectrum in the van der Kolk study, their frequency is referred to as high alpha as the 12–15 Hz range is only referred to as SMR when recorded in the sensorimotor area of the brain. The occurrence of this frequency in other brain sites is referred to as high alpha. The only major difference in protocols was in the electrode placement. For van der Kolk et al. (2016), a sequential placement was made at T4 (active) and P4 (reference) and A1 (ground), based on previous research that showed increased right temporal lobe activation in PTSD. A temporal lobe focus for protocols would target aspects of memory, auditory and visual perception and affective behaviour and therefore there is a sound rationale for temporal lobe training.

In this research, Study 2 used C3–C4 as active sites, A1 and A2 as reference and the upper forehead as ground. Considering the studies together can solidify confidence in the efficacy of neurofeedback.

Chapter 5: Discussion

The first study of this thesis had the primary aim of exploring 'staging' of the possible pathway to PTSD. Staging has the potential to improve intervention designs that can specifically address the level and severity of symptoms. The results showed that homogeneous subgroups can be identified and aligned with the staging model reflecting stages 0–2 with a concomitant theoretical spread of numbers within each stage reflecting reported prevalence rates. The outcomes of Study 2 also demonstrate the efficacy of neurofeedback as a feasible way to improve symptoms in the population of interest that were maintained over long-term follow-up. Discussion of the major findings are described below.

Study 1: The Staging Model and Theoretical Implications

The staging model represents a profoundly useful model on which to base assessment and intervention.

The staging model (see Chapter 3) has been proposed by a number of authors (McFarlane et al., 2017; McGorry, 2015; McGorry et al., 2006; Scott et al., 2013). The interest in staging was born out of the recognition of increasing struggles in psychiatry to guide treatment and predict outcomes. To remedy this, it is proposed to stage mental health disorders in a way that is analogous to stages widely used in clinical medicine. McGorry et al. (2006) state that the value of diagnosis in psychiatry has been repeatedly questioned given that multiple disorders (such as depression, anxiety and PTSD) are too broad for treatment selection, not to mention the broad variation between individuals with the same disorders. Clinical staging, in contrast, can provide for refinement in managing and treating disorders.

This research was able to demonstrate that staging can be accomplished, clearly addressing the stated needs for staging. To the best of knowledge, it is the first time this staging model has been tested. Recently, Nijdam et al. (2023) stated that "a staging perspective in the field of PTSD is highly needed" (p. 65). Like this research, the work of Nijdam et al. (2023) indicates that allostatic load should serve as a framework, with stress and emotion regulation incorporated into this perspective. This research clearly addresses these calls for action and the proposals made by these authors.

While the original focus of McFarlane's staging model was to identify the biological excursions in PTSD, it may also be argued that, as this research has shown, there is value in non-biological models. This research successfully identified homogeneous groups via self-report measures of pre-clinical PTSD with potential for targeted psychological interventions to reduce or prevent symptom progression.

This research was able to demonstrate that staging and symptom profiles can be applied to the population of interest. The findings clearly show a significant portion of the sample fell below the clinical cut-off for a PTSD diagnosis and yet had symptomatology reported to be negative and distressing. The impact of intervening in this subset of the sample could be profound in its ability to reduce symptoms and improve quality of life.

The outcome of this study indicates the necessity for incorporating staging into clinical practice. The benefits to individuals of accessing treatment early cannot be overstated, given the burgeoning statistics of the rise in mental health disorders. Not only do individuals benefit, but society benefits, with likely less time in therapy reducing overall costs, and the opportunity to build resilience contributing to healthy individuals personally and within the workplace.

Study 1 demonstrates that the staging model may inform early intervention and preventative strategies that addresses the impediment of heterogeneity in samples.

Study 1, through the alignment of self-report measures with the DSM-5 criteria and investigation using latent profile analysis, demonstrates that classes can be identified. In addition, the percentage of individuals within the classes reflects the spread of symptom concerns reported in the literature.

The importance of staging cannot be overstated. As McFarlane et al. (2017) suggest, there is a distinct disadvantage in developing interventions when PTSD is only considered in a binary way—that is, a diagnosis of having PTSD or not, resulting in being offered a PTSD intervention or not. Current interventions do not sufficiently recognise heterogeneity within the samples studied, resulting in suboptimal outcomes (Steenkamp, 2016; 2012; Yehuda & Hoge, 2016). Latent profile analysis has the advantage of using a range of measures of symptoms rather than categories of diagnoses or the dichotomised presence or absence of symptoms (Jongedijk et al., 2019). Multiple studies investigating the prevalence of PTSD reflect this binary thinking (Petrie, Milligan-Saville, et al., 2018; Syed et al., 2020; Wagner et al., 2020).

Studies that use early intervention strategies are applied without staging and this could potentially impact their effectiveness (Brown, 2014; Jongedijk et al., 2019). Most often, resiliency programmes are used, by design, for early intervention. These programmes offer a useful initial point for examining whether there has been any parsing out for homogeneous subgroups. However useful, a number of meta-analyses of resilience programmes do not reflect any staging (Joyce, Shand, Tighe, et al., 2018; Leppin et al., 2014; Venegas et al., 2019).

For example Joyce et al. (2019) conducted an online mindfulness trial for resilience with NSW Fire and Rescue, but the study did not use any staging, and the participants varied broadly in areas such as years of service. In contrast, years of service was considered in this research (see Study 1) with the largest number of participants (n = 25) serving more than 25 years. Study 1 demonstrated worsening symptoms were associated with longer time in service. Joyce, Shand, Lal, et al.'s (2019) study reported that fire and rescue personnel who had served for more than 20 years had 37 trauma incidents compared with three incidents for those careers of one to five years. This demonstrates that, while their intervention showed some positive results, the application of staging may have provided greater insights and more useful outcomes. Therein lies the importance of the current research.

According to Qi et al. (2016), preventive interventions, whether CBT or pharmacological, are efficacious in selected samples. Nevertheless, effectiveness of early clinical interventions remains largely unknown, and results are aggregates of large groups. This means that heterogeneity and staging considerations are largely overlooked. Current preventative interventions are also largely derived from those already having diagnosed PTSD. PTSD is likely multi-causal, expressed through individual-specific pathways and responsive to individual-specific interventions. The current research, presented in Study 1, addressed this gap by mapping a heterogenous group into subsets that can support a personalised early intervention that may replace the generic protocols currently utilised, as suggested by (Qi et al., 2016).

Study 2: Neurofeedback Intervention and Theoretical Implications

The neurofeedback intervention was able to demonstrate efficacy in positively modifying symptoms, theoretically through brain plasticity.

Demonstrating improved stress management and mental health for firefighters offers a profound opportunity of significant scale and importance, particularly in light of the findings of the parliamentary inquiry (Parliament of Australia, 2018), which identified a desperate need for improved interventions. The introduction of evidence-based interventions that are practical, affordable, and accessible to firefighters in the workplace would deliver substantive improvements in economic costs to the organisation and, importantly, to the lives of the individual workers. This thesis uniquely contributes to the growing body of evidence that improving stress and mental health (resilience) may play a pivotal role in preventative intervention as part of the organisation's broader support program. The research was able to show that neurofeedback can be applied at all levels of intervention—primary, secondary and tertiary—as all were represented in the sample.

Further, the results of the NFB intervention demonstrated the potential of brain plasticity. Importantly, it demonstrated the ability to learn to improve self-regulation and to rebuild the functional coupling of the brain regions between the executive pre-frontal cortex and limbic system. This has major significance for our understanding of large-scale neural networks as well as what is known from anatomical and histological studies. The resulting improvements in sleep and a reduction of overarousal in both the behavioural and cognitive domains further positively contribute to ongoing self-regulation.

This is particularly the case for firefighters and other personnel who work in trauma fields who are being regularly 'physiologically entrained' to an altered level

of arousal with an increasing inability to ‘bounce back’. Allostatic load implies the inability to self-regulate arousal and the neurofeedback study demonstrated that positive changes can occur that restore normal functions. This further links to General Adaptation Syndrome (Selye, 1976), which is aligned with the exhaustion phase. The individual in this case, as the staging model suggests, expresses increasing functional decline across a broad range of physical systems, including mental health. Most importantly, however, it is not until the later stages of poor health (physical and mental) that there may be an inability to return to normal functioning.

This speaks to the importance of understanding the malleability of the ‘system’ as indicated by both the theory of allostasis and the staging model. This conceptual alignment is startling in its simplicity, and it is something of a mystery as to why this approach is not standard across the field of mental health. Neuronal plasticity is well understood (Ganzel et al., 2010; McCarty, 2016; McEwen, 1998; Sapolsky, 2003), and chronic stress can create neuronal attrition; equally, restoration of health and wellbeing can promote neurogenesis. Restoration of such factors as sleep, good coping strategies, counselling, good diet, exercise and neurofeedback can contribute to mental and physical wellness, reflecting the multiple factors of allostatic theory and the interacting mediators that operate in a nonlinear way.

A recent paper from Nijdam et al. (2023) proposed psychological interventions at Stage 1b (subsyndromal distress), including NFB. While this research did not formally stage participants, the neurofeedback intervention scores across measures were indicative of Stage 0 up to and including Stage 2 (full-threshold symptoms of PTSD) and argues the case for neurofeedback to be considered at the primary, secondary, and tertiary levels. While Nijdam et al. (2023) have yet to conduct

research on both staging and NFB, this research can contribute to further investigations.

Neurofeedback theoretically links to allostasis.

This research has uniquely considered the multiple contributors to stress in the manner offered by the theory of allostasis. This includes the biological underpinnings of stress from medical research and the contributions of stimulus-based theory (Selye, 1976) as well as cognitive-based theories (Hobfoll, 1989). The integration of our understanding of the processes of self-regulation with our understanding of the disruption of neural networks and how the EEG is generated contributes to better insight into how NFB is linked to the theoretical underpinnings of the field. It is explicit in allostasis that the brain is the underlying mediator of systemwide responses to stress (Ganzel et al., 2010). NFB appears to directly influence the neural networks, and as indicated by allostasis, allows a person to adapt, respond and flexibly cope.

Early intervention, such as using NFB, is important to mitigate early symptoms to prevent the embedding of and adaptation to a chronically low level of altered physiological arousal. The argument for this can be found in the literature of allostatic theory (Ganzel et al., 2010), where fatigue of resilience and return to baseline functioning are compromised.

Overall Contribution of Thesis

This thesis has contributed to existing knowledge in a number of important ways. First, it contributes to moving the fields of psychiatry and psychology towards a more robust way of conceptualising mental health problems. Rather than considering a mental health disorder at the clinical diagnostic level, it advocates the view that mental health problems are a progressive concern that can and should be

intervened in, at earlier time points. Identification of patient profiles can provide greater insight into the current heterogeneity experienced in research, and may help explain differences in treatment response, as well as contributing to treatment modification and enhanced therapeutic outcomes (Jongedijk et al., 2019).

As shown in this research staging can also contribute to improving the pursuit of the gold standard in psychological research by reducing the bane of heterogeneity in samples. The staging model should be explored for all categories of mental health problems.

Parsing of the heterogeneity of mental health disorders provides understanding on the basis of known neural networks rather than the nosology (classification) of descriptive psychiatric diagnoses that are currently used. This research contributes to bridging the gaps between traditional studies from disparate theoretical perspectives, which can appear to have little to do with one another—for example, in the case of stress, research from purely a psychosocial perspective (such as cognitive appraisal) versus that which focuses on stress from a neuroscience perspective (such as biological underpinnings). While these approaches are independently informative, each single perspective gives an incomplete picture (R. Davidson, Pizzagalli, Nitschke, & Putnam, 2002).

Second, the neurofeedback intervention, while novel for many, has shown itself to be a efficacious therapy option. While the research has been challenged by methodological issues, it has consistently shown positive benefits, grounded in neuroscience. This research uniquely supported and justified the efficacy of neurofeedback through strong links to the underlying biological processes, including the generation of the EEG and the involvement of large-scale neural networks that

were able to be understood through alignment with a number of stress theories, particularly allostasis.

This research thus uniquely considers multiple theoretical contributions that remarkably, when used together, provide a more robust and complete understanding of mental health. The literature review illustrated the challenge of thinking about stress and mental health from a holistic perspective, including the fact that mind-body dualism represents the 19th and 20th century Zeitgeist for building multiple perspectives of stress, such as stimulus response by Selye and cognitive approaches such as by Lazarus, Hobfoll, Schwarzer and Bandura. Alongside these developments has been the successful mapping of the brain through anatomical, histological and neuroimaging studies. In large part, it appears that many past studies of theory development have been conducted in silos, reflecting narrow academic interests and emerging separately from one another (R. Davidson et al., 2002). When these multiple perspectives are combined, there is a greater appreciation for the complexity and inter-relationships that can underpin our understanding of mental health. Importantly, allostasis considers this multiplexity.

Practical Implications

This research has broken new ground in testing a staging model for the development of PTSD, as well as applying an intervention at multiple stages. This research is novel and appears to be one of the first studies to consider the staging model in the form proposed by this research, with its link to the theory of allostasis as well as the intervention of neurofeedback as applied to firefighters. Identification of early symptoms in mental health can assist clinicians in developing personalised programs for support. This can have implications for workers in reducing stress and strain and reducing the burden on organisations in lost employee engagement. In

other types of organisations, such as defence, where members have mental health issues, the managers involved can be provided with strategies for supporting staff within the workplace itself. It is also hoped that this research will stimulate some critical thinking around how mental health is understood and managed, as it has demonstrated that staging for early recognition of issues has benefits.

Further, this research has promoted the imperative to assist those who work in industries that expose workers to adverse conditions, whether that be emergency hospital workers, emergency call operators, or emergency services personnel. These adverse conditions expose workers on multiple levels—for example, in terms of the hours they work, the situations or operations they face, and the sometimes-difficult organisational culture. The results of Study 2 demonstrated the potential positive impact of this intervention with workers in stressful or challenging occupations.

Beyond its application to emergency workers, this work also has relevance to other occupations, and the general community that experiences stress. Recent global events, such as the Covid-19 pandemic, have had substantial impacts on mental health, as the efforts to manage them exacerbated social, economic, and personal challenges. Locally, emergency services personnel pre-pandemic dealt with extensive bush fires across Queensland, necessitating significant additional deployment of firefighters and extensive and exhaustive working hours. During the final stages of the pandemic, extensive flooding occurred across Queensland, with similar impacts on emergency workers.

It was previously noted that the overall health-related cost of occupational stress in Australia was around $14.81 billion annually in 2008 (Medibank Private, 2008). More recently, this has increased to $17.4 billion, with the overall costs of mental health problems to the economy being in the order of $200 billion

(Pupazzoni, 2022). The findings from this study in terms of a promising intervention, if applied broadly, have the potential to alleviate the economic burden of mental health problems with early intervention preventative programs for stress management.

While there is growing interest in fMRI neurofeedback, it is limited by practicality, cost, and portability. This reduces its viability for being the neurofeedback method of choice, particularly when EEG neurofeedback continues to produce positive outcomes. NFB is cost effective and does not require extensive commitment of personnel or equipment, and it is portable or can easily be installed within a workplace.

Unusually, all the participants were retained for the duration of this study, which strongly suggests the acceptability of the intervention and an intrinsic motivation to improve resilience. It is posited that if there were any perceived lack of benefit from the intervention, there would have been dropout rates detected. This is a very unusual finding, separating this study from many similar early intervention studies, such as that reported by Joyce et al. (2019), where over 50% of the sample were lost to six-month follow-up. This has practical implications in terms of the likelihood of achieving better outcomes when an individual completes an intervention.

Limitations of the thesis

There were some important limitations to this study, most notably the small sample sizes in both Study 1 and 2, and the absence of longer-term follow-up in the control group of Study 2. Another consideration for both studies is the nature of the outcome measures, which were all self-reported. The participants in Study 1 did not all complete the survey, and it is possible that the number of measures used may

have been unnecessary. An alternative reason is the possibility that not all firefighters took note of the availability of the survey, as notification was part of a general email newsletter from the United Firefighters Union and may have been overlooked. Further, although the survey was genuinely anonymous, it is possible that there was some reluctance to engage due to mistrust (as noted in the parliamentary inquiry).

The participants for Study 2 were derived from a small area of southeast Queensland and may not be representative of the broader firefighter community. Those in the intervention study had to travel to sessions and therefore came from urban units. Those from Brisbane city centre deal with specific types of incidences such as high-rise callouts, and those who attended from outer areas are more frequently faced with, for instance, high-impact crashes or bushfires. While the sample was likely homogeneous, and this may be considered a limitation, it can be argued that homogeneity is not a factor when the objective is to reduce symptom concerns at an individual level. A limitation may also include other factors for positive change such as therapist interest or by virtue of taking part in the study.

Alternate physiological measures, such as salivary cortisol testing or sleep actigraphy, were beyond the scope of this research and would have likely added to the outcome data; however, they would not have influenced the outcomes of the neurofeedback intervention itself.

Self-report measures may have resulted in participants giving socially desirable answers, particularly post-intervention; however, much psychological research uses such measures, and any bias present is likely to be equal across studies. Equally, responses were consistent across measures at each time period and the time intervals between measurements were very well spaced.

Future Research

This research raises some questions that may be considered in future research into stress in firefighters as well as neurofeedback. Both studies would ideally be replicated in larger samples and across a number of industry sectors, such as other emergency services, including call centres and hospital settings. Both staging and matched intervention could be applied. To understand the staging model more fully, it has been suggested by multiple authors that longitudinal rather than cross-sectional research is needed (Armour et al., 2015; Contractor et al., 2018; Griffith et al., 2022; McFarlane et al., 2017). More broadly, the staging model could be applied across other mental health conditions. Importantly, future research could consider mapping the staging model, and including factors such as time in service to better understand the gestalt of the findings from this research.

Further, research of stress in firefighters may consider parsing out unique aspects, such as shift work, sleep deprivation and physiological demands on stress symptoms. Essentially addressing such questions as to which comes first and how these factors contribute to stress or whether these factors contribute to increased stress symptoms and therefore vulnerability to PTSD or vice versa? The theoretical underpinnings of this research would suggest neither, as excursions and demands on the brain, regardless of origin, can have negative impacts when chronic or persistent to the extent that neuronal remodelling occurs.

It is noted that there was a slight, and not statistically significant, return of some symptoms in the long-term follow-up of the neurofeedback experimental group. Future research should consider the impacts of training programs annually as the ongoing exposure to stressor events is unavoidable for firefighters and other emergency responders. The firefighters who engaged in this study had to attend a

number of NFB training sessions and this necessitated fitting them around shift rosters, as well as accommodating deployment to disaster management sites throughout the term of the research. This challenge could be overcome with in-station neurofeedback training in future studies, as the equipment is entirely portable.

Another possible area for future research addresses methodological issues, such as the electrode placements, the use of the raw EEG in feedback, and the method of operant conditioning used in Study 2. While there was justification for the electrode placements used in the study, it would advance understanding of the multiplicity of positive findings to further investigate this and the potential impact of neurofeedback on the large-scale brain networks. The continued reporting of the positive results of neurofeedback may, in fact, reflect that the neurofeedback has a global effect and impacts the large-scale brain networks, rather than having a localised effect. In addition, future research could investigate whether the use of the raw EEG signal or a game screen alters or impacts the outcomes for neurofeedback. The operant conditioning paradigm was explicated and justified, but outcomes may be further refined by considering these factors in future research.

There continues to be some scepticism about neurofeedback within the academic research community. One reason for this is that the clinical practice of neurofeedback has outpaced the academic research. While efforts have been made to create some standardisation within the practitioner field via professional associations, there remain large gaps in the research concerning requirements for the practice of neurofeedback. By and large, clinicians attend courses that are primarily sponsored by equipment manufacturers that offer only brief overviews of the biological underpinnings and place a large focus on learning the software. Practitioners can be under-trained in EEG and all the other factors that underpin this research, and the

risk is that clinical outcomes could be compromised, resulting in efficacy rates that are no different from traditional psychological interventions. This demonstrates the importance of continued quality studies using neurofeedback that may contribute to solidifying the field and the evidence base with opportunities for improved clinical practice and outcomes.

Concluding remarks

The staging model is a necessary advancement required for understanding mental health and for building useful interventions that can demonstrate efficacy. This research was also an intervention effectiveness study and demonstrated the impact of the intervention in a way that suggests a pragmatic naturalistic element for how neurofeedback could be used and incorporated into the emergency services and more broadly used for any individual who may experience stress. Neurofeedback achieves more than might be initially obvious. For instance, a firefighter does not have to 'talk' about the problem. This reluctance to discuss or admit to experiencing negative mental health is a notable feature from the parliamentary inquiry (Parliament of Australia, 2018). Firefighters can experience positive changes without, or prior to, the application of exposure therapy—and when an individual experiences positive change, their appraisal of events can result in engagement with better coping strategies. Through operant conditioning principles, this suggests that generalisation can occur to the broader experiences in work and life, creating a positive feedback loop.

Further, firefighters may enjoy a challenge, and resilience training as a form of peak performance is motivating and reduces the stigma of labelling. It is engaging as it can be genuinely fascinating to observe and influence one's own physiology.

Neurofeedback is entirely non-invasive, and a sense of self-control and self-efficacy can be retained by any participant.

Neurofeedback as an early intervention resilience program has the advantage of reducing stigma. Most importantly, it can result in a sense of wellbeing, and improve sleep and general self-regulation. This is reflected in the absence of attrition in this study. It is hoped that, at some point, neurofeedback therapy will become an integral part of district fire stations. To conclude, according to Frank H. Duffy, M.D., associate editor of *Clinical Electroencephalography*, "any pharmaceutical drug that had as wide a range of effectiveness as neurofeedback would be universally accepted and widely used" (Duffy, 2000, p. v).

References

Abadin, A. F. M., Imtiaz, A., Ahmed, M., & Dutta, M. (2021). A Brief Study of Binaural Beat: A Means of Brain-Computer Interfacing. *Advances in Human-Computer Interaction, 2021*, 1-8. doi:10.1155/2021/6814208

Abdallah, C., Averill, L., Akiki, T., Raza, M., Averill, C., Gomaa, H., . . . Krystal, J. (2018). The Neurobiology and Pharmacotherapy of Posttraumatic Stress Disorder. *Annual Review of Pharmacology and Toxicology, 59*. doi:10.1146/annurev-pharmtox-010818-021701

Aisbett, B., Wolkow, A., Sprajcer, M., & Ferguson, S. A. (2012). " Awake, smoky, and hot" : Providing an evidence-base for managing the risks associated with occupational stressors encountered by wildland firefighters. *Applied Ergonomics, 43*(5), 916-925. doi:10.1016/j.apergo.2011.12.013

Akerboom, S., & Maes, S. (2006). Beyond demand and control: The contribution of organizational risk factors in assessing the psychological well-being of health care employees. *Work & Stress, 20*(1), 21-36. doi:10.1080/02678370600690915

Alex, F.-P., Shannon, W., & Luke, H. R. (2017). Firefighters and traumatic stress: a review. *International Journal of Emergency Services, 6*(1), 67-80. doi:doi:10.1108/IJES-10-2016-0020

Allen, P., Bennett, K., & Heritage, B. (2014). *SPSS Statistics version 22: A practical guide*.

Almedom, A., & Glandon, D. (2007). Resilience is not the Absence of PTSD any More than Health is the Absence of Disease. *Journal of Loss and Trauma, 12*(2), 127-143. doi:10.1080/15325020600945962

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders : DSM-IV*: Fourth edition. Washington, DC : American Psychiatric Association, [1994] ©1994.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders : DSM-5*: Fifth edition. Arlington, VA : American Psychiatric Publishing, [2013] ©2013.

American Psychological Association. (2018). The State-Trait Anxiety Inventory (STAI). Retrieved from https://www.apa.org/pi/about/publications/caregivers/practice-settings/assessment/tools/trait-state.aspx

Ancoli, S., & Kamiya, J. (1978). Methodological issues in alpha biofeedback training. *Biofeedback and Self-regulation, 3*(2), 159-183. doi:10.1007/bf00998900

Antony, M., Bieling, P., Cox, B., Enns, M., & Swinson, R. (1998). Psychometric properties of the 42-item and 21-item versions of the depression anxiety stress scales in clinical groups and a community sample. *Psychological Assessment, 10*(2), 176-181. doi:10.1037/1040-3590.10.2.176

Armour, C., Contractor, A., Elhai, J. D., Stringer, M., Lyle, G., Forbes, D., & Richardson, J. D. (2015). Identifying latent profiles of posttraumatic stress and major depression symptoms in Canadian veterans: Exploring differences across profiles in health related functioning. *Psychiatry Research, 228*(1), 1-7. doi:10.1016/j.psychres.2015.03.011

Armstrong, D. M. (2014). *Investigating well-being and mental health in Queensland fire-fighters.* Queensland University of Technology.

Armstrong, D. M., Shakespeare-Finch, J., & Shochet, I. (2014). Predicting post-traumatic growth and post-traumatic stress in firefighters. *Australian Journal of Psychology, 66*, 38-46.

Armstrong, D. M., Shakespeare-Finch, J., & Shochet, I. (2016). Organizational belongingness mediates the relationship between sources of stress and posttrauma outcomes in firefighters. *Psychological Trauma: Theory, Research, Practice, and Policy, 8*(3), 343-347. doi:10.1037/tra0000083

Arns, M., Heinrich, H., & Strehl, U. (2014). Evaluation of neurofeedback in ADHD: the long and winding road. *Biological Psychology, 95*, 108-115.

Asmundson, G. J., Thorisdottir, A. S., Roden-Foreman, J. W., Baird, S. O., Witcraft, S. M., Stein, A. T., . . . Powers, M. B. (2019). A meta-analytic review of cognitive processing therapy for adults with posttraumatic stress disorder. *Cognitive Behaviour Therapy, 48*(1), 1-14. doi:https://www.tandfonline.com/action/showCitFormats?doi=10.1080/16506073.2018.1522371

Au, T. M., Dickstein, B. D., Comer, J. S., Salters-Pedneault, K., & Litz, B. T. (2013). Co-occurring posttraumatic stress and depression symptoms after sexual assault: A latent profile analysis. *Journal of Affective Disorders, 149*(1-3), 209-216. doi:10.1016/j.jad.2013.01.026

. Bandura's Social Cognitive Theory : An Introduction. (2016). San Francisco, California, USA: Kanopy Streaming.

Bandura, A. (1989). Regulation of Cognitive Processes Through Perceived Self-Efficacy. *Developmental Psychology, 25*(5), 729-735. doi:10.1037/0012-1649.25.5.729

Barefoot, J. C., Dodge, K. A., Peterson, B. L., Dahlstrom, W. G., & Williams, R. B. (1989). The Cook-Medley hostility scale: item content and ability to predict survival. *Psychosomatic Medicine, 51*(1), 45-57.

Barger, L., Rajaratnam, S., Wang, W., O'Brien, C., Sullivan, J., Qadri, S., . . . Czeisler, C. A. (2015). Common sleep disorders increase risk of motor vehicle crashes and adverse health outcomes in firefighters. *Journal of Clinical Sleep Medicine, 11*(3), 233-240B.

Bauer, C. C., Okano, K., Ghosh, S. S., Lee, Y. J., Melero, H., de Los Angeles, C., . . . Niznikiewicz, M. A. (2020). Real-time fMRI neurofeedback reduces auditory hallucinations and modulates resting state connectivity of involved brain regions: Part 2: Default mode network-preliminary evidence. *Psychiatry Research, 284*, 112770. doi:https://doi.org/10.1016/j.psychres.2020.112770

Beatty, J. (1972). Similar effects of feedback signals and instructional information on EEG activity. *Physiology and Behavior, 9*(2), 151-154. doi:https://doi.org/10.1016/0031-9384(72)90227-2

Beauregard, M., & Lévesque, J. (2006). Functional magnetic resonance imaging investigation of the effects of neurofeedback training on the neural bases of selective attention and response inhibition in children with attention-deficit/hyperactivity disorder. *Applied Psychophysiology and Biofeedback, 31*, 3-20.

Berger, W., Coutinho, E., Figueira, I., Marques-Portella, C., Luz, M., Neylan, T., . . . Mendlowicz, M. (2012). Rescuers at risk: a systematic review and meta-regression analysis of the worldwide current prevalence and correlates of PTSD in rescue workers. *Social Psychiatry and Psychiatric Epidemiology, 47*, 1001-1011.

Bernardy, N. C., Lund, B. C., Alexander, B., & Friedman, M. J. (2012). Prescribing trends in veterans with posttraumatic stress disorder. *The Journal of clinical psychiatry, 73*(3), 297-303.

Berninger, A., Webber, M. P., Cohen, H. W., Gustave, J., Lee, R., Niles, J. K., . . . Prezant, D. J. (2010). Trends of Elevated PTSD Risk in Firefighters Exposed to the World Trade Center Disaster: 2001-2005. *Public Health Reports (1974-), 125*(4), 556-566. doi:10.1177/003335491012500411

Berninger, A., Webber, M. P., Niles, J. K., Gustave, J., Lee, R., Cohen, H. W., . . . Prezant, D. J. (2010). Longitudinal study of probable post-traumatic stress disorder in firefighters exposed to the World Trade Center disaster. *American Journal of Industrial Medicine, 53*(12), 1177-1185. doi:10.1002/ajim.20894

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. *Journal of Traumatic Stress, 28*(6), 489-498. doi:10.1002/jts.22059

Bonanno, G. (2008). Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? *Psychological Trauma: Theory, Research, Practice, and Policy, S*(1), 101-113. doi:10.1037/1942-9681.S.1.101

Brodal, P., & Bjaalie, J. G. (1992). Organization of the pontine nuclei. *Neuroscience Research, 13*(2), 83-118.

Brown, N. J. (2014). A critical examination of the US Army's Comprehensive Soldier Fitness program. *The Winnower, 2*, 1-21.

Bryant, R. A. (2003). Early predictors of posttraumatic stress disorder. *Biological Psychiatry, 53*(9), 789-795.

Bryant, R. A., & Guthrie, R. M. (2007). Maladaptive Self-Appraisals Before Trauma Exposure Predict Posttraumatic Stress Disorder. *Journal of Consulting and Clinical Psychology, 75*(5), 812-815. doi:10.1037/0022-006X.75.5.812

Buss, H., & Perry, M. (1992). The Aggression Questionnaire. *Journal of Personality and Social Psychology, 63*(3), 452-459. doi:10.1037/0022-3514.63.3.452

Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193-213.

Chevalier, G., & Deniau, J. M. (1990). Disinhibition as a basic process in the expression of striatal functions. *Trends in Neurosciences, 13*(7), 277-280.

Chiba, T., Kanazawa, T., Koizumi, A., Ide, K., Taschereau-Dumouchel, V., Boku, S., . . . Kawato, M. (2019). Current status of neurofeedback for post-traumatic stress disorder: A systematic review and the possibility of decoded neurofeedback. *frontiers in Human Neuroscience, 13*, 233-233. doi:10.3389/fnhum.2019.00233

Clark, S. L., & Muthén, B. (2009). Relating latent class analysis results to variables not included in the analysis: Los Angeles, California, USA.

Clemente, C. D., Sterman, M. B., & Wyrwicka, W. (1964). Post-reinforcement EEG synchronization during alimentary behavior. *Electroencephalography and Clinical Neurophysiology, 16*(4), 355-365. doi:10.1016/0013-4694(64)90069-0

Cloitre, M., Garvert, D. W., Brewin, C. R., Bryant, R. A., & Maercker, A. (2013). Evidence for proposed ICD-11 PTSD and complex PTSD: a latent profile analysis. *European Journal of Psychotraumatology, 4*(1). doi:10.3402/ejpt.v4i0.20706

Cockshaw, W., & Shochet, I. (2010). The link between belongingness and depressive symptoms: An exploration in the workplace interpersonal context. *Australian Psychologist, 45*(4), 283-289. doi:10.1080/00050061003752418

Contractor, A. A., Caldas, S., Weiss, N. H., & Armour, C. (2018). Examination of the heterogeneity in PTSD and impulsivity facets: A latent profile analysis. *Personality and Individual Differences, 125*, 1-9. doi:10.1016/j.paid.2017.12.022

Contractor, A. A., Roley-Roberts, M. E., Lagdon, S., & Armour, C. (2017). Heterogeneity in patterns of DSM-5 posttraumatic stress disorder and depression symptoms: Latent profile analyses. *Journal of Affective Disorders, 212*, 17-24. doi:10.1016/j.jad.2017.01.029

Contrada, R. J., & Jussim, L. (1992). What Does the Cook-Medley Hostility Scale Measure? In Search of an Adequate Measurement Model1. *Journal of Applied Social Psychology, 22*(8), 615-627. doi:doi:10.1111/j.1559-1816.1992.tb00993.x

Cook, B., & Mitchell, W. (2013). Occupational health effects for firefighters: The extent and implications of physical and psychological injuries. *Centre of full employment and equity, Melbourne*.

Corneil, W., Beaton, R. D., Murphy, S. A., Johnson, L. C., & Pike, K. (1999). Exposure to traumatic incidents and prevalence of posttraumatic stress symptomatology in urban firefighters in two countries. *Journal of Occupational Health Psychology, 4*(2), 131-141. doi:10.1037//1076-8998.4.2.131

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334.

Davidson, J., Book, S., Colket, J., Tupler, L., Roth, S., David, D., . . . Smith, R. (1997). Assessment of a new self-rating scale for post-traumatic stress disorder. *Psychological Medicine, 27*(1), 153-160.

Davidson, P., & Parker, K. C. (2001). Eye movement desensitization and reprocessing (EMDR): a meta-analysis. *Journal of Consulting and Clinical Psychology, 69*(2), 305.

Davidson, R., Pizzagalli, D., Nitschke, J. B., & Putnam, K. (2002). Depression: perspectives from affective neuroscience. *Annual Review of Psychology, 53*(1), 545-574.

de Kloet, E. R. (2016). Chapter 3 - Corticosteroid Receptor Balance Hypothesis: Implications for Stress-Adaptation. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 21-31). San Diego: Academic Press.

Dębiec, J., Bush, D. E. A., & Ledoux, J. E. (2011). Noradrenergic enhancement of reconsolidation in the amygdala impairs extinction of conditioned fear in rats--a possible mechanism for the persistence of traumatic memories in PTSD. *Depression and Anxiety, 28*(3), 186. doi:10.1002/da.20803

Devonport, T. J. (2013). *Managing Stress : From Theory to Application*. New York: Nova.

Dillon, A., Kelly, M., Robertson, I. H., & Robertson, D. A. (2016). Smartphone applications utilizing biofeedback can aid stress reduction. *FRONTIERS IN PSYCHOLOGY, 7*, 832.

Duffy, F. H. (2000). The state of EEG biofeedback therapy (EEG operant conditioning) in 2000: an editor's opinion. *Clinical EEG (electroencephalography), 31*(1), V-VII.

Dupee, M., Forneris, T., & Werthner, P. (2016). Perceived Outcomes of a Biofeedback and Neurofeedback Training Intervention for Optimal Performance: Learning to Enhance Self-Awareness and Self-Regulation With Olympic Athletes. *The Sport Psychologist, 30*(4), 339-349.

Education and Employment References Committee. (2019). *The people behind 000: mental health of our first responders*. Commonwealth of Australia.

EEG Education & Research Inc. (2018). EEG Education & Research. Retrieved from http://www.eegspectrum.com/

Egner, T., & Gruzelier, J. H. (2001). Learned self-regulation of EEG frequency components affects attention and event-related brain potentials in humans. *Neuroreport, 12*(18), 4155-4159.

Egner, T., & Gruzelier, J. H. (2004). EEG biofeedback of low beta band components: frequency-specific effects on variables of attention and event-related brain potentials. *Clinical Neurophysiology, 115*(1), 131-139.

Egner, T., & Sterman, M. B. (2006). Neurofeedback treatment of epilepsy: from basic rationale to practical application. *Expert Review of Neurotherapeutics, 6*(2), 247-257.

Elliot, G. R., & Eisdorfer, C. (1982). Stress and human health: An analysis and implications of research. A study by the Institute of Medicine. *National Academy of Sciences, 79*, 11-24.

Evans, C., & Mulholland, T. B. (1969). Attention as a Concept in Neurophysiology. *Science, 163*(3866), 495-496.

Evans, J., & Abarbanel, A. (1999). *Introduction to quantitative EEG and neurofeedback*: Elsevier.

Ferguson, S. L., G. Moore, E. W., & Hull, D. M. (2020). Finding latent groups in observed data: A primer on latent profile analysis in Mplus for applied researchers. *International Journal of Behavioral Development, 44*(5), 458-468. doi:10.1177/0165025419881721

Fernández-Álvarez, J., Grassi, M., Colombo, D., Botella, C., Cipresso, P., Perna, G., & Riva, G. (2022). Efficacy of bio-and neurofeedback for depression: a meta-analysis. *Psychological Medicine, 52*(2), 201-216.

Fink, G. (2016). Chapter 1 - Stress, Definitions, Mechanisms, and Effects Outlined: Lessons from Anxiety. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 3-11). San Diego: Academic Press.

Foa, E. B., Keane, T. M., & Friedman, M. J. (2000). Guidelines for treatment of PTSD. *Journal of Traumatic Stress, 13*(4), 539-588. doi:https://doi.org/10.1023/A:1007802031411

Foa, E. B., Steketee, G., & Rothbaum, B. O. (1989). Behavioral/cognitive conceptualizations of post-traumatic stress disorder. *Behavior Therapy, 20*(2), 155-176. doi:https://doi.org/10.1016/S0005-7894(89)80067-X

Fraess-Phillips, A., Wagner, S., & Harris, R. L. (2017). Firefighters and traumatic stress: a review. *International Journal of Emergency Services, 6*(1), 67-80. doi:10.1108/IJES-10-2016-0020

Friedman, M. J. (2014). *Handbook of PTSD, Second Edition : Science and Practice* (2nd ed. ed.). New York: Guilford Publications.

Gámez, W., Chmielewski, M., Kotov, R., Ruggero, C., Suzuki, N., & Watson, D. (2014). The brief experiential avoidance questionnaire: development and initial validation. *Psychological Assessment, 26*(1), 35.

Ganzel, B. L., Morris, P. A., & Wethington, E. (2010). Allostasis and the human brain: Integrating models of stress from the social and life sciences. *Psychological Review, 117*(1), 134-174. doi:10.1037/a0017773

Gapen, M., van der Kolk, B., Hamlin, E., Hirshberg, L., Suvak, M., & Spinazzola, J. (2016). A pilot study of neurofeedback for chronic PTSD. *Applied Psychophysiology and Biofeedback, 41*(3), 251-261.

Gayton, S. D., & Lovell, G. P. (2012). Resilience in ambulance service paramedics and its relationships with well-being and general health. *Traumatology, 18*(1), 58-64.

Gloor, P. (1969). Hans Berger on electroencephalography. *American Journal of EEG Technology, 9*(1), 1-8.

Gnanavel, S., & Robert, R. S. (2013). Diagnostic and statistical manual of mental disorders, and the impact of events scale-revised. *Chest, 144*(6), 1974.

Griffith, E. L., Jin, L., Contractor, A. A., Slavish, D. C., & Vujanovic, A. A. (2022). Heterogeneity in patterns of posttraumatic stress disorder symptoms and sleep disturbances among firefighters: Latent profile analyses. *Journal of Psychiatric Research, 153*, 64-72. doi:10.1016/j.jpsychires.2022.06.052

Halpern, J., Maunder, R. G., Schwartz, B., & Gurevich, M. (2011). Identifying risk of emotional sequelae after critical incidents. *Emergency Medicine Journal, 28*(1), 51-56. doi:10.1136/emj.2009.082982

Hammond, D. C. (2011). What is neurofeedback: An update. *Journal of Neurotherapy, 15*(4), 305-336.

Harner, P., & Sannit, T. (1974). *A review of the international ten-twenty system of electrode placement*: Grass Instrument Company.

Harper, R., & Sterman, M. (1972). *Subcortical unit activity during a conditioned 12–14 Hz sensorimotor EEG rhythm in the cat.* Paper presented at the Federation Proceedings.

Harvey, S., Devilly, G., Forbes, D., Glozier, N., McFarlane, A., Phillips, J., . . . Bryant, R. (2015). Expert guidelines: Diagnosis and treatment of post-traumatic stress disorder in emergency service workers. *NSW, Australia: The Royal Australian and New Zealand College of Psychiatrists*.

Harvey, S., Henderson, M., Lelliott, P., & Hotopf, M. (2009). Mental health and employment: much work still to bedone. *The British Journal of Psychiatry, 194*(3), 201-203. doi:10.1192/bjp.bp.108.055111

Harvey, S., Milligan-Saville, J., Paterson, H., Harkness, E., Marsh, A., Dobson, M., . . . Bryant, R. (2016). The mental health of fire-fighters: an examination of the impact of repeated trauma exposure. *Australian and New Zealand Journal of Psychiatry, 50*(7), 649-658.

Heinrichs, M., Wagner, D., Schoch, W., Soravia, L. M., Hellhammer, D. H., & Ehlert, U. (2005). Predicting Posttraumatic Stress Symptoms From Pretraumatic Risk Factors: A 2-Year Prospective Follow-Up Study in Firefighters. *American Journal of Psychiatry, 162*(12), 2276-2286. doi:10.1176/appi.ajp.162.12.2276

Hetrick, S., Parker, A., Hickie, I., Purcell, R., Yung, A., & McGorry, P. (2008). Early identification and intervention in depressive disorders: towards a clinical staging model. *Psychotherapy and Psychosomatics, 77*(5), 263-270.

Hickendorff, M., Edelsbrunner, P. A., McMullen, J., Schneider, M., & Trezise, K. (2018). Informative tools for characterizing individual differences in learning: latent class, latent profile, and latent transition analysis. *Learning and Individual Differences, 66*, 4-15.

Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. *American Psychologist, 44*(3), 513-524. doi:10.1037/0003-066X.44.3.513

Hobfoll, S. E., Tirone, V., Holmgreen, L., & Gerhart, J. (2016). Chapter 7 - Conservation of Resources Theory Applied to Major Stress. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 65-71). San Diego: Academic Press.

Hoge, C., Yehuda, R., Castro, C. A., McFarlane, A., Vermetten, E., Jetly, R., . . . Rothbaum, B. O. (2016). Unintended Consequences of Changing the Definition of Posttraumatic Stress Disorder in DSM-5: Critique and Call for Action. *JAMA Psychiatry, 73*(7), 750-752. doi:10.1001/jamapsychiatry.2016.0647

Hoge, E., Acabchuk, R. L., Kimmel, H., Moitra, E., Britton, W. B., Dumais, T., . . . Fulwiler, C. (2021). Emotion-Related Constructs Engaged by Mindfulness-Based Interventions: a Systematic Review and Meta-analysis. *Mindfulness, 12*(5), 1041-1062. doi:10.1007/s12671-020-01561-w

Holder, N., Woods, A., Neylan, T. C., Maguen, S., Seal, K. H., Bernardy, N., . . . Cohen, B. E. (2021). Trends in Medication Prescribing in Patients With PTSD From 2009 to 2018: A National Veterans Administration Study. *Journal of Clinical Psychiatry, 82*(3). doi:10.4088/JCP.20m13522

Hourani, L., Tueller, S., Kizakevich, P., Lewis, G., Strange, L., Weimer, B., . . . Spira, J. (2016). Toward preventing post-traumatic stress disorder: development and testing of a pilot predeployment stress inoculation training program. *Military Medicine, 181*(9), 1151-1160.

Howe, R., & Sterman, M. B. (1973). Somatosensory system evoked potentials during waking behavior and sleep in the cat. *Electroencephalography and Clinical Neurophysiology, 34*(6), 605-618.

Howe, R. C., & Sterman, M. (1972). Cortical-subcortical EEG correlates of suppressed motor behavior during sleep and waking in the cat. *Electroencephalography and Clinical Neurophysiology, 32*(6), 681-695.

IBM Corp, S. (2017). IBM SPSS 25.0 for Windows [Computer software]. *Chicago, IL: SPSS*.

Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Kozak, M., Pine, D. S., . . . Wang, P. (2010). Research Domain Criteria (RDoC): toward a new classification framework for research on mental disorders. *American Journal of Psychiatry, 167*. doi:10.1176/appi.ajp.2010.09091379

Jongedijk, R. A., van Der Aa, N., Haagen, J. F. G., Boelen, P. A., & Kleber, R. J. (2019). Symptom severity in PTSD and comorbid psychopathology: A latent profile analysis among traumatized veterans. *Journal of Anxiety Disorders, 62*, 35-44. doi:10.1016/j.janxdis.2018.11.004

Jonsson, A., Segesten, K., & Mattsson, B. (2003). Post-traumatic stress among Swedish ambulance personnel. *Emergency Medicine Journal, 20*(1), 79. doi:10.1136/emj.20.1.79

Joyce, S. (2019). *The development and evaluation of an online mindfulness based resilience training program to enhance psychological resilience among first responders.* (Doctoral Dissertation), UNSW.

Joyce, S., Shand, F., Bryant, R. A., Lal, T. J., & Harvey, S. (2018). Mindfulness-based resilience training in the workplace: pilot study of the internet-based Resilience@ Work (RAW) mindfulness program. *Journal of Medical Internet Research, 20*(9), e10326.

Joyce, S., Shand, F., Lal, T. J., Mott, B., Bryant, R. A., & Harvey, S. (2019). Resilience@ Work Mindfulness Program: Results From a Cluster Randomized Controlled Trial With First Responders. *Journal of Medical Internet Research, 21*(2), e12894. doi:https://doi.org/10.2196/10326.

Joyce, S., Shand, F., Tighe, J., Laurent, S. J., Bryant, R. A., & Harvey, S. (2018). Road to resilience: a systematic review and meta-analysis of resilience training programmes and interventions. *BMJ Open, 8*(6), e017858. doi:https://doi.org/10.1136/bmjopen-2017-017858

Julian, L. J. (2011). Measures of anxiety: State-Trait Anxiety Inventory (STAI), Beck Anxiety Inventory (BAI), and Hospital Anxiety and Depression Scale-Anxiety (HADS-A. *Arthritis Care & Research, 63*(S11), S467-S472. doi:10.1002/acr.20561

Kehl, D., Knuth, D., Hulse, L., & Schmidt, S. (2014). Posttraumatic Reactions among Firefighters after Critical Incidents: Cross-National Data. *Journal of Aggression, Maltreatment & Trauma, 23*(8), 842-853. doi:10.1080/10926771.2014.938143

Kennedy, L., & Parker, S. H. (2018). Biofeedback as a stress management tool: a systematic review. *Cognition, Technology & Work*. doi:10.1007/s10111-018-0487-x

Kim, J. J., & Diamond, D. M. (2002). The stressed hippocampus, synaptic plasticity and lost memories. *Nature Reviews Neuroscience, 3*(6), 453-462. doi:10.1038/nrn849

Kohn, M., & Senyak, J. (2024). Sample Size Calculators for designing clinical research. Retrieved from https://sample-size.net/sample-size-means/

Konstantinos, P. (2017). Examining the Psychophysiological Efficacy of CBT Treatment for First Responders Diagnosed With PTSD: An Understudied Topic. *SAGE Open, 7*(3), 2158244017729407. doi:10.1177/2158244017729407

Krause, F., Kogias, N., Krentz, M., Lührs, M., Goebel, R., & Hermans, E. J. (2021). Self-regulation of stress-related large-scale brain network balance using real-time fMRI neurofeedback. *Neuroimage, 243*, 118527. doi:https://doi.org/10.1016/j.neuroimage.2021.118527

Kyron, M. J., Rikkers, W., Bartlett, J., Renehan, E., Hafekost, K., Baigent, M., . . . Lawrence, D. (2022). Mental health and wellbeing of Australian police and emergency services employees. *Archives of Environmental & Occupational Health, 77*(4), 282-292. doi:10.1080/19338244.2021.1893631

Laerd Statistics. (2013). SPSS statistics tutorials and statistical guides. *Accessed online at https://statistics. laerd. com.*

Lazarus, R. S. (1984). *Stress, appraisal, and coping*. New York: Springer Pub.

Lazarus, R. S. (1998). *Fifty years of the research and theory of R.S. Lazarus: an analysis of historical and perennial issues*. Mahwah, N.J: Lawerence Erlbaum Associates.

Lee, J. H., Lee, D., Kim, J., Jeon, K., & Sim, M. (2017). Duty-Related Trauma Exposure and Posttraumatic Stress Symptoms in Professional Firefighters. *Journal of Traumatic Stress, 30*(2), 133-141. doi:10.1002/jts.22180

Leppin, A. L., Bora, P. R., Tilburt, J. C., Gionfriddo, M. R., Zeballos-Palacios, C., Dulohery, M. M., . . . Boehmer, K. R. (2014). The efficacy of resiliency training programs: a systematic review and meta-analysis of randomized trials. *PLoS ONE, 9*(10), e111420. doi:https://doi.org/10.1371/journal.pone.0111420

Lethbridge, R., & Phoenix Australia. (2021). Australian Guidelines for the Prevention and Treatment of Acute Stress Disorder, Posttraumatic Stress Disorder, and Complex Posttraumatic Stress Disorder. (version 6). Retrieved from https://www.phoenixaustralia.org/australian-guidelines-for-ptsd/

Liu, J. J., Ein, N., Gervasio, J., Battaion, M., Reed, M., & Vickers, K. (2020). Comprehensive meta-analysis of resilience interventions. *Clinical Psychology Review, 82*, 101919. doi:https://doi.org/10.1016/j.cpr.2020.101919

Lovibond, P. F. (2018). Depression Anxiety Stress Scales (DASS). Retrieved from http://www2.psy.unsw.edu.au/dass/over.htm

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy, 33*(3), 335-343.

Main, C. J. (1983). The modified somatic perception questionnaire (MSPQ). *Journal of Psychosomatic Research, 27*(6), 503-514. doi:10.1016/0022-3999(83)90040-5

Marmot, M. G., & Sapolsky, R. (2014). *Of baboons and men: Social circumstances, biology, and the social gradient in health.* Paper presented at the Sociality, hierarchy, health: Comparative biodemography: Papers from a workshop.

Marmot, M. G., Smith, G. D., Stansfeld, S., Patel, C., North, F., Head, J., . . . Feeney, A. (1991). Health inequalities among British civil servants: the Whitehall II study. *Lancet, 337*(8754), 1387-1393. doi:10.1016/0140-6736(91)93068-k

Martin, M., Marchand, A., & Boyer, R. (2009). Traumatic events in the workplace: Impact on psychopathology and healthcare use of police officers. *International Journal of Emergency Mental Health, 11*, 165-176.

Maslach, C., Jackson, S., & Leiter, M. (1997). *The Maslach Burnout Inventory Manual* (Vol. 3): Scarecrow Education.

Masten, A. S. (2001). Ordinary magic: Resilience processes in development. *American Psychologist, 56*(3), 227-238. doi:10.1037/0003-066X.56.3.227

McCarty, R. (2016). Chapter 4 - The Fight-or-Flight Response: A Cornerstone of Stress Research. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 33-37). San Diego: Academic Press.

McCraty, R., & Shaffer, F. (2015). Heart rate variability: new perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. *Global Advances in Health and Medicine, 4*(1), 46-61.

McCubbin, J., Zinzow, H., Hibdon, M., Nathan, A., Morrison, A., Hayden, G., . . . Switzer, F. (2016). Subclinical posttraumatic stress disorder symptoms: relationships with blood pressure, hostility, and sleep. *Cardiovascular Psychiatry and Neurology*. doi:http://dx.doi.org/10.1155/2016/4720941

McEwen, B. S. (1998). Stress, Adaptation, and Disease: Allostasis and Allostatic Load. *Annals of the New York Academy of Sciences, 840*(1), 33-44. doi:10.1111/j.1749-6632.1998.tb09546.x

McEwen, B. S. (2016a). Central Role of the Brain in Stress and Adaptation: Allostasis, Biological Embedding, and Cumulative Change *Stress: Concepts, Cognition, Emotion, and Behavior: Handbook of Stress* (pp. 39-55).

McEwen, B. S. (2016b) In pursuit of resilience: stress, epigenetics, and brain plasticity. *Vol. 1373. Annals of the New York Academy of Sciences* (pp. 56-64).

McEwen, B. S., & Gianaros, P. (2010). Central role of the brain in stress and adaptation: links to socioeconomic status, health and disease. *Annals of the New York Academy of Sciences, 1186*, 190-222.

McEwen, B. S., & Lasley, E. N. (2002). *The end of stress as we know it*. Washington, DC, US: Joseph Henry Press.

McEwen, B. S., & Magarinos, A. M. (2001). Stress and hippocampal plasticity: implications for the pathophysiology of affective disorders. *Human Psychopharmacology: Clinical and Experimental, 16*(S1), S7-S19. doi:10.1002/hup.266

McEwen, B. S., & Seeman, T. (1999) Protective and damaging effects of mediators of stress. Elaborating and testing the concepts of allostasis and allostatic load. *Vol. 896. Annals of the New York Academy of Sciences* (pp. 30-47).

McFarlane, A. (20 Nov 2016). *The need for improved treatments for PTSD: the challenge of evidence tempering aspiration.* Paper presented at the Applied Neuroscience Society of Australia, Sydney.

McFarlane, A. (2017). Post-traumatic stress disorder is a systemic illness, not a mental disorder - is Cartesian dualism dead? *Medical Journal of Australia, 206*(6), 248-249.

McFarlane, A. (2018). The high rates of mental health conditions experienced by first responders, emergency service workers and volunteers. Submission 46 *Secretary, Senate Education and Employment Committees* (pp. 1-11).

McFarlane, A., Atchison, M., Rafalowicz, E., & Papay, P. (1994). Physical symptoms in post-traumatic stress disorder. *Journal of Psychosomatic Research, 38*(7), 715-726. doi:https://doi.org/10.1016/0022-3999(94)90024-8

McFarlane, A., & Bryant, R. A. (2017). PTSD: the need to use emerging knowledge to improve systems of care and clinical practice in Australia: SAGE Publications Sage UK: London, England.

McFarlane, A., Ellis, N., Barton, C., Browne, D., & Hooff, M. V. (2008). The conundrum of medically unexplained symptoms: questions to consider. *Psychosomatics, 49*(5), 369-377.

McFarlane, A., Lawrence-Wood, E., Van Hooff, M., Malhi, G., & Yehuda, R. (2017). The Need to Take a Staging Approach to the Biological Mechanisms of PTSD and its Treatment. *Current Psychiatry Reports, 19*(2), 1-9. doi:10.1007/s11920-017-0761-2

McGorry, P. (2015). Early intervention in psychosis. *Journal of Nervous and Mental Disease, 203*(5), 310-318.

McGorry, P., Hickie, I. B., Yung, A. R., Pantelis, C., & Jackson, H. J. (2006). Clinical staging of psychiatric disorders: a heuristic framework for choosing earlier, safer and more effective interventions. *Australian and New Zealand Journal of Psychiatry, 40*(8), 616-622.

McGrady, A. (2007). Psychophysiological Mechanisms of Stress: A foundation for the stress managment therapies. In P. M. Lehrer, R. L. Woolfolk, W. E. Sime, & D. H. Barlow (Eds.), *Principles and practice of stress management* (3rd ed., pp. 16-37). New York, United States: Guilford Publications.

Medibank Private. (2008). The cost of workplace stress in Australia. Retrieved from https://www.medibank.com.au/Client/Documents/Pdfs/The-Cost-of-Workplace-Stress.pdf

Medibank Private. (2017). Was 2017 Australia's most stressful year? Retrieved from https://www.medibank.com.au/livebetter/health-brief/health-insights/was-2017-australias-most-stressful-year/

Mellman, T. A., Clark, R. E., & Peacock, W. J. (2003). Prescribing Patterns for Patients With Posttraumatic Stress Disorder. *Psychiatric Services, 54*(12), 1618-1621. doi:10.1176/appi.ps.54.12.1618

Menon, V. (2011). Large-scale brain networks and psychopathology: a unifying triple network model. *Trends in Cognitive Sciences, 15*(10), 483-506.
Metcalf, O., Varker, T., Forbes, D., Phelps, A., Dell, L., DiBattista, A., . . . O'Donnell, M. (2016). Efficacy of Fifteen Emerging Interventions for the Treatment of Posttraumatic Stress Disorder: A Systematic Review: Efficacy of Emerging Interventions for PTSD. *Journal of Traumatic Stress, 29*(1), 88-92. doi:10.1002/jts.22070
Micoulaud-Franchi, J., Jeunet, C., Pelissolo, A., & Ros, T. (2021). Eeg neurofeedback for anxiety disorders and post-traumatic stress disorders: a blueprint for a promising brain-based therapy. *Current Psychiatry Reports, 23*, 1-14.
Mirifar, A., Keil, A., & Ehrlenspiel, F. (2022). Neurofeedback and neural self-regulation: a new perspective based on allostasis. *Reviews in the Neurosciences, 33*(6), 607-629. doi:10.1515/revneuro-2021-0133
Mitchell, J. T. (2016). Stress in Emergency Personnel. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 385-391). San Diego: Academic Press.
Monson, C., Schnurr, P., Resick, P., Friedman, M., Y-Xu, Y., & Stevens, S. (2006). Cognitive processing therapy for veterans with military-related posttraumatic stress disorder. *Journal of Consulting and Clinical Psychology, 74*(5), 898-907.
Murphy, S. A., Beaton, R. D., Pike, K. C., & Cain, K. C. (1994). Firefighters and paramedics: Years of service, job aspirations, and burnout. *AAOHN Journal, 42*(11), 534-540.
Muthén, L., & Muthen, B. (2017). *Mplus user's guide: Statistical analysis with latent variables, user's guide*: Muthén & Muthén.
Najavits, L. (2015). The problem of dropout from "gold standard" PTSD therapies. *F1000Prime Reports, 7*(43), 1-8.
National Center for PTSD. (2022). PTSD Checklist for DSM-5 (PCL-5). Retrieved from https://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp
Nicholson, A. A., Rabellino, D., Densmore, M., Frewen, P. A., Paret, C., Kluetsch, R., . . . McKinnon, M. C. (2017). The neurobiology of emotion regulation in posttraumatic stress disorder: Amygdala downregulation via real-time fMRI neurofeedback. *Human Brain Mapping, 38*(1), 541-560.
Nicholson, A. A., Ros, T., Jetly, R., & Lanius, R. A. (2020). Regulating posttraumatic stress disorder symptoms with neurofeedback: Regaining control of the mind. *Journal of Military, Veteran and Family Health, 6*(S1), 3-15.
Niedermeyer, E., Da Silva, F. L., Niedermeyer, E., & Lopes Da Silva, F. H. (2004). *Electroencephalography : Basic Principles, Clinical Applications, and Related Fields*. Philadelphia, United States: Wolters Kluwer.
Nijdam, M. J., Vermetten, E., & McFarlane, A. C. (2023). Toward staging differentiation for posttraumatic stress disorder treatment. *Acta Psychiatrica Scandinavica, 147*(1), 65-80. doi:10.1111/acps.13520
Novaco, R. W. (2016). Chapter 35 - Anger. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 285-292). San Diego: Academic Press.
Nursey, J., & Phelps, A. J. (2016). Chapter 20 - Stress, Trauma, and Memory in PTSD. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 169-176). San Diego: Academic Press.

Nylund-Gibson, K., & Choi, A. Y. (2018). Ten Frequently Asked Questions About Latent Class Analysis. *Translational issues in psychological science, 4*(4), 440-461. doi:10.1037/tps0000176

Oginska-Bulik, N., & Kobylarczyk, M. (2016). Association between resiliency and posttraumatic growth in firefighters: the role of stress appraisal. *International Journal of Occupational Safety and Ergonomics, 22*(1), 40-48.

Pacák, K., & Palkovits, M. s. (2001). Stressor Specificity of Central Neuroendocrine Responses: Implications for Stress-Related Disorders. *Endocrine Reviews, 22*(4), 502-548. doi:10.1210/edrv.22.4.0436

Panisch, L. S., & Hai, A. H. (2018). The Effectiveness of Using Neurofeedback in the Treatment of Post-Traumatic Stress Disorder: A Systematic Review. *Trauma, Violence, & Abuse*, 1524838018781103. doi:10.1177/1524838018781103

Panisch, L. S., & Hai, A. H. (2020). The Effectiveness of Using Neurofeedback in the Treatment of Post-Traumatic Stress Disorder: A Systematic Review. *Trauma, Violence, & Abuse, 21*(3), 541-550. doi:10.1177/1524838018781103

Papazoglou, K., & Tuttle, B. M. (2018). Fighting Police Trauma: Practical Approaches to Addressing Psychological Needs of Officers. *SAGE Open, 8*(3), 2158244018794794. doi:10.1177/2158244018794794

Parliament of Australia. (2018). The role of Commonwealth, state and territory Governments in addressing the high rates of mental health conditions experienced by first responders, emergency service workers and volunteers.

Patel, R., Spreng, R. N., Shin, L. M., & Girard, T. A. (2012). Neurocircuitry models of posttraumatic stress disorder and beyond: a meta-analysis of functional neuroimaging studies. *Neuroscience and Biobehavioral Reviews, 36*(9), 2130-2142.

Peeters, F., Oehlen, M., Ronner, J., van Os, J., & Lousberg, R. (2014). Neurofeedback as a treatment for major depressive disorder–a pilot study. *PLoS ONE, 9*(3), e91837. doi:https://doi.org/10.1371/journal.pone.0091837

Peniston, E. G., & Kulkosky, P. J. (1991). Alpha-theta brainwave neurofeedback for Vietnam veterans with combat-related post-traumatic stress disorder. *Medical Psychotherapy, 4*(1), 47-60.

Petrie, K., Joyce, S., Tan, L., Henderson, M., Johnson, A., Nguyen, H., . . . Harvey, S. (2018). A framework to create more mentally healthy workplaces: A viewpoint. *Australian and New Zealand Journal of Psychiatry, 52*(1), 15-23. doi:10.1177/0004867417726174

Petrie, K., Milligan-Saville, J., Gayed, A., Deady, M., Phelps, A., Dell, L., . . . Harvey, S. (2018). Prevalence of PTSD and common mental disorders amongst ambulance personnel: a systematic review and meta-analysis. *Social Psychiatry and Psychiatric Epidemiology, 53*(9), 897-909. doi:10.1007/s00127-018-1539-5

Phelps, A. J., Lethbridge, R., Brennan, S., Bryant, R. A., Burns, P., Cooper, J. A., . . . Silove, D. (2022). Australian guidelines for the prevention and treatment of posttraumatic stress disorder: Updates in the third edition. *Australian and New Zealand Journal of Psychiatry, 56*(3), 230-247. doi:10.1177/00048674211041917

Pupazzoni, R. (2022). Anxiety in the workplace costs the economy billions. *The Business*. Retrieved from https://www.abc.net.au/news/2022-03-10/anxiety-in-the-workplace-costs-australia-billions/100894478

QFES Annual Report. (2022). *Human Resources Strategic workforce palnning and performance.* Retrieved from

https://www.qfes.qld.gov.au/sites/default/files/2022-09/QFES-2021-22-Annual-Report-Governance-Human-resources.pdf.
Qi, W., Gevonden, M., & Shalev, A. (2016). Prevention of Post-Traumatic Stress Disorder After Trauma: Current Evidence and Future Directions. *Current Psychiatry Reports, 18*(2), 20-20. doi:10.1007/s11920-015-0655-0
Qualtrics Provo Utah. (2005). Qualtrics (Version 2021). Provo, Utah, USA: Qualtrics. Retrieved from www.qualtrics.com
Queensland Government. (2019). *Counselling*. Retrieved from https://www.qfes.qld.gov.au/fessn/counselling/Pages.
Queensland Office of the Governor General. (2019). Group Bravery Citation [Press release]. Retrieved from https://www.gg.gov.au/sites/default/files/2019-12/20130325_-_media_notes_-_group_citation.pdf
Regehr, C., Hill, D. J., & Glancy, D. G. (2000). Individual Predictors of Traumatic Reactions in Firefighters. *The Journal of Nervous and Mental Disease, 188*(6), 333-339. doi:10.1097/00005053-200006000-00003
Regehr, C., & LeBlanc, V. (2017). PTSD, Acute stress, performance and decision-making in emergency service workers. *Journal American Academy of Psychiatry Law, 45*, 184-192.
Reiter, K., Andersen, S., & Carlsson, J. (2016). Neurofeedback treatment and Posttraumatic Stress Disorder: Effectiveness of Neurofeedback on Posttrarmatic Stress Disorder and the optimal choice of protocol. *The Journal of Nervous and Mental Disease, 204*(2), 69-77. doi:DOI: 10.1097/NMD.0000000000000418
Resick, P. A., Monson, C. M., & Chard, K. M. (2016). *Cognitive processing therapy for PTSD: A comprehensive manual*: Guilford Publications.
Romas, J. A., & Sharma, M. (2017a). Chapter 1 - Understanding Stress. In J. A. Romas & M. Sharma (Eds.), *Practical Stress Management (Seventh Edition)* (pp. 1-21): Academic Press.
Romas, J. A., & Sharma, M. (2017b). Chapter 5 - Managing Anger and Resolving Conflicts. In J. A. Romas & M. Sharma (Eds.), *Practical Stress Management (Seventh Edition)* (pp. 91-109): Academic Press.
Ros, R., Theberge, J., Frewen, P., Kluetsch, R., Densmore, M., Calhoun, V., & Lanius, R. (2013). Mind over chatter: plastic up-regulation of the fMRI salience network directly after EEG neurofeedback. *Neuroimage, 65*, 324-335.
Roth, S., Sterman, M., & Clemente, C. D. (1967). Comparison of EEG correlates of reinforcement, internal inhibition and sleep. *Electroencephalography and Clinical Neurophysiology, 23*(6), 509-520. doi:10.1016/0013-4694(67)90017-X
Rowe, A., & Regehr, C. (2010). Whatever Gets You Through Today: An Examination of Cynical Humor Among Emergency Service Professionals. *Journal of Loss and Trauma, 15*(5), 448-464. doi:10.1080/15325024.2010.507661
Ruppert, D. (2014). Trimming and winsorization. In S. Kotz (Ed.), *Wiley StatsRef: Statistics Reference Online*. Hoboken, New Jersey: Wiley.
Russell-Chapin, L., Kemmerly, T., Liu, W.-C., Zagardo, M. T., Chapin, T., Dailey, D., & Dinh, D. (2013). The effects of neurofeedback in the default mode network: Pilot study results of medicated children with ADHD. *Journal of Neurotherapy, 17*(1), 35-42.
Rydzik, Ł., Wąsacz, W., Ambroży, T., Javdaneh, N., Brydak, K., & Kopańska, M. (2023). The Use of Neurofeedback in Sports Training: Systematic Review. *Brain Sciences, 13*(4), 660.

Salleh, M. N. B. M., Ismail, H. B., & Yusoff, H. B. M. (2020). Prevalence and predictors for PTSD among firefighters. A systematic review. *International Journal of Public Health Research, 10*(1).
Sapolsky, R. M. (1982). The endocrine stress-response and social status in the wild baboon. *Hormones and Behavior, 16*(3), 279-292.
Sapolsky, R. M. (1990). Stress in the wild. *Scientific American, 262*(1), 116-123.
Sapolsky, R. M. (2003). Stress and Plasticity in the Limbic System. *Neurochemical Research, 28*(11), 1735-1742. doi:10.1023/A:1026021307833
Sapolsky, R. M. (2004). *Why zebras don't get ulcers: The acclaimed guide to stress, stress-related diseases, and coping*: Holt paperbacks.
Sapolsky, R. M. (2005). The influence of social hierarchy on primate health. *Science, 308*(5722), 648-652.
Sapolsky, R. M., Krey, L. C., & McEwen, B. S. (2002). The Neuroendocrinology of Stress and Aging: The Glucocorticoid Cascade Hypothesis. *Science of Aging Knowledge Environment, 2002*(38), cp21-.
Sartory, G., Cwik, J., Knupertz, H., Schurholt, B., Lebens, M., Seitz, R., & Schulze, R. (2013). In search of the trauma memory: A meta-analysis of functional neuroimaging studies of symptoms provocation in posttraumatic stress disorder (PTSD). *PLoS ONE, 8*(3), e58150. doi:https://doi.org/10.1371/journal.pone.0058150
Saxby, E., & Peniston, E. G. (1995). Alpha-theta brainwave neurofeedback training: An effective treatment for male and female alcoholics with depressive symptoms. *Journal of Clinical Psychology, 51*(5), 685-693. doi:doi:10.1002/1097-4679(199509)51:5<685::AID-JCLP2270510514>3.0.CO;2-K
Schnurr, P. (2014). A guide to the literature on partial PTSD (Vol. 25). Vermont USA: National Center for PTSD.
Schnurr, P., Friedman, M. J., Engel, C. C., Foa, E. B., Shea, M. T., Chow, B. K., . . . Haug, R. (2007). Cognitive behavioral therapy for posttraumatic stress disorder in women: A randomized controlled trial. *JAMA, 297*(8), 820-830.
Schultz, D. P. (2014). *A History of Modern Psychology* (2nd ed. ed.). Saint Louis: Elsevier Science.
Schwarzer, R. (2001). Stress, resources, and proactive coping. *Applied Psychology, 50*(3), 400-407.
Scott, J., Leboyer, M., Hickie, I., Berk, M., Kapczinski, F., Frank, E., . . . McGorry, P. (2013). Clinical staging in psychiatry: a cross-cutting model of diagnosis with heuristic and practical value. *The British Journal of Psychiatry, 202*(4), 243.
Selye, H. (1951). The General-Adaptation-Syndrome. *Annual Review of Medicine, 2*(1), 327-342. doi:10.1146/annurev.me.02.020151.001551
Selye, H. (1976). *Stress in Health and Disease*. US: Butterworth Heinemann.
Serrano-Ibáñez, E. R., Corrás, T., del Prado, M., Diz, J., & Varela, C. (2023). Psychological Variables Associated With Post-Traumatic Stress Disorder in Firefighters: A Systematic Review. *Trauma, Violence, & Abuse, 24*(4), 2049-2066. doi:10.1177/15248380221082944
Shapiro, F. (2001). *Eye movement desensitization and reprocessing (EMDR): Basic principles, protocols, and procedures* (2nd ed.): Guilford Press.
Shaw, S. B., Nicholson, A. A., Ros, T., Harricharan, S., Terpou, B., Densmore, M., . . . Lanius, R. A. (2023). Increased top-down control of emotions during symptom provocation working memory tasks following a RCT of alpha-down

neurofeedback in PTSD. *NeuroImage: Clinical, 37*, 103313. doi:https://doi.org/10.1016/j.nicl.2023.103313

Sherlin, L. H., Arns, M., Lubar, J., Heinrich, H., Kerson, C., Strehl, U., & Sterman, M. B. (2011). Neurofeedback and basic learning theory: implications for research and practice. *Journal of Neurotherapy, 15*(4), 292-304.

Sinha, P., Calfee, C. S., & Delucchi, K. L. (2021). Practitioner's Guide to Latent Class Analysis: Methodological Considerations and Common Pitfalls. *Critical Care Medicine, 49*(1), e63-e79. doi:10.1097/ccm.0000000000004710

Skeffington, P. M., Rees, C. S., & Mazzucchelli, T. (2017). Trauma exposure and post-traumatic stress disorder within fire and emergency services in Western Australia. *Australian Journal of Psychology, 69*(1), 20-28. doi:10.1111/ajpy.12120

Skeffington, P. M., Rees, C. S., Mazzucchelli, T. G., & Kane, R. T. (2016). The Primary Prevention of PTSD in Firefighters: Preliminary Results of an RCT with 12-Month Follow-Up. *PLoS ONE, 11*(7), e0155873-e0155873. doi:10.1371/journal.pone.0155873

Southwick, S., Bonanno, G., Masten, A., Panter-Brick, C., & Yehuda, R. (2014). Resilience definitions, theory, and challenges: interdisciplinary perspectives. *European Journal of Psychotraumatology, 5*.

Spielberger, C., Gorsuch, R., Lushene, R., Vagg, P., & Jacobs, G. (1970). State-trait anxiety inventory. Palo Alto: ca: consulting psychologists press.

Spurk, D., Hirschi, A., Wang, M., Valero, D., & Kauffeld, S. (2020). Latent profile analysis: A review and "how to" guide of its application within vocational behavior research. *Journal of Vocational Behavior, 120*, 103445. doi:https://doi.org/10.1016/j.jvb.2020.103445

Squire, L. R. (2011). *The history of neuroscience in autobiography* (Vol. 7): Oxford University Press.

Steenkamp, M. (2016). True Evidence-Based Care for Posttraumatic Stress Disorder in Military Personnel and Veterans. *JAMA Psychiatry, 73*(5), 431-432.

Steenkamp, M., Litz, B. T., Hoge, C., & Marmar, C. R. (2015). Psychotherapy for military-related PTSD: a review of randomized clinical trials. *JAMA, 314*(5), 489-500.

Steenkamp, M., Nickerson, A., Maguen, S., Dickstein, B. D., Nash, W. P., & Litz, B. T. (2012). Latent Classes of PTSD Symptoms in Vietnam Veterans. *Behavior Modification, 36*(6), 857-874. doi:10.1177/0145445512450908

Steriade, M., Gloor, P., Llinás, R. R., Lopes Da Silva, F. H., & Mesulam, M. M. (1990). Basic mechanisms of cerebral rhythmic activities. *Electroencephalography and Clinical Neurophysiology, 76*(6), 481-508. doi:10.1016/0013-4694(90)90001-Z

Sterman, M. B. (1981). EEG biofeedback: Physiological behavior modification. *Neuroscience and Biobehavioral Reviews, 5*(3), 405-412. doi:10.1016/0149-7634(81)90036-1

Sterman, M. B. (1996). Physiological origins and functional correlates of EEG rhythmic activities: Implications for self-regulation. *Biofeedback and Self-regulation, 21*(1), 3-33. doi:10.1007/bf02214147

Sterman, M. B. (1998). *Tools for explanation*. Workbook. Futurehealth Conference, Palm Springs. Feb 4-5.

Sterman, M. B., & Mann, C. A. (1995). Concepts and applications of EEG analysis in aviation performance evaluation. *Biological Psychology, 40*(1), 115-130. doi:10.1016/0301-0511(95)05101-5

Sterman, M. B., Wyrwicka, W., & Roth, S. (1969). Electrophysiological correlates and neural substrates of alimentary behavior in the cat. *Annals of the New York Academy of Sciences, 157*(2), 723-739.

Syed, S., Ashwick, R., Schlosser, M., Jones, R., Rowe, S., & Billings, J. (2020). Global prevalence and risk factors for mental health problems in police personnel: a systematic review and meta-analysis. *Occupational and environmental medicine (London, England), 77*(11), 737-747. doi:10.1136/oemed-2020-106498

Terhaag, S., Cowlishaw, S., Steel, Z., Brewer, D., Howard, A., Armstrong, R., . . . Phelps, A. (2019). Psychiatric Comorbidity for Veterans With Posttraumatic Stress Disorder (PTSD): A Latent Profile Analysis and Implications for Treatment. *Psychological Trauma: Theory, Research, Practice, and Policy*. doi:10.1037/tra0000520

Thompson, M. S., & Cooper, C. L. (2001). A rose by any other name ...: A commentary on Hobfoll's Conservation of Resources theory. *Applied Psychology, 50*(3), 408-418. doi:10.1111/1464-0597.00063

Totawar, A. K., & Nambudiri, R. (2012). An overview of depersonalization in the organizational context. *Indore Management Journal, 4*(2), 64-72.

van der Kolk, B., Hodgdon, H., Gapen, M., Musicaro, R., Suvak, M. K., Hamlin, E., & Spinazzola, J. (2016). A Randomized Controlled Study of Neurofeedback for Chronic PTSD. *PLoS ONE, 11*(12), e0166752. doi:https://doi.org/10.1371/journal.pone.0166752

van der Ploeg, E., & Kleber, R. J. (2003). Acute and chronic job stressors among ambulance personnel: predictors of health symptoms. *Occupational and Environmental Medicine, 60*(suppl 1), i40. doi:10.1136/oem.60.suppl_1.i40

Varker, T., & Devilly, G. J. (2012). An analogue trial of inoculation/resilience training for emergency services personnel: Proof of concept. *Journal of Anxiety Disorders, 26*(6), 696-701. doi:https://doi.org/10.1016/j.janxdis.2012.01.009

Varker, T., Jones, K. A., Arjmand, H.-A., Hinton, M., Hiles, S. A., Freijah, I., . . . O'Donnell, M. (2021). Dropout from guideline-recommended psychological treatments for posttraumatic stress disorder: A systematic review and meta-analysis. *Journal of Affective Disorders Reports, 4*, 100093. doi:https://doi.org/10.1016/j.jadr.2021.100093

Varker, T., Metcalf, O., Forbes, D., Chisolm, K., Harvey, S., Van Hooff, M., . . . Phelps, A. J. (2017). Research into Australian emergency services personnel mental health and wellbeing: An evidence map. *Australian and New Zealand Journal of Psychiatry*, 0004867417738054. doi:10.1177/0004867417738054

Venegas, C. L., Nkangu, M. N., Duffy, M. C., Fergusson, D. A., & Spilg, E. G. (2019). Interventions to improve resilience in physicians who have completed training: A systematic review. *PLoS ONE, 14*(1), e0210512. doi:https://doi.org/10.1371/journal.pone.0210512

Visser, E., Den Oudsten, B. L., Lodder, P., Gosens, T., & De Vries, J. (2022). Psychological risk factors that characterize acute stress disorder and trajectories of posttraumatic stress disorder after injury: a study using latent class analysis. *European Journal of Psychotraumatology, 13*(1), 2006502-2006502. doi:10.1080/20008198.2021.2006502

Viviani, G., & Vallesi, A. (2021). EEG-neurofeedback and executive function enhancement in healthy adults: A systematic review. *Psychophysiology, 58*(9), e13874. doi:https://doi.org/10.1111/psyp.13874

Vohs, K. D., & Baumeister, R. F. (2016). *Handbook of self-regulation: Research, theory, and applications*: Guilford Publications.

Vyas, A., Mitra, R., Rao, B. S., & Chattarji, S. (2002). Chronic stress induces contrasting patterns of dendritic remodeling in hippocampal and amygdaloid neurons. *Journal of Neuroscience, 22*(15), 6810-6818.

Wagner, S. L., White, N., Fyfe, T., Matthews, L. R., Randall, C., Regehr, C., . . . Fleischmann, M. H. (2020). Systematic review of posttraumatic stress disorder in police officers following routine work-related critical incident exposure. *American Journal of Industrial Medicine, 63*(7), 600-615. doi:10.1002/ajim.23120

Wang, L., Norman, I., Edleston, V., Oyo, C., & Leamy, M. (2024). The Effectiveness and Implementation of Psychological First Aid as a Therapeutic Intervention After Trauma: An Integrative Review. *Trauma, Violence, & Abuse, 0*(0), 15248380231221492. doi:10.1177/15248380231221492

Weathers, F. W., Litz, B. T., Keane, T. M., Palmieri, P. A., Marx, B. P., & Schnurr, P. (2013). The ptsd checklist for dsm-5 (pcl-5). *Scale available from the National Center for PTSD at www. ptsd. va. gov*.

Weathers, F. W., Marx, B. P., Friedman, M. J., & Schnurr, P. P. (2014). Posttraumatic stress disorder in DSM-5: New criteria, new measures, and implications for assessment. *Psychological Injury and Law, 7*, 93-107.

Wilcox, R. (2005). Trimming and winsorization *Encyclopedia of biostatistics* (2nd ed.). West Sussex, England: John Wiley.

Wild, J., Smith, K. V., Thompson, E., Béar, F., Lommen, M. J. J., & Ehlers, A. (2016). A prospective study of pre-trauma risk factors for post-traumatic stress disorder and depression. *Psychological Medicine, 46*(12), 2571-2582. doi:10.1017/S0033291716000532

Wooding, S., & Raphael, B. (2012). Handbook 2 - Psychological First Aid (PFA) *Level 1 Intervention following Mass Disaster*. NSW Health,: Disaster Response, Resilience and Research Group (DRRRG).

Wu, G., Feder, A., Cohen, H., Kim, J., Calderon, S., Charney, D., & Mathé, A. (2013). Understanding resilience. *Frontiers in Behavioral Neuroscience, 7*. doi:10.3389/fnbeh.2013.00010

Wyrwicka, W., & Sterman, M. B. (1968). Instrumental conditioning of sensorimotor cortex EEG spindles in the waking cat. *Physiology and Behavior, 3*(5), 703-707. doi:10.1016/0031-9384(68)90139-X

Yehuda, R., & Hoge, C. (2016). The Meaning of Evidence-Based Treatments for Veterans With Posttraumatic Stress Disorder. *JAMA Psychiatry, 73*(5), 433-434. doi:10.1001/jamapsychiatry.2015.2878

Yoo, S.-S., Gujar, N., Hu, P., Jolesz, F. A., & Walker, M. P. (2007). The human emotional brain without sleep — a prefrontal amygdala disconnect. *Current Biology, 17*(20), R877-R878. doi:10.1016/j.cub.2007.08.007

American Psychological Association (APA). (2020). *Publication Manual of the American Psychological Association* (7th ed.).

Appendices

Appendix A: Recruitment to Study

Participate in a research study:
Exploration of stress symptoms and interventions in Queensland Firefighters

Dear Firefighter,

My name is Tamara Lorensen from the School of Management, Queensland University of Technology (QUT) and I'm doing a PhD into stress management in Emergency Responders.

I would like to invite operational career firefighters who work across the state of Queensland and between the ages of 18 and 65 to complete a 15-minute online survey. Participation is voluntary.

This research project may have the potential to benefit emergency responders in the future as it aims to identify different levels of stress symptoms. A clearer understanding of stress may lead to the development of targeted resilience and training programs to improve stress reactions.

Participation will involve completing a survey with statements to which you indicate whether you agree – disagree.

The Information sheet about the project is on the landing page of the survey. After reading this you have the option of leaving the survey. Remember it is voluntary. The survey will initially remain open for four weeks.

Below is the link to the survey:

https://qutc.syd1.qualtrics.com/jfe/form/SV_1UoDkGa3S86bouV

If you have any questions, please contact me via email or phone.

Please note that this study has been approved by the QUT Human Research Ethics Committee 2000000588.

Many thanks for your consideration of this request.

Tamara Lorensen

PhD Student

[redacted]

Dear UFUQ Member

Re: QUT Research – an anonymous online survey about stress symptoms in Queensland Firefighters

Earlier this year I notified UFUQ members of a research project being conducted by Ms Tamara Lorensen (PhD Candidate) from the School of Management, Queensland University of Technology (QUT) into stress management in Firefighters.

The research is not endorsed by the UFUQ, nor do we have any involvement in it. However, Ms Lorensen sought the UFUQ's assistance in notifying prospective participants (you) of the existence of the research project. I wrote to you for that purpose earlier this year, and I write to you for that purpose again.

Ms Lorensen is still seeking participants to complete an anonymous online survey consisting of nine questionnaires that ask questions about stress.

Your participation is voluntary and confidential.

The research aims to investigate the types of symptoms associated with stress and measuring the levels of health and wellbeing that may indicate the potential of future stress disorders. Ms Lorensen hopes this will aid in the design of targeted treatment options that will improve the mental health, wellbeing and resilience of firefighters.

You can find out more details about the anonymous online survey in the attached document, and you can access the survey via the link below:

https://qutc.syd1.qualtrics.com/jfe/form/SV_1UoDkGa3S86bouV

If you would like further information on any aspect of the research project or you would like to be a participant, please contact Ms Lorensen [redacted]

Regards

John Oliver

General Secretary

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT
– Survey –

Exploration of Stress Symptoms and Interventions in Queensland Firefighters

QUT Ethics Approval Number 2000000588

Research team

Principal Researcher: [redacted]

Ms Tamara Lorensen PhD Candidate
[redacted]

Why is the study being conducted?

This research project is being undertaken as part of a PhD study for Tamara Lorensen. The purpose of this research project is to measure health and wellbeing such as stress, sleep, and other symptoms and behaviours. This may assist in identifying different levels of stress in firefighters.

You are invited to participate in this research project because you are an operational career firefighter 18-65 years and are considered to face extra stressors due to your occupation.

What does participation involve?

Participation will involve completing a survey with statements to which you indicate whether you agree – disagree and is estimated to take 15 minutes of your time. Questions will include for example:

"I feel emotionally drained from my work" and "I tended to over-react to situations"

Your participation in this research project is entirely voluntary you can discontinue the survey at any time by simply closing your web browser. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT or any external organisation. As the survey does not request any personal identifying information, once it has been submitted it will not be possible to withdraw.

What are the possible benefits for me if I take part?

There is no direct benefit to you for participation. This research can potentially benefit emergency responders who face stressful challenges in their occupation by contributing to the body of research in the management of stress as it is an aim of the project to understand levels of stress. This may better inform policy and may lead to the development of targeted resilience and training programs to improve stress

reactions.
A summary of the outcomes of the study will be provided to the Queensland Firefighters Charity who can provide you with this information or you may contact the research team for a copy. This is expected to occur December 2020. For any further information you are welcome to contact the researchers.

What are the possible risks for me if I take part?

There may be some risks associated with your participation in this research project. The risks may include the discomfort or perhaps distress in answering the survey questions about how you manage stress and your experiences of stress in your occupation. This may include questions about:

"How much you are bothered by memories of a stressful experience" or
"How much you are bothered by not experiencing any positive feelings" or
"How much you are bothered by feeling upset when something reminds you of a stressful event"
"Having strong negative beliefs about yourself" and "Avoiding reminders of the stressful experience"

You do not need to answer any question you feel uncomfortable about. If you have an existing mental health condition, stressed due to COVID or are currently seeking support for mental health you may not wish to participate, and this is okay. You are not required to participate; the study is voluntary. You can opt out of the survey at any time or at the end of this information sheet however if 90% of the survey is completed your survey data will still be used in analyses.
If you experience discomfort, support can be provided to you if you wish to access it. The researcher is able to provide telehealth assistance in the form of psychological first-aid and help with accessing sources of support.

QUT provides for limited free psychology, family therapy or counselling services for research participants of QUT research projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please call the Clinic Receptionist on **07 3138 0999** (Monday–Friday only 9am–5pm), QUT Psychology and Counselling Clinic, 44 Musk Avenue, Kelvin Grove, and indicate that you are a research participant. Alternatively, Lifeline provides access to online, phone or face-to-face support, call **13 11 14** for 24 hour telephone crisis support.
Please note, during COVID-19 restrictions the QUT Psychology and Counselling Clinic will offer telehealth only services. If you required urgent counselling support: Lifeline-131114; Mensline Australia-1300 789 978; Suicide Call Back Service-1300 659 467; Beyond Blue-133 22 4636; FESSN-free call 1800 805 980

What about privacy and confidentiality?

All comments and responses are anonymous i.e. it will not be possible to identify you at any stage of the research, because personal identifying information is not sought in any of the responses. The survey does not collect your IP address. The data will only be used in an aggregated form.

Any data collected as part of this research project will be stored securely as per QUT's Management of research data policy. Data will be stored for a minimum of 5 years. The aggregated data may be used in the future for extended research.

How do I give my consent to participate?

The submission or return of the completed survey is accepted as an indication of your consent to participate in this research project. You can withdraw at any time prior to submission.

What if I have questions about the research project?

If you have any questions or require further information please contact one of the listed researchers:

Tamara Lorensen [redacted]

What if I have a concern or complaint regarding the conduct of the research project?

QUT is committed to research integrity and the ethical conduct of research projects. If you wish to discuss the study with someone not directly involved, particularly in relation to matters concerning policies, information or complaints about the conduct of the study or your rights as a participant, you may contact the QUT Research Ethics Advisory Team on +61 7 3138 5123 or email humanethics@qut.edu.au.

Thank you for helping with this research project. Please keep/print this sheet for your information.

Appendix B: Structured Interview & Measures used in Study 1 & 2

What is your gender M/F/Other/Prefer not to answer

What is your age?

For how long have you been a firefighter?

Do you have a partner?

Do you have children?

This question asks about problems you may have had after a very stressful experience involving death, serious injury or violence. It could be something that happened to you directly or something you witnessed.

How long ago did it happen?

How did you experience it?

It happened to me directly

I witnessed it

I learned about it happening to a close friend or family member

I was exposed to it as part of my job (for example: first responder)

Thank you for your time in participating in this survey.
QUT provides for limited free psychology, family therapy or counselling services for research participants of QUT research projects who may experience discomfort or distress as a result of their partiicpation in the research. Should you wish to access this service please call the Clinic Receptionist on 07 3138 0999 (M-F 9-5), QUT Psychology and Counselling Clinic, Musk Ave, Kelvin Grove, and indicate you are a research participant. Alternatively, Lifeline provides access to online, phone or face-to-face support, call 13 11 14 for 24hr crisis support. Please note during COVID-19 restrictions QUT Couselling will offer telehealth services.
If you require urgent counselling support
Lifeline - 13 11 14
Mensline Australia - 1300 78 99 78
Suicide Call Back Service - 1300 659 467
Beyond Blue - 133 22 4636
FESSN - free call 1800 805 980

Paper and Pencil Psychological Measures

Posttraumatic Checklist – 5

The Posttraumatic Checklist-5 (PCL-5) is a 20 item self-report measure that corresponds to the 20 DSM-5 symptoms of PTSD (Blevins et al., 2015). The measure is not diagnostic, however is used to monitor symptom change during and after treatment; screen individuals for PTSD; and assists with provisional diagnosis. The measure takes approximately 5-10 minutes to complete.

Aggression Questionnaire

The Aggression Questionnaire (AQ) consists of 29 items rating each statement on a Likert scale ranging from 1 "*extremely uncharacteristic of me*" to 5 "*extremely characteristic of me*" (Buss & Perry, 1992). Each item describes a characteristic related to aggression. In the broad psychological domain of Hostility, traits include anger, cynicism, aggression and mistrust and these have in turn been linked to increased risk of coronary heart disease, hypertension and adverse health outcomes as well as psychological dysfunction (Barefoot et al., 1989; Contrada & Jussim, 1992).

Depression, Anxiety, Stress Scale

The Depression, Anxiety, Stress Scale-21 (DASS-21) is a self-report measure that aims to discriminate the central symptoms of anxiety and depression (Lovibond & Lovibond, 1995). During development a new factor emerged that had the highest loadings on items referring to nervous tension, irritability and agitation and thus the addition of stress as part of the scale.

The State-Trait Anxiety Inventory

This widely used self-report assesses the presence and severity of current symptoms of anxiety (Spielberger et al., 1970). It examines how respondents feel currently such as subjective feelings of tension, worry and autonomic system arousal and; their propensity for anxiety; as well as calmness and confidence; and thus, differentiates state versus trait features (Julian, 2011).

Maslach Burnout Inventory

The Maslach Burnout Inventory (MBI) was developed to assess people who work for the service of others in, for example, human services who can experience chronic stress which is emotionally draining and leads to burnout (Maslach et al., 1997). As defined by Maslach et al. (1997) burnout is a psychological syndrome of three features: emotional exhaustion and depleted resources of being able to give of oneself to others emotionally; depersonalisation or negative, and cynical feelings and attitudes; and reduced personal accomplishment. It is on this basis that the MBI is considered an appropriate measure in firefighters.

Psychological Sense of Organisational Membership

The Psychological Sense of Organisation Membership (PSOM) scale measures the psychological sense of organisational membership and social support (Cockshaw & Shochet, 2010).

Pittsburgh Sleep Quality Index

Sleep quality is an important construct due to the fact that greater than a third of the adult population complains of poor quality sleep such as difficulty falling asleep and further that poor sleep quality can be an important indicator of medical disorders

(Buysse et al., 1989). The Pittsburgh Sleep Quality Index (PSQI) was developed to provide discrimination of good and poor sleepers as well as a useful assessment of sleep disturbances.

Modified Somatic Perception Questionnaire

The Modified Somatic Perception Questionnaire (MSPQ) scale aims to measure somatic and autonomic perception (Main, 1983). This scale is included to specifically measure a participants heightened awareness of bodily functioning which is a reflection of sympathetic activity (Main, 1983).

PCL-5

Instructions: Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then circle one of the numbers to the right to indicate how much you have been bothered by that problem in the past month. **In the past month, how much were you bothered by:**	**Not at all**	**A little bit**	**Moderately**	**Quite a bit**	**Extremely**
1. Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2. Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	0	1	2	3	4
4. Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	0	1	2	3	4
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	0	1	2	3	4
8. Trouble remembering important parts of the stressful experience?	0	1	2	3	4
9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?	0	1	2	3	4
10. Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?	0	1	2	3	4
12. Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13. Feeling distant or cut off from other people?	0	1	2	3	4
14. Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?	0	1	2	3	4
15. Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16. Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17. Being "superalert" or watchful or on guard?	0	1	2	3	4
18. Feeling jumpy or easily startled?	0	1	2	3	4
19. Having difficulty concentrating?	0	1	2	3	4
20. Trouble falling or staying asleep?	0	1	2	3	4

DASS21

Name: *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0 1 2 3
2	I was aware of dryness of my mouth	0 1 2 3
3	I couldn't seem to experience any positive feeling at all	0 1 2 3
4	I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0 1 2 3
5	I found it difficult to work up the initiative to do things	0 1 2 3
6	I tended to over-react to situations	0 1 2 3
7	I experienced trembling (eg, in the hands)	0 1 2 3
8	I felt that I was using a lot of nervous energy	0 1 2 3
9	I was worried about situations in which I might panic and make a fool of myself	0 1 2 3
10	I felt that I had nothing to look forward to	0 1 2 3
11	I found myself getting agitated	0 1 2 3
12	I found it difficult to relax	0 1 2 3
13	I felt down-hearted and blue	0 1 2 3
14	I was intolerant of anything that kept me from getting on with what I was doing	0 1 2 3
15	I felt I was close to panic	0 1 2 3
16	I was unable to become enthusiastic about anything	0 1 2 3
17	I felt I wasn't worth much as a person	0 1 2 3
18	I felt that I was rather touchy	0 1 2 3
19	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0 1 2 3
20	I felt scared without any good reason	0 1 2 3
21	I felt that life was meaningless	0 1 2 3

MBI Human Services Survey

How often	0 Never	1 A few times a year or less	2 Once a month or less	3 A few times a month	4 Once a week	5 A few times a week	6 Every day

		How often 0-6	Statements:
E	1.		I feel emotionally drained from my work.
E	2.		I feel used up at the end of the workday.
E	3.		I feel fatigued when I get up in the morning and have to face another day on the job.
PA	4.		I can easily understand how my recipients feel about things.
DP	5.		I feel I treat some recipients as if they were impersonal objects.
E	6.		Working with people all day is really a strain form me.
PA	7.		I deal very effectively with the problems of my recipients.
E	8.		I feel burned out from my work.
PA	9.		I feel I'm positively influencing other people's lives through my work.
DP	10.		I've become more callous toward people since I took this job.
DP	11.		I worry that this job is hardening me emotionally.
PA	12.		I feel very energetic.
E	13.		I feel frustrated by my job.
E	14.		I feel I'm working too hard on my job.
DP	15.		I don't really care what happens to some recipients.
E	16.		Working with people directly puts too much stress on me.
PA	17.		I can easily create a relaxed atmosphere with my recipients.
PA	18.		I feel exhilarated after working closely with my recipients.
PA	19.		I have accomplished many worthwhile things in this job.
E	20.		I feel like I'm at the end of my rope.
PA	21.		In my work, I deal with emotional problems very calmly.
DP	22.		I feel recipients blame me for some of their problems.

Buss Perry Aggression Questionnaire

Using this 5-point scale, indicate how uncharacteristic or characteristic each of the following statements is in describing you.

		1 Extremely uncharacteristic	2 Somewhat uncharacteristic	3 Neither	4 Somewhat characteristic	5 Extremely characteristic
1. Some of my friends think I am a hothead.	A					
2. If I have to resort to violence to protect my rights, I will.	PA					
3. When people are especially nice to me, I wonder what they want.	H					
4. I tell my friends openly when I disagree with them.	VA					
5. I have become so mad that I have broken things.	PA					
6. I can't help getting into arguments when people disagree with me.	VA					
7. I wonder why sometimes I feel so bitter about thing.	H					
8. Once in a while, I can't control the urge to strike another person.	PA					
*9. I am an even-tempered person.	A*					
10. I am suspicious of overly friendly strangers.	H					
11. I have threatened people I know.	PA					
12. I flare up quickly but get over it quickly.	A					
13. Given enough provocation, I may hit another person.	PA					
14. When people annoy me, I may tell them what I think of them.	VA					
15. I am sometimes eaten up with jealousy.	H					
*16. I can think of no good reason for ever hitting a person.	PA*					

		1 Extremely uncharacteristic	2 Somewhat uncharacteristic	3 Neither	4 Somewhat characteristic	5 Extremely characteristic
17. At times I feel I have gotten a raw deal out of life.	H					
18. I have trouble controlling my temper.	A					
19. When frustrated, I let my irritation show.	A					
20. I sometimes feel that people are laughing at me behind my back.	H					
21. I often find myself disagreeing with people.	VA					
22. If somebody hits me, I hit back.	PA					
23. I sometimes feel like a powder keg ready to explode	A					
24. Other people always seem to get the breaks.	H					
25. There are people who pushed me so far that we came to blows.	PA					
26. I know that "friends" talk about me behind my back.	H					
27. My friends say that I'm somewhat argumentative.	VA					
28. Sometimes I fly off the handle for no good reason.	A					
29. I get into fights a little more than the average person.	PA					

A	
H	
PA	
VA	
TOTAL	

SELF-EVALUATION QUESTIONNAIRE STAI Form Y-1
Please provide the following information:

Name_____Date_____S_____
Age_____ Gender (*Circle*) **M** **F** T_____

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

NOT AT ALL
SOMEWHAT
MODERATELY SO
VERY MUCH SO

A number of statements which people have used to describe themselves are given below.

1. I feel calm 1 2 3 4
2. I feel secure 1 2 3 4
3. I am tense **1 2 3 4**
4. I feel strained 1 2 3 4
5. I feel at ease 1 2 3 4
6. I feel upset 1 2 3 4
7. I am presently worrying over possible misfortunes 1 2 3 4
8. I feel satisfied 1 2 3 4
9. I feel frightened 1 2 3 4
10. I feel comfortable 1 2 3 4
11. I feel self-confident **1 2 3 4**
12. I feel nervous 1 2 3 4
13. I am jittery 1 2 3 4
14. I feel indecisive 1 2 3 4
15. I am relaxed..... **1 2 3 4**
16. I feel content 1 2 3 4
17. I am worried 1 2 3 4
18. I feel confused 1 2 3 4
19. I feel steady 1 2 3 4
20. I feel pleasant 1 2 3 4

Brief Experiential Avoidance Questionnaire

Please indicate the extent to which you agree or disagree with each of the following statements.

1 2 3 4 5 6

strongly disagree moderately disagree slightly disagree slightly agree moderately agree strongly agree

1 The key to a good life is never feeling any pain	1	2	3	4	5	6
2 I'm quick to leave any situation that makes me feel uneasy	1	2	3	4	5	6
3 When unpleasant memories come to me, I try to put them out of my mind	1	2	3	4	5	6
4 I feel disconnect from my emotions	1	2	3	4	5	6
5 I won't do something until I absolutely have to	1	2	3	4	5	6
6 Fear or anxiety won't stop me from doing something important	1	2	3	4	5	6
7 I would give up a lot not to feel bad	1	2	3	4	5	6
8 I rarely do something if there is a chance it will upset me	1	2	3	4	5	6
9 It's hard for me to know what I'm feeling	1	2	3	4	5	6
10 I try to put off unpleasant tasks for as long as possible	1	2	3	4	5	6
11 I go out of my way to avoid uncomfortable situations	1	2	3	4	5	6
12 One of my big goals is to be free from painful emotions	1	2	3	4	5	6
13 I work hard to keep out upsetting feelings	1	2	3	4	5	6
14 If I have any doubts about doing something, I just won't do it	1	2	3	4	5	6
15 Pain always leads to suffering						

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name_____ Date_____

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

ALMOST NEVER / SOMETIMES / OFTEN / ALMOST ALWAYS

A number of statements which people have

21. I feel pleasant 1 2 3 4
22. I feel nervous and restless 1 2 3 4
23. I feel satisfied with myself **1 2 3 4**
24. I wish I could be as happy as others seem to be 1 2 3 4
25. I feel like a failure 1 2 3 4
26. I feel rested..... **1 2 3 4**
27. I am "calm, cool, and collected" 1 2 3 4
28. I feel that difficulties are piling up so that I cannot overcome them **1 2 3 4**
29. I worry too much over something that really doesn't matter 1 2 3 4
30. I am happy 1 2 3 4
31. I have disturbing thoughts 1 2 3 4
32. I lack self-confidence **1 2 3 4**
33. I feel secure 1 2 3 4
34. I make decisions easily 1 2 3 4
35. I feel inadequate 1 2 3 4
36. I am content..... **1 2 3 4**
37. Some unimportant thought runs through my mind and bothers me 1 2 3 4
38. I take disappointments so keenly that I can't put them out of my mind 1 2 3 4
39. I am a steady person 1 2 3 4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests 1 2 3 4

Modified Somatic Perceptions Questionnaire

Main C, Wood P, Hillis S, et al (1992)

Please describe how you have felt during the PAST WEEK by marking a check mark (√) in the appropriate box. Please answer all questions. Do not think too long before answering.

	Not at all	A little, slightly	A great deal, quite a bit	Extremely, could not have been worse
Heart rate increase				
Feeling hot all over				
Sweating all over				
Sweating in a particular part of the body				
Pulse in neck				
Pounding in head				
Dizziness				
Blurring of vision				
Feeling faint				
Everything appearing unreal				
Nausea				
Butterflies in stomach				
Pain or ache in stomach				
Stomach churning				
Desire to pass water				
Mouth becoming dry				
Difficulty swallowing				
Muscles in neck aching				
Legs feeling weak				
Muscles twitching or jumping				
Tense feeling across forehead				
Tense feeling in jaw muscles				

Psychological Sense of Organisational Membership Scale (PSOM)

On this page there are 18 statements about how a person might feel about their workplace. Beside each statement is a scale from 1 to 5, with 1 representing "not at all true" and 5 representing "completely true". Please read each statement and tick the box which most applies to the way you feel.

	Not at all true 1	Somewhat true 2	As often true as not true 3	Almost always true 4	Completely true 5
1 I feel like a real part of this organisation	☐	☐	☐	☐	☐
2 People here notice when I'm good at something	☐	☐	☐	☐	☐
3 it is hard for people like me to be accepted here	☐	☐	☐	☐	☐
4 Other people in this organisation take my opinions seriously	☐	☐	☐	☐	☐
5 Most managers/supervisors in this organisation are interested in me	☐	☐	☐	☐	☐
6 Sometimes I don't feel as if I belong here	☐	☐	☐	☐	☐
7 There's at least one supervisor/manager in this organisation I can talk to if I have a problem	☐	☐	☐	☐	☐
8 People in this organisation are friendly to me	☐	☐	☐	☐	☐
9 Managers/supervisors here are not interested in people like me	☐	☐	☐	☐	☐
10 I am included in lots of activities at this organisation	☐	☐	☐	☐	☐
11 I am treated with as much respect as other employees	☐	☐	☐	☐	☐
12 I feel very different from most other employees	☐	☐	☐	☐	☐
13 I can really be myself in this organisation	☐	☐	☐	☐	☐
14 The managers/supervisors here respect me	☐	☐	☐	☐	☐
15 People here know I can do good work	☐	☐	☐	☐	☐
16 I wish I were in a different organisation	☐	☐	☐	☐	☐
17 I feel proud to belong to this organisation	☐	☐	☐	☐	☐
18 Other employees here like me the way I am	☐	☐	☐	☐	☐

Name_____ Date_____

Sleep Quality Assessment (PSQI)

What is PSQI, and what is it measuring?

The Pittsburgh Sleep Quality Index (PSQI) is an effective instrument used to measure the quality and patterns of sleep in adults. It differentiates "poor" from "good" sleep quality by measuring seven areas (components): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month.

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month,

1. When have you usually gone to bed? _____
2. How long (in minutes) has it taken you to fall asleep each night? _____
3. What time have you usually gotten up in the morning? _____
4. A. How many hours of actual sleep did you get at night? _____
   B. How many hours were you in bed? _____

5. During the past month, how often have you had trouble sleeping because you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
A. Cannot get to sleep within 30 minutes				
B. Wake up in the middle of the night or early morning				
C. Have to get up to use the bathroom				
D. Cannot breathe comfortably				
E. Cough or snore loudly				
F. Feel too cold				
G. Feel too hot				
H. Have bad dreams				
I. Have pain				
J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)

Scoring

Component 1	#9 Score	C1 _____
Component 2	#2 Score (<15min (0), 16-30min (1), 31-60 min (2), >60min (3)) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2 _____
Component 3	#4 Score (>7(0), 6-7 (1), 5-6 (2), <5 (3)	C3 _____
Component 4	(total # of hours asleep) / (total # of hours in bed) x 100 >85%=0, 75%-84%=!, 65%-74%=2, <65%=3	C4 _____
Component 5	# sum of scores 5b to 5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5 _____
Component 6	#6 Score	C6 _____
Component 7	#7 Score + #8 score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7 _____

Add the seven component scores together _____ *Global PSQI* _____

A total score of "5" or greater is indicative of poor sleep quality.
If you scored "5" or more it is suggested that you discuss your sleep habits with a healthcare provider

Appendix C: The EEG and Neurofeedback

An important aspect of electroencephalographic (EEG) recording is the quality of the signal, determined in part, by how well the electrodes are connected to the skin. The interface between a participant and the electrode should result in the minimum possible resistance and is measured by Kilo Ohms (Kohms). Gold cup electrodes (10mm) on shielded leads (1m) were used.

EEG waveforms are usually classified according to their frequency measured in Hertz (Hz), amplitude measured in microvolts (mV), shape and where they occur on the scalp when recorded. The most general waveforms are shown below and the waveforms of interest here are measured across the sensorimotor cortex: theta (4-7 Hz); Sensorimotor Rhythm (SMR) (12-15 Hz) as measured across the sensorimotor cortex; and hibeta (> 18 Hz). An electrode placed on the scalp provides a tracing that reflects an awake, alert state although generally contains different frequencies components. The fast Fourier transform allows for the display of the frequency components individually to permit review of amplitudes of interest and for use in neurofeedback for training purposes.

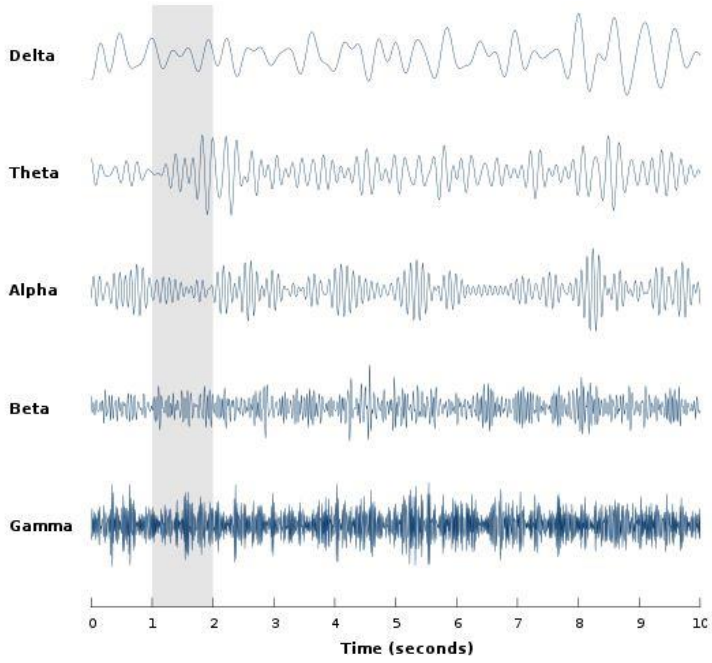


Figure C 1. **Waveforms major frequencies and names**

As an illustration of the neurofeedback process electrodes are placed on the scalp areas of interest and the waveforms are displayed on a therapist computer screen where goals are set for training. When the brainwave activity meets the set goals by a person adjusting their own levels of arousal, focus, attention and motoric quiescence the participant gets positive feedback in visual and auditory form to guide their success.

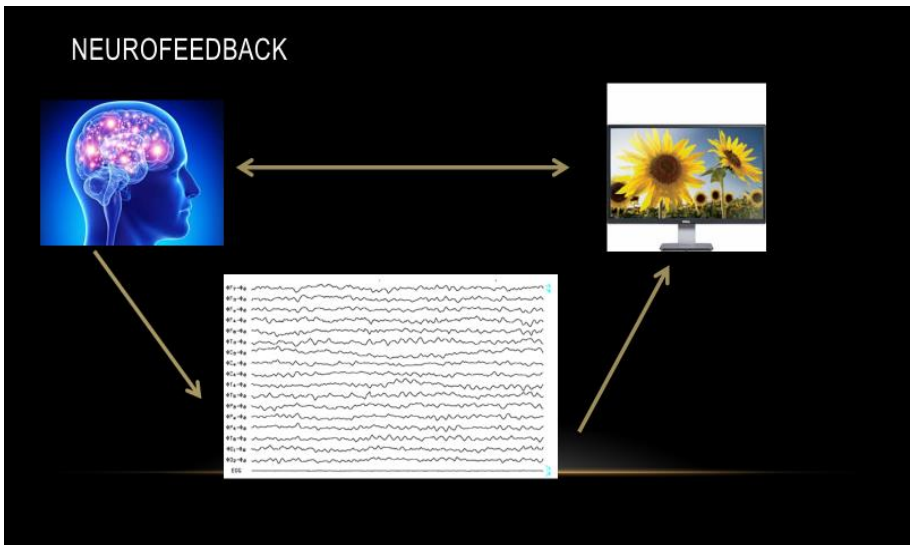


Figure C 2. **Brain-computer interface example**

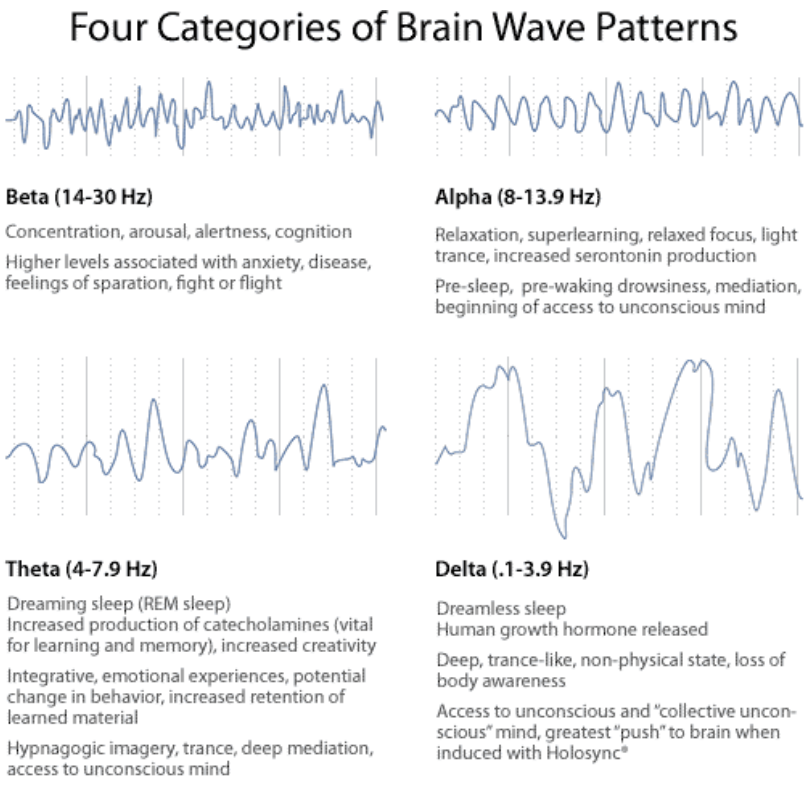


Figure C 3. **Brain wave patterns and associated state of arousal.** https://www.researchgate.net/publication/357293575_A_Brief_Study_of_Binaural_Beat_A_Means_of_Brain-Computer_Interfacing. **CC by 4.0**

The participants were provided with the information contained in this appendix. The aim of training was to reduce the high amplitudes in the hi-beta frequency range to an amplitude reading similar to that which is occurring in the 12-15 Hz or 13-16 Hz range. These frequencies are associated with a calm, focussed state. The theta frequency will be set to inhibit excessive amplitude to maintain attention without becoming drowsy and hi-beta (> 20Hz) is also set to inhibit, to train downregulation of excessive flight/flight and anxiety responses. This is described to the participant as learning to adjust the 'smoke detector' to be less sensitive to non-threatening triggers.

Appendix D: Recruitment Study 2

21 Sep 2018

To Whom It May Concern,

I am writing to you to request your support in a project I am undertaking as part of my doctoral dissertation at the Queensland University of Technology.

This project aims to assist firefighters build resilience, wellbeing and prevent mental health problems developing.

I come to this project from a long history as a registered private practising psychologist with a special interest in stress disorders. I have, over ten years, personal experience working with stress disorders such as Posttraumatic Stress Disorder in the context of my work as an Australian Defence Reservist Psychologist and contractor to Defence providing on-base support. I have first-hand experience working with personnel and members of the public with significant mental health disorders.

An area of special interest for me are firefighters. As members of our community who face extraordinary emotional and physical demands I highly value firefighters and the work they do.

I am approaching the Queensland Firefighters Charity based on our shared interests in support and assistance to Firefighters during times of hardship.

The role of Firefighter is one of bravery, loyalty and devotion to service however there is a well-known stigma attached to seeking mental health support. As part of the support from the Charity would be the dissemination of information about this research that will allow members of QFES the opportunity to engage in assistance in a highly confidential manner.

I would appreciate your acknowledgement of initial interest and support of this important project. Further, I would like to invite you and other interested parties to the presentation of the details of this project so that you may be fully informed at a date to be confirmed.

Your sincerely,

Tamara Lorensen

Psychologist

Tamara Lorensen
Queensland University of Technology
2 George Street
Brisbane QLD 4000

The Queensland Firefighters Charity (QFC) welcomes your interest in the mental of health of Firefighters and acknowledges your understanding of the roles and challenges that face Firefighters today.

As President of the QFC, I am willing to provide tacit support of your studies as outlined in your letter 29th September 2018. To formalise this arrangement it will be necessary on your behalf to meet and present the following to members of the board:

A. Scope of your studies
B. Rationale incl. timeframes
C. Ethical considerations incl. study funding/ sponsorship
D. Outcomes for Firefighter mental health

To manage time effectively we will allow 60 minutes of presentation time including questions. To assist you in this the QFC has a question *on notice*:

1. How do current Fire & Rescue measures compare to contemporary clinical knowledge and practices.

The QFC board will meet on 18th October 2018, subsequently there will be another board meeting prior to the Christmas holiday period on a date to be determined.

Please feel free to email me directly at [redacted] with any questions you may have.

I wish you the best in your studies.

Regards

[redacted]

Philip Pafford AFSM MIFireE CFO
President

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT
– Initial Information –

Investigation of Biofeedback interventions in symptom remediation of stress disorders in Emergency Responders

QUT Ethics Approval Number 1900000154

Research team

Principal Researcher: Ms Tamara Lorensen PhD candidate
[redacted]

Why is the study being conducted?

This research project is being undertaken as part of a PhD study for Tamara Lorensen.

The purpose of this project is to:

1. Measure your levels of health and wellbeing as they relate to stress.
2. Design biofeedback options that address your levels of stress.
3. Implement and evaluate the biofeedback intervention to see if this has helped your stress levels.

You are invited to participate in this research project because you are an operational career Emergency Service working employed in a Queensland Emergency Services organisation and considered to face extra stressors due to your occupation.

If you are healthy, working as an operational career emergency service worker and do not have any mental or health condition that is not stable such as taking a new medication you may be able to participate.

Exclusion criteria: There are some situations that may mean you are not eligible to take part these include:

Currently not working (the study focus is on working emergency responders), a history of head injury, a PTSD diagnosis, an unstable medical condition, suicide risk or ideation, history of seizures, current substance abuse.

Unstable medical condition: is any medical condition that is in the early stages of investigation or management. For example: an unresolved orthopedic concern and the use of pain medications; the early stages of controlling blood sugar (pre-diabetic) where stability is still being assessed or where a condition is not considered stable and well controlled (pre-hypertension).

The reason for this is that it helps to keep the information we learn about the results reliable and that the people in the study are similar.

What does participation involve?

The first session you attend will require your consent to allow the researcher to meet face to face with you to explain all aspects of the study. As the biofeedback will use electronic equipment it is important that you see this and understand how it will work. The devices measure different physical signals such as your heart rate and breathing and you can see these signals on a computer monitor. The devices do not do anything to you and are just monitors but it is important that you are well informed about them. For example, the brain wave biofeedback requires placement of three small electrodes, about the size of a small fingernail, on your head with a sticky paste and cotton ball. These are easily removed and cleaned before you leave. There is nothing special you need to do to prepare for this.

If you are satisfied with the information explaining the details of the study and wish to participate in the research a second consent will be provided that acknowledges that you wish to volunteer.

You can elect to commence your participation in this first session or have time to think about it.

If you wish to commence I have eight surveys that will assist in measuring your levels of stress. These are standard measures and ask questions such as "I felt as though I was using a lot of nervous energy" or "I tended to over react to situations". You answer the questions mostly with a check box such as *some of the time* or *always*.

I will also collect information about you such as:

- How long have you been employed as an Emergency Responder?
- What is your marital status?
- How old are you?

I will also ask you questions about your occupation and experiences as an emergency responder such as:

- What do you consider the challenges of your occupation?
- Do you consider your job stressful?
- Do you feel supported by your organization?

This will conclude your first 90-minute session.

There are different types of biofeedback and the scores from the surveys will indicate which type of biofeedback you may be doing. Once your levels of stress are measured a biofeedback condition will be matched to you. For mild levels of stress there is biofeedback training, for moderate levels of stress there is neurofeedback training and for those with more significant levels of stress biofeedback and neurofeedback will be combined.

In order to investigate whether the training is beneficial there is a group of participants that commences training. There is also a matched group that is called a control. The control group does not do the training. This design allows the researcher to compare

the training group with a group that does not do the training to see if the training has been helpful. When the training group finishes, the results are examined and if it is shown that the training is beneficial the control group can commence training if they wish to.

You are placed into the training group or control group in a random way. After the surveys have been scored and if you are allocated to a training group I will contact you to arrange some appointments that fit in with your shift schedule. All treatments include education and training about the stress response to improve your understanding of what happens to the body during stressful experiences.

When you come to your sessions I will take your blood pressure and you will be coached in the biofeedback so that you can learn to reduce your stress and build resilience. Blood pressure may be a way of measuring stress as stress can increase your blood pressure. If you are able to learn to relax after a stressful situation then your resilience may improve.

In your first session there is also a computerized test of attention where you press a micro-switch when you see a target. This is called a TOVA. The USA-based company is assisting the researcher with reduced costs of the test and a part of this arrangement is their request to share the data. Your data is entered via a code only and the information sent to TOVA is your ID, age and gender. Prior to TOVA using the data they remove researcher and participant information. Your specific consent to use TOVA will be required.

You will need to attend training sessions at a clinic in Paddington, Brisbane. This clinic has the necessary resources and equipment in place, so the study will be conducted here rather than at QUT. The initial visit will take approximately 90 minutes of your time as above. Subsequent training visits will take approximately 30-40 minutes. The number of visits required will depend on which biofeedback intervention you will do however the range is from 6-15 visits. This is to ensure that you have every opportunity to practice the skills for stress reduction. If you find benefit in the training and require further sessions, you are most welcome to have more.

During your training sessions some questions may include:

- What have you noticed about your stress response during the week?
- Have you found that you have reacted more positively or differently to challenging situations?

Your participation in this research project is entirely voluntary and is confidential. If you do agree to participate you can withdraw from the research project without comment or penalty. You can withdraw anytime during the initial interview. If you withdraw within 2 weeks after your interview, on request, any identifiable information already obtained from you will be destroyed. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT or your employer.

What are the possible benefits for me if I take part?

It is expected that this research project will have the potential to benefit you directly as it is an aim of the project to build resilience and wellbeing and provide training to improve stress reactions. It may also be that not all individuals would benefit. The research seeks to explore this. However, it can also potentially benefit the emergency

responders who face stressful challenges in their occupation by contributing to the body of research in the management of stress.

There will be no out-of-pocket expenses other than your travel to sessions and you will receive compensation for this.

What are the possible risks for me if I take part?

The risks associated with your participation may include the discomfort of discussing how you manage stress and your experiences of stress in your occupation.

You may also experience some discomfort while you are having your blood pressure taken as the cuff on the blood pressure monitor tightens around your arm.

The biofeedback procedures are non-invasive. You will have a monitor on your finger as a small clip and an elastic belt around your chest for monitoring your breathing patterns. If you have brain wave biofeedback you will have electrodes placed on your scalp with a paste. The electrodes do not do anything to you. They are best described as small stethoscopes that just monitor your brain wave activity which you can see on a computer monitor. If you attend the face to face information session this will be explained in detail and you will be able to see the equipment that is used.

For the physical measures, these are experiences that are not uncommon to have, such as having your blood pressure taken. The biofeedback procedures are not considered uncomfortable.

If you experience discomfort in discussing your stress, support can be provided to you. The researcher is a registered practicing psychologist and can provide you with information about further support or on-referral to appropriate services.

QUT provides for limited free psychology, family therapy or counselling services (face-to-face only) for research participants of QUT research projects who may experience discomfort or distress as a result of their participation in the research. Should you wish to access this service please call the Clinic Receptionist on **07 3138 0999** (Monday–Friday only 9am–5pm), QUT Psychology and Counselling Clinic, 44 Musk Avenue, Kelvin Grove, and indicate that you are a research participant. Alternatively, Lifeline provides access to online, phone or face-to-face support, call **13 11 14** for 24 hour telephone crisis support.

What about privacy and confidentiality?

All comments and responses will be treated confidentially unless required by law, or regulatory or monitoring bodies, such as the ethics committee.

I do have a regulatory requirement to report under certain circumstances however. This would occur where failure to disclose the information would place you or another person at imminent risk of harm or disclosure is required by law such as illegal activities. If this were to occur the researcher will follow the recommendations made by the Australian Psychological Code of Ethics. The researcher would discuss with you whether your doctor would be informed, a crisis assessment and treatment team notified or notifying the police.

You may decide this conflict of interest means you would not take part in the study and this is okay.

The names of individual persons are not required in any of the responses on the surveys or other tests. As an example, surveys will only have a code written on the paper such as JSO123. You will generate the code and the answers will only be known to you.

As the research project involves session notes:

- You will have the opportunity to verify your comments and responses, your name will not be on the notes.
- The record will be destroyed 5 years after the last publication.
- The record will not be used for any other purpose.
- Only the named researchers will have access to the records which are de-identified and coded.
- Only the principal researcher will know your name.
- It is not possible to participate in the research project without clinical notes. This is a requirement of good clinical practice. The clinical notes are held by the researcher only and are available for you to see at each session. Your code will be on the notes, not your name.

Every effort will be made to ensure that the data you provide cannot be traced back to you in reports, publications and other forms of presentation. For example, we will only include combined data from all the participants. An example to help you understand is: *80% of participants reported positive benefits*. If you provide some highly relevant feedback about your training, we will not use any names to describe your comments.

Any data collected as part of this research project will be stored securely as per QUT's Management of research data policy.

Please note that non-identifiable data from this research project may be used as comparative data in future research projects or stored on an open access database for secondary analysis. If this occurs the data is not able to be identified by anyone else, for example, the data may include only the scores from the surveys you complete.

How do I give my consent to participate?

If you would like to attend the initial information session, please contact Tamara Lorensen.

We would like to ask you to sign a written consent form on your first appointment to confirm your agreement to participate in the initial information session.

After showing you the equipment to be used and explaining how the study will work, there is a second consent form for you to indicate your understanding and consent to proceed if you wish to.

What if I have questions about the research project?

If you have any questions or require further information, please contact one of the listed researchers:

Tamara Lorensen [redacted]

What if I have a concern or complaint regarding the conduct of the research project?

QUT is committed to research integrity and the ethical conduct of research projects. If you wish to discuss the study with someone not directly involved, particularly in relation to matters concerning policies, information or complaints about the conduct of the study or your rights as a participant, you may contact the QUT Research Ethics Advisory Team on 07 3138 5123 or email humanethics@qut.edu.au.

Thank you for helping with this research project. Please keep this sheet for your information.

CONSENT FORM FOR QUT RESEARCH PROJECT
Information Session

Investigation of Biofeedback interventions in symptom remediation of stress disorders in Emergency Responders

QUT Ethics Approval Number 1900000154

RESEARCH TEAM

Tamara Lorensen [redacted]

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document sent to you regarding this research project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw without comment or penalty.
- Understand that if you have concerns about the ethical conduct of the research project you can contact the Research Ethics Advisory Team on 07 3138 5123 or email humanethics@qut.edu.au.
- Agree to participate in the research project initial information session.

Name _____

Signature _____

Date _____

PLEASE RETURN THE SIGNED CONSENT FORM TO THE RESEARCHER.

CONSENT FORM FOR QUT RESEARCH PROJECT
Participation in Study

Investigation of Biofeedback interventions in symptom remediation of stress disorders in Emergency Responders

QUT Ethics Approval Number 1900000154

Research team

Tamara Lorensen [redacted]

Statement of consent

By signing below, you are indicating that you:

- Understand the procedures of the project to my satisfaction.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw without comment or penalty. You can withdraw from the study at any time. If you withdraw within 2 weeks after your interview, on request, any identifiable information already obtained from you will be destroyed.
- Understand that if you have concerns about the ethical conduct of the research project you can contact the Research Ethics Advisory Team on 07 3138 5123 or email humanethics@qut.edu.au.
- Understand that non-identifiable data from this project may be used as comparative data in future research projects.
- Understand that the TOVA™ Company USA, as a result of their support in providing the test will receive data about the attention test results and include an ID number, gender and age in years and months only.
- Agree to participate in the research project.

Name _____

Signature _____

Date _____

Phone _____

Code _____

Please return the signed consent form to the researcher.

Appendix E: Neurofeedback process

Neurofeedback is the name given for brain wave biofeedback. Electrodes placed on your scalp can detect the brain waves and display them on a computer monitor. Nothing is going into you and the brain waves are just being monitored and displayed. A doctor uses a stethoscope to listen to a heart; in brain wave recording the electrodes detect the brain waves and allow you and I to see the signal.

Figure E 1. **Example of participant in neurofeedback session**

Skin Preparation:

An alcohol swab is used to clean the skin surface of parted hair only at the site of the electrode placement (brand: Mediswab). This is similar to the swab a person receives prior to having a blood test. Next a gel is applied by a cotton tip to slightly abrade the area. This area is not rubbed but gently massaged by the cotton tip (brand: Nu-Prep Gel).

Electrode Placement:

The cup of the gold head and ear clip electrodes are filled with a conductive medium paste (brand: 10-20 Paste). The electrode is pressed lightly onto the skin and covered with a cotton ball to secure it. At the conclusion of the Electroencephalogram (EEG) recordings the electrode is lifted from the skin and a warm water cotton ball is used to wipe the excess or remaining paste off the hair and skin.

The electrodes are about the size of the little finger fingernail. There are only three electrodes placed on your head. There is no preparation that you have to do, and the

three placements are cleaned before you leave so you will not have any paste left in your hair.

The signal does not provide for any diagnosis as there are only two scalp electrodes.

There are different types of brain waves. To understand, think of a car that is having the revving of the engine checked electronically. The car may be in neutral but the engine is running too quickly, or maybe the engine is running too slowly. We can notice these things when we are stopped at traffic lights and we know that the car needs servicing. Brain waves are similar, and we can detect that even if you are sitting still the engine or your brain is still overactive. Sometimes people describe this as overthinking, feeling stressed, having trouble switching off or winding down.

By seeing this brain wave activity, you can practice relaxation exercises and have a visual feedback of how you are doing at calming down. This is reflected in the brain wave patterns we can see. If you continue to train and practice these exercises you can learn to more naturally manage stress.

This technique can be very helpful. This is because you can see how you are doing and the feedback is very useful. Generally, when a psychologist is providing training for stress management, instructions are given verbally but there is no way of knowing exactly how you are doing. This method of providing feedback is considered more helpful.

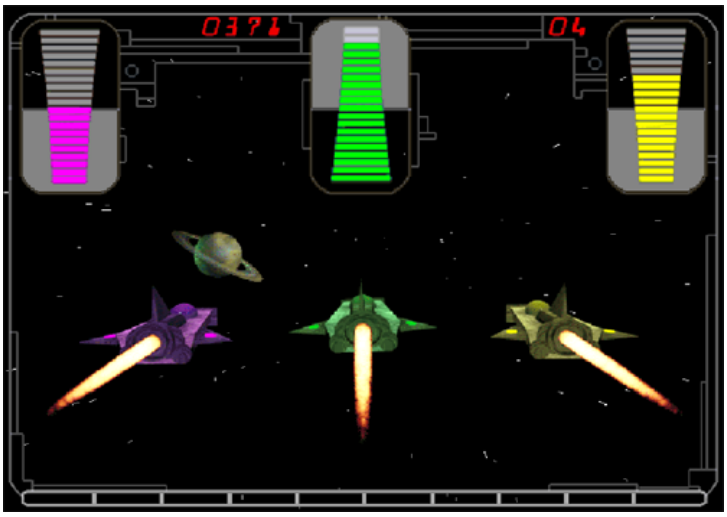


***Figure E 2*. Example of participant training screen**

The training screen that you will watch will have something that looks like a game but it is linked in the software to your actual brain waves. When you are relaxing and staying focussed on the task the game will work.

The potential benefits of training and learning stress management can assist in building your resilience and reactions to stressful situations. There are minimal risks with this intervention. This is because nothing is being done to you. You are just being provided with information about your brain waves and you are the one that is making changes. This can be relaxing your muscles, calming your breathing, maybe relaxing a tense jaw or remaining focussed.

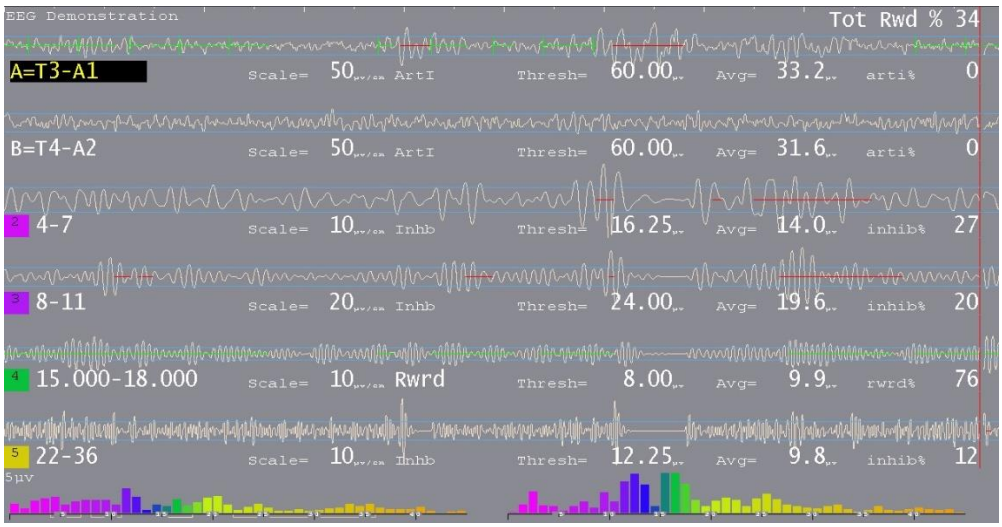


***Figure E 3*. Example of raw EEG signal of therapist's screen**