



**SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT
PSYCHOLOGY**

**A Systematic Review Examining the use of Neurofeedback as an Intervention in the
Management of Burnout**

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List of Abbreviations

BAT – Burnout Assessment Tool

BIS - Bispectral Index

CAM - Complementary and Alternative Healthcare and Medical Practices

CBT- Cognitive Behavioural Therapy

CPT – Computerised Performance Test

DSM-5 TR- Diagnostic Statistical Manual of Mental Disorders (Fifth Edition, Text Revision)

EBM - Evidence-Based Medicine practices

EEG - Electroencephalogram

HEG - Hemoencephalography

ICD-11 - International Classification of Diseases

JBI – Joanna Briggs Institute

LENS –Low Energy Neurofeedback System

LOERETA - Low-Resolution Brain Electromagnetic Tomography Neurofeedback Training

MBI - Maslach Burnout Inventory

NASA-TLX - National Aeronautics and Space Administration Task Load Index

NFT/NFB – Neurofeedback Training

Non-WEIRD – non Western, Educated, Industrialised, Rich, Democratic countries

PRISMA 2020 -The Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROSPERO - International Prospective Register of Systematic Reviews

qEEG – Quantitative Electroencephalogram

QOLI – Quality of Life Inventory

RCT – Randomised Controlled Trial

SBI - School Burnout Inventory

TABS - Traumatic Attachments and Belief Scale

WEIRD – Western, Educated, Industrialised, Rich, Democratic countries

WHO – World Health Organisation

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Chapter 1: Study Contextualisation

In the first chapter, the study's main topic of burnout will be introduced in relation to neurofeedback training. Thereafter, the study's rationale and main aims will be presented. Finally, the study's research problem and research question will be posed.

1.1 Introduction

Stress significantly impacts health, well-being, and behaviour (Epel et al., 2018; Schneiderman et al., 2005). Stress involves the activation of specialised functions of the nervous system to produce specific neurobehavioural responses (such as the “fight-flight-freeze” system) to respond and adapt to physically and psychologically demanding situations (Donahue, 2020; McEwen, 2017; Salleh, 2008). In the modern industrialised age, rapid social, economic, and cultural changes have increased the psychological pressures that people face (Schaufeli et al., 2009). For instance, one of the most pressing demands in today's world includes the need to obtain and sustain fiscal resources (such as money, job security and status) to survive (Hobfoll, 1998; Lucassen et al., 2013). One of the ways that people secure these resources is through paid employment (also known as work) (James, 2018). Work is deeply ingrained in certain social values and cultural beliefs (James, 2018) and remains a central priority in many people's lives (Giattino et al., 2020). Thus, it is understandable that work-related stress remains one of the biggest sources of stress in present times (Nakao, 2010; Tennant, 2001).

One work-related stress condition that has presented a major risk to a variety of different professions is burnout (Maslach & Leiter, 2016). However, burnout is not a formal diagnosis that is captured in the Diagnostic Statistical Manual of Mental Disorders (DSM-5) (Kakiashvili et al., 2013). Although hotly debated, it is considered a condition that overlaps with other syndromes and disorders such as stress, depression, and anxiety (Bianchi et al., 2015; Koutsimani et al., 2019; Golonka et al., 2019). Due to its ambiguous definition, interventions tailored specifically for burnout have not been implemented (Kakiashvili et al., 2013). While it may be advisable to consider the common pharmacological and

psychotherapeutic methods typically used in treating stress, depression and anxiety (First, 2022; Leichsenring et al., 2022) when implementing an intervention for burnout, it may also be worthwhile to explore other alternative interventions to ensure that burnout is addressed as adequately and holistically as possible (Tabish et al., 2008). One such alternative and non-invasive intervention is neurofeedback training (also known as Electroencephalogram (EEG) biofeedback or Neurotherapy). Although the efficacy of neurofeedback training is still under question (Kuznetsova et al., 2022), some studies have argued that it may be able to modulate patterns of psychological stress into more positive ones (Hammond, 2011; Theiler, 2015) and could improve depressive symptoms and decrease anxiety (Cheon et al., 2015). However, the use of neurofeedback training as a viable option for the management of burnout merits further investigation.

1.2 Rationale and Research Aims

Burnout is a condition that is not recognised as a disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5-TR) and no specific treatment or intervention method is assigned to managing it (Kakiashvili et al., 2013). Although this is the case, research has shown that burnout has serious implications for health and well-being and affects many different people in different spheres (Abramson, 2022; Amanullah & Shankar, 2020; Maslach & Leiter, 2016). Thus, it is of critical importance to study burnout and determine ways of addressing it. However, there is major ambiguity concerning the condition of burnout, as there is no formalised diagnostic criteria to support a particular intervention method (Bianchi, 2017). Relatedly, there is uncertainty regarding the effectiveness and practice of neurofeedback training as an intervention (Orndorff-Plunkett et al., 2017). Therefore, it is uncertain whether neurofeedback could potentially be applied in the management of burnout. One way to address these uncertainties would be to examine the existing literature for consensus on neurofeedback's applications in the burnout context. Therefore, a systematic review is needed to summarise, confirm, and contrast the existing evidence (Munn et al., 2018). By doing so, this may help synthesise the information on these

topics, provide some clarification into the efficacy and practice of neurofeedback and potentially provide some valuable insight in this area to serve as a benchmark for further research (Sataloff et al., 2021). Therefore, the main aim of this study is to systematically examine the neurofeedback training intervention in the management of burnout by employing a systematic literature review in this area.

While the main study aim is focused on the overall efficacy of neurofeedback training in the context of burnout, the secondary aim of this study is to examine how neurofeedback training and burnout studies are structured and executed by evaluating the various methodological, procedural, and practical choices made in the research process. Thus, the study also aims to determine what study information is depicted (such as the country of publication, year of publication, study design, the use of control groups and specification of control conditions), the various measures used to measure burnout (such as the types of instruments used as well as pre- and post- measures), what sample information is depicted (such as sample size, age group, ethnicity, occupation, gender and any inclusion or exclusion criteria for the participants), neurofeedback intervention characteristics (such as where the intervention took place, intervention duration, session length, number of sessions, training targets, whether the intervention was conducted by itself, in combination with or in comparison to other interventions and how this was accomplished), overall study results (such as whether the neurofeedback intervention showed significant or non-significant improvements in burnout characteristics), any specified study limitations (such as in measurement tools, intervention structure, study design, instruments or sample limitations) and the methodological quality of the studies utilised.

By systematically reviewing these procedures, we can determine the standards by which this intervention is implemented, the populations that have been utilised in burnout studies and how applicable and appropriate the neurofeedback intervention is in the burnout context. This will allow us to determine not only the long-term and short-term efficacy of neurofeedback but also allow us to highlight and address any potential gaps and uncertainties in neurofeedback training research designs. This will help to improve future

practice in this field and allow us to determine if neurofeedback training is an effective intervention. In doing so, we can determine the answer to whether neurofeedback training can be utilised as an intervention in the management of burnout.

1.3 Research Problem and Research Questions

Chronic work-related stress (an indicator associated with burnout) is being recognised as a significant occupational hazard across professions (Abramson, 2022; Maslach & Leiter, 2016) and a major contributor to the development of psychological disorders and the global burden of disease (Amanullah & Shankar, 2020; Atroszko et al., 2020; Seaward, 2018). The magnitude of this issue is evident as burnout has been recently added as an 'occupational phenomenon' in the International Classification of Diseases (ICD-11) (Atroszko et al., 2020; World Health Organisation [WHO], 2019). This highlights burnout not only as a specific workplace issue with implications for individuals but also as a larger social dilemma with implications for global health and well-being (Schaufeli et al., 2009; Tennant, 2001). Although burnout has been identified as a global phenomenon and its management has been recognised as important (Moustaka & Constantinidis, 2010; Schaufeli et al., 2009), there is no universal and empirically accepted definition of burnout (De Hert, 2020; Hillert et al., 2020). Consequently, the way burnout is conceptualised differs greatly between countries (Schaufeli et al., 2009) and has resulted in vague and subjective criteria used to define and guide management (De Hert, 2020; Rama-Maceiras et al., 2015). Although standardised diagnostic measures used to manage burnout and other mental health disorders such as the Maslach Burnout Inventory (MBI), Assessment of Quality of Life (AQoL) instrument, Primary Care Evaluation of Mental Disorders Patient Health Questionnaire, and Burnout Assessment Tool (BAT) have been developed and are widely accepted as scientifically valid (Anakwenze, 2022; Hawthorne et al., 1999; Williamson et al., 2018), the lack of objective diagnostic criteria and sanctioned intervention strategies makes the selection of holistic measures and specialised intervention strategies very difficult (De Hert, 2020; Kumar, 2015).

Despite these challenges, there is a growing number of interventions that may be used to deal with burnout (Williams et al., 2015). Burnout shares characteristics with other clinical conditions and disorders (Golonka al., 2019; Lacovides et al., 2002) and so the use of Evidence-Based Medicine practices (EBM) that apply and integrate quantifiable scientific principles, clinical expertise, and patient values may be the most logical intervention option (Tabish et al., 2008; Masic et al., 2008). However, due to burnout's complexity and ambiguity, causal explanations for it have not been resolved by EBM (Engebretsen, 2018) and this could limit its applicability to burnout (Sheridan & Julien, 2016).

Therefore, the consideration of complementary and alternative healthcare and medical practices (CAM) (Tabish et al., 2008) may be worthwhile in this context. One alternative intervention that has shown potential efficacy in the treatment of several conditions such as attention deficit hyperactivity disorder (ADHD), anxiety, depression, epilepsy, and autistic spectrum disorders is neurofeedback training (Marzbani et al., 2016). Consequently, neurofeedback training may present an additional treatment alternative for many conditions (Hammond, 2011). However, there seems to be a lack of unanimity in control criteria for neurofeedback studies, meaning that major ambiguity exists in the design and interpretation of protocols used in current neurofeedback research (Sorger et al., 2019). This has resulted in uncertainty regarding neurofeedback's effectiveness and efficacy (Niv, 2013). So ultimately, it is unclear whether neurofeedback training could be a possible intervention for burnout. Therefore, the main research questions (RQ) guiding this study are:

RQ1: How effective is neurofeedback training as an intervention in the management of burnout?

RQ2: What study design information, methods and intervention protocols are used in neurofeedback training and burnout studies?

RQ3: How are burnout outcomes characterised and measured in neurofeedback training studies?

RQ4: What types of burnout populations and sample characteristics are utilised in neurofeedback training studies?

Chapter 2: Literature Review

In this second chapter, a literature review will be presented that focuses on the main research topic of burnout and neurofeedback training. Initially, general mental health disorders will be introduced and then narrowed down to focus specifically on stress and anxiety. Subsequently, the stress and anxiety-related condition of burnout will be identified and discussed. After this, anxiety and stress will be contextualised in terms of their classifications as disorders and then their recommended treatments will be discussed. After this, alternative treatment methods will be briefly identified and then specifically focused on the fundamentals of neurofeedback training as an alternative intervention. Lastly, the debates, challenges and solutions of the neurofeedback intervention will be discussed.

2.1. Mental Health Disorders

Mental health disorders affect a considerable portion of the global population (Rehm & Shield, 2019) and are a major contributor to economic and social burden (Barlow et al., 2017; Jorm et al., 2017). In particular, anxiety and stress disorders are some of the most prevalent mental health disorder categories globally (Duval et al., 2015; Katzman et al., 2014; Remes et al., 2016; Stein et al., 2022). A recent study that was conducted during the Corona Virus disease (COVID-19) pandemic found that the global prevalence estimate for psychological distress was 50.0%, 36.5% for stress, 26.9% for anxiety and 24.1% for post-traumatic stress symptoms (Nochaiwong et al., 2021). Although these high estimates might be attributed solely to the pandemic, another study that compared anxiety and depression symptoms before and during the pandemic found that mental health was either unchanged or only minimally worsened by it (Sun et al., 2023). Thus, these high prevalence rates highlight stress disorders as a pervasive issue that has a severe impact not only on individuals and their well-being (Theiler, 2015) but also on global healthcare systems and the economy to manage them (Manchia et al., 2021). Consequently, it is of global socio-economic importance to identify and define these conditions, reduce negative symptoms, and improve well-being through interventions (Theiler, 2015; Remes et al., 2016).

Despite the acknowledgement that it is important to address these mental health issues, limited attention and resources are used to manage them, resulting in a significant mental health gap that exists globally (Bolton, 2014). Some of the most common contributors to this gap include a lack of access to necessary services, shortages in health care specialists and resources, an absence of effective mental health research, lack of necessary policy implementation and socio-cultural stigma associated with mental health conditions (Wainberg et al., 2017). These factors are particularly evident in low-to-middle-income countries where the prevalence of mental health disorders is much higher and access to mental health facilities and resources is much lower than in wealthier-income countries (Rathod et al., 2017; Sashidharan et al., 2016). Although global organisations such as World Health Organisation (WHO) have attempted to scale up mental health care services in these countries by introducing programmes such as The WHO Mental Health Gap Action Programme (WHO, 2024), there has been little global acknowledgement regarding how diverse cultural and religious beliefs about mental illness and receiving care may complicate and impede access to mental health care and the outcomes associated with it (Rathod et al., 2017). For instance, some cultures may believe that displaying characteristics associated with mental illness is a spiritual calling that must be nurtured and celebrated while others may believe that it is a sign of evil and the individual must be ostracised from society (Barlow et al., 2017; Caplan, 2019). Some of these stigmatising beliefs are even evident in countries where typical Westernised mental health practices are normalised, where people are viewed as “crazy” or “weak-minded” for having certain mental health conditions (Barlow et al., 2017). Therefore, not only can certain belief systems about mental health make it difficult to diagnose disorders and create and implement holistic interventions, but it can also make it difficult to determine which mental states should be medicalised and endorsed by industries and governments (Heinmann & Heinmann, 2017). Although some of these mental states (such as stress and anxiety) are becoming more prevalent and visible as debilitating disorders, some categories of these disorders are seen as merely “modern epidemics” or as non-scholarly “pop psychology” problems and are not viewed as important to address

(Maslach, 2004; Weber & Jaekel-Reinhard, 2000). Thus, it is important to have a full understanding of stress and anxiety and how debilitating these conditions can be to mental health and wellbeing.

2.2 Stress and Anxiety

Stress is defined as the bodies' physiological survival mechanism that allows adaptation to perceived or imagined pressures, challenges, and threats in the environment (Seaward, 2018; Siegrist, 2016). These perceived threats are managed by the activation of nervous system, endocrine system and immune system mechanisms that prepare the body for activity (Chu et al., 2023). Neurobehavioural responses such as the 'fight-flight-freeze' response are triggered by these systems to adapt immediately to these potential threats (Donahue, 2020; McCorry, 2007). Therefore, exposure to acute stress may be seen as positive as it strengthens biological mechanisms to cope with challenging situations (Salleh, 2008). However, exposure to chronic stress that involves continuous activation of these systems can become detrimental to physiology and cause and exacerbate physical and mental health problems (Chu et al., 2023; Seaward, 2018; Siegrist, 2016).

This acute and chronic stress response shares behavioural and neurological foundations with anxiety (Daviu et al., 2019). The main difference is that stress is the body's ingrained physiological adaption mechanism to immediate challenges (Daviu et al., 2019; Seaward, 2018), while anxiety is defined as an unpleasant emotional state characterised by persistent and excessive worry in anticipation of future threats (Sarason et al., 1990; Newman et al., 2017). Thus, anxiety can be understood as a psychological and physiological signal that is initiated by the stress response (Robinson, 1990). As with stress, anxiety is also associated with debilitating psychological and psychosomatic symptoms as well as severe behavioural consequences (Spielberger, 1971).

Although chronic stress is seen as detrimental to health, and stress and anxiety conditions are recognised as a global problem, the treatment of these conditions and other mental health disorders are currently limited by definitions and classifications from the

updated Diagnostic Statistical Manual of Disorders, Fifth Edition, Text Revised (DSM-5-TR) (American Psychiatric Association [APA], 2016; Barlow et al., 2017). The DSM-5-TR determines how disorders are understood and experienced, what disorders are considered legitimate and what treatments are considered appropriate (Bredström, 2019; Horwitz, 2021). Thus, stress and other anxiety issues are only considered to be disorders if they adhere to the DSM-5-TR's criteria of "clinically significant disturbance[s] in an individual's cognition, emotional regulation, or behaviour" (World Health Organisation [WHO], 2023, para.12). The DSM-5-TR does currently recognise some stress conditions as disorders and clusters them under *Trauma and Stressor related disorders* and includes disorders such as Reactive Attachment Disorder, Acute Stress disorder, Adjustment disorder, Disinhibited Social Engagement Disorder, Posttraumatic Stress Syndrome, and other specified and unspecified trauma and stressor-related disorders (Friedman et al., 2011). Relatedly, some anxiety conditions are recognised and clustered under *Anxiety Disorders* and include disorders such as Separation Anxiety Disorder, Panic Disorder, Social Anxiety Disorder and other specified and unspecified anxiety disorders (APA, 2016). However, the DSM-5-TR does not include and conceptualise all stress and anxiety disorders and conditions. This means that there may be a limited understanding of the scope, impact, and appropriate interventions of non-manualised conditions. One pervasive non-manualised condition that has been referred to as an 'epidemic' of many professions is burnout (Bianchi, 2017; Nadon et al., 2022; Zhang et al., 2020).

2.3 Burnout

Burnout is described as a stress-related condition that is commonly characterised by emotional depletion, mental exhaustion, depersonalisation, loss of motivation and cognitive workload impairment from prolonged exposure to chronic emotional and interpersonal stressors in the context of the workplace (Ossebaard, 2000; Leiter et al., 2015; Maslach & Leiter, 2016; Mazur et al., 2019). Although burnout affects an individual's performance in a working environment, it can also have far-reaching negative impacts on all aspects of an

individual's life (Carod-Artal & Vázquez-Cabrera, 2013). For instance, work is one of the most predominant ways that people obtain resources to survive (Hobfoll, 1998; Lucassen et al., 2013) and it is ingrained in sociocultural expectations of individual purpose and life fulfilment (Giattino et al., 2020; James, 2018; Siegrist, 2016). From this, it is clear that work is an important mediator for meeting sociocultural needs and gaining personal and life satisfaction through skill development, personal agency and control, reward, and recognition (Nakao, 2010; Siegrist, 2016; Tennant, 2001). Therefore, not only can work stress impact employee satisfaction, work productivity and mental health in the workplace but can also affect relationships, and general functioning and provoke manifestations of other mental disorders such as anxiety and depression disorders (Carod-Artal & Vázquez-Cabrera, 2013).

These issues coupled with the substantial changes evident in modern working environments due to technological advancements have greatly impacted people's productivity, working hours and overall mental health (Al-Khudhayr et al., 2021). Since burnout is not just a result of personal and psychosocial factors but also a result of larger organisational and environmental factors (Galletta et al., 2016), it is comprehensible how normalised workplace variables such as high demands, disagreement in workplace values, low sense of control and lack of social support can contribute to higher overall stress levels and general life dissatisfaction (Lindblom et al., 2006) and why work-related stress remains one of the biggest sources of stress in present times (Nakao, 2010; Tennant, 2001).

Relatedly, research has shown that burnout can affect almost anyone in almost any occupation (De Hert, 2020) and has been recognised across other non-work-related categories of people such as competitive athletes and students in the academic sphere (Gustafsson, 2007; Rahmati, 2015). Even though burnout is widespread across a variety of these contexts, the prevalence of burnout cannot be accurately determined as there is no existing diagnostic criteria to support it (Bianchi, 2017). Although burnout is not formalised in this way, there have been attempts to identify and quantify burnout. For instance, one measure that has been used as the gold standard for evaluating burnout is the Maslach Burnout Inventory (MBI) model (Williamson et al., 2018).

According to Maslach et al. (1997), MBI is a multidimensional model that is designed to measure and assess the continuous levels and patterns of burnout amongst groups of employees in a variety of occupations. The authors' MBI model encompasses three scales; exhaustion, depersonalisation and reduced personal accomplishment. These scale items are further elaborated upon with exhaustion described as feelings of fatigue, exhaustion, and energy depletion. Depersonalisation referred to as irritability, negative attitudes, and a loss of optimism and reduced personal accomplishment referred to as withdrawal from others, low morale and lack of perceived capacity to handle situations. (Maslach et al., 1997).

Although the MBI model is widely accepted and utilised (such as the three-scale model used as part of the ICD-11 conceptualisation of burnout) and considered to be extremely valid and reliable (Maslach et al., 2009; Sinval et al., 2022), it has also been criticised for its outdatedness as well as numerous conceptual, technical, and practical limitations (Schaufeli et al., 2020). Thus, other highly endorsed burnout measures such as Burnout Assessment Tool (BAT) have expanded on some of MBI's features and added elements to address the shortcomings present in these instruments (Lazauskaitė-Zabielské et al., 2023). For instance, the developers of BAT (Schaufeli et al., 2020) characterise burnout as a state of mental exhaustion, rather than just exhaustion. Similarly, there is the addition of the capacity to regulate emotional and cognitive processes rather than just having negative attitudes or emotions. These characteristics manifest as chronic fatigue which induces the inability and unwillingness to work due and mental distancing towards one's profession (Schaufeli et al., 2020). It has also added secondary burnout characteristics to these main attributes, such as psychological stress manifestations which manifest as aspects such as feelings of worry or sleep problems and psychosomatic symptoms which manifest as aspects such as muscle tension, headaches and depressed mood (Lazauskaitė-Zabielské et al., 2023).

Although the BAT model could arguably be seen as more comprehensive than the MBI model, both rely on questionnaires that employ burnout characteristics are highly contestable in psychological, scientific and medical practices (Heinemann & Heinnemann,

2017). Similarly, both models include characteristics that are present in or shared with other disorders (Maslach et al., 1997). Specifically, there is a high comorbidity with depressed mood, fatigue, diminished interest in activities, diminished cognitive abilities, sleep disturbances, negative affect and an inability to concentrate which are also characteristics associated with disorders such as depression, anxiety and stress (Maslach et al., 1997; Substance Abuse and Mental Health Services Administration, 2001). Therefore, it is uncertain whether these models are measuring a separate burnout condition or if burnout should be classified as an extension of these disorders (Nadon et al., 2022). Thus, determining an appropriate and effective intervention method specifically for burnout may be problematic. However, because the current conceptualisations determine that burnout is a separate condition that shares characteristics with these disorders (although debated), it is argued that current recommended intervention methods may be designed to facilitate these components (Maslach et al., 1997).

2.4 Current Intervention Methods

Currently, the most recommended intervention methods for depression, anxiety and stress disorders are pharmacological and psychotherapeutic options (First, 2022; Leichsenring et al., 2022) that have shown empirical evidence-based efficacy (Horwitz, 2021; Theiler, 2015; Tolin, 2010). Some of the most common pharmacological treatment options for these disorders include antidepressant agents such as selective serotonin reuptake inhibitors (Bandelow et al., 2012; Bertolini et al., 2020) serotonin-norepinephrine reuptake inhibitors and norepinephrine-dopamine reuptake inhibitors (Fasipe, 2018). These drugs may improve symptoms, reduce disability, and shorten the progression of these disorders especially where other interventions or appropriate professionals are unavailable (WHO, 2009). However, such pharmacological treatments are not specifically recommended for burnout but rather target overlapping characteristics such as depression and anxiety. Consequently, it is unclear how these pharmacological methods would work to reduce burnout specifically. Relatedly, there are possible undesirable consequences associated with

pharmacological interventions. For instance, pharmaceutical treatments involve the risk of developing distressing physical, cognitive, and behavioural side effects from drug use (Asher et al., 2017; Aronson, 2016). These side effects along with the cost, tolerance and individual perceptions of specific drugs may negatively impact adherence to pharmacological treatment outcomes (Asher et al., 2017; Carvajal, 2004). Therefore, the use of pharmaceutical methods to manage burnout remains controversial and unsanctioned (Kakiashvili et al., 2013).

However, there have also been various psychotherapeutic treatments that have been developed to treat these disorders (Barth et al., 2016). Some psychotherapeutic treatments include interpersonal, psychodynamic, and humanistic approaches (Barth et al., 2016). Research has shown that therapeutic interventions can help reduce symptoms, accelerate the healing process, and increase coping skills (Lambert, 2015). This is also evidenced in the burnout context as certain therapeutic intervention methods have shown some efficacy in the management of burnout (Korczak et al., 2012). For instance, one randomised controlled trial (RCT) study implemented an 8-week group cognitive-behavioural therapy (CBT) program. It involved addressing thoughts and behaviours for a group of 242 Iranian English teachers (62 in the CBT group) presenting with burnout characteristics as measured by a modified MBI educator survey (Ghasemi et al., 2023). The study results found that participants in the CBT group showed greater improvements in their overall scores when compared to the control group and that these improvements were maintained in the follow-up measures six months later (Ghasemi et al., 2023). Similarly, another study implemented a 12-week rational emotive behaviour therapy program (a type of CBT therapy involving addressing negative beliefs, emotions, and behaviours) on 124 undergraduate students in Nigerian public tertiary institutions presenting with burnout characteristics as measured by a modified Maslach Burnout Inventory-Student Survey (Ogbuyana et al., 2019). The results of the study showed that the program has a significant effect on the symptoms of burnout in the intervention group than the participants in the non-intervention group, illustrating its potential effectiveness for managing burnout (Ogbuyana et al., 2019).

Although some psychotherapeutic therapies such as Cognitive Behavioural Therapy (CBT) have shown the potential to manage the characteristics associated with burnout, the results of many studies involving therapeutic approaches are considered preliminary, insufficiently evaluated, and limited in their reach (Korczak et al., 2012). Relatedly, like pharmacological approaches, psychotherapeutic approaches may also have negative outcomes associated with their practice. For instance, individual client variables such as stigma, tolerance, and intention to seek therapy, external variables such as therapist expertness and style and intervention techniques such as satisfaction and effectiveness of treatment may severely impact adherence and effectiveness of the intervention method (Barlow, 2010; Constantino et al., 2019). Thus, it is uncertain whether psychotherapeutic interventions may be effective in the management of burnout.

Considering the negative outcomes associated with both psychotherapeutic and pharmacological approaches, it may be worthwhile to consider other intervention methods that could potentially be more effective at inducing change and improving patient outcomes for burnout (Carruthers, 1999; Rebello et al., 2014). There have been major research developments, experimental work, and technological advancements in brain imaging mechanisms, and neuromodulatory techniques that may address these conditions without the side effects or negative outcomes associated with psychotherapeutic and pharmacological interventions (Dudek & Dodell-Feder, 2021; Duval et al., 2015; Hannan, 2022). One such technique that utilises electroencephalography (EEG) technology is the neurofeedback training intervention (Dudek & Dodell-Feder, 2021).

2.5 Neurofeedback Training

Neurofeedback training (also known as EEG biofeedback) is a non-invasive, non-medical intervention that emerged in the 1960's (Thibault et al., 2016; Tursic et al., 2020). It involves training and reconditioning the electrical wave activity inside the brain (Budzynski et al., 2009; Hammond, 2011; Mazur et al., 2019; Yeh et al., 2021). Neurofeedback training is based on operant conditioning which reinforces desirable brain activities and reduces

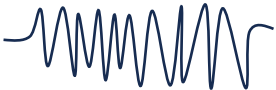
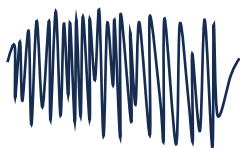
undesirable activities through positive or negative feedback (Marzbani et al., 2016; Mcleod, 2023). Training is done by placing electrodes (which measure the brain's electrical patterns) on specific areas on a patient's scalp that correlate to specific cortical brain regions (Marzbani et al., 2016) and using specialised computer software to transmit live, real-time audio and visual feedback to the patient (Budzynski et al., 2009; Hammond, 2011; Mazur et al., 2019; Yeh et al., 2021). The patient becomes aware of their own brainwave activity and can influence and change, regulate and attune it over time through continued training (Budzynski et al., 2009; Hammond, 2011; Thibault et al., 2016; Mazur et al., 2019; Yeh et al., 2021).

The fundamental tenet of neurofeedback training is based on the brain's ability to change, reorganise, and remodel its structure, function, and connections to respond to and adapt to internal or external stimuli, which is known as neuroplasticity (Cramer et al., 2011; Demarin et al., 2014; Socolovsky & Malessy, 2021). It is understood then that these structural and functional changes can either strengthen neural connections and increase cognitive reserve (i.e., positive neuroplasticity) or weaken neural connections and decrease cognitive reserve (i.e., negative neuroplasticity) (Vance et al., 2010). Factors such as physical activity and cognitive remediation may promote positive neuroplasticity, while factors such as poor sleep, poor health, chronic stress, depression, and neurodegenerative disorders may promote negative neuroplasticity (Pittenger & Duman, 2008; Vance et al., 2010). The neurofeedback training intervention has demonstrated positive neuroplastic changes by enhancing cognitive abilities and improving brain and behavioural outcomes (Dessy et al., 2020; Dudek & Dodell-Feder, 2021; Liu et al., 2014) in a variety of conditions (Budzynski et al., 2009; Hammond, 2011; Micoulaud-Franchi et al., 2015; Marzbani et al., 2016; Arns et al., 2017; Huang et al., 2019; Paret et al., 2019; Mazur et al., 2019; Yeh et al., 2021), such as Attention Deficit Hyperactivity Disorder (Gevensleben et al., 2009; Enriquez-Geppert et al., 2019), Obsessive Compulsive Disorder (Sürmeli & Ertem, 2011), stroke (Mihara et al., 2013) insomnia (Pérez-Elvira et al., 2019) and autism (Mekkawy, 2021).

Neurofeedback training facilitates these positive neuroplastic changes by using EEG analyses to measure the brain's electrical activity (Trayford, 2023). Quantitative Electroencephalogram (qEEG) is a modern EEG technique that records, processes, and analyses digital EEG data using complex algorithms (Livint Popa et al., 2020). These analyses are then used to develop a training protocol that will help clients self-induce increases or decreases in targeted EEG bands based on real-time feedback of brainwave activity to ultimately produce long-term changes in behaviour (Kropotov & Kropotov, 2009; Rogala et al., 2016; Tas et al., 2014). These targeted bands refer to brain waves that occur at various fast or slow frequencies (delta, theta, alpha, beta, and gamma) and at various amplitude speeds which are measured in cycles per second (hertz) (Hammond, 2011; Marzbani et al., 2016). Each frequency band is associated with different mental states and functioning (Hammond, 2011; Marzbani et al., 2016). This is captured in more detail in Table 1 below.

Table 1.

Specific brainwaves with their characteristics

Brainwave	Example of Brain wave (per second)	Amplitude (Hz)	Speed	Associated Characteristic
Delta (δ)		(Extremely Slow) 0.5-4		Sleep, deep unconsciousness
Theta (θ)		(Slow) 4-8		Creativity, depression, anxiety, meditative state, distractibility
Alpha (α)		(Medium) 8-13		Meditation, relaxation, peacefulness, passive attention
Beta (β)		(Fast) 13-30		Thinking, sustained attention, alertness, active mind, anxiety
Gamma (γ)		(Extremely Fast) 30-100		Learning, problem-solving, mental sharpness, concentration

Note. Adapted from “Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications,” by H. Marzbani, H.R Marateb and M. Mansourian, 2016, *Basic and Clinical Neuroscience Journal*, 7(2), p.144 (<https://doi.org/10.1016/B978-0-12-800951-2.00044-3>) and from “Measuring Brain Waves in the Classroom” by N. van Atteveldt, T.W.P Janssen, and I. Davidesco, 2020, *Frontiers for Young Minds*, 8, p.96 (10.3389/frym.2020.00096)

Essentially, neurofeedback training protocols involve conditioning EEG waves (brainwaves) associated with a particular frequency band using real-time auditory or visual feedback (Wang et al., 2015). This will be accompanied by changes in the relative power of that band, either by amplitude suppression or upregulation (Wang et al., 2015). These induced changes will then produce beneficial alterations to cognitive and motor performance that are associated with the targeted band’s function (Rogala et al., 2016). For instance, the training of alpha waves can induce a relaxation response in people who suffer from anxiety, Attention Deficit Hyperactivity Disorder and insomnia (Ossebaard, 2000; Marzbani et al., 2016). The active training of specific power bands in specific brain locations is also known as frequency/power neurofeedback and is the most commonly used method in neurofeedback training interventions (Marzbani et al., 2016). However, as shown in Table 2, there are also other types of neurofeedback training protocols which make use of other training protocols.

Table 2.

Types of Neurofeedback Training Protocols

Training Protocol	Image Modality	Method	
Frequency/power Neurofeedback	EEG	Changes the amplitudes of brain waves at specific brain areas (surface level)	Active
Low Energy Neurofeedback System (LENS)	EEG	Introduces weak electromagnetic signals to change brain waves	Passive
Hemoencephalography (HEG)	NIR (Near-infrared Spectroscopy)	Measures blood flow circulation and oxygenation in the brain	Active

Live Z-Score Neurofeedback Training	EEG	Produces continuous feedback by comparing live EEG activity to normative databases (age and gender)	Active
Low-resolution brain electromagnetic tomography Neurofeedback Training (LORETA)	EEG	Estimates relative electric activity, brain density and volume in specific brain regions and targets them (underlying brain areas)	Active
Functional Magnetic Resonance Imaging Neurofeedback (fMRI)	fMRI	Regulate brain activity from feedback of deep brain structures	Active
Infra-slow Neurofeedback training protocols (ISF-NF)	AC/DC Amplifier	Utilises specific setting protocols to encourage and promote slower EEG brain wave capacities	Passive

Note. Data for frequency/power neurofeedback is from “Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications,” by H. Marzbani, H.R. Marateb and M. Mansourian, 2016, *Basic and Clinical Neuroscience Journal*, 7(2), p.147 (<https://doi.org/10.1016/B978-0-12-800951-2.00044-3>). Data for Low Energy Neurofeedback System (LENS) is from “Improvement of Neurofeedback Therapy for Improved Attention Through Facilitation of Brain Activity Using Local Sinusoidal Extremely Low-Frequency Magnetic Field Exposure” by Y. Z. Mehran, M. Firoozabadi and R. Rostami, 2015, *EEG and Clinical Neuroscience Society*, 46(2), p.1 (10.1177/1550059414524403). Data for Hemoencephalography (HEG) is from “Clinical Efficacy of a New Automated Hemoencephalographic Neurofeedback Protocol,” by A.M. Dias, A.M. Van Deusen, E. Oda and M.R. Bonfim, 2012, *Spanish Journal of Psychology*, 15(3), p.931 (https://doi.org/10.5209/rev_SJOP.2012.v15.n3.39385). Data for Live Z-Score Neurofeedback Training is from “Live Z-Score Neurofeedback”, by T.F. Collura, 2016, *Association for Applied Psychophysiology & Biofeedback*, 44(4), p.212 (10.5298/1081-5937-44.4.01) and “Changes in EEG Activity Following Live Z-Score Training Predict Changes in Persistent Post-concussive Symptoms: An Exploratory Analysis” by J. Hershaw and C.A. Hill-Pearson, 2022, *Frontiers in Neurology*, 13, p.3 (<http://dx.doi.org/10.3389/fneur.2022.714913>). Data for Low-resolution brain electromagnetic tomography Neurofeedback Training (LORETA) from “Clinical Neurotherapy: Chapter One - Definitions, Standard of Care and Ethical Considerations” by C. Hammond, 2014, *Academic Press*, p.2 (<https://doi.org/10.1016/B978-0-12-396988-0.00001-5>). Data for Functional MRI Neurofeedback (fMRI) from “Functional

Magnetic Resonance Imaging (fMRI) Neurofeedback: Implementations and Applications" by W.I. Dewiputri and T. Auer, 2013, *Malaysian Journal of Medical Sciences*, 20(5), p.5. Data for Infra-slow Neurofeedback training protocols (ISF-NF) from "Infra-Low Frequency Neurofeedback: A Systematic Mixed Studies Review" by F.Bazzana, S. Finzi, G. D. Fini and F. Veglia, 2022, *Frontiers in Human Neuroscience*, 16, p.2 (<https://doi.org/10.3389/fnhum.2022.920659>).

As with frequency/power neurofeedback, these other types of neurofeedback protocols have also shown potential to be effective interventions. For instance, LENS neurofeedback has shown promise in its ability to manage and treat certain disorders (Gilham et al., 2012). One case report study examined the use of LENS to treat individuals with chronic anger and violent tendencies as a result of significant traumatic brain injuries (Hammond, 2010). The results showed that significant changes in feelings of anger and improvements in behaviour and mood were reported by participants after participating in the LENS training session, thus illustrating its potential to deal with and manage different diagnoses (Hammond, 2010). Similarly, live Z score and LORETA neurofeedback protocols have also shown promise to be effective cognitive enhancement tools (Koberda, 2014). For instance, one study utilised LORETA Z-score neurofeedback to treat a 55-year-old man suffering from a substance abuse disorder (alcohol) coupled with a depression/mood disorder (Center, 2014). The results of the study showed that the participant demonstrated significant improvements in overall cognitive function and mood as well as a significant reduction in alcohol consumption which was still evident at 14 months post-intervention training session (Center, 2014). Thus, like frequency/power neurofeedback, these other protocols have also shown the potential to produce positive outcomes and possibly reduce negative characteristics associated with certain disorders/conditions.

2.5.1 Neurofeedback Training Debates

However, despite the development of these progressive training protocols and evidence of positive outcomes in the management of certain conditions, the neurofeedback intervention remains controversial (Orndorff-Plunkett et al., 2017). There have been major

debates regarding the clinical efficacy of neurofeedback (Thibault et al., 2016). For instance, there are relatively few neurofeedback studies that are well-designed with stringent control conditions resulting in inadequate reports of crucial measures, a lack of quality randomised controlled trial studies available and recommendations based on small sample sizes (Fovet et al., 2015; Niv, 2013; Tursic et al., 2020). For example, one study conducted a systematic review of 99 neurofeedback studies and found that 38 studies did not utilise a control condition, 39 utilised a placebo condition (with only six utilising a double-blind condition) and 19 used a slightly altered control condition (such as no treatment control) (Thibault et al., 2018). Similarly, another study focusing on neurofeedback reporting and effects conducted a systematic review of 66 studies and noted that many of the studies utilised small samples but only three studies justified their sample size with power calculations (Tursic et al., 2020). Similarly, only 43 studies indicated a control condition, with 27 of them receiving feedback from a different brain region, 1 receiving artificially created (sham) neurofeedback intervention and 5 receiving no alternative intervention (Tursic et al., 2020). The results of these two studies indicate the presence of varied and sometimes non-existent control conditions, small sample sizes and inadequate study designs that are currently evident in neurofeedback training studies. Due to these inconsistencies, other arguments suggest that neurofeedback training results are no better than a placebo as without control conditions (such as a sham group) is difficult to determine if neurofeedback training is solely responsible for improvement or if certain psychosocial elements can lead to nonspecific effects (Thibault et al., 2016; Schabus et al., 2017).

While these systematic reviews illustrate the fundamental issues present in neurofeedback training studies, both do not focus on neurofeedback's effectiveness in the context of burnout. So, while these reviews are useful for understanding neurofeedback training's limitations, more is needed to determine its usefulness in the context of burnout

Despite neurofeedback training's design limitations, evidence has shown that neurofeedback training has the potential to change brain activity and has been linked to clinical improvements in many different disorders (Fovet et al., 2015). However, there are

disputes as to whether a positive relationship between frequency band changes and behavioural effects exists and if these changes translate to meaningful improvements over time (Rogala et al., 2016; Thibault et al., 2018). Certain longitudinal studies, such as one conducted in children with autism, found that the improvement and maintenance of executive functions and social behaviour that was evident at the end of a 40-session neurofeedback training intervention was still present in the same population at the 12 months post-intervention follow up (Kouijzer et al., 2009). However, another study that implemented a neurofeedback intervention and sham neurofeedback intervention focusing on executive function impairments in 58 adults (Smit et al., 2023), found improvements in working memory, reaction time and conflict monitoring were present at the 6 month-follow up that were specific to the neurofeedback group. However, the findings also highlighted that no immediate improvements were noted in the intervention group and that changes in executive functioning in daily life were not specific to the neurofeedback training intervention (Smit et al., 2023). Thus, from these results, it is difficult to determine if these long-term positive effects were due to neurofeedback training itself or some other factor.

Along with study design inadequacy and long-term efficacy uncertainty, another major criticism is that a large proportion of participants fail to gain significant control and self-regulate their brain activity even after several training sessions (Khodakarami & Firoozabadi, 2020; Weber et al., 2020). However, various factors such as learning strategies, cognitive differences, working memory abilities, internalisation of sensory information, mood, sleeping difficulties and comorbid conditions can influence an individual's ability to learn and sustain these changes (Sakurada et al., 2022; Smit et al., 2023). Similarly, external factors such as the type of feedback, duration of training, environment and rewards may also influence the ability to self-regulate (Sepulveda et al., 2016). Therefore, some critiques determine that the reason for the lack of self-regulation is that the application of standardised neurofeedback protocols is not adjusted for these individual variances (Weber et al., 2020).

However, there is uncertainty regarding which neurofeedback protocol is optimal as some argue that standardised protocols are more efficacious and produce results that would

allow generalisability and more acceptance in medical and professional domains (Evans, 2002; Hasslinger et al., 2022). However, others argue that individualised approaches improve clinical outcomes (Escolano et al., 2014; Hellrung et al., 2022). For instance, one study compared an individualised versus non-individualised neurofeedback training intervention for improving attention (Gu et al., 2022). The results of the study showed that the individualised group had higher activation in certain brain areas, a more significant decrease in reaction times and an overall higher improvement rate of attention than the non-individualised group (Gu et al., 2022).

Although there is no definite conclusion to determine which protocol is most effective or optimal, both methods have also been criticised for being time-consuming, expensive, and inaccessible (Marzbani et al., 2016). While some neurofeedback sessions have shown positive improvements in just a few weeks, other more severe disorders may need more continuous and long-term sessions (Rance et al., 2018). This means that the potential cost to implement these sessions along with the general expense of operating expensive equipment may be costly and make it difficult for those with financial hardships and limited availability to fully participate in this intervention method (Arns et al., 2017; Oliviera et al., 2022).

Taken together, mental health disorders are extremely detrimental to the global burden of disease. In particular, stress and anxiety disorders are some of the most prevalent mental health disorder categories worldwide and are a significant contributor to global health and economic burdens. Although the treatment of these disorders is important, a significant mental health gap currently exists due to a lack of service delivery, lack of resources and professionals, absence of mental health research and stigma and socio-cultural beliefs that prevent and reduce adequate care. One such work condition that is becoming more prevalent in many professions and other spheres of society is burnout. Although it is acknowledged as detrimental to well-being and functioning, it is not officially recognised as a disorder and thus no treatment/intervention plan has been assigned to it. This has resulted in

vague and subjectively applied burnout measures and no clear understanding of its aetiology to guide an appropriate intervention method.

Thus, recommended interventions such as pharmacological and psychotherapeutic interventions may not be sanctioned or relevant for managing burnout. However, alternative non-invasive interventions such as neurofeedback training may be considered for the management of burnout due to its potential to produce positive outcomes in the management and treatment of other disorders. However, neurofeedback training has been criticised for being time-consuming, expensive, and inaccessible as well as having poorly designed studies with no stringent control conditions. This has resulted in uncertainty regarding its long-term effectiveness, what is the most optimal protocol to follow and whether participants can actually gain self-control over their brain wave activity. Therefore, it is difficult to clearly ascertain neurofeedback's efficacy as an intervention tool in this context (Marzbani et al.,2016; Rogala et al., 2016; Schabus et al.,2017).

Therefore, the main aim of this study is to investigate if neurofeedback can be considered a viable intervention alternative for burnout by conducting a systematic review of the current literature. This study also aimed to determine what study information is depicted, what study designs and intervention protocols are utilised, how burnout is measured, and what kinds of populations are used in these studies- as a clearer understanding of protocols, methodologies, study designs and measures is needed in this context.

Chapter 3: Methods

In the third chapter, the chosen study design of a systematic review will be introduced. Subsequently, the methodological steps utilised in the review will be outlined. These steps will outline the search strategy undertaken as well as the eligibility criteria for the types of studies, types of participants, types of interventions and types of outcomes that were included and excluded in the study. Following this, the selection process, data collection process, critical appraisal and synthesis methods will be presented. Finally, the study's ethical considerations will be discussed.

3.1 Systematic Review

The methodology that was utilised in this study is a systematic review. A systematic review is used to summarise, confirm, or refute available knowledge and current practice by establishing and critiquing the quality of its evidence and addressing any uncertainty or variation (Munn et al., 2018; de Vet et al., 2005). In doing so, a systematic review may provide valuable insight into the effectiveness of certain treatments (de Vet et al., 2005).

Systematic reviews are highly regarded as the best source of evidence (Moher, 2007) and are widely used as a starting point for developing clinical practice, guiding policy decisions, and orienting future research (Gholizadeh et al., 2020; Møller & Myles, 2016). However, the value of a systematic review is dependent on the quality of the review and how robust, reproducible, and generalisable the results are (Møller & Myles, 2016; Moher, 2018). Therefore, it is important that a systematic review follows stringent established standards to maintain the required level of quality and consistency (Gholizadeh et al., 2020). There are a few main guides that many researchers make use of to ensure this standard of excellence (Gholizadeh et al., 2020). One such method is The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). The main reason this method was selected is that one of the goals of this method is to evaluate the effectiveness of an intervention (Page et al., 2021) which is the main feature of this study.

Thus, the systematic review was conducted utilising The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. In accordance with PRISMA protocols, the systematic review was pre-registered at its inception via The International Prospective Register of Systematic Reviews (PROSPERO) database (registration number: CRD42023448860) to avoid duplication and enable comparison between reviews (Page et al., 2021). To complete the review, the study made use of the PRISMA 2020 27-item checklist which included detailed criteria that is recommended for reporting within the systematic review (Page et al., 2021).

3.1.1 Search Strategy

The following online databases were accessed manually via Wits online Library from the first of January 2003 to the 28th of August 2023 by two separate reviewers (DP & NT, a research assistant for the study); Web of Science, Google Scholar, Scopus, Medline, ProQuest, PsycINFO and EBSCOhost. These databases were chosen because they include a vast range of studies in health sciences and social sciences and thus could produce more results in this area. Searches were rerun by both reviewers on the databases one week later (the fourth of September 2023) and one month later (the fourth of October 2023) to ensure all eligible studies were considered. The databases were searched using search terms for burnout and neurofeedback with Boolean operators shown in Table 3.

Table 3.

Search terms with Boolean Operators for Burnout and Neurofeedback

Search terms
“burnout” AND “neurofeedback training” OR “burnout” AND “neurofeedback” OR burnout AND “EEG biofeedback” OR “burnout” AND “EEG” OR “burnout” AND “neurotherapy” OR “burnout” AND neuroimaging therapy”.

3.1.2 Eligibility Criteria

The following inclusion and exclusion criteria were used to filter searches used in the search strategy and to determine if articles met the requirements to be included in the review. As mentioned in the PRISMA 2020 checklist, these characteristics describe the types of studies, types of interventions, types of participants and types of outcomes included and excluded in the review (Page et al., 2021).

3.1.2.1 Types of Studies.

Inclusion Criteria. Studies were included if they mentioned the use of the neurofeedback intervention and burnout together. Studies were allowed to mention anxiety or stress and neurofeedback if these specifically mentioned burnout characteristics and no other official stress or anxiety disorders. There were no restrictions on the demographic parameters of studies as the study's aim was for a general understanding of neurofeedback not on a specific population. Relatedly, all research designs (such as experimental, quasi-experimental and non-experimental research designs) and study types (such as cross-sectional or longitudinal) were included in the review. Studies were included if they met the date parameter (2003-2023) and were published and available on online electronic database (could include pre-prints). Studies were only included if they were in English as this is the researcher's language of origin.

Exclusion Criteria. Studies were filtered and excluded if they were older than 20 years old (before 2003) and were in other languages other than English. Studies not in English were excluded because the translation of studies from other languages may potentially have resulted in discrepancies in meaning and complicated the research process. Studies that were systematic reviews, presentations, keynotes, or other unpublished material were excluded. Studies were also be excluded if they mentioned neurofeedback in relation to other psychological disorders other than stress and anxiety. This is because if neurofeedback was measured against other physiological disorders, it would not be measuring burnout itself and thus would be difficult to apply in this context. Older studies were excluded because technology and measures of mental health have changed and

improved significantly over time (Naslund et al., 2017). Thus, older studies may not reflect current practices or effectiveness in neurofeedback training or current conceptualisations of burnout.

3.1.1.2 Types of Participants.

Inclusion Criteria. Participants of all ages, genders and nationalities were included if they had experienced burnout whether with mild, moderate, or severe indications.

Participants who experienced indicators outside of MBI or other predominant model measures were also included. Participants were included regardless of occupation, educational or socioeconomic level.

Exclusion Criteria. Participants were excluded if they experienced comorbidities with other mental or physical health disorders (such as Autism or Schizophrenia). Participants were excluded if they did not have symptoms associated with burnout. The reason for these exclusions is that the inclusion of other mental or physical disorders may complicate the understanding of the results of the neurofeedback intervention, making it more difficult to ascertain if neurofeedback training is effective for managing burnout specifically.

3.1.1.3 Types of Interventions.

Inclusion Criteria. The intervention methods were included if they specified neurofeedback training as the intervention in the study. Other Interventions were included if were used in conjunction with neurofeedback training but had to explicitly specify neurofeedback training as one intervention method. Other known names (as mentioned in search terms) of neurofeedback were included such as EEG biofeedback or neurotherapy/ neuroimaging therapy. All Interventions were included regardless of the duration of treatment, time constraints implemented, or the setting conducted in.

Exclusion Criteria. Interventions were excluded if they utilised other similar EEG intervention options instead of neurofeedback training (such as using EEG to measure cognitive changes but not for neurofeedback training).

3.1.1.4 Outcomes.

Inclusion Criteria. All study outcomes were included in the review (such as clinically significant and non-significant outcomes as well as effective and non-effective outcomes for neurofeedback training).

Exclusion Criteria. Outcomes were excluded if they were not reported. This is because if outcomes are not reported, it would be difficult to understand neurofeedback's role in the outcome.

3.1.3 Selection Process

Following the search strategy, both reviewers manually downloaded the articles from each database and uploaded and stored them in Zotero independently. Once uploaded, all duplicate studies were removed. These final studies without duplicates were uploaded to Rayyan, an online research tool that helps organise and manage collaboration in conducting systematic reviews (Ouzzani et al., 2016). Once uploaded, the abstracts and titles of each study were screened by the two reviewers (DP & NT) independently according to the inclusion and exclusion criteria. The use of this second reviewer may help increase the number of relevant studies identified in the review and increase reliability and validity (Stoll et al., 2019). Once a study was determined to meet the inclusion criteria, the reviewer pressed "include" and Rayyan automatically grouped these studies into one category named "included". If a study did not meet the inclusion criteria, the reviewer pressed "exclude" and made a note pertaining to the reason for exclusion and Rayyan grouped these studies under the category "excluded". Those that the reviewer was not certain met inclusion or exclusion criteria, pressed "Maybe" and Rayyan grouped these under the "Maybe" category. Once all studies had been categorised, Rayyan identified the studies that were in conflict between the reviewers. These disagreements in study eligibility were reviewed by a third reviewer (JB, the study's co-supervisor) and then discussed and negotiated between the reviewers until a consensus was reached. Once the final approved sample of "included" studies was accepted by all reviewers, full-text transcripts of the final studies were collected and examined by the

reviewers independently to determine if they met the inclusion criteria or not. Once these studies were analysed and agreed upon, the final sample of studies was downloaded and then assessed for methodological quality to determine if they were fit to be included in the review.

3.1.4 Critical Appraisal

The methodological quality of the final sample of studies was assessed using two different critical appraisal checklists. Initially, this study made use of a modified version of the Downs & Black checklist which is used to evaluate the procedural and methodological quality of randomised and non-randomised studies (Downs & Black, 1998). The checklist consisted of 27 questions pertaining to reporting, external validity, internal validity (bias), internal validity (selection bias) and the statistical power of each study's methods. The two reviewers independently reviewed each study in the final sample and rated them based on these characteristics. Twenty-six of the 27 questions could either be answered Yes= 1, No = 0 or Unable to determine = 0 while 1 of the 27 questions could be answered Yes = 2, Partial = 1 or No = 0. Total score ranges were given corresponding quality levels with ranges between 26-28 being excellent quality, 20-25 being good quality, 15-19 being fair quality and anything below 14 being poor quality (Downs & Black, 1998). The two reviewers reviewed each article according to the checklist and discussed any discrepancies in scoring to achieve consensus.

However, because some of the studies in the sample either did not explicitly specify if they were randomised/non-randomised or fit neither of these categories, the Downs & Black checklist was not entirely adequate for this review. Thus, the study also made use of the JBI critical appraisal checklist for RCTS, quasi-experimental and case studies. Similarly to the Downs & Black checklist, the JBI critical appraisal tools assess the methodological quality of a study and determine whether the possibility of bias has been addressed in research design, analysis, and conduct (JBI Global, 2023). The JBI critical appraisal checklist for randomised control trials contains 13 questions, the checklist for quasi-experimental studies

contains 9 questions and the checklist for case studies contains 8 questions. All questions can either be answered “Yes”, “No”, “Unclear” or “NA” and finally decided whether to be included or excluded from the review. In similarity with the Downs & Black checklist, “Yes” answers were given a rating of 1, while “No”, “unclear” or “NA” were given a rating of 0. Total score ranges between 90%-100% were deemed to be excellent quality, 70%-90% being good quality, 50%-70% being fair quality and anything below 50% being poor quality. Two reviewers reviewed each article separately according to the checklist and negotiated and discussed any discrepancies in scoring. Cohen’s Kappa was used to measure Inter-Rater Reliability

3.1.5 Data Collection Process

Once the studies were deemed to fit the inclusion criteria, one reviewer (DP) manually extracted data from each of the studies into a data extraction table on an Excel spreadsheet. This information was divided into four separate information tables (Tables 7-10 in the results section) according to the study’s specific research questions.

3.1.6 Synthesis Methods

The final sample of studies consisted of both quantitative and qualitative data which were grouped into tables. Data was then grouped according to the research questions outlined in Chapter 1 and their content and themes were analysed accordingly.

3.2 Ethical Considerations

Systematic reviews do not collect sensitive or confidential information from participants as the dataset that is collected is based on publicly accessible documents (Suri, 2020). Thus, systematic reviews do not generally need full ethics committee approval (Wormald & Evans, 2018). Therefore, for the purposes of this study, I applied for and was granted an ethics waiver (protocol number: MAPSYC/23/10W) as shown in Appendix A. Nevertheless, I have completed an ethics training module to conduct research in accordance with the required ethical code. The certificate for this module will be added in Appendix B. Relatedly, once ethical clearance was given for this study, this systematic review was pre-

registered with PROSPERO (registration number: CRD42023448860) (Page et al., 2018).

This registration is made public record and thus ensures transparency in methods and helps avoid duplication with other reviews and reduces reporting bias (Centre for Reviews and Dissemination, 2023; Page et al., 2018).

Chapter 4: Results

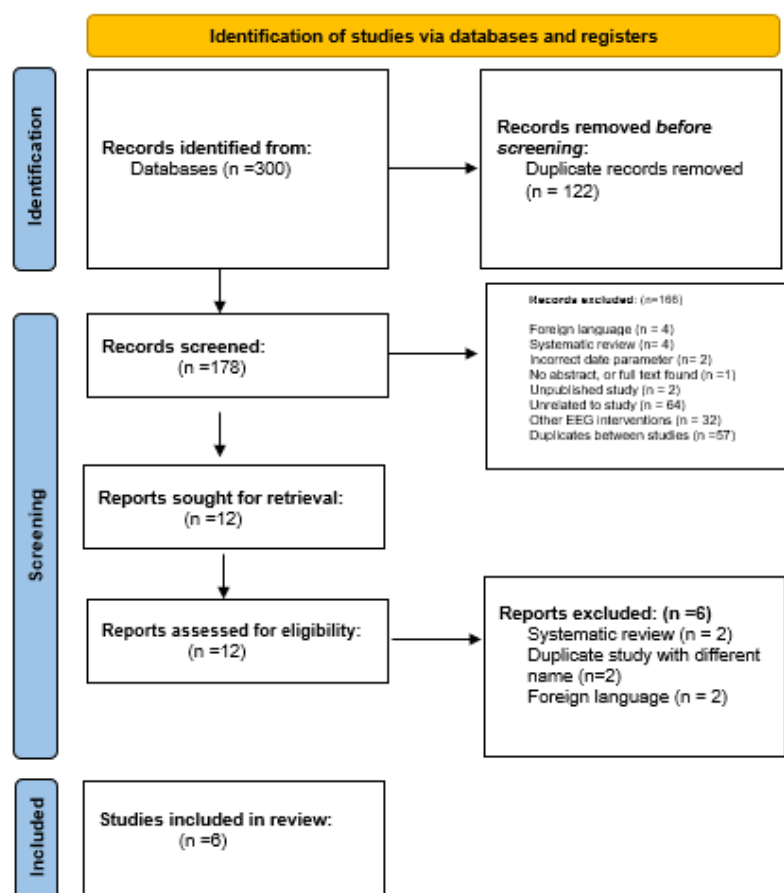
The fourth chapter will discuss the results of the methodological steps outlined in chapter three. The search strategy results are presented first with the identification process of the relevant studies depicted as well as the number of studies retrieved from each database using the specified search terms. Following this, the selection process results are presented, with descriptions of the selection process undertaken, the exclusion reasons as well as the full-text retrieval process. Subsequently, the critical appraisal evaluation results of the final sample's methodological quality are depicted and then discussed. After this, the data collection results are presented. These results are divided into identified study information and characteristics, sample characteristics, burnout measures and general intervention characteristics detailing how each intervention was conducted. These identified intervention characteristics are then separated into three groups, namely, the neurofeedback-only intervention group which describes the studies which utilised only neurofeedback training as an intervention, the neurofeedback intervention in comparison to other interventions group and the neurofeedback intervention in combination with other interventions group. After this, the overall study results/outcomes are presented. Subsequently, detailed results are described for each of the three groups (neurofeedback-only intervention group, comparison intervention group and combination intervention group). Finally, the study limitations mentioned in the studies are described.

4.1 Search Strategy Results

The full results depicting the steps for identification, screening and inclusion processes conducted in the review are depicted in Figure 1 below.

Figure 1.

PRISMA 2020 flow diagram illustrating identification, screening, and inclusion processes



The search strategy utilising the burnout search terms yielded 300 studies identified across the seven databases. Before screening against inclusion and exclusion criteria, 122 studies were removed because they were duplicates. After removing duplicates, 178 studies remained. Table 4 depicts the number of studies retrieved from each database.

Table 4.

Number of studies retrieved from each database using search terms

Database	Number of studies retrieved
EBSCOhost	62
Google Scholar	35
PsycINFO	41
ProQuest	25
Medline	57
Scopus	15
Web of Science	65

Total after duplicate removal	(178)
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4.2 Selection Process Results

After removing the duplicates, the remaining 178 records abstracts and titles were screened by two reviewers independently against the inclusion and exclusion criteria. Of the 178 records, 166 records were excluded. The main reasons for these exclusions (as depicted in Figure 1 above), include that no abstract or full text was found for the record, the record was in a foreign language other than English, the record was a systematic review, the record did not meet the date parameters (before 2003), the record was an unpublished study (e.g. notes for a seminar presentation/ how-to-guide), the record was unrelated to the study (e.g., record not relevant to burnout or neurofeedback training), or other EEG interventions were used (e.g., record relevant to burnout and EEG but utilised EEG/biofeedback for purposes other than neurofeedback training). Although duplicates were removed before the screening stage, one other reason highlights “duplicates between the studies” as an exclusion reason. This is because both reviewers conducted the search strategy independently and uploaded each set of studies to Rayyan, meaning there was an overlap between some of the studies that were uploaded. Thus, once both sets of studies were uploaded, duplicate records between studies had to be removed.

After exclusion, 12 records were sought for full-text retrieval. These full-text records were then assessed for eligibility according to the inclusion and exclusion criteria. Six of the records were excluded. Upon full-text retrieval, two of the records that had initially been accepted with English titles and abstracts were found to be in foreign languages (Spanish and Persian) with no full-text English version found. Similarly, two of the records did not mention in the title and abstract that they were systematic reviews and only upon full-text retrieval was that methodology made clear. Finally, two studies were duplicates of other included studies but had different titles, abstracts and author citation structures. Only once full texts were compared to each other was it made apparent they were duplicates. Thus, the

final sample included in the review was (n= 6) records.

4.3 Critical Appraisal Evaluation Results

The final sample of studies was evaluated for methodological quality by the two reviewers independently using both the Downs & Black Appraisal Checklist (Table 5) and the JBI Critical Appraisal checklist (Table 6). Some incongruities were found in scores between reviewers which were discussed until there was unanimous agreement regarding ratings. In reference to the Downs & Black Appraisal Checklist, 3 studies scored in the 20-25 range, obtaining a good quality rating. 2 studies scored in the 15-19 range obtaining a fair quality rating. Finally, 1 study was a case study and thus could not be attributed scores according to the checklist. The average reporting score (out of the 5 eligible studies) was 9.2 out of 11 (83%) illustrating strong overall reporting of the main key elements (such as hypothesis, aim, objective, outcomes, study characteristics etc). However, the studies only showed a relatively high internal validity (bias) with an average score of 5.2 out of 7 (74%), a mid-to-lower score for external validity with an average score being 2 out of 3 (67%), a mid-to-lower score for effect size with an average of 0.6 out of 1 (60%) and an even lower score for internal validity confounding (selection bias) with an average of 3.2 out of 6 (53%).

Inter-rater reliability was measured using Cohen's Kappa and the following formula;

$$\kappa = \frac{p_0 - p_e}{1 - p_e}$$

$$p_0 \text{ (percentage of agreement)} = 2/6 \text{ (0.33)}$$

$$p_e \text{ (Random Agreement)} = 4/6 \times 4/6 + 2/6 \times 2/6 \text{ (0.56)}$$

$$\kappa = \frac{0.33 - 0.56}{1 - 0.56}$$

$$\kappa = -0.5227$$

This result illustrates that agreement between the raters was worse than expected or no agreement was found (McHugh, 2012). However, because the Downs & Black checklist

could not assess all the studies, the ratings were not considered applicable and thus were compared to the JBI checklist in order to determine if studies met methodological quality and needed to be exempt from the review.

Table 5.

Article	Reporting	External	Internal	Internal Validity -	Power/	Total	Score
Authors	score	Validity	Validity-	confounding	Effect	Score	Quality
	(/11)	score	bias	(selection bias)	Size	(/28)	Rating
		(/3)	(/7)	(/6)	(/1)		
Campbell et al.	9	1	5	1	0	16	Fair
Dunham et al.	11	3	5	3	1	23	Good
Jackson-Cook et al.	10	2	5	5	1	23	Good
Janssen & van Atteveldt	10	3	6	4	1	24	Good
Kratzke et al.	6	1	5	3	0	15	Fair
Swingle& Hartney	NA	NA	NA	NA	NA	NA	NA

Critical Appraisal Evaluation based on Downs & Black Appraisal Checklist

In reference to the JBI Critical Appraisal checklist, 2 studies scored in the 90%-100% category, obtaining an excellent rating. Two studies scored in the 70%-90% category, obtaining a good rating. Finally, the remaining 2 studies scored in the 50%-70% range obtaining a fair rating. The Campbell et al (2020) article received the same rating across both checklists (fair), with a score of 57% on the Downs & Black and a score of 67% on the JBI checklist. Similarly, the Dunham et al (2019) article also received the same rating across both checklists (good), with a score of 82% on the Downs & Black and a score of 89% on the JBI checklist. The Janssen & van Atteveldt (2022) article had the most congruent ratings and scores across both checklists with a rating of good across both checklists and a score of 86% on Downs & Black and a score of 85% for the JBI checklist. However, there was a large discrepancy between scores for the Jackson-Cook et al (2023) article, with a rating of good (82%) on the Downs & Black checklist versus a rating of fair (62%) on the JBI checklist.

Finally, the Swingle & Hartney (2018) article was not compared as it was not able to be scored on the Downs & Black checklist but received an excellent quality rating (100%) on

the JBI checklist. Although the rating scores differed between the checklists, none of the studies obtained a rating below 50% (poor quality) in the JBI checklist or below a score of 14 (poor quality) in the Downs & Black checklist, so all studies were deemed fit to be included in the review.

Table 6.

Critical Appraisal Evaluation based on JBI Critical Appraisal Checklist

Article Authors	Year	Study type	Rating (“YES”)	Total (Percentage)	Quality Rating
Campbell et al.	2020	Quasi-Experimental	6/9	67%	Fair
Dunham et al.	2019	Quasi-Experimental	8/9	89%	Good
Jackson-Cook et al.	2023	RCT	8/13	62%	Fair
Janssen & van Atteveldt	2022	RCT	11/13	85%	Good
Kratzke et al.	2021	Quasi-Experimental	9/9	100%	Excellent
Swingle& Hartney	2018	Case Study	8/8	100%	Excellent

4.4 Data Collection Results

Information from the final sample of studies was extracted into separate data extraction tables according to the specific research questions of this study. To answer RQ2, “What study design information, methods and intervention protocols are used in neurofeedback training and burnout studies?” data was extracted into Table 7 which includes general study information such as author information, year of publication, journal, and country of origin, Table 8 which includes study design characteristics such as study design, study aim, sample size, intervention method, and control conditions and Table 10 which includes intervention information such as setting, duration, results, and study limitations. To answer RQ3, “How are burnout outcomes characterised and measured in neurofeedback training studies?”, data was extracted into Table 10 which includes intervention information such as pre-test and post-test measures. To answer RQ4, “What types of burnout populations and sample characteristics are utilised in neurofeedback

training studies?”, data was extracted into Table 9 which includes sample characteristics such as demographic information, age group, socio-economic/ workplace sector and inclusion and exclusion criteria. Finally, to answer the main Research Question (RQ1), “How effective is neurofeedback training as an intervention in the management of burnout?”, results and limitations in Table 10 were combined and discussed.

Table 7.

General Study Information

Authors	Year	Title	Journal	Country of origin
A. Campbell, M. Mattoni, M.N Yefimov, K. Adapa, L.M. Mazur	2020	Improving Cognitive Workload in Radiation Therapists: A Pilot EEG Neurofeedback Study	Frontiers in Psychology	United States of America
C.Dunham, A.L Burger, B.M. Hileman, E.A Chance, A.E. Hutchinson, C.M. Kohli, L. DeNiro, J.M Tall, P. Lisko	2019	Brainwave Self-Regulation During Bispectral Index (TM) Neurofeedback in Trauma Centre Nurses and Physicians After Receiving Mindfulness Instructions	Frontiers in Psychology	Spain
L. Jackson-Cook	2023	Combatting Counsellor Exhaustion: Neurofeedback Versus Mindfulness	ProQuest Dissertations Publishing	United States of America
T.W.P Janssen, N. van Atteveldt	2022	Explore your brain: A randomized controlled trial into the effectiveness of a growth mindset intervention with psychosocial and psychophysiological components	British Journal of Educational Psychology	Netherlands

I.M.Kratzke, A. Campbell, M.N. Yefimov, P.R. Mosaly, K. Adapa S. Meltzer-Brody T. M. Farrell L.M Mazur	2021	Pilot Study Using Neurofeedback as a Tool to Reduce Surgical Resident Burnout	Journal of the American College of Surgeons	United States of America
P. G. Swingle, E. Hartney	2018	Enhancing health leadership performance using neurotherapy	Healthcare Management Forum	Canada

Table 8.*Study Characteristics*

Authors	Study design	Study Aim	Study duration	Sample	Control Conditions
Campbell et al.	Pilot study (Not specified)	To test if 12 Radiation therapy therapists (RTTs) could learn alpha-theta neurofeedback (NF) protocol and exhibit behaviour and brain performance-related benefits.	3-week period	12 healthy adult radiation therapists	No control condition
Dunham et al.	Experimental (Quasi)	To determine if neurofeedback (NFB) participants could learn to self-regulate their brain wave activities immediately after receiving mindfulness instructions	4-day intervention for each participant totalling 228 days	57 level I trauma centre nurses/physicians	Passive control condition (191 nurses/physicians did not participate in the Bispectral Index (BIS) NFB investigation but completed the 11-item Wellbeing Inventory survey)
Jackson-Cook et al.	Experimental pilot study (RCT)	To explore the benefits of using neurofeedback as a self-care strategy with counsellors experiencing various levels of counsellor exhaustion.	8 weeks (both NFB and Mindfulness)	24 Licenced counsellors (12 in burnout intervention group)	Active control condition (mindfulness)
Janssen & van Atteveldt	Randomised control trial (RCT)	To address small effect for growth mindset interventions and to improve school outcomes and improve effectiveness	1 month (school 1) 1 month (school 2)	20 7th grade high-school Dutch classes (N=439)	Active control condition (no mindset messaging)
Kratzke et al.	Experimental with Control (Quasi)	To assess the impact of neurofeedback on the cognitive workload and personal growth areas of surgery residents with burnout and depression.	8-week interval	15 surgical residents from 1 academic institution (10 with severe burnout)	Passive control condition (5 others with less severe symptoms were treated as controls)
Swingle & Hartney	Case study	to outline the application of the concept of optimal performance training to organizational leadership in a healthcare context, by describing approaches to Neurotherapy and illustrating their application	Not specified	1 mid-career health director	No control condition

4.4.1 Study Information and Characteristics

Table 7 provides a summary of the study information and Table 8 provides a summary of the study characteristics used in the studies. Both tables address part of RQ2 of the study which aimed to determine what study design information, methods and intervention protocols were used in neurofeedback training and burnout studies. Consequently, all of the studies were published in the global North with three of the studies being published in the United States of America (Campbell et al., 2020; Jackson-Cook et al., 2023; Kratzke et al., 2021), two of the studies published in Europe (Spain and Netherlands) (Dunham et al., 2019; Janssen & van Atteveldt, 2022) and one study published in Canada (Swingle & Hartney, 2018). All studies were published in the last six years (2018-2023) with two studies published before 2020 (Dunham et al., 2019; Swingle & Hartney, 2018), one study in 2020 (Campbell et al., 2020) and three studies after 2020 (Jackson-Cook et al., 2023; Janssen & van Atteveldt, 2022; Kratzke et al., 2021).

In terms of study information, only one study mentioned burnout and neurofeedback clearly in the title and aims of the study (Kratzke et al., 2021). Four studies mentioned neurofeedback training clearly in the title and the study aims but did not refer to burnout specifically (Campbell et al., 2020; Dunham et al., 2019; Jackson-Cook, 2023; Swingle & Hartney, 2018). Instead, aspects such as cognitive workload (Campbell et al., 2020), counsellor exhaustion (Jackson-Cook, 2023), enhancing leadership (Swingle & Hartney, 2018) and aspects of stress (Dunham et al., 2019) were utilised. However, only upon further inspection of keywords and abstract was it made clear that these studies were focusing on burnout specifically. Finally, the remaining study did not mention neurofeedback or burnout in the title (Janssen & van Atteveldt, 2022) but mentioned neurofeedback in its aims and measured and referred to burnout as a syndrome in the study.

In terms of study design, only one of the six studies explicitly specified the design type, stating it was a randomised control trial (RCT) with a control condition (Janssen & van Atteveldt, 2022). While three of the six studies also utilised experimental designs, they did not explicitly specify design type, only stating experimental with a control condition (see

Table 8) (Dunham et al., 2019; Jackson-Cook et al., 2023; Kratzke et al., 2021). However, because one experimental study (Jackson-Cook, 2023) stated a randomised assignment to either a control group or intervention group, it was also taken as an RCT study design. In contrast, because the two remaining experimental studies (Dunham et al., 2019; Kratzke et al., 2021) did not explicitly specify a randomised condition, they were taken to be quasi-experimental designs (Harris et al., 2006). Of the remaining two studies, one study specified its design as a case study (Swingle & Hartney, 2018) and the remaining study did not specify the design type, only specifying it was a pilot study (Campbell et al., 2020). However, because it focused on one intervention and did not specify a control condition, it was also taken as a quasi-experimental study (Harris et al., 2006).

Of the studies that specified control conditions, two of the studies specified an active control condition (Jackson-Cook, 2023; Janssen & van Atteveldt, 2022) in which the control group is assigned to a different intervention which was directly compared with the experimental neurofeedback group (Dunn et al., 2023). The remaining two control studies specified a passive or inactive control condition (Dunham et al., 2019; Kratzke et al., 2021) in which the control group either only participates in the same pre-test/post-test procedure or participates in the same experimental procedure which differs in some capacity (Au et al., 2021).

Table 9.

Sample Characteristics

Authors	Participant Information					Inclusion Criteria	Exclusion Criteria
	Sample size	Age Groups	Gender	Ethnicity	Occupation		
Campbell et al.	12	adult (not specified)	6 males 6 females	Not specified	Radiation therapists	Not specified	Not specified
Dunham et al.	57 intervention group 191 control group	24–67 years (mean age was 36.5 +/- 11.8 years)	11 males [19.3%] (intervention) 46 females [80.7%] (intervention)	Not specified	level I trauma center nurses/physicians	Physicians (resident, attending, and assistant) and nurses (registered, practitioner, and anaesthetist), employed by St. Elizabeth Youngstown	Individuals undergoing psychological or psychiatric counselling Those requiring psychiatric medications

						Hospital Level I Trauma Centre	
Jackson-Cook et al.	12 neurofeedback group 12 mindfulness group [only 9 completed] (24 total)	25-63 years (M = 41.83, SD= 12.0) [NFB] 25-64 years (M = 40.22, SD= 13.75) [Mindfulness]	1 male [8.3%] (NFB) 11 female [91.7%] (NFB) 2 male [22.2%] (Mindfulness) 7 female [77.8%] (Mindfulness)	6 White [50%] (NFB) 2 Hispanic/Latino [16.7%] (NFB) 1 African American [8.3%] (NFB) 4 white [44.4%] (Mindfulness) 3 Hispanic/Latino [33.3%] (Mindfulness) 1 African American [11.1%] (Mindfulness) 1 More than one race [11.1%] (Mindfulness) 3 more than 1 race [3.25%] (NFB)	5 Licensed Professional Counsellor Associate [41.7%] (NFB) 5 Licensed Professional Counsellor [41.7%] (NFB) 2 Licensed Professional Counsellor Supervisor [16.7%] (NFB) 3 Licensed Professional Counsellor Associate [33.3%] (Mindfulness) 5 Licensed Professional Counsellor [55.6%] (Mindfulness) 1 Licensed Professional Counsellor Supervisor [11.1%] (Mindfulness)	Licensed counsellors or interns who have worked for at least 2 years with clients who have experienced various levels of trauma.	participants experiencing counsellor exhaustion as measured by TABS, QOLI, and qEEG Taking benzodiazepine medications (interfere with brain wave patterns) Been exposed to someone with COVID-19 or have been diagnosed within the past 14-days
Janssen & van Atteveldt	222 intervention group 217 control group (439 total/ 20 7th grade high-school Dutch classes)	12.73 years (.48) [control] 12.73 years (.46) [intervention]	110 males (control) 107 female (control) 120 males (intervention) 102 female (intervention)	Not specified	7th grade high school students	Schools had to be a maximum travel distance of 1.5 hours from Amsterdam Minimum of 4 classes had to participate in each school, Even numbers of classes within a school track had to participate for stratification	Those that did not respond Those that declined to participate
Kratzke et al.	10 intervention group 5 control group (15 total)	Not specified	Not specified	Not specified	surgical residents	Maslach Burnout Inventory (MBI) score of more than 27 Patient Health Questionnaire -9 Depression Screen (PHQ-9) score of more than 10	Not specified
Swingle & Hartney	1	Not specified	1 male	Not specified	mid-career health director	Not specified	Not specified

4.4.2 Sample Characteristics

Table 9 provides a summary of the studies' sample characteristics that address RQ4 of this study which aimed to determine what types of burnout populations and sample characteristics are utilised in neurofeedback training studies. Accordingly, sample sizes varied greatly between studies ranging from the smallest sample size of one participant (Swingle & Hartney, 2018) to the largest sample size of 439 participants (Janssen & van Atteveldt, 2022). The total amount of participants across studies was 739 ($M = 123.16$, $SD = 165.40$). Of the six studies, three did not specify the age groups of the participants (Campbell et al., 2020; Kratzke et al., 2021; Swingle & Hartney, 2018). However, because these samples included descriptive occupation information such as radiation therapists (Campbell et al., 2020), surgical residents (Kratzke et al., 2021) and a mid-career health director (Swingle & Hartney, 2018), it was clear that the samples utilised adult participants. Of the studies that did specify ages, two studies utilised similar age groups with participants being between the ages of 25 and 64 years old (Jackson-Cook, 2023) and between the ages of 24 and 67 years old (Dunham et al., 2019), while the remaining study specified a younger age demographic with all participants in the sample being 12.73 (13) years old (Janssen & van Atteveldt, 2022).

In terms of gender information, only one study did not specify the gender of participants (Kratzke et al., 2021). Four studies utilised both male and female participants (Campbell et al., 2020; Dunham et al., 2019; Jackson-Cook et al., 2023; Janssen & van Atteveldt, 2022) and one study only utilised a male participant (Swingle & Hartney, 2018). However, there were more female participants utilised across studies (those that were reported) with a total of 279 ($M = 93$; $SD = 83.19$). In contrast, the total amount of male participants across studies was 251 ($M = 62.75$; $SD = 96.75$).

In terms of participant ethnicity, only one study specified the ethnicity of the participants with ten of the total twenty-one participants (across both control and experimental groups) being white-identifying, five of the participants being Hispanic or Latino-identifying, four of the participants identifying with more than one race, and two of the

participants identifying as African American (Jackson-Cook et al., 2023).

Overall, only three (half of the total) studies reported exclusion criteria for participants, with common reasons including taking medications that may interfere with brain wave patterns (Dunham et al., 2019; Jackson-Cook et al., 2023), those experiencing psychological or psychiatric issues/ exhaustion or receiving treatment for these issues (Dunham et al., 2019; Jackson-Cook et al., 2023), exposure to COVID-19 (Jackson-Cook, 2023) and participants that declined to participate (Janssen & van Atteveldt, 2022).

Table 10.*Intervention Information, Outcomes, Measures, Results and limitations*

Authors	Intervention Method	Intervention duration			Setting	Burnout and Well-Being measures		Results	limitations
		Session Amount	Session length	Total duration		Pre-measures	Post Measures		
Campbell et al.	Alpha/theta neurofeedback (NF)	8 sessions	28 minutes in length	Over 3 week period	Within medical Hospital	Pre-intake wellbeing questions answered with Clinician BrainPaint CPT was administered pre-NF intervention with EEG pre-assessments of cognitive workload through the NASA-TLX)	BrainPaintR CPT was administered post-NF intervention with EEG recording Post NF assessments of cognitive workload using NASA-TLX	Results show linked cognitive workload improvements Results highlight NF can be learned and implemented in a busy setting	No control group Sample size was small
Dunham et al.	EEG Neurofeedback and Mindfulness-based instructions	2 sessions per day (8 sessions)	12 minutes	4 days + 1 follow up after 30 days	Not specified	11-item St. Elizabeth Youngstown Hospital Wellbeing Inventory Each session was preceded by participant mindfulness instructions Non-burnout Inventory Documented BIS (EEG) base value	participants were asked to subjectively rate NFB cognitive states and asked to rate their current state of relaxation. 11-item Wellbeing Inventory survey approximately 30 days after learning day 4 with three interrogatory (yes or no) questions.	Results highlight overall Improvements in Wellbeing	No well-being score follow-up for the control that did not participate in the BIS NFB study.
Jackson-Cook et al.	Neurofeedback Training and Mindfulness online group sessions	2 sessions per week (total of 16 sessions)	30 minutes	8 weeks	Home/office	Pre-screening questionnaire Demographic Questionnaire, Traumatic Attachment and Beliefs Scale Quality of Life Inventory pre qEEGs (brain mapping)	Post- qEEG	Results reflected a non-significant finding for NF. However, decrease in counsellor exhaustion evidenced for both neurofeedback group and the mindfulness group	Use of Self-report instruments and Did not examine vicarious resiliency.

Janssen & van Atteveldt	Theta/Beta Neurofeedback	4 sessions (1 per week)	50 minutes	Over period of 25 days	School setting during regular Mentor hours	School Outcomes evaluated The nine-item School Burn-out Inventory Mindset revised self-theory scale. The nine-item Effort Beliefs scale adapted version of the 2x2 achievement goal scale short version of the Academic Self-Regulation Questionnaire (SRQA)	School Outcomes evaluated directly after as manipulation check and 1 year later	Results show increased mindset directly after the intervention, and at follow up (1 year later) Demonstrated a protective effect against deterioration of math grades at 1-year follow-up compared to controls.	COVID-19 pandemic: lack of follow up, high dropout rates, confounding effect Not able to discern contributions of psychosocial/physiologic al components to intervention effects comparison indirect so large effect size found should be interpreted with caution.
Kratzke et al.	Alpha/Theta neurofeedback	8 sessions each	35 minutes	Over period of 3 months (June to August 2018)	Not specified	Cognitive workload assessed initially via (EEG) Participants to report their progress (or regression) using a -100 to 100-point Each participant to report daily on their overall status (eg amount and quality of sleep, stress, anxiety, self-confidence, feeling depressed, thoughts of suicide) Maslach Burnout Inventory [MBI] Patient Health Questionnaire–9 Depression Screen [PHQ-9]	Cognitive workload assessed again after treatment via (EEG) while the subjects performed n-back working memory tasks.	Results showed a significant improvement in cognitive workload (not noted in the control group). Results highlight significant correlation between time (NFB sessions) and average improvement in all growth areas	Results are based on 1 experiment with few subjects and without a "sham" neurofeedback control group. Non-random allocation of subjects led to an intentionally higher level of initial burnout-depression in the treatment group
Swingle & Hartney	Alpha/ Beta Neurofeedback	Not specified	Not specified	Not specified	Not specified	Self-reported experience of burnout and stress ClinicalQ brain map (EEG)	Not specified	Results show Martin improved in measures (sleep problems, worrying, reduced cognitive effectiveness, depressed mood states, and irritability) He reported being very much more effective cognitively in his leadership functions	Not specified

4.4.2 Intervention Characteristics

Table 10 provides a summary of intervention characteristics, outcomes, measures, results and study limitations that address RQ2 which aimed to determine what study design information, methods and intervention protocols were used in neurofeedback training and burnout studies. All studies utilised a neurofeedback training intervention, either with a combination of mindfulness training (Dunham et al., 2019; Jackson-Cook et al., 2023), in direct comparison to mindfulness training (Janssen & Van Atteveldt, 2022) or by itself (Campbell et al., 2020; Kratzke et al., 2021; Swingle & Hartney, 2018). In terms of targeted training, two studies utilised Alpha-Theta neurofeedback training (Campbell et al., 2020; Kratzke et al., 2021), one study utilised Alpha-Beta neurofeedback training (Swingle & Hartney, 2018), one study utilised Theta-Beta neurofeedback training (Janssen & van Atteveldt, 2022) and two studies did not explicitly specify the targets of the training protocol (Dunham et al., 2019; Jackson-Cook et al., 2023). In terms of intervention setting, three of the studies did not specify where the intervention took place (Dunham et al., 2019; Kratzke et al., 2021; Swingle & Hartney, 2018). Only three studies specified setting, with one being conducted within a medical hospital (Campbell et al., 2020), one being conducted in a school setting during regular schooling hours (Janssen & Van Atteveldt, 2022) and one conducted via remote software in the home or office of the participant (Jackson-Cook et al., 2023).

Intervention duration varied across studies with the shortest duration being 5 days (4 intervention days and 1 follow-up after 30 days) (Dunham et al., 2019) and the longest duration being 3 months (91 days) long (Kratzke et al., 2021). The total intervention duration across studies was 198 days ($M=39.6$, $SD= 30.55$). In terms of intervention session length, the shortest session duration was 12 minutes (Dunham et al., 2019), and the longest session duration was 50 minutes (Janssen & van Atteveldt, 2022), with the total time duration across interventions of 155 minutes ($M=31$, $SD= 12.23$). Total amount of sessions also varied across studies with the least number of total sessions being 8 sessions (Campbell et al., 2020; Dunham et al., 2019; Kratzke et al., 2021) and the greatest number of sessions being

16 sessions (Jackson-Cook, 2023) with a total amount of sessions across interventions being 44 sessions ($M=8.8$ sessions, $SD= 3.91$; Range = 12). Only one study did not specify intervention duration, session duration or number of sessions (Swingle & Hartney, 2018).

In terms of study design and methodology, the included studies fit into one of three categories, either neurofeedback training was conducted as the sole intervention with no other intervention, neurofeedback training was conducted by itself but compared to another separate intervention or neurofeedback was combined with another intervention. Because the inclusion and exclusion criteria for the study allowed for the inclusion of other interventions, the interventions were categorised into one of the three categories and discussed as such. The results of each group were then compared to each other.

Neurofeedback-Only Intervention. Three studies conducted interventions where neurofeedback was the only intervention with either a control condition or no control condition (Campbell et al., 2020; Kratzke et al., 2021; Swingle & Hartney, 2018). Two of the studies had similar intervention time protocols, with both conducting eight neurofeedback sessions each (Campbell et al., 2020; Kratzke et al., 2021). However, one study conducted 35-minute sessions over an eight-week interval (Kratzke et al., 2021) and the other study conducted 28-minute sessions over a three-week interval (Campbell et al., 2020). The remaining study did not specify session length or interval of intervention (Swingle & Hartney, 2018).

In terms of intervention protocol, all three studies conducted prior EEG baseline measures of brain function to identify target areas for the subsequent neurofeedback intervention and identify a baseline for reward and inhibit frequencies. Two of the studies utilised BrainPaint software (Campbell et al., 2020; Kratzke et al., 2021) while one study utilised a clinicalQ brain map (Swingle & Hartney, 2018). The Campbell et al. (2020) study also assessed cognitive workload (N-back test) via EEG both prior and post-intervention. Only the Swingle & Hartney (2018) study mentioned that the brain mapping software identified individual areas of concern such as elevated alpha waves, excessive beta waves, suppressed theta waves and a ratio of high to low alpha waves which were then used as

targets for the intervention at areas O1 and Cz. The remaining two studies did not specify the individualised results of the brain mapping software, only that they targeted alpha/theta waves (Kratzke et al., 2021) or alpha/theta/beta activity in the temporal lobes at C5 and C6 (Campbell et al., 2020).

Overall, the sessions began similarly, with the participants being instructed to remain relaxed and still while the software calibrated their brain map (Campbell et al., 2020; Kratzke et al., 2021). After this, all three studies proceeded with alpha-theta/alpha-beta training (eyes closed), with instructions to maintain a cognitive state for deep relaxation (Kratzke et al., 2021) or to quiet the mind while remaining awake (Campbell et al., 2020; Swingle & Hartney, 2018). These alpha training sessions took up a majority of the intervention time, with two studies mentioning this portion as 24 minutes (of a total 28-minute session/35-minute session) (Campbell et al., 2020; Kratzke et al., 2021). The alpha training period was then followed by an arousal period (eyes open), either continuing to target alpha/theta activity (Kratzke et al., 2021; Swingle & Hartney, 2018) or targeting theta/beta activity (Campbell et al., 2020). These arousal periods were shorter, only constituting four minutes (Campbell et al., 2020) or nine minutes (Kratzke et al., 2021) of the total intervention time. Only two studies specified reward and inhibit conditions (Campbell et al., 2020; Kratzke et al., 2021). In the Campbell et al. (2020) study, the frequency range for alpha was 8-11 Hz and the frequency range for theta was 5-8 Hz. The reward condition was 40-60% above the threshold for theta and the inhibit condition was 10-20% below the threshold. The reward conditions (including higher pitched sounds for alpha, lower pitched sounds for theta and visual EEG graph feedback) informed the EEG peak amplitudes in the range between 15-18 Hz. The inhibit condition caused a stop of all sounds and the graph to elevate. Similarly, in the Kratzke et al. (2021) study, the frequency ranges for deep relaxation sessions were 2-4 Hz and 15-30 Hz with the reward frequencies set to 5-7 Hz and 8-11 Hz. The frequency ranges for the arousal sessions were 1-2 Hz and 20-30 Hz and the reward frequencies were set to 15-18 Hz. If the frequency ranges were 30% greater than the baseline amplitudes, the participant was notified via verbal and visual feedback from the software. The Swingle &

Hartney (2018) study did not specify reward or inhibit conditions, only that there was a focus on regaining optimal cognitive performance through increasing Alpha Peak Frequency (APF) at specific locations O1 and Cz.

Neurofeedback Training Compared to Mindfulness Intervention. Only one study included a direct comparison between neurofeedback training and another separate intervention (mindfulness training) (Jackson-Cook et al., 2023). The comparative mindfulness training intervention was defined as a tool for cultivating essential internal skills through active consciousness, attention, and awareness (Jackson-Cook et al., 2023). In terms of training sessions, the neurofeedback training group received two thirty-minute sessions a week for eight weeks (total of 16 sessions), while the mindfulness group received one, one-hour session a week for eight weeks (total of 8 sessions). The intervention protocol for both groups included an initial qEEG (both closed-eye and open-eye condition) and a post-intervention qEEG (both closed-eye and open-eye conditions) to determine a comparative difference between the groups. Along with these initial qEEG recordings, all participants also participated in questionnaires (such as pre-screening, demographic, Counsellor Exhaustion Assessment, Trauma and Attachment Belief Scale, Quality of Life Inventory) before the intervention took place. The initial qEEG brain mapping results (maps created via Neuroguide software) determined the individualised intervention protocol (protocol created via Bioexplorer software) for the neurofeedback group. Although not explicitly stated, the study looked at theta/beta index and looked at changes between groups at Fp2, F7, F8, Cz, Pz, P3 and P4 (Jackson-Cook et al., 2023).

In the remote neurofeedback training sessions, the researcher measured 19 channels of real-time brainwave activity via three/four electrodes placed at specific locations on the scalp (Jackson-Cook et al., 2023). Based on the initial qEEG map and individual protocol design, the clinician was able to set goals for the participant's specific brain wave activity. Using operant conditioning, audio and visual feedback was used to promote the enhancement of desired brain wave patterns and suppression of undesired brain wave

patterns. Once brainwave activity fell into a particular goal pattern, the participant received positive visual (play a video game, watch tv, watch movie), auditory (nature or musical sounds) or a combination of the two as feedback.

In comparison, the remote mindfulness group training sessions were facilitated by a certified mindfulness instructor who guided and taught the participants mindfulness skills over the eight-week period (Jackson-Cook et al., 2023). The following skills were taught; week 1 (overview and introduction into mindfulness), week 2 (being in the body), week 3 (the body-mind), week 4 (identification and integrating mindfulness into the day), week 5 (listening to/tracking personal triggers), week 6 (self-regulation), week 7 (observation and experiences) and week 8 (cultivate, witness and resources). In addition to these lessons, the participants were required to complete daily self-practice of mindfulness, self-report on tracking sheets, complete daily journaling prompts and reflection points. The participants were also given additional resources for self-practice such as audio guidance, bubbles for breath awareness, tennis balls for self-massage and access to discussions with the facilitator between the sessions (Jackson-Cook et al., 2023).

Neurofeedback Training Combined with another Intervention. Although somewhat similar to the comparative group (in the addition of another intervention), the neurofeedback training intervention combined with another intervention involved a mix of the neurofeedback training intervention and another intervention rather than a direct comparison of effectiveness between the two interventions. Two studies conducted interventions where there was a combination of neurofeedback training and another type of intervention such as mindfulness training (Dunham et al., 2019) or a growth mindset intervention (Janssen & van Atteveldt, 2022). Both studies conducted four lessons/sessions each, with one of the studies conducting one 50-minute session per week for four weeks (Janssen & van Atteveldt, 2022) and the other study conducting two 12-minute sessions each day over four days (not specified if consecutive or non-consecutive) (Dunham et al., 2019). Both studies conducted a follow-up session post-intervention, with one conducting the follow-up immediately after the intervention and one year later (Janssen & van Atteveldt, 2022) and the other conducting

the follow-up after approximately 30 days post-intervention (Dunham et al., 2019).

In the Dunham et al. (2019) study, before the start of the intervention procedure on each learning day, participants completed the 11-item St Elizabeth Youngstown Hospital Wellbeing inventory which assessed relaxation and current wellbeing over the most recent three days. Subsequently, the participants would be connected to the Bispectral Index Monitor (BIS) EEG machine which then documented a baseline of the participant's brainwave activity. The participants were then given verbal mindfulness instructions which instructed them to sit comfortably with their eyes open and focus on the EEG BIS monitor with relaxed attention. The participants were then informed that a BIS score of more than 94 indicated fast brainwave activity and that the number might be reduced by balancing relaxation with focused attention. Then the first 12-minute neurofeedback session would take place. After a short break following the first session, the participants would receive more verbal mindfulness instructions indicating that participants should focus on the monitor utilising relaxed attention and then continue to complete the second neurofeedback session. After the conclusion of the second session, participants were asked to subjectively rate the neurofeedback cognitive states that may have influenced the reductions in the BIS values. After the first day of sessions, participants were then given mindfulness instructions to apply in everyday life. Although the exact targets of the neurofeedback intervention were not stated explicitly, the study did mention that a reduction in the BIS value indicated that the power in the high-frequency band (30-47 Hz) has reduced and the power in the intermediate-frequency band (11-20 Hz) has increased (Dunham et al., 2019).

In the Janssen & van Atteveldt (2022) study, school outcomes for individuals were measured before the start of the intervention and post-intervention via several instruments (Nine-item School Burnout Inventory, Mindset Revised Self-Theory Scale, Adapted Version of 2x2 Achievement Goal Scale, and Short Version of the Academic Self-Regulation Questionnaire). Both the growth mindset intervention protocol and the control condition protocol involved a series of four class lessons in which participants learnt about the brain, actively participated in lesson-related activities both individually and in groups, had workbook

exercises, had take-home messages, and were shown teasers for the following lessons. The main difference between the groups was that the growth mindset intervention group focused on brain plasticity, controllability of the brain, mindset training and included elements of Cognitive Behavioural Training (CBT) to challenge fixed mindset. The intervention group training protocol was conducted as follows; lesson one included learning about brain plasticity and conducted activities such as mirror drawing and juggling, and lesson two included learning about growth mindset and included watching related videos and completing CBT exercises. Lesson three included learning about neurofeedback training and EEG and included participation in neurofeedback training (such as getting a baseline recording, looking at raw EEG data, real-time attention, focusing on own influence of brainwave activity and then completing attention exercises [line exercise, neuron exercise, free-choice exercise and reading exercise] during neurofeedback). While the study did not mention the specifics of the neurofeedback training procedure (such as electrode placement or amplitude), the study mentioned that the target of the sessions was measured by a decrease in theta/beta index when compared to baseline. Lesson four included setting SMART goals and included connecting all lessons and applying it to a school context, setting personal goals, identifying obstacles and possible solutions and then writing a message in a bottle to future self (Janssen & van Atteveldt, 2022). Outcomes were then measured directly after the intervention and one-year post-intervention (Janssen & van Atteveldt, 2022).

4.4.3 Burnout Measures

To answer RQ3 which aims to assess burnout measures characterised in neurofeedback training studies, summary data on burnout measures was extracted into Table 10. Across all of the studies, a total of 20 measures were used to measure burnout or related characteristics. All studies reported more than one burnout measure used. Of the tools used to measure burnout, five studies utilised brain mapping (EEG) measures, either by itself (Jackson-Cook et al., 2023; Janssen & van Atteveldt, 2022; Swingle & Hartney, 2018), or in conjunction with the completion of a task to measure cognitive workload such as a Left-Right-Pause Computerised Performance Test (CPT) (Campbell et al., 2020) or

computerised n-back Working Memory Task (Kratzke et al., 2021). Four studies utilised questionnaires, such as pre-screening questionnaires to ascertain general health and well-being levels (Campbell et al., 2020; Jackson-Cook et al., 2023; Kratzke et al., 2021) as well as academic self-regulation levels (Janssen & van Atteveldt, 2022). Three studies used scales to measure burnout, general well-being, and cognitive workload such as the Traumatic Attachments and Belief Scale (TABS) (Jackson-Cook et al., 2023), the National Aeronautics and Space Administration Task Load Index (NASA-TLX) (Campbell et al., 2020), as well as the Mindset Revised Self-Theory Scale, Nine-Item Effort Belief Scale, and an adaptation of the 2x2 Achievement Goal Scale (Janssen & van Atteveldt, 2022). Four studies used inventories to measure burnout and well-being such as the 11-Item Elizabeth Youngstown Hospital Wellbeing Inventory and an unspecified Non-Burnout Inventory (Dunham et al., 2019), the Quality-of-Life Inventory (QOLI) (Jackson-Cook et al., 2023), the Nine Item School Burnout Inventory (SBI) (Janssen & van Atteveldt, 2022) and the Maslach Burnout Inventory (MBI) (Kratzke et al., 2021). Three studies utilised self-reporting measures to ascertain burnout levels, attempting to understand a personal account of overall status, sleep, stress and anxiety (Kratzke et al., 2021) as well as personal experience with burnout and stress (Swingle & Hartney, 2018). Lastly, one study used school outcomes as a measure of burnout (in conjunction with other measures) (Janssen & van Atteveldt, 2022).

All studies reported these as pre-measures, while only one study did not specify a post-measure (Swingle & Hartney, 2018). Of the five studies that did report, all reported the same pre-measures as post-measures, such as qEEG measurement both pre- and post-intervention (Campbell et al., 2023; Jackson-Cook et al., 2023; Kratzke et al., 2021), pre- and post-computerised assessments/tests (Campbell et al., 2020; Dunham et al., 2019), pre- and post-subjective rating cognitive states (Dunham et al., 2019) and pre- and post-assessment of school outcomes both (Janssen & van Atteveldt, 2022).

4.4.5 Study Results

Study results were extracted and summarised in Table 10 and used to answer RQ1, which aimed to determine the effectiveness of the neurofeedback training intervention in the

management of burnout. Overall, five of the six studies reported an improvement in some capacity or multiple capacities after the neurofeedback intervention. These consisted of improvements in cognitive workload (Campbell et al., 2020; Kratzke et al., 2021; Swingle & Hartney, 2018), improvements in well-being (Dunham et al., 2019; Swingle & Hartney, 2018), improvements in pre-selected areas of desired personal growth (Janssen & van Atteveldt, 2022; Kratzke et al., 2021) and protection against deterioration of certain academic skills (Janssen & van Atteveldt, 2022). While the remaining study noted a non-significant finding for neurofeedback in comparison to the mindfulness group, it did find changes in brain areas associated with counsellor exhaustion for those who participated in the neurofeedback group (Jackson-Cook et al., 2023).

Neurofeedback-Only Intervention. Of the three studies that used only neurofeedback as an intervention, all three showed improvements in post-measures when compared to pre-measures (Campbell et al., 2020; Kratzke et al., 2021; Swingle & Hartney, 2018). In the Campbell et al. (2020) study, there was a significant decrease ($t(11) = 2.4, p < 0.04$) in response time in the computerised tests (CPT), from pre-test (640 ms, SD= 41 ms), to post-test (619 ms, SD =56ms) as well as a significant reduction ($t(11) = 6.05, p < 0.01, B = -8.91$) in the subjective cognitive workload scores (NASA-TLX), from pre-test ($M=24.3, SD =12.25$) to post-test ($M=19.7, SD =13.3$). In terms of baseline EEG measures, the study found that there was a decrease in alpha ($t(12) = 2.36, p = 0.04$) from pre-test ($M= -3.1, SD=1.4$) to post-test ($M= -2.2, SD=1.4$) and a moderate increase in theta ($t(11) = 1.99, p = 0.072$) from pre-test ($M= -2.4, SD =2.3$) to post-test ($M= -0.9, SD= 1.9$). Similarly, the Kratzke et al. (2021) study found that there was a significant improvement in working memory task performance in the intervention group with changes in EEG oscillatory power in theta (0.49, 95% CI -1.09 to 2.06, $p < 0.05$) and alpha (-0.35, 95% CI -1.13 to 1.82, $p < 0.05$) which were not noted in the control group. The study also found significant improvements in twenty personal growth areas (selected by participants), with a significant correlation between the number of neurofeedback sessions and average improvement in growth areas such as stress ($r = 0.91$) and sleep ($r = 0.67$). While the Swingle & Hartney (2018) did not

specify the exact statistical figure changes from pre- to post-measures, it did specify that Martin was able to increase alpha amplitude at locations O1 and Cz which enabled him to enhance his visualisation skills, increase mental clarity, reduce lag time between changes in states (from relaxation to attention), mitigate negative emotional conditions and improve substantially in his previous symptoms such as sleep problems, worry, reduced cognitive effectiveness, depressed mood and irritability.

Neurofeedback Training compared to Mindfulness Intervention. In the single comparison study (Jackson-Cook et al., 2023), there was a marginally significant finding [$t(11) = 2.544$, $p = .063$, medium effect size ($d = .73$)] in the Trauma and Belief Scale (TABS) scores for neurofeedback training group from initial pre-intervention ($M = 50.75$, $SD = 8.15$) to post-intervention ($M = 45.67$, $SD = 5.82$). There was also a significant finding [$t(6.105) = 11$, $p = <.001$], large effect size ($d = 1.76$)] in the Quality of Life (QOLI) assessment for the participants in the neurofeedback group, from pre-intervention scores ($M = 46.25$, $SD = 9.61$) to post-intervention scores ($M = 58.17$, $SD = 10.26$). In comparing the neurofeedback group TABS scores to the mindfulness group TABS scores, the study found no statistical significance between the groups [$F(1,20) = .371$, $p = .550$], with a decrease in counsellor exhaustion evidenced in both the neurofeedback ($n = 12$, $M = -5.08$, $SD = 2$) and mindfulness ($n = 9$, $M = -3.33$, $SD = 1.97$) groups. Similarly, there was also a nonsignificant finding for the QOLI assessment between the groups [$F(1,20) = 2.072$, $p = .166$], with a decrease in counsellor exhaustion evidenced in both the neurofeedback ($n = 12$, $M = 11.92$, $SD = 6.76$) and mindfulness ($n = 9$, $M = 7.56$, $SD = 7.02$) groups. However, there was a statistically significant difference in participant mean scores from baseline to post-intervention in the neurofeedback group, with a significant reduction in theta waves in the frontal lobe (F7, Fp2, F8 and Cz), a significant reduction in beta brain waves and an increase in alpha brain waves in the parietal lobe (P3, P4, Pz), while the mindfulness group showed virtually no changes in areas of the brain impacted by counsellor exhaustion (such as parietal and frontal). However, the brain areas that were impacted for these participants (such as T4, T5 and O1) are considered periphery lobes and could be attributed to other aspects such as muscle tension.

Neurofeedback Combined with another Intervention. In the combination intervention studies, the Janssen & van Atteveldt (2022) growth mindset intervention study compared theta/beta index during resting baseline with each neurofeedback exercise and showed that the intervention group was able to lower the theta/beta index by increasing focused attention during the line exercise [$F(1, 203) = 28.18, p < .001, N 2/p = .12$], the neuron exercise [$F(1, 203) = 28.18, p < .001, N 2/p = .26$] and the free choice exercise [$F(1, 202) = 60.98, p < .001, N 2/p = .23$]. The participants were not able to do so during the reading exercise due to self-reported difficulty in concentrating on both reading and auditory instructions simultaneously. In relation, the average objective control and participant's subjective control rating (0-100) were strongly correlated ($r(201) = -.420, p < .001$), meaning that the 91.7% of participants were more convinced they could influence their brain which was also found in the objective control results. The study also found a significant Time x Condition interaction [$F(1, 450.89) = 11.98, p < .001$.] with a medium effect size ($d = .38$), indicating that the intervention resulted in more growth mindset endorsement from pre-intervention to post-intervention than the control group. The follow-up check (one year later) also illustrated that the growth mindset intervention group continued reporting increased growth mindset compared to the control group ($\beta = 1.62, 95\% \text{ CI } [.01, 3.25]$) with a small effect size ($d = .25$). However, the intervention did not affect school burnout symptoms from pre-intervention to post-intervention as both control and intervention groups reported an increase in burnout symptoms over time ($\beta = 4.82, 95\% \text{ CI } [3.63, 6.02]$). In terms of school outcomes, gender and SES did not moderate Time X Condition, however, girls reported less growth mindset endorsement, more school burnout symptoms and higher academic achievement. Relatedly, students from higher SES reported higher growth mindset endorsement regardless of time or condition (Janssen & van Atteveldt, 2022).

In the Dunham et al. (2019) mindfulness combination study, the BIS neurofeedback group showed higher post-session relaxation scores after the 228 learning days (3.6 ± 0.8) than pre-session relaxation scores (2.7 ± 0.8 ; paired t-test $p < 0.0001$; Cohen $d = 1.0$; paired Wilcoxon $p < 0.0001$). Similarly, the mean BIS neurofeedback values were lower after the

228 learning days (90.3 ± 4.5) than the 228 BIS baseline values (97.5 ± 0.8 ; paired t-test $p < 0.0001$; Cohen d 2.2). Among the 57 participants in the BIS neurofeedback intervention group, 44 participants showed an improved score for positive affect, non-stress scores, well-being scores and non-burnout scores that were significantly higher on day four of the learning days than on day one. In particular, 28 of these 44 participants showed the greatest improvements in non-stress scores from day one (25.0 ± 4.6) to day four (30.8 ± 3.2 ; paired t-test $p < 0.0001$; Cohen d 1.5; paired Wilcoxon $p < 0.0001$) while 16 participants showed the greatest improvements in positive affect scores with scores being higher on day four (13.1 ± 2.3), compared to day one (10.6 ± 2.5 ; paired t-test $p < 0.0001$; Cohen d 1.0; paired Wilcoxon $p < 0.0001$). However, 13 participants out of the 57 BIS neurofeedback group failed to show an improvement in the non-stress scores or the positive affect scores on day four compared to day one.

When comparing scoring results from both intervention and control groups, the 11-item well-being scores for participants in both the control group and neurofeedback group were similar on day one of learning, however, were significantly higher for the BIS neurofeedback participant group (paired t-test $p = 0.0056$; paired Wilcoxon $p = 0.0067$) on learning day four compared to the control group on day four. This was also found in non-stress and non-burnout scores on learning day four when compared to learning day one.

4.5 Study Limitations

Study limitations were extracted and summarised in Table 10 and used to answer RQ1, which aimed to determine the effectiveness of the neurofeedback training intervention in the management of burnout. Regarding study limitations, only one study did not specify any limitations of their study (Swingle & Hartney, 2018). The remaining five studies all mentioned more than one limitation in their study. Two studies specified external confounding factors as a limitation to their study, such as the COVID-19 pandemic which prevented follow-up assessments with participants or caused high dropout rates (Jackson-Cook et al., 2023; Janssen & van Atteveldt, 2022) and not being able to dissociate the contributions of psychosocial and psychophysiological components from the effects of the

intervention (Janssen & van Atteveldt, 2022). Three studies specified study design limitations, such as a lack of a control group (Campbell et al., 2020), non-random allocation of subjects group (Kratzke et al., 2021), not utilising a sham neurofeedback group (Kratzke et al., 2021) and choosing an individualised treatment rather than a standardised treatment (limits group comparisons) (Jackson-Cook et al., 2023). Three studies mentioned equipment/measurement limitations such as only utilising a two-channel EEG (Campbell et al., 2020), a lack of additional measurements related to cognitive performances and mood (such as N back test) (Campbell et al., 2020), a lack of physiological measurements (Campbell et al., 2020), a lack of inventory score for the control group (to establish normal variance) (Dunham et al., 2019) and a lack of reliability of questionnaire scales (Janssen & van Atteveldt, 2022). Four studies mentioned participant/sample limitations such as a small sample size (and subsequently a lack of generalisability) (Campbell et al., 2020; Jackson-Cook et al., 2023; Kratzke et al., 2021), a predominantly female sample (substantial lack of males in the sample) (Jackson-Cook et al., 2023), only focusing on high-stress professionals (Jackson-Cook et al., 2023), not taking to consideration a participant's history of trauma (Jackson-Cook, 2023) and lacking extensive epidemiological data for the participants (Dunham et al., 2019).

Chapter 5: Discussion and Conclusion

The fifth chapter will discuss the results presented in chapter four. Firstly, a brief conclusion of study background, aims, research questions and study highlights will be presented. Following this, the study results will be discussed followed by study recommendations and then the study's limitations will be presented. Finally, a conclusion of whether neurofeedback training can be applied to the management of burnout will be discussed.

In the context of this study, chronic work-related stress is described as a significant occupational hazard and a major contributor to the development of psychological disorders and the global burden of disease. Although this “occupational phenomenon” (known as burnout) is highly prevalent across a multitude of professions and societal domains and has been recognised as debilitating to global mental health and well-being, it is not formally recognised as a mental health disorder and has no assigned intervention or treatment method. This has resulted in vague and subjective definitions of burnout which vary widely across contexts. Although standardised burnout measures exist, their applications are implemented based on these unpredictable and individual definitions, making it difficult to determine what burnout is and how it should be managed. Due to these uncertainties, traditionally applied evidence-based medicine practices may not necessarily be the most effective or applicable in this context and thus, the consideration of alternative intervention methods may be worthwhile. A non-invasive alternative intervention that has shown promise in the treatment and management of other disorders is neurofeedback training which focuses on actively teaching participants how to change and influence their brain wave activity. However, neurofeedback training studies have been criticised for poor study design implementation, lack of stringent control conditions, and limitations in methodological protocols, which has resulted in uncertainty regarding its effectiveness as an intervention method and if it could be applied as an intervention in the burnout context.

Therefore, the main aim of the study was to determine if neurofeedback training would be an effective intervention method for the management of burnout. To determine this,

the study conducted a systematic review of the existing literature to evaluate and summarise the evidence in the field. While the main aim of the study was concerned with overall efficacy (such as the overall results and limitations of the studies) and guided by the RQ1: How effective is neurofeedback training as an intervention in the management of burnout? The secondary aim of the study was to determine how the existing studies were structured and executed by evaluating the methodological, procedural and practical choices made in the research process. This was guided by RQ2: What study design information, methods and intervention protocols are used in neurofeedback training and burnout studies?, RQ3: How are burnout outcomes characterised and measured in neurofeedback training studies? and RQ4: What types of burnout populations and sample characteristics are utilised in neurofeedback training studies? The answers to these questions would help to determine the standards by which neurofeedback training was implemented, as well as how the burnout populations and measures are identified and described. This would enable an understanding of how applicable and appropriate neurofeedback training is in the burnout context and highlight any potential gaps in the literature to improve future research.

To answer these questions, the study conducted a systematic review guided by the 2020 Prisma Guidelines. The following databases (Web of Science, Scopus, Medline, ProQuest, PsycINFO and Ebscohost) and one search engine (Google Scholar) were searched according to inclusion and exclusion criteria (must mention neurofeedback and burnout together, no physical or mental comorbidities, can specify neurofeedback and another intervention, no restrictions on demographics, research designs and outcomes, published on online electronic databases, only studies in English, date parameter of 20 years (2003-2023)). The search strategy yielded 300 identified studies, of these 122 duplicate studies were removed before screening resulting in 178 studies. These records were screened according to the inclusion and exclusion criteria and 166 records were excluded. Thus, 12 remaining studies were sought for full-text retrieval and screened for eligibility. Six studies were excluded, resulting in six remaining studies being included in the final sample.

The final sample of studies was then assessed and categorised according to their methodological protocol, populations, burnout measures and overall results. The results of these studies will be discussed below according to the study's main research questions. This section will also provide specific recommendations for the field, based on the results of the review.

5.1 Neurofeedback Training Study Design and Intervention Protocol Ambiguity

RQ2 in the study was concerned with what study design information, methods and intervention protocols are used in neurofeedback training and burnout studies. As previously noted, neurofeedback training shows the potential to possibly manage various mental health disorders and resolve the negative neurobiological consequences associated with these disorders (Panisch & Hai, 2018). However, neurofeedback training studies are often criticised for the major ambiguity that exists in the research designs and protocols in current neurofeedback research (Sorger et al., 2019). The main criticisms have found that there is an overall lack of scientific rigour in the studies including limited descriptions of control conditions, lack of reporting of meaningful results and substantial variability in the study design, implementation of the training protocols and the focus of neural targets (Chiasson et al., 2023; Rogala et al., 2016). Similarly, it has also faced major criticism regarding the lack of standardised equipment and reporting procedures (Pigott et al., 2021; Swingle, 2021). This may also be due to the small number of documented research studies in the area as well as the individualisation of neurofeedback training which is challenging for producing controlled and generalisable findings (Bazzana et al., 2022).

These main issues were evident in the results of this study as only six studies were included in the final sample of studies, illustrating the scarcity of relevant research in this area. Relatedly, there was either vagueness or omission of one or more aspects in the reporting of study information and design, control conditions, methodological procedures, sample information, neurofeedback training protocols and intervention settings across all the studies. Although the lack of rigour and apparent ambiguity in research design is relatively common in older and outdated research strategies (Langtree et al., 2019), all of the studies

in the sample were published in the last six years (2018-2023), thus reflecting the most current and up-to-date practices in this area of research. While these concerns coincide with the main critiques in neurofeedback research, all of the studies (except one) acknowledged and addressed many of these limitations. For instance, the main limitations mentioned in the studies include equipment or measurement weaknesses, external confounding factors, participant/sample limitations and study design limitations. Although each study in the sample recognised these limitations and proposed them as areas of improvement in future research, it is clear that these issues still remain across all the studies over the six-year period.

Besides the apparent ambiguity in the study design and protocols of the studies, there was also major ambiguity and inarticulateness in the titles, aims and abstracts of the studies. Only one study clearly stated in its title and aim that its focus was burnout and neurofeedback training. The other studies either explicitly referred to neurofeedback training but only mentioned burnout by some related characteristic or outcome (such as cognitive workload or exhaustion) or did not mention burnout at all in their title or aims. Despite these omissions, all the studies mentioned burnout and neurofeedback training in their studies, used some form of burnout measure to measure burnout and mentioned burnout outcomes in their results. Not only does this illustrate the variability and subjectivity that exists in the conceptualisations of burnout but also the lack of objective and rigorous reporting standards evident in these studies. Not only is this problematic for determining the efficacy of neurofeedback training as an intervention and for comprehensively understanding what burnout is but can also present major issues for collating and finding relevant research in this field. For instance, if these issues (omission in reporting, use of unclear definitions and vagueness in study aims) are evident in almost all the studies in the sample, studies that might have been included in this study may have been disregarded too early or not found at all due to omissions in keywords, titles, abstracts and aims.

There was also an evident lack of reporting of procedures in the study as only half of

the studies specified the location and setting of the neurofeedback training. However, the studies that did specify the setting were vague and ambiguous regarding details (only specifying it was conducted at a medical hospital, at the participant's house via remote software or during specific school hours). Although not typically seen as important in the study, the setting (researcher presence and operations) and location (context) in which the intervention is delivered play a crucial role not only in the intervention procedure and its results but also in how the intervention is ultimately evaluated (Wells et al., 2012). Relatedly, the use of these precise descriptions allows for replication of the study (external validity) (Mohajan, 2017). Thus, the setting in which the neurofeedback training intervention takes place may impact the ability to concentrate and potential stress levels (such as during busy hours in a hospital setting vs at home alone) as well as the impact on future research.

Similarly, although many of the studies adhered to a similar neurofeedback training protocol (an initial baseline reading of the participant's brain waves measured by qEEG software, the participant receives verbal instructions, the neurofeedback session commences (relaxed attention with eyes closed), followed by a break and then a second session(alert attention with eyes open) no information was provided regarding how the equipment was set up, whether the participants had prior knowledge of neurofeedback training or if they were informed of what neurofeedback entails before engaging in the study. Although this may not be seen as important for neurofeedback protocol, research has shown that any existing or prior knowledge of material allows learning to occur more rapidly and efficiently and can have a powerful influence on a person's ability to learn new things (Yates & Chandler, 1994). This is also evident in the neurofeedback training context where internal factors and external factors may influence the participant's ability to regulate and sustain changes to brain waves (Sakurada et al., 2022; Sepulveda et al., 2016). Thus, any prior knowledge of how neurofeedback works and what is expected of the participant could potentially influence how quickly the participants can reach targets, sustain attention and make progress, ultimately affecting the results of the study. Thus, to avoid potential confounding factors, studies should standardise reporting of protocols.

This lack of reporting is also evident in other aspects of the research protocol. For instance, only two studies explicitly specified that the neurofeedback training protocol would be based on the participant's individualised EEG frequency ranges (individualised neurofeedback training). While the remaining studies conducted the neurofeedback training protocols using similar protocols (such as baseline EEG and amplitude training with rewards and suppression), it was not made explicitly clear whether the neurofeedback training protocol was conducted differently for each participant based on their individualised baseline qEEG results or rather based on standardised procedures for all participants. Although a majority of research practice and clinical trials utilise standardised protocols and are tentative regarding personalised methods due to the difficulty in generalising results and proving empirical effectiveness (Hasslinger et al., 2022), other research challenges this notion and suggests that individualised training increases neurofeedback training's effectiveness and improves potential outcomes (Escolano et al., 2014). Thus, despite the lack of reporting present in the study, the use of individualised protocols may help facilitate neurofeedback training's effectiveness in the management of burnout.

Another aspect of neurofeedback training that has faced major ambiguity is regarding the most optimal training schedule (Esteves et al., 2021). For instance, there is uncertainty regarding how many sessions are needed to control one's brainwaves, what intensity of sessions produce the most optimal results, and how long the effects of neurofeedback last are of main concern (Marzbani et al., 2016). This uncertainty has resulted in large variability in the construction of neurofeedback intervention protocols. This is evident in the findings of this study as there was large variability in the intervention duration (five days [least], 91 days [most]), the duration of sessions (12 minutes [lowest], 50 minutes [highest]) and the number of sessions (eight sessions [least], 16 sessions [most]). Although there is no official consensus regarding the optimal training schedule, some findings suggest that neurofeedback training should adhere to brief and condensed sessions (approximately 10-30 minutes) more frequently (such as two to three sessions per week) (Domingos et al., 2021; Ward et al., 2019). While the exact training interval period may vary depending on the

severity of the condition and progress of the individual, many may report improvements from five to ten sessions (Collura et al., 2010). The findings in the study are consistent with these recommendations as on average there were ($M=8.8$) sessions of neurofeedback for an average of ($M=31$) minutes per session with an average frequency of ($M=1.6$) sessions per week over an average period of ($M=39.6$) days or ($M=1.28$) months. Although the average session frequency was slightly lower than the recommended, the interval period of recommended sessions was lower ($M=23.31$) days or ($M=0.77$) months when compared to the average of the study. This use of a much longer intervention period might be more beneficial for understanding neurofeedback's effectiveness as some findings suggest that conditions continue to improve over time after the neurofeedback intervention (Rance et al., 2018). This is also evidenced in the study's findings where two studies conducted long-term follow-ups with the participants (one at 30 days post-intervention and one at one-year post-intervention) and found that participants showed the same or higher scores post-intervention, illustrating the durability and sustainability of the learnt skills (Dunham et al., 2019) or that certain school outcomes were preserved or protected after the neurofeedback training intervention (Janssen & van Atteveldt, 2022). Thus, the study utilises "optimal" neurofeedback training protocols and with the addition of a longitudinal intervention, could potentially be effective in the management of burnout over time.

5.1.2 Intervention Conditions: Comparison, Combination or Alone

The findings of the study illustrate that neurofeedback training was utilised in three separate conditions (either by itself, in combination with another intervention or compared to a mindfulness intervention). The neurofeedback-only studies showed significant improvements in post-measures when compared to pre-measures (such as a decrease in response time, reduction in cognitive workload scores, increases in memory task performance and improvements in individualised problem areas, such as sleep problems, depressed mood, reduced mental clarity, negative emotions and reduced cognitive effectiveness. These changes were also noted in the EEG measures of brain wave amplitudes (showing significant changes in theta and alpha amplitude). However, when compared to another intervention

involving relaxed awareness (such as mindfulness), the results were less significant. For instance, no statistically significant results were found when comparing burnout score measures between the neurofeedback group and the mindfulness groups, as both groups showed a decrease in burnout symptoms (such as counsellor exhaustion). However, there were significant changes found in the brain waves of participants who participated in the neurofeedback group (showing a significant reduction in theta, beta and an increase in alpha amplitudes) which were not shown in the EEG measures of the mindfulness group. This illustrates that although mindfulness training could be utilised instead of neurofeedback training as they produce similar results, neurofeedback training may be more effective in producing long-term physical and neurological changes in the brain.

However, because neurofeedback training involves a level of calm and relaxed awareness (Kirk & Dhal, 2022) which is similar to mindfulness' active awareness of the present moment (Black, 2011), it may be worthwhile to consider interventions that combine these two intervention strategies. In the studies that combined mindfulness strategies and neurofeedback training, results showed that burnout measure scores and post-relaxation scores were significantly higher in the combined group than in the control group. Similarly, the post-EEG values in the combined group showed a significant reduction when compared to baseline values. However, some participants in the group failed to improve on certain burnout measures throughout the intervention and this was similar for those who completed the follow-up testimonial surveys. Thus, the subjective evaluation of the intervention's effectiveness and its impact on the individual may be a factor to consider in evaluating the effectiveness of neurofeedback training.

This was also evident in the other combined study which utilised neurofeedback training in combination with a growth mindset intervention. The growth mindset intervention aims to develop intellectual abilities by teaching people to believe that their abilities can progress and improve (Yeager et al., 2019). The study included learning about neurofeedback training and how to control brain waves and then conducted neurofeedback training. The study found a strong correlation between the objective neurofeedback results and the participant's

subjective rating of control, meaning that their personal belief about their ability to influence their brain did influence their brain. During the follow-up tests (after approximately a year), the study found that there was a continued increase in the growth mindset of the intervention group when compared to the control group. However, the growth mindset intervention did not affect burnout symptoms (from pre-measures to post-measures). In this case, the growth mindset intervention may be beneficial for teaching participants how neurofeedback works, influencing brain changes and increasing personal resilience to deal with negative outcomes associated with burnout, but it may not be the most beneficial on its own as an intervention for burnout.

Although the neurofeedback training intervention on its own showed improvements in negative outcomes associated with burnout, the other study results indicate that neurofeedback training in combination with other interventions may be more effective. In particular, if elements from other interventions such as both mindfulness training (such as learning calm and present awareness) and the growth mindset intervention (such as learning about neurofeedback, inducing mindset changes and increasing feelings of personal resilience) were included with neurofeedback training (which induces physical and neurological changes in the brain), it may be the most effective solution to manage and deal with burnout. Similarly, the inclusion of these other interventions may help to mitigate the limitations that neurofeedback training faces on its own.

Overall, these results showed that many aspects of neurofeedback training research design and intervention protocols were ambiguous, vague or not reported at all. One way these could be addressed practically (as set forth by the International Society for Neurofeedback and Research) is by implementing an internationally recognised standard of practice which may guide assessment procedures, training protocols and equipment for neurofeedback training (Hammond et al., 2011). This will enable researchers to establish a basis for consistency in reporting measures and potentially ensure higher-quality neurofeedback studies are produced. Similarly, this standard will ensure that future studies' titles, abstracts and research aims are clearly and comprehensively reported to ensure that

relevant research is easy to find and examine.

Similarly, another way to encourage transparent and rigorous reporting practices in neurofeedback training studies would be to encourage pre-registration of studies, which refers to publishing the key facets of research before data collection (Evans et al., 2021). This practice is already encouraged in some research methods (such as systematic reviews) and is used to ensure transparency and reduce reporting bias (Pieper, 2022). Similarly, ensuring that published papers allow open access to data and peer-review may ensure that research papers are evaluated more thoroughly and that better-quality research is published (Ule, 2020). However, there is currently no such defining standard of practice, no pre-registration procedure, and no peer-review requirement in these studies. If this is taken with the results of this study which reflect the larger issues currently present in neurofeedback training as a mental health intervention, it remains uncertain whether neurofeedback training may be a suitable intervention method to manage burnout.

However, the results of the study also indicated that “optimal” neurofeedback training has been evidenced in individualised procedures and that positive outcomes have continued to improve over a longer period of intervention. Similarly, the study showed that the inclusion of other intervention methods (such as mindfulness training and growth mindset) may help to mitigate the current limitations of neurofeedback training and increase its effectiveness. Thus, neurofeedback training may potentially be considered an effective intervention for burnout if future research enforces a good practice guide, higher quality research, standardised methodological practices and includes individualised longitudinal neurofeedback training combined with other interventions (Baena et al., 2021; Micoulaud-Franchi et al., 2015).

5.2 Burnout Measures and Characteristics

RQ3 aimed to investigate how burnout outcomes are characterised and measured in neurofeedback training studies. Current burnout research is wrought with underlying concerns such as measurement issues and a lack of concrete conceptual clarity (Nadon et al., 2022). As previously mentioned, the ambiguity in burnout’s definitions, management, and

diagnostic criteria has resulted in inconsistent assumptions of what burnout is conceptualised as, subsequently resulting in the implementation of many different burnout instruments and measures that have unknown validity and reliability (Bianchi, 2017; Chirico et al., 2022). Evidence of this variability is present in this current study as a total of 20 instruments and measures were used across all six of the studies. While these measures were not all explicitly measuring burnout itself, because of the lack of a standardised definition for burnout, many of these studies utilised measures of characteristics related to burnout outcomes. Of these total measures, five consisted of qEEG measures to gather a baseline of neural activity and identify areas of concern. Although these brain mapping measures can be included as part of the neuropsychological evaluation for burnout (Everhart et al., 2001) as well as used to corroborate the results of the other burnout measures, its primary function is to calibrate the neurofeedback training protocol (Krepel et al., 2020). Apart from the studies conducting the same necessary EEG baseline measures, none of the studies utilised the same burnout measures (such as questionnaires, inventories, scales or self-report techniques), despite all studies utilising more than one measure. This illustrates how ambiguous burnout definitions have resulted in inconsistent and varied burnout measures.

Relatedly, these measures focused on several different burnout characteristics that were not necessarily related to one another or provided a comprehensive overall measure of burnout. For instance, some measures focused specifically on assessing cognitive workload and working memory performance. This is because burnout is typically associated with cognitive deficits in executive functioning, attention and memory (Gavelin et al., 2022). Other measures in the study focused on the individual's mindset, belief systems, perceived performance, outcomes and sense of achievement. This is because burnout is also associated with lower self-efficacy, feelings of incompetence and lack of achievement and productivity (Maslach, 2015). In contrast, other measures concentrated on the individual's emotional state such as perceived satisfaction with one's life, level of cynicism, perceived exhaustion, and other positive (such as relaxation) and negative feelings (such as tension).

This is because burnout has also been associated with a reduction in well-being, high emotional exhaustion and an increase in negative emotions (Chang, 2009; Spiller et al., 2021). Finally, other burnout measures in the study focused on personal experiences with a traumatic event. This is because repeated exposure to highly stressful environments or scenarios is considered a risk factor for burnout (Kim et al., 2019).

These results practically demonstrate how the absence of clearly defined classifications and measurement guidelines has resulted in ambiguous and diverse interpretations of what burnout is and how it should be quantified. Not only does this make it difficult to determine what burnout should be conceptualised as but also difficult to determine how separate it is from other disorders and conditions (Nadon et al., 2022).

Although the characteristics found in the study are also conceptualised in both the BAT and MBI models (such as cognitive workload impairments, mental exhaustion, depressed mood and sleep issues), only one study explicitly mentioned MBI as the main tool used to measure burnout. Thus, despite these models being highly endorsed and considered the gold standards of burnout measurement, this illustrates that there are no widely enforced measurement standards in the context of burnout. Similarly, one critique of these models was that the characteristics being measured are seen in other disorders such as depression and anxiety. The results of the study are consistent with these critiques as the burnout characteristics mentioned could also be associated with other conditions. Although burnout is currently recognised as a phenomenon by WHO, one potential solution to this issue may be for burnout to be added as an official diagnosis to the DSM 5, which will provide clear and concise definitions of burnout and how it should be measured and managed as a separate disorder.

However, although the use of these varying measures highlights the general inconsistencies that are associated with how burnout is currently measured, this study also highlighted how all studies in the sample included more than one burnout measure. The inclusion of more than one measure allows for a more comprehensive understanding of burnout as well as provides compensation for the shortcomings of each individual measure

(Nassaji, 2020). This increases the validity of the assessment and leads to more trustworthy results (Nassaji, 2020). Relatedly, all but one of the studies mentioned the measures used as both a pre-and post-measure. This allows for a comprehensive assessment of the intervention and thus increases the reliability and validity of the studies (Stratton, 2019).

However, a large portion of the total measures used in the studies rely on self-reporting measures. Although the use of self-reporting measures is beneficial for understanding personal and environmental characteristics, affective responses, and the physical and mental health of participants with burnout, there are concerns regarding the construct validity and potential response distortions (such as the tendency to respond positively, extreme responses, negative affectivity bias, social desirability bias and providing untrue answers) that may occur when utilising these measures (Betts Razavini, 2001). Although there is no way to determine if the participants were accurately and honestly representing themselves and their burnout characteristics in this context, the use of the qEEG as both a baseline and post-measure may help to corroborate the answers presented in the self-report measures.

Similarly, some of the measures utilised in the study are still considered to be highly useful, evidence-based measures that have shown scientific validity (such as QOLI, NASA-TLX and SBI) (Frisch et al., 2005; Williamson et al., 2018) or are considered to be the “gold standard” of burnout measures (such as the MBI) (Chirico et al., 2022). However, there have been major critiques regarding these measures (such as limitations in interpretation of results, appropriateness for settings and populations outside of countries in the global north, and a limited focus on how these burnout measures can be adapted cross-culturally) (Williamson et al., 2018; Redelinguys & Morgan, 2023; Squires et al., 2014). Thus, the use of these “gold standard” measures is favourable in the context of this study (where all of the populations were from Western countries), but it is difficult to determine if the same burnout measures would be as appropriate or applicable in other countries or population contexts. One potential solution may be to modify or adapt these measures for context-specific differences (Stewart et al., 2012). Evidence of this is present in this study as measures were

adapted, such as the Mindset Revised Self-Theory Scale, Adapted Version of the 2x2 Achievement Goal Scale, Short Version of the Academic Self-Regulation Questionnaire (SQRA) and Traumatic Attachments and Beliefs Scale (TABS), or constructed, such as the 11 Item St Elizabeth Youngstown Hospital Well-Being Inventory, to increase pertinency to the specific context. However, because language and translatability may be problematic when adapting these instruments in other countries, it is necessary to implement more rigorous cross-cultural adaptation methods when measuring burnout (Squires et al., 2014).

5.3 Burnout Populations and Sample Characteristics

RQ4 in the study was concerned with the types of burnout populations and sample characteristics that were utilised in the neurofeedback training studies. As previously stated, burnout faces major ambiguity in its definition, management and diagnostic criteria (Bianchi et al., 2015). However, it is often commonly characterised by exhaustion (physical and mental) from prolonged exposure to demanding work situations (Dubale et al., 2019). While burnout has been shown to occur in almost all spheres, this emphasis on “demanding work positions” has resulted in a large proportion of burnout studies being conducted in highly stressful and taxing occupations such as healthcare professions where workers seem to be at particular risk for developing burnout (De Hert, 2020). Of these populations, women are more likely to report professional burnout than men (Artz et al., 2022). In terms of age groups, women aged between 20 and 55+ years of age as well as younger men seem to be more susceptible to burnout (Marchand et al., 2018). This is also evidenced in the papers reviewed in this study, where five of the six studies were conducted in healthcare settings with healthcare professionals being the target of the intervention. Although most of the studies utilised male and female populations, there was a slightly higher number of females (279) than males (251) in the sample, which is consistent with generalised target populations. Similarly, all but one of the studies utilised adult populations (with two specifying the age range as between 24-67 years old) which is also consistent with high burnout populations. Although this study’s focus on adult (mostly female) healthcare professionals is useful for burnout research as these populations face a higher prevalence of burnout, the

overuse of these populations may make understanding other populations that face burnout difficult. Similarly, neurofeedback training may be implemented in this context and with this specific population group, but it is difficult to ascertain whether that may be the case in other contexts and with other populations.

While it is important to further burnout and neurofeedback training research in other professional contexts, another aspect to consider is the demographics of the populations utilised in the study. All the studies in the sample were conducted in the global north and thus utilised samples from healthcare professions in Western countries. This illustrates one of the most prolific and enduring issues in behavioural and psychological research; many of the claims about human behaviour are drawn from Westernised, Educated, Industrialised, Rich and Democratic (WEIRD) societies (Henrich et al., 2010). Subsequently, these populations are deemed as representative of all other populations or used as the standard for psychological procedure and practice (Henrich et al., 2010; Kanazawa, 2020). This is problematic in a context such as the healthcare field, where the Western Pacific and European regions have reported the highest number of doctors and nurses globally (WHO, 2022). Comparatively, countries in African regions and other non-WEIRD countries have considerably fewer healthcare workers and an uneven distribution of healthcare workforce resulting in daunting problems such as severe shortages in healthcare provision and an inability to meet workforce needs (WHO, 2022). Therefore, the severity of burnout amongst these populations may differ considerably depending on the region it is conducted.

Other aspects such as diversity in culture and varying belief systems may also impede countries' access to healthcare and attitudes towards mental health disorders and novel intervention methods (Rathod et al., 2017) such as neurofeedback training. However, if these types of studies are only conducted on certain populations in certain countries, it can be difficult to determine how other cultures may respond to adhere to this intervention. This is evident in this context as few burnout studies have focused on the prevalence and consequences of burnout on different ethnic and racial groups in multicultural contexts (Lawrence et al., 2022; Rothmann, 2003). Evidence of this is present in this study's context

as only one study specified the ethnicity distribution of their sample and mentioned it as a risk factor in the study. The study noted that ten of the total twenty-one participants (across both control and experimental groups) were white-identifying, five of the participants were Hispanic or Latino-identifying, four of the participants identified with more than one race, and two of the participants identified as African American (Jackson-Cook et al., 2023). Although this study was the only one which specified these aspects, the lack of representation of ethnicities (other than white), reflects the lack of understanding of different ethnicities' experiences with burnout and how effectively neurofeedback training can manage it.

However, the remaining study in the sample focused on an adolescent population (13 years old) and burnout in a school setting. Although neurofeedback training has been well established in child populations with other mental health disorders such as attention deficit hyperactivity disorder and autism (Schutz & Herbert, 2022), there seems to be a lack of research focusing specifically on burnout and neurofeedback training in child/adolescent populations (even more so than the adult populations). In this school study, burnout was not defined explicitly but burnout characteristics were related to schoolwork outcomes (such as academic achievement). Similarly, the study utilised neurofeedback training as part of a growth mindset intervention for adolescents and not as an intervention by itself. Although the results showed that intervention did not mediate school burnout symptoms, participants did show increased attention and better control of brainwave function which could be important for understanding adolescents' ability to mediate their brainwaves in the context of a neurofeedback training intervention. Subsequently, the use of this population is potentially noteworthy for future neurofeedback studies and may provide new insight into neurofeedback training applications, mechanisms, and intervention procedures.

Another aspect to consider when utilising a population such as adolescents in neurofeedback training is neuroplasticity. For instance, the fundamental underlying principle of neurofeedback training is that the brain is plastic and can change its structure and function to adapt to stimuli (Cramer et al., 2011). The adolescent period is already a time where major neural, biological and behavioural transformation and learning take place and

includes increased connectivity among brain regions and changes amongst them (Galle, 2016; Sisk & Gee, 2021). Thus, adolescence may be considered a highly sensitive period for neuroplastic and cognitive changes (Fuhrmann et al., 2015). In this case, conducting neurofeedback training during this period may be optimal for producing positive neuroplastic changes in the brain and preventing or modifying negative cognitive changes from occurring, such as depression and anxiety associated with burnout (Deilami et al., 2016; Quevedo et al., 2019). Similarly, a significant relationship between time and the growth mindset intervention was found in the adolescent study which may indicate that the effectiveness of the intervention may be impacted by when exactly it is implemented. Therefore, although very few studies have been conducted in this area, it may be worthwhile for future research to determine if early neurofeedback training in childhood or adolescence may be optimal for the prevention of burnout in adulthood (i.e if the neuroplastic changes from neurofeedback training in adolescence are effective long term or are preventative in some way).

Taken together, future burnout research should be conducted in non-WEIRD contexts and consider the impact of ethnicity, race and multicultural contexts on burnout populations. Similarly, burnout research should focus more on contextually diverse population groups rather than on one subset of professionals. These recommendations could enable researchers to determine if neurofeedback training is generalisable or effective in different contexts with different populations and how it can be individualised to be more relevant and effective in non-WEIRD settings and populations.

5.4 Key Recommendations

Accordingly, this study has outlined key recommendations for the field in the above discussion based on the results of this review. Specifically, it is recommended that future studies investigating the effectiveness of neurofeedback as an intervention for burnout need to ensure consistency and rigour in reporting, adhere to higher quality study designs and meticulously conduct and reproduce protocols either by adhering to an international standard of procedure (such as the International Society for Neurofeedback and Research), or pre-registering studies and allowing open access to data and peer-reviews. To enhance the

quality of the study designs, a consistent and standardised definition of burnout is needed (such as advocating for classification as an official diagnosis in the DSM-5) to ensure that more consistent and validated burnout measures are used. Furthermore, more diverse burnout populations need to be utilised in a variety of contexts and countries to ensure that more is known about how burnout is conceptualised and to determine neurofeedback training efficacy outside of the WEIRD healthcare professional's context.

5.5 Study Limitations

The main limitations of this study include search strategy limitations, inclusion and exclusion criteria limitations and the use of a small sample size. In terms of search strategy limitations, the study chose to use the keyword “EEG” to gather relevant results. However, because EEG is a broad term and can refer to a multitude of interventions that utilise this technology, the results of the search strategy gathered many irrelevant studies which could have been avoided if the search terms were more narrowed down. Another limitation of the study was the choice for both reviewers to conduct the entire search strategy independently of each other. Although a second reviewer is recommended for a systematic review, there are no consistent recommendations regarding at which time the second reviewer should be included (Stoll et al., 2019). However, because the second reviewer also proceeded with the search strategy and got the same results, it resulted in numerous overlapping studies between the samples and thus more time was needed to remove these duplicates once samples were compared. Thus, the addition of a second reviewer after the search strategy is conducted would have assisted in removing redundant steps from the process. Regarding inclusion and exclusion criteria limitations, the study chose to not include studies in other languages. One limitation of this is that the sample size was very small, and the addition of these other language studies might have been beneficial to the review. Similarly, some of these excluded studies were from non-WEIRD countries which could have also been beneficial for understanding how these countries conceptualise and use neurofeedback training in burnout studies. Likewise, the decision to not include these other language studies may also have unintentionally added more focus and understanding of

WEIRD studies and research contexts rather than the multi-cultural/multi-ethnic contexts that were advocated for in this study. Thus, the addition of other languages in the review would ensure that other non-WEIRD research contexts would be potentially accounted for.

One of the main limitations present in the study is the small sample size. Small samples can comprise and limit the conclusions drawn from the study, prevent the findings from being generalisable and undermine the internal and external validity of the study (Faber & Fonesca, 2014). Thus, generalisability and validity criteria are extremely important, especially in the context of this study where the main aim is to determine if neurofeedback is a generally effective intervention. This limits this study from making conclusive statements regarding neurofeedback training as an intervention in the management of burnout and definite statements regarding how these studies are conducted.

Although the scope of this review was narrow and wanted to strictly focus on studies that mentioned burnout, one solution to increase the number of studies may be to include a broader definition of burnout in the search strategy. Burnout is currently conceptualised as sharing characteristics with other mental health disorders and conditions such as stress, anxiety and depression (Golonka al., 2019). So, it may be worthwhile to add these terms to the search strategy to gather more potentially relevant results. However, because the definitions of burnout are ambiguous, it may be difficult to differentiate studies that are particularly relevant to burnout if other disorders are included. Thus, the use of other conditions in the search strategy may help to look at the efficacy of neurofeedback training as a potential mental health intervention in general rather than just as a specific intervention for burnout. However, because there is not a vast number of studies currently published on burnout and neurofeedback interventions, this study is still important for the research field. In particular, this study can be used as a starting point to bring awareness to the current issues present in the literature and advocate for better quality studies, clearer definitions and more standardised protocols which will benefit future research in this area.

5.6 Conclusion

In conclusion, the study highlighted burnout as an occupational hazard which

presents a major risk to a variety of professions and is a significant contributor to the development of psychological disorders and the global burden of disease. However, despite the magnitude of this issue, burnout has no formal diagnosis and subsequently no tailored treatment/intervention has been assigned to manage it. Although some pharmacological and psychological evidence-based medicine practices (EBM) have shown success in treating anxiety and stress disorders, other complementary alternative medicine practices such as neurofeedback training have also shown efficacy in other disorders without the potential negative outcomes associated with EBM practices. However, neurofeedback training has also faced criticisms regarding its methodological practices, effectiveness, and efficacy, making it uncertain whether it could be a possible intervention method for managing burnout. To determine whether neurofeedback training would be effective in the context of burnout, this study conducted a systematic review of the literature.

In terms of study results, the findings in the study indicate that neurofeedback training has shown effectiveness in reducing negative outcomes associated with burnout (such as mood disturbances, sleep problems and negative emotions) and shown improvements in the areas affected by burnout (such as well-being, cognitive workload, memory performance and positive emotions). However, when compared to another intervention (such as mindfulness training), the neurofeedback training intervention did not show more significant improvements. However, the neurofeedback intervention did highlight fundamental physical and neurological changes that were not present in the other group. Nevertheless, when combined with other interventions (such as mindfulness and a growth mindset intervention), significant improvements were found over a long period. Therefore, although neurofeedback training by itself may be considered effective in the management of burnout, it may be more effective in managing burnout if combined with elements of other interventions (such as learning active awareness from mindfulness training and adopting a more resilient mindset in conjunction with the growth mindset intervention).

However, the same issues that the critiques of burnout and neurofeedback studies have found were also evident in this study. For instance, there was vagueness and omission

in the reporting of study designs, control conditions, methodological procedures, and intervention protocols evident in the study. Similarly, there were also issues in the implementation of burnout measures where unvalidated self-reporting burnout measures were utilised based on varying definitions of characteristics associated with burnout. Similarly, the study found that there was an overreliance of the use of healthcare populations in a WEIRD context evident in the studies. Although many of the studies acknowledged some of these issues as problems to be solved, there was little to no improvement seen in the newer research conducted in this area.

Therefore, due to the vagueness of methodological and procedural reports, varied study designs, variability in burnout measures and inconsistent definitions of burnout present in this study, it cannot be conclusively determined whether neurofeedback training is an effective intervention for managing burnout. Accordingly, as outlined above, three key recommendations to the field have been identified by this systematic review: (1) consistency in study designs and neurofeedback protocols; (2) use of a standardised definition of burnout and (3) increase sample representations. Furthermore, the results of the study illustrated that neurofeedback training showed the potential to reduce negative outcomes associated with burnout and improve aspects such as cognitive workload capacity, working memory, and mood disturbances, and potentially produce fundamental changes in the brain which were still evident over a long period of time. By implementing the key recommendations of this systematic review, future studies will be able to provide greater insight into the effectiveness of those associated outcomes as a non-invasive intervention for the management of burnout.

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Appendix A

Ethics Clearance Waiver

	
<u>SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE</u> <u>CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)</u>	
<u>CLEARANCE CERTIFICATE</u>	<u>PROTOCOL NUMBER: MAPSYC/23/10W</u>
<u>PROJECT TITLE:</u>	A Systematic Review Examining the use of the Neurofeedback as an Intervention in the Management of Burnout.
<u>INVESTIGATOR</u>	Patron Daniella (1353944)
<u>SCHOOL/DEPARTMENT OF INVESTIGATOR</u>	SHCD/Psychology
<u>DATE CONSIDERED</u>	07 June 2023
<u>DECISION OF THE COMMITTEE</u>	Approved unconditionally
<u>RISK LEVEL</u>	No Risk
<u>EXPIRY DATE</u>	31 December 2025
<u>ISSUE DATE OF CERTIFICATE</u>	03 June 2023
	<u>CHAIRPERSON</u>  (Dr Aline Ferreira Correia)
cc: Dr Sahba Besharati (Supervisor)	
<u>DECLARATION OF INVESTIGATOR</u> To be completed in duplicate and ONE COPY returned to the Chairperson of the School/Department ethics committee. I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure be contemplated from the research procedure as approved, I/we undertake to submit an amendment of the protocol to the Committee.	
 Signature	Date <u>13</u> / <u>03</u> / <u>2024</u>

Appendix B

Ethics Course Certificate

 TRREE	Zertifikat Certificat	Certificado Certificate
Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale Promoting the highest ethical standards in the protection of biomedical research participants		
Certificat de formation - Training Certificate		
Ce document atteste que - this document certifies that		
 Clinical Trials Centre The University of Hong Kong	Daniella Patron	
a complété avec succès - has successfully completed		
Introduction to Research Ethics		
du programme de formation TRREE en évaluation éthique de la recherche of the TRREE training programme in research ethics evaluation		
Release Date: 2023/04/02 CTD - 0000000000	 Professeur Dominique Sprumont Coordonateur TRREE Coordinator	
APPROVED BY SIWF_{FMH} ISFM	Foederatio Pharmaceutica Helveticae	FPH Programmes de formation continue Continuing Education Programme Programmes de formation postgraduée et continue
Ce programme est soutenu par - This program is supported by : European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (http://www.cihr-irsc.gc.ca/fr/2081.html) - Swiss Academy of Medical Sciences (SAMS/ASIM/ASAMW) (www.sams.ch) - Commission for Research Partnerships with Developing Countries (www.crpdc.ch)		
[REV : 20220217]		